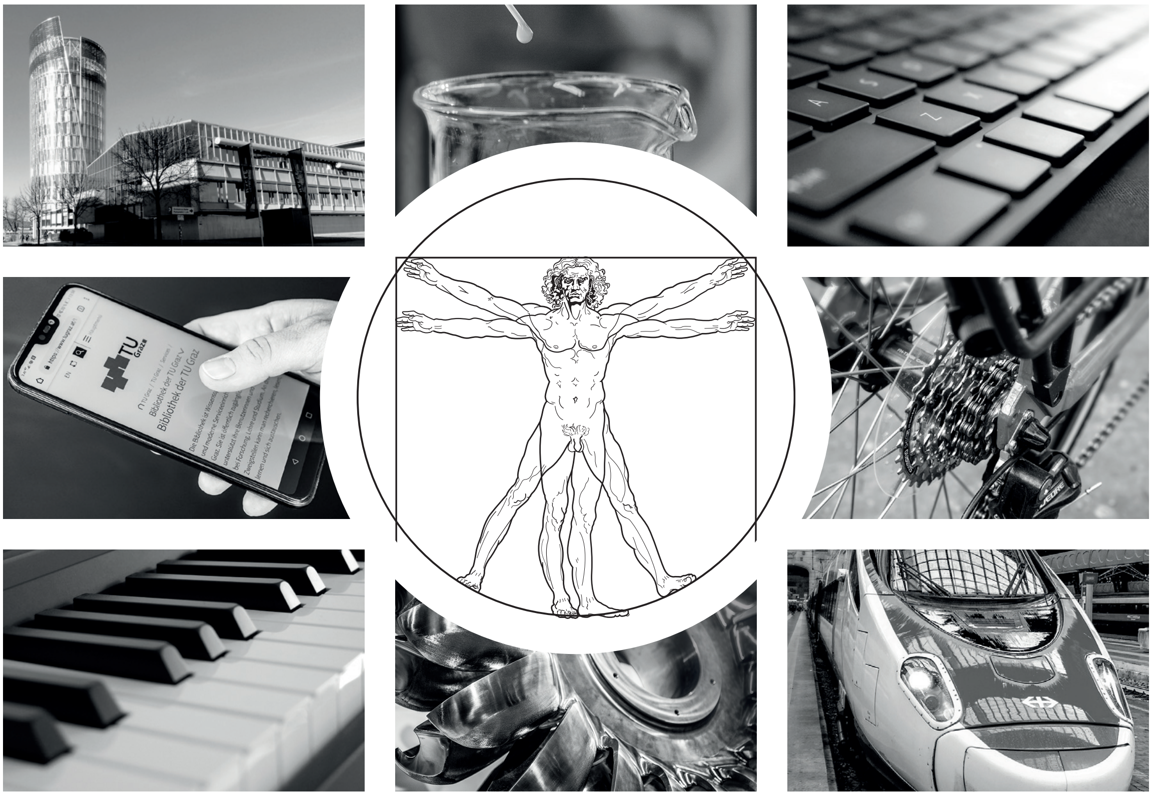
SCIENCE, TECHNOLOGY AND SOCIETY



Günter Getzinger | Michaela Jahrbacher (editors)

Conference Proceedings of the STS Conference Graz 2019

Critical Issues in Science, Technology, and Society Studies

6-7 May 2019

TU Graz

Editor	Günter Getzinger, Michaela Jahrbacher
Layout	Stefanie Egger
Cover	Stefan Schleich

Verlag der Technischen Universität Graz
www.tugraz-verlag.at

E-Book
ISBN 978-3-85125-668-0
DOI 10.3217/978-3-85125-668-0
ISSN: 2663-9440

Günter GETZINGER, Michaela JAHRBACHER (Ed.)
DOI: 10.3217/978-3-85125-668-0-01

Preface

Critical Issues in Science, Technology and Society Studies

Conference Proceedings of the STS Conference Graz 2019, May 6th-7th

The annual STS Conference Graz provides a space for scholars from all parts of the world to present and discuss their research with peers. In their papers, the conference participants address the complex ways in which science, technology and society co-evolve and mutually shape one another.

Without exception, the participants of the conference aim to provide a better understanding of the world(s) in which we live. This includes the assessment of emerging technologies, the scrutiny of ethical, legal and social aspects of contemporary scientific practices as well as the transition to environmentally friendly and socially desirable techno-scientific futures.

This volume of proceedings documents part of the work that has been presented at the 18th STS Conference in Graz in 2019. It presents the wealth of ideas discussed at this occasion and fosters collaboration.

The STS Conference Graz is the joint annual conference of the Science, Technology and Society (STS) Unit at Graz University of Technology, the Interdisciplinary Research Centre for Technology, Work and Culture (IFZ) and the Institute for Advanced Studies on Science, Technology and Society (IAS-STS).

Find the **Programme of the Conference** at the DOI: 10.3217/978-3-85125-668-0-00
and the **Book of Abstracts** at the DOI: 10.3217/978-3-85125-671-0

Günter GETZINGER, Michaela JAHRBACHER (Ed.)
DOI: 10.3217/978-3-85125-668-0-01

Contents

Günter GETZINGER, Michaela JAHRBACHER (Ed.)
DOI: 10.3217/978-3-85125-668-0-01

Günter GETZINGER, Michaela JAHRBACHER (Ed.)
DOI: 10.3217/978-3-85125-668-0-01

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

Blockchain and the Promise(s) of Decentralisation: A Sociological Investigation of the Sociotechnical Imaginaries of Blockchain

Moritz BECKER

Weizenbaum-Institute for the Networked Society, Berlin, Germany

Abstract

The idea of revolutionary social change is common topos within the discussion around decentralised technologies. An example for this is the recently emerged blockchain technology. This article aims to characterise the techno-utopian promises associated with the idea of decentralisation in the context of blockchain technology and to assess their significance within the discourses surrounding the technology. Based on different materials from the community discourse, three promises of decentralisation in the context of blockchain are identified, namely the promise of self-organised social order, automated coordination by technology and disruptive social change. It is found that while these promises characterised the normative foundation surrounding the technology in its early days, other ideals have emerged that now stand next to it. This presumed pluralisation of imaginaries is interpreted as an indication for a diversification of the blockchain community that has occurred since its inception. Thereby, the research hints to two largely neglected factors within the discussion about the promises associated with blockchain technology: Firstly, it shows that decentralisation can mean different things and should rather be understood as a metaphor. Secondly, it demonstrates that the idea of decentralisation is not uncontested within the discourses around blockchain technology. Only if these insights are taken into account, a realistic representation of the techno-utopian ideals behind blockchain can be attained.

Keywords: Blockchain, decentralisation, techno-utopianism, technology, imaginaries

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

1 Introduction

"Technologically, blockchain is enabling us to revive that spirit and build the decentralized digital community that the founding fathers of the internet initially envisioned."

(Seguin 2018)

"We just want to take the internet to its logical conclusion: total decentralization."

Stephen Tual, Former CCO Ethereum (Volpicelli 2015)

The idea of disruptive social change by technology is a common topos in the public and academic discourse about emerging information and communication technologies. Since the inception of the internet, network technologies such as the blockchain have often been associated with promises of revolutionary social change that centre around the idea of decentralisation. Due to its unique technological architecture, blockchain technology is often said to bring about a new mode of socio-economic organisation characterised by decentral and non-hierarchical cooperation (Swan 2015). To date, blockchain technology has received enthusiasm by observers that is unrivalled since the early days of the internet and has become a buzzword in community, media, industry and academia alike (Galati 2018). Understanding the promises associated with the technology within the current public discourse seems more important than ever. Against this background, the question emerges: How can the techno-utopian promises of decentralisation be characterised in the case of blockchain?

This article deals with this question from a sociological perspective. It is argued that in the case of blockchain, decentralisation acts as a powerful imaginary that is connected to promises of a self-organised social order, coordination by technology and disruptive social change. Instead of understanding decentralisation solely as a technological principle, it rather appears to have metaphorical capabilities and be associated with different meanings in different contexts.

The significance of decentralisation as a normative ideal in the context of blockchain is, however, not uncontested. Against the background of an increased tendency towards centralisation on the level of blockchain projects as well as a more predominant use of blockchain-based applications for investment purposes, it is argued that there has been a pluralisation of imaginaries within the discourses surrounding the technology. In this sense, blockchain technology is interpreted as a powerful illustration of how ways of attributing meaning to a technology change over time.

This argument is laid out in three steps. In the first step, the connection between blockchain and decentralisation is dealt with in more general terms (2). This part introduces the case of blockchain by explaining blockchain's twofold existence as a decentralised technological system (2.1.) as well as an ideological community (2.2.), before dealing with the significance of the idea of decentralisation within the normative foundation of blockchain (2.3.). It is found that while there is a high importance of the role of decentralisation, its meaning affords a closer look, which is provided in a second step (3). Based on community documents, three promises of decentralisation are presented (3.1-3.3) and situated within different lines of thinking. In a third step (4), these results are set into perspective by asking whether decentralisation has lost its significance over time, which is discussed against the background of recent developments surrounding blockchain technology (4.1-4.3). The article closes by reflecting about the role of decentralisation in the normative foundation of blockchain (5).

The article aims to add to an emerging strand of sociological literature which critically engages with the ideas, narratives and visions surrounding blockchain technology (e.g. (Golumbia 2018; Kow and Lustig 2018; Swartz 2016). It complements existing works by providing a framework to describe the promises of decentralisation and exploring their significance against the background of recent developments. Therefore, it serves the objective of providing a better understanding of the normative visions associated with blockchain within the discourses surrounding the technology.

2 Blockchain technology and the imaginary of decentralisation

2.1 What is blockchain technology?

In order to fully understand the role of decentralisation in the case of blockchain, it is first necessary to note that the idea of decentralisation lies at the base of its technological architecture. Blockchain is a data base technology that has been first presented in late 2008 by an individual or collective under the pseudonym of 'Satoshi Nakamoto' (Nakamoto

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

2008). It is most well-known for its first and most prominent application, the digital currency (‘crypto-currency’) Bitcoin. In terms of its technological properties, blockchain can best be described as a decentralised database (or: ledger) that is shared between different computers participating in a peer-to-peer network of computers. The technological novelty of blockchain is that complex cryptographic algorithms enable all computers within the network to come to a ‘consensus’ about what the correct state of the database is (Tschorsch and Scheuermann 2016). Therefore, the technology allows the implementation of decentralised databases that are shared between many different computers within a blockchain network.

Before the invention of blockchain technology, decentralised networks had always needed an intermediary – a third party – to verify that the content written in a decentralised database has not been manipulated. For instance, in the context of digital currencies, there always had to be a central bank or a payment provider to ensure that the money supply (which was registered in the shared database) was correct. With the inception of blockchain, this third party becomes obsolete, as it is guaranteed by technological means that all computers (‘node’) within the network can access the correct state of the database. Therefore, the technology allows the implementation of decentralised databases that are shared between many different computers within a blockchain network in many contexts that previously required the existence of a centralised instance.

Blockchain’s most prominent use case lies in the field of digital currencies, with over 2000 cryptocurrencies and tokens and a market capitalisation of roughly 100 billion Euros (Bundesministerium für Wirtschaft und Energie and Bundesministerium der Finanzen 2018). However, the technology yields many other potential fields for application and is hence often described as an emerging ‘general purpose technology’ of digitalisation (Kane 2017). Apart from the area of payments, a vast ecosystem of start-ups, companies, communities and individuals developing new applications to blockchain technology has emerged. By now, blockchain projects are experimenting with the technology for applications in many areas of social and economic life, ranging from fields of application such as land registering, identity management, copyright registering or logistics to more exotic fields such as gambling or online gaming. Even new fields might be opened up by the potentials of so-called ‘smart-contracts’ and decentralised autonomous organisations (DAOs) (Buterin 2014).

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

2.2 Blockchain as an ideological project

The history of blockchain technology can not only be described as a technological project, but also as an ideological project. In the technology's early days, blockchain was only known to a small number of people invested in the topic of cryptography[1]. Bitcoin as well as other cryptocurrencies entered the public discourse to a larger extent starting from 2009 in the form of an 'alternative currency movement' (Vidan and Lehdonvirta 2018: 43). Within the following years, a change became evident: Had blockchain been primarily a technological solution within the field of digital currencies, it soon became a cultural phenomenon closely connected to promises of social change by technology (Golumbia 2016: 66). As Dodd remarks for the case of Bitcoin: "Bitcoin is arguably a social movement as much as it is a currency" (Dodd 2018: 40).

At the heart of these promises made around blockchain technology is the idea of decentralisation. Having been released only shortly after the financial crisis in 2008, particularly Bitcoin seemed to many as the technological remedy to a seemingly corrupt international system of banks and governments, being a technology based on principles such as anonymity, transparency and decentralisation. The ambition behind blockchain (and particularly Bitcoin) seemed appealing to many: To take the power away from these 'intermediaries' and decentralise it to foster the creation of a free and democratic social order. This tenor of anti-authoritarian thinking runs through many blockchain-projects, which are not only limited to the area of digital currencies. As Swartz remarks, many blockchain-projects are working towards the creation of "revolutionary social, economic, and political change." (Swartz 2016: 86).[2]

---

1. The document lining out the design principles for Bitcoin ('whitepaper') was first posted to the Cryptography mailing list at metzdowd.com, a list of users invested in the topic of cryptography (Redshaw 2017: 52).

2. Nowadays, these promises around blockchain technology have exceeded the boundaries of the blockchain community and are well-established within the public discourse. Within the scope of this article, the focus will be rather on the community discourses around blockchain rather than the public image of blockchain.

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

To date, the promises associated with the technology are kept alive by the large community[1] that has developed around blockchain. The importance of normative values within the community is visible in the inception of an emerging 'cryptoculture', which manifests itself in the community's own magazines (https://www.cryptoculturemagazine.com/), slang terms (e.g. hodl), symbolism (as the stylized B for Bitcoin), song (Bitcoin song) and persona cult (Satoshi Nakamoto). Against this background, blockchain appears less as technological infrastructure, but rather as an ideological project that has promoted an idea of blockchain technology that is closely connected to hopes, expectations and visions. Golumbia even argues that the community behind Bitcoin shares more similarities with religious cults rather than technological projects (Golumbia 2018).

From a sociological perspective, this close connection between technology and normative orientations might not seem surprising, considering the large number of technologies that are closely connected with utopian visions.[2] A prominent role within the theoretical discussion around the promises of technology plays the idea of 'imaginaries', which has more recently been popularised by Jasanoff's concept of 'sociotechnical imaginaries' (Jasanoff 2015). Jasanoff argues that visions of the future take a key role within technological projects, as they provide social actors with a sense of orientation and foster legitimacy and motivation within collective projects (Borup et al. 2006; Jasanoff 2015: 10). Imaginaries can therefore be seen as a major factor determining the shape and success of technological projects. Exploring the content and ways of interpreting the imaginaries around the idea of decentralisation within the context of blockchain constitutes a key objective within the scope of this article.

1. Comparable to the Free and Open Source Software (FOSS)-movement, blockchain can be characterised as an instance of community-driven software development, meaning that developers and users of the technology are often geographically dispersed and organised via digital media and online boards instead of one company or party being responsible for the software's development.

2. One could e.g. think of the discussion around Big Data and AI within the current public discourse (Elish and boyd 2018). Borup et al. argue that the idea that technology will bring about progress is actually anchored in Western thinking, which dates back to the Enlightenment (Borup et al. 2006: 291).

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

2.3 The normative foundation of blockchain as an imaginary of decentralisation

When attempting to characterise the meaning of the imaginary of decentralisation in the case of blockchain, the documents of the discourses around the technology provide an important starting point for research. Following Jasanoff, a diverse set of material potentially qualifies for this purpose, such as “symbolic and cultural resources, such as images, texts, memories, metaphors and language itself” (Jasanoff 2015: 25). In the case of blockchain, there is no such thing as a key document to the blockchain community outlining the meaning of decentralisation within its normative foundation. Instead, diverse kinds of material such as developer statements, whitepapers, media articles and posts in online boards provide promising resources for research. By analysing a diverse set of materials this article seeks to identify understandings of decentralisation that are common within the discourses surrounding the technology, rather than focusing on one specific case (such as Bitcoin or Ethereum). Within the discourses around blockchain-technology, the high significance of decentralisation within the normative foundation of blockchain technology is immediately visible. As Swartz states, decentralisation constitutes a key “rhetorical pillar” and “one of the most frequently” used words in discourses around the technology (Swartz 2016: 88). Ethereum founder Vitalik Butarin even states that it is “often even viewed as a blockchain’s entire raison d’être” (Buterin 2017). Several quotes provide evidence for the view that decentralisation is an ideal that is of high significance within the community, which is shared across different kinds of blockchain projects and users of the technology:

> “Entering the Aragon Nest program [...] is about entering a community whose every member is committed to help every other to pursue a common goal: working toward the decentralization of human worlds.” (Sarrouy 2019)

> “An exciting alternative has arisen in the form of a movement toward *decentralization*, in which networks of peers self-organize to act collectively without such concentrated power centers.” (Zemel 2018)

> “Euphoria stems from the realisation that Bitcoin could be the vehicle that transforms the financial system from centralised to decentralised.” (Kelly 2015: 59)

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

However, while the normative importance of decentralisation seems immediately evident,[1] it is less clear what the vision of a ‘decentralised digital community’ (Seguin 2018) is actually supposed to look like. In this context, it is important to clarify that the term ‘decentralisation’ – as it is used within the discourses around blockchain technology – exceeds a strictly technological understanding of the term, as e.g. in computer science. According to a technological understanding, ‘decentralisation’ could be understood as a principle of the organisation of computers in a network which can be distinguished from centralised systems and (sometimes) distributed systems (e.g. Baran 1962). ‘Decentralising’ would then refer to implementing decentralised network architectures in specific applications, e.g. by implementing a decentralised land register instead of a system maintained by a centralised authority. While the implementation of (technically) decentralised systems is an important part of the vision of blockchain, reducing it to this aspect would surely fall too short and strip it of the ideological richness connected to the visions behind the technology.[2]

Instead, we follow the idea of Golumbia to understand decentralisation as a *metaphor* that can have different meanings in different contexts (Golumbia 2016: 64-65). According to this view, the meaning of decentralisation cannot be defined *a priori* and needs to be defined on the basis of the actual discourses surrounding the technology. This allows to account for the multiple understandings of decentralisation that are put forward within the community discourse. The different meanings of decentralisation are reflected within the promises that are made around blockchain technology. In the following, three promises of decentralisation will be identified based on materials from the community discourse: the promise of self-organised social order, the promise of automated coordination by technology and the promise of disruptive social change. These promises illustrate the different meanings that are associated with decentralisation within the discourses surrounding the technology.

1. From a critical normative perspective, this glorification of decentralisation as a mode of horizontal power has been criticised under the label of ‘network fetishism’ (e.g. Baldwin 2018; Garcia 2016).

2. In fact, blockchain is not the first and only technology that is revolved by promises of decentralisation. Schrape (2019) shows that the promises around decentralisation can be traced back the DIY-scene of the late 1960s, and similar promises can also be found within the computer counterculture of the 1970s and 1980s as well as the early days of the internet.

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

3 The promises of decentralisation

3.1 The promise of self-organisation

In order to understand the promise of self-organisation that is being made in the context of blockchain technology, it is key to understand the role of intermediaries. Blockchain technology is often promised to abolish intermediaries – such as banks, governments or companies – which are often seen as a key problem within present society that is associated with capitalism, oppression and corruption (Swartz 2016: 90). From the early days of blockchain technology, the idea of abolishing these intermediaries was central to the normative foundation of the technology (Garrod 2016). Already the first known document presenting the technological concept of blockchain to the public, the Bitcoin whitepaper carries the idea of disintermediation:

> "A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another *without going through a financial institution*." (Nakamoto 2008, italics added)

Instead of a system dominated by powerful intermediaries, blockchain is posited to bring about a social order based on self-organisation. The 'cyber-utopia' (Baldwin 2018) constructed here is one that upholds individual values such as freedom and equality, and is said to replace vertical relations between individuals and institutions with horizontal relations between individuals. In this sense, the normative foundation of blockchain can be seen as an instance of horizontalist thinking (characterised by distrust in authorities and promoting values such as self-management, autonomy and direct democracy) which can also be observed in social movements such as the Occupy-movement (Sitrin 2012). The horizontalist belief surrounding the technology can be exemplified by two quotes, of blockchain project Bitnation and the 'Church of Bitcoin' respectively:

> "The Church of bitcoin has a simple and clear mission. We want to free the world from the oppression that is currently enabled by government and central bank control over exchange." (Church of Bitcoin 2019)

> "In BITNATION's world sovereignty shifts decisively from the State to the Citizen. By reducing competition between citizens for services and increasing competition

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

between Nations for citizens we will improve the quality of governance and reduce incentives for coercion and violence." (Bitnation Whitepaper 2018: 2)

The idea of self-organisation in the promises of blockchain can be situated in a libertarian line of thinking that upholds individual liberty as a core principle. The techno-utopian vision constructed around blockchain technology strongly reminds of the 'cyberlibertarianism'[1] (Winner 1997) of internet enthusiasts of the early days of the technology such as Nicolas Negroponte and John Perry Barlow. At the same time, it can be argued that the idea of self-organisation that lies at the base of these promises can be traced back as far as to the political theory of Jean-Jacques Rousseau. In fact, the vision of a self-organised social order in the case of blockchain strongly reminds of Rousseau's dream of direct democracy: In 'The Social Contract', Rousseau put forward a radical vision of society that would be under the direct control of the people, which govern the state based on the general and common interest (volonté générale) (Rousseau 2013). This utopian thinking of self-organised democratic beliefs is also prominent within the promise of social order associated to blockchain. Against this background, it can be agreed with author Brett Scott, who argued that Bitcoin can be seen as a Rousseauean approach to finance, contrasted by a Hobbesian world of central banks (Scott 2013).

3.2 The promise of coordination through technology

Connected to the vision of implementing a self-organised social order is a strong idea of automating social relations. At the base of this vision lies the idea that blockchain replaces human-based institutions and experts by automated code that functions all by itself. This idea of automation is reflected in statements claiming that blockchain-based currencies are 'math-based money' (Seward 2013) or that blockchain-based money works "over and above social life" (Dodd 2018: 35). According to this vision, human trust is no longer deemed necessary: instead, blockchain acts as a 'trustless consensus machine' (Davidson, De Filippi, and Potts 2018: 2) that 'governs' social behaviour on the basis of

1. Winner describes cyber-libertarianism as "collection of ideas that links ecstatic enthusiasm for electronically mediated forms of living with radical, right wing libertarian ideas about the proper definition of freedom, social life, economics, and politics in the years to come." (Winner 1997, for an alternative definition cp. Malcom 2013). A classic example that is often referred to as an example of cyber-libertarianism is John Perry Barlow's "Declaration of the freedom of the internet" (Barlow 2016).

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

technological algorithms and cryptographic mechanisms such as consensus algorithms or smart contracts.[1] Therefore, the vision imagined for the future of blockchain can be described as one of automation, where blockchain coordinates and regulates different kinds of human behaviour:

> "Blockchain technology and smart contracts eliminate the need for middlemen to enforce contracts, verify transactions, or perform background checks. This means that BPM [business process management] software can more fully automate business processes and manage new technology embedded in the process." (Saunders 2017)

The epitome of this dream of the automation is a new emerging kind of blockchain projects, the DAO ('decentralised autonomous organisation'). The DAO refers to the project of creating a decentralised automated organisation on the blockchain that coordinates the behaviour of individuals by the means of smart-contracts and algorithms. While the first implementation of a DAO on the Ethereum blockchain has actually failed in practice – in the sense that the 'coins' were stolen by an unknown individual (DuPont 2017) – there is a growing number of blockchain-projects which are seeing a large potential within the technology. According to Josh Zemel of blockchain-project DAO-stack, DAOs are "the future of collaboration" (Zemel 2018). Today, an increasing number of DAO-based blockchain-projects such as Aragon or Democracy Earth indicate that the dream of automated social coordination is very much alive.[2] This idea of automated governance of social relations in the case of blockchain can be seen as related to the idea of steering social processes with technological means that is present within the cybernetic thinking of Stafford Beer (1994). As in the promise of automation around blockchain, cybernetic thinking assumes similarities between biological and physical models and the governability of both. Beer put these cybernetic models into practice by applying them to governance

1. Against this background, Vidan and Lehdonvirta interpret blockchain as an important shift in the interrelationship of human and technology: "Nakamoto here seems to appreciate Actor-Network Theory's call for symmetry by equating participants and nodes, votes, and CPUs. His imagined community fully embraces hybridity" (Vidan and Lehdonvirta 2018: 47).

2. While one might initially think that the vision of an automation of social relations might be at odds with the idea of autonomy, Swartz argues that both automation and autonomy should be rather seen as interlinked, with the former being a prerequisite for the latter (Swartz 2016: 93).

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

organisations and political change, e.g. in the case of the Chilenean Cybersyn project (cp. Espejo 2009). The idea of representing human behaviour in formal models and governing it aided by technological means is one idea that is reflected within cybernetic thinking as well as the discourses surrounding blockchain technology.

3.3 The promise of disruptive social change

Promises of disruptive social change have been with blockchain technology from its inception and can be found within discourses in community, media, industry and academia alike. For instance, Tapscott and Tapscott state that blockchain might be “the most important and most revolutionary digital innovation since the inception of the world wide web, with enormous potential for change” (Tapscott and Tapscott 2016: 225). Adopting this line of thinking, academic researchers Van den Hoven et al. believe that “Blockchain technology may be the basis of the next step in human, social and cultural evolution” (Van den Hoven et al. 2018). Andrew Keys of blockchain-start-up ConsenSys even predicts a fourth industrial revolution that will draw on blockchain-based technology:

> “This year, the Fourth Industrial Revolution will ignite, as the buzzwords of artificial intelligence, robotics, Internet-of-Things, quantum computing, ad biotechnology actuate from proofs-of-concepts into production. All of the aforementioned technologies will be deployed on blockchain substrates.” (Keys 2019)

Therefore, the notion of social change brought forward within such claims of social change by blockchain is clearly one of revolutionary and disruptive change. As opposed to a steady, evolutionary understanding of social change, descriptions of the perceived impact by blockchain are often depicted as historic breaks within history.[1]

A common stylistic device that is used to illustrate the presumed ability of blockchain for social change is the comparison to other technologies, most notably the internet. For instance, founder Mark Metry claims that blockchain can be seen as the “most important invention since the internet and electricity” (Metry 2017). The comparison of blockchain to the internet elucidates the high expectations of bringing about social change that are

1. This conception of social change can be characterised as an ‘epochalist’ understanding of social change, making a rhetorical distinction between the age ‘before blockchain’ and ‘after blockchain’ in order to make “the new visible through the juxtaposition of the old” (Savage 2009: 218).

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

connected to the technology. It is this presumed capability of bringing about change that observers calling blockchain the "new internet" (e.g. Sharma 2018) are referring to. At the same time, the internet also acts as negative example, as it is seen as a disappointment by many, being seemingly dominated by centralised platforms and profit-oriented businesses (Swartz 2016: 90).

The idea of encompassing social change by technologies is not a new idea, as it can be traced back to Schumpeter's notion of 'creative destruction'. Creative destruction in the Schumpeterian sense describes a form of innovation, that "enables to establish new markets and market principles through new technologies and thereby disrupt existing markets and conventional rule patterns" (Wagener 2018: 387, own translation). Schumpeter illustrates this view using the example of the railroadization of the US-American Middle West, which he sees as a "death sentence for the agriculture of the west" (Schumpeter 1991: 349). The idea of disrupting traditional market structures by technology[1] strongly reminds of the promises around blockchain and its supposed "potential to revolutionise the world economy" (Tapscott and Kirkland 2016). Within the community discourse, this change is – different from Schumpeter's conception of destructive change – something that is solely connoted in a positive sense.

Dimension of promise	**Manifestation**	**Tradition of thought**
Social order	Self-organised	Libertarian (e.g. J.J. Rousseau)
Mode of coordination	Automated	Cybernetics (e.g. S. Beer)
Social change	Disruptive	J. Schumpeter

Table 1: *Dimensions of promises within the blockchain community discourse*

Taken together, the three promises of decentralisation in the context of blockchain presented above clearly show that decentralisation is more than just a mode of technical organisation in the context of blockchain discourse – it can rather be understood as a socially powerful imaginary connected to multiple promises regarding social order, the mode of coordination and social change (see Table 1). In this context, it could be shown

1. More recently, this idea of 'disruptive technologies' has been taken up and popularised by Harvard Professor Clayton Christensen (Christensen et al. 2015).

that these promises draw on different lines of thinking such as libertarianism, cybernetics and Schumpeterian economics. At the same time, this typology of the visions connected to blockchain opens up new questions regarding their interrelationship and how the role of decentralisation has developed over time. As the sociology of expectation has argued, imaginaries should not be thought of as stable entities, but can also change over time, responding and adapting to new conditions (Borup et al. 2006: 286). Since its inception, the blockchain-ecosystem has undergone considerable changes and has developed from a small technological project to a new base technology of digitalisation. In this context, it is questionable how the changes that the blockchain-ecosystem has undergone have also resulted in a change of the *normative* importance of the idea of decentralisation.[1] In the following, this question will be addressed against the background of two recent developments within the blockchain community: Firstly, a tendency towards (technologically) centralised blockchain-systems and, secondly, an increased interest in blockchain as an instrument for financial speculation.

4 Setting the promises of decentralisation into perspective

4.1 Has decentralisation run out of steam?

An important aspect that should be considered when speaking of a tendency towards more (technologically) centralised blockchain-systems is the fact that many of the ‘radical blockchain dreams’ (Swartz 2016) associated with decentralisation have actually not materialised.

Firstly, instead of moving towards self-organised systems that are characterised by equality and horizontalism, many blockchain systems have rather developed into the direction of (technological) centralisation. Perhaps the most prominent example for this development is the centralisation of mining power within the Bitcoin blockchain system, which factually allows a small number of actors (‘mining-pools’) to be the decisive force in

1. Following Jasanoff, imagination and the material world are not disconnected, but rather stand in a close interrelationship. This is reflected by her use of the word ‘socio-technical’, which suggests that “these imaginaries are at once products of and instruments of the co-production of science, technology, and society in modernity” (Jasanoff 2015: 28).

decisions about protocol changes (Böhme et al. 2015: 220).[1] As De Filippi remarks: “The governance of many blockchain-based applications is, despite their decentralised infrastructure, often a lot more centralised than it might seem at first glance” (De Filippi 2017: 68-69, own translation). Secondly, the ambitious visions of automation put forward in the case of Decentralised Autonomous Organisations (DAOs) have, to date, remained an idea rather than reality.[2] And, thirdly, while blockchain technology, without doubt, has had a considerable impact in the area of payments, the promises of radical disruptive change of the societal mode of coordination seem, at the present moment, to have been strongly over-exaggerated.

At the same time, one can witness an emerging trend towards more technically centralised blockchain-systems (for example so-called ‘private permissioned blockchains’[3]). In fact, there is an increasing number of cryptocurrencies and blockchain applications that rely on centralisation as a key design feature (Hsieh, Vergne, and Wang 2017: 58), such as the blockchain-projects Tether (combining a decentralised currency with a centrally managed money supply). Particularly business actors have caught a lively interest in the topic of more technically centralised blockchain designs, as these compensate for some of the drawbacks of (technologically) decentralised blockchain-systems. Therefore, a growing number of actors surrounding the technology are actually working towards a future that is characterised by greater centralisation, rather than decentralisation:

> “A private blockchain comes with more privacy and a greater degree of control. (…) Private blockchains are perfect for intra-business usage.” (Berlia 2017, IT service provider Indus Net Technologies)

1. A more recent example could be seen within the Ethereum-blockchain-system, where a recent decision to half the block-rewards was taken “by a single elite of 15 developers” (Tomasicchio 2018).

2. Zemel states: Up until this point, however, DAOs have remained largely an abstract idea, not yet in practice except in a handful of limited cases. And the decentralization movement has not yet scaled” (Zemel 2018).

3. In this context it is important to note that – as opposed to the common opinion within the public discourse on blockchain technology – that blockchain-systems can be implemented in ways that are not fully (technologically) decentralised. This could, for instance, be realised by only allowing a limited number of actors to read the content that is stored on a respective blockchain. For a technical overview on different types of blockchains cp. Wüst and Gervais 2018: 2.

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

> "Are we still going to be hung up on "It is not really decentralized"? Do we care?"
> (Krishnakumar 2019, Venture capital investor)

4.2 Blockchain between ideological community and investment opportunity

A second development that should be considered when asking about the normative role of decentralisation as a community ideal is the increased interest in blockchain as an instrument for financial speculation. Zook and Blankenship (2018) argue that the failure of decentralisation has resulted in a change of direction within blockchain currencies, which are now tending more towards the goal of creating economic investments while having abandoned their initial normative goals and visions:[1]

> "The initial vision of blockchain to create a global alternative currency and do away with financial intermediaries has largely failed. Far from the reworking of exchange envisioned by Nakamoto (2008), blockchain currencies have become merely another means of speculative accumulation." (Zook and Blankenship 2018: 14)

There are several reasons that speak for the validity of this claim. Firstly, many blockchain-based digital currencies have developed a large appeal to financial investors interested in generating monetary gains through speculative investments, facilitated by their monetary instability (Yermack 2015).[2]

Secondly, a growing number of large companies have developed a key interest in generating financial gains by the use of blockchain technology, as can e.g. be seen in the case of the Hyperledger-project, which is supported by large industry players such as IBM, Intel and SAP.[3]

---

1. Very fitting within this context is Garrod's critique of Bitcoin who argues that the notion of freedom brought forward within the context of blockchain only conceives of freedom as freedom from intermediaries such as the state, but does not take into account the 'tyranny of the market' (Garrod 2016: 62).

2. As Yermack points out in the case of Bitcoin: "Bitcoin appears to behave more like a speculative investment than a currency" (Yermack 2015: 42).

3. Another development that could be mentioned here is that many smaller companies have discovered blockchain technology as an instrument to raise money by investors, as can be seen in the case of ICOs ('initial coin offerings'), a method of crowd-funding which is based on blockchain-technology (Allen et al. 2018: 20-21).

And thirdly, within the community's discourses one can also observe the view that blockchain technology rather serves as an instrument for investment purposes rather than fostering social change:

> "I don't care about decentralization, it gives me profit and that is enough, and centralized coins don't hurt investors." (gedor (2017), user of online Board Bitcoin-Talk).

> "Decentralisation has become a boom thanks to Bitcoin, but what happens today, is that people are trying to get rich thanks to investors who don't know the difference between 'decentralised' and 'distributed'. [...] So yeah, decentralisation is a very rare thing today." (AleksandraSandra (2017), user of online Board Bitcointalk)

In the light of these claims, the promises of decentralisation do not seem to constitute ways of imagining the future that are unequivocally shared among community members. Instead of understanding decentralisation as a key value, some users of the technology appear to see blockchain primarily as a way to yield monetary gains by investments rather than being interested in it as an ideological project.

4.3 Towards a pluralisation of imaginaries?

Against the background of the two developments lined out above, it is questionable how the imaginary of blockchain technology can actually be characterised: As one of financial investment, as one of centralisation, or – as initially assumed – one of decentralisation? Considering the recent developments within the blockchain eco-system, it is argued here that it can be either of those options, depending on the context. As more businesses and users with large economic interest have become interested in the technology, new imaginaries have emerged around the technology which are now visible within the community discourse. The diverse promises and visions associated with blockchain technology reflect not only one idea of decentralisation, but rather several ideals that could be described as community goals. Therefore, the developments described above can be interpreted less as an absolute loss in the normative importance of the idea of decentralisation, but rather pointing to a pluralisation of imaginaries.

This pluralisation of imaginaries could be interpreted as reflecting the changes that blockchain technology has undergone since its inception. While the technology has initially started off being an ideological project of technologists (Redshaw 2017) centred around the idea of abolishing powerful intermediaries such as banks within the field of finance, it

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

has developed into a large and diverse community that now includes actors that exhibit (economic) interests of these very intermediaries, such as companies or investors.[1] Within blockchain's diverse community, the promises of decentralisation might act as normative orientation for some, but not for all members of the community. The existence of multiple imaginaries thus, which are situated between utopian idealist views on the one hand and pragmatic realist views on the other could be seen as illustrating the diversity of the visions and hopes associated with blockchain technology.[2] In the end, navigating between these opposing idealistic and pragmatic visions in order to facilitate further technological progress might open up new challenges for the communities that centre around the technology. While different visions of the future may stand next to one another without interference, they might sometimes also lead to conflicts within social groups, in case imagined futures are not compatible with one another (Pfotenhauer and Jasanoff 2017: 804).[3] These conflicts are dealt with on a community level, as the controversial discussions about the idea of decentralisation in the blockchain community illustrate. It is thus in the hands of the community that has developed around the technology to mediate between conflicting views and decide whether an ideal of decentralisation (Xu 2018), centralisation (Kikovic 2018) or a mediating perspective[4] between both (Ahsan 2018) is the right way to go for the future of blockchain-technology.

1. Against this background, the young history of blockchain could be seen as reminiscent of the history of the internet, which is often described as a decentralised network technology that has eventually come to be dominated by large businesses. Following this line of thinking, it would be questionable whether blockchain is heading into a similar direction of 'economisation' (cp. De Filippi 2017: 77).

2. This seeming contradiction between idealistic and more pragmatic perspectives within the community reminds of the common narrative associated with the Free and Open Source Software (FOSS) movement, which is often seen to embody the same conflict (e.g. Tozzi 2017).

3. A recent example for the contestedness of imaginaries from a different area could e.g. be seen in the Brexit-votes, in which visions for Britain to remain in the EU were opposed to one in favour of Brexit (Pfotenhauer and Jasanoff 2017: 804).

4. As Ahsan states: "An ideal future would be one where we can combine the speed, efficiency and focus of centralized systems, with the security, incorruptibility, and inherent creative capacity of decentralized ones" (Ahsan 2018).

DOI: 10.3217/978-3-85125-668-0-02

5 Conclusion: An imaginary of decentralisation?

This article has aimed to characterise the techno-utopian promises of decentralisation surrounding blockchain technology and assessed their significance against the background of recent developments. Therefore, a broad approach has been taken that has dealt with different interpretations of the technology that are brought forward within the current discourses surrounding the technology. Drawing on different documents from the community discourse, the imaginary behind blockchain was characterised as one of decentralisation. In order to make sense of the visions attached to the technology, three promises of decentralisation were identified, based on documents of the community discourse around blockchain. It has been found that the imaginary of decentralisation is connected to specific notions of social order (self-organisation), coordination by technology (automation) and social change (disruption), which have their roots in different traditions of Western social and political thought. This exemplifies the important insight that there is not *one* meaning of decentralisation within the discourses around blockchain technology, but rather *different* meanings that differ depending on the context.

In order to assess the normative significance of these promises of decentralisation within the blockchain community, the article has then discussed the role of decentralisation against two developments around the technology: Firstly, the tendency towards (technologically) centralised blockchain-systems and, secondly, an increased interest in blockchain as an instrument for financial speculation. It has been argued that while decentralisation has been a key ideal within the early days of the technology, it now seems that the idea of decentralisation is rather contested: As more businesses and investors have become interested in the technology, imaginations of the future centred more around the idea of (technical) centralisation as well as blockchain as an opportunity to create economic gain by monetary investments. This pluralisation of imaginaries can be interpreted as indicative of the diversification of the community around blockchain that has occurred since its inception. These results point towards two important points that have been rarely considered within the current sociological discussion on the ideals of decentralisation in the case of blockchain. Firstly, it points towards the insight that decentralisation is not only to be defined as a technological principle but is rather a metaphor that is connected to different meanings and promises in different contexts. Exploring these different meanings is thus an important goal for further sociological research. Secondly, it shows that research on the normative ideals surrounding blockchain needs to consider the contestedness of imaginaries to a larger extent, instead of resorting to the common narrative of blockchain as a project of decentralisation.

In the end, the example of blockchain has very much demonstrated that thinking about futurity is a key feature of technological projects and that there is a close connection between technological projects and (techno-) utopian thinking (Turner 2006). Blockchain can thus be seen in a long line of technologies that have been associated with claims of revolutionary social change such as the internet. At the same time, the example of blockchain can also be read as a powerful example of how thinking about futurity might change over time. This illustrates the importance of social interpretation for the societal reception of technologies more generally. In this light, while the analysis of the promises of decentralisation has focused on *what* the promises of decentralisation entail, the insights gained open up as many new questions about *why* utopian promises surround technologies in the way they do.

References

Ahsan, Jiyad (2018): ‘Centralization vs. Decentralization: The Best (and Worst) of Both Worlds’. *Hacker Noon*. https://hackernoon.com/centralization-vs-decentralization-the-best-and-worst-of-both-worlds-7bfdd628ad09 (May 29, 2019).

Aleksandra Sandra (2017): ‘Re: Decentralised! Really?’ *bitcointalk.org*. https://bitcointalk.org/index.php?topic=2157167.20 (May 29, 2019).

Allen, Darcy, and Berg, Chris and Novak, Mikayla (2018), Blockchain: An Entangled Political Economy Approach. In *SSRN Electronic Journal*: pp. 1-26. Doi: https://ssrn.com/abstract=3158805.

Baldwin, Jon (2018): ‘In Digital We Trust: Bitcoin Discourse, Digital Currencies, and Decentralized Network Fetishism’. In *Palgrave Communications* 4 (1): pp. 14. Doi: 10.1057/s41599-018-0065-0.

Baran, Paul (1962): ‘On Distributed Communication Networks’. First Congress of the Information System Science, November 1962, New York.

Barlow, John Perry (2016): ‘A Declaration of the Independence of Cyberspace’. *Electronic Frontier Foundation*. https://www.eff.org/de/cyberspace-independence (May 29, 2019).

Beer, Stafford (1994): *Decision and control: the meaning of operational research and management cybernetics.* Wiley: Chichester, New York.

Berlia, Bharat (2017): 'Which Blockchain Model Should You Choose To Begin With?' *Indus Net Technologies.* https://www.indusnet.co.in/blockchain-model-choose-begin/ (May 29, 2019).

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

Bitnation (2018): Pangea Jurisdiction: The Internet of Sovereignty. https://tse.bitnation.co/ (May 29, 2019).

Böhme, Rainer, Nicolas Christin, Benjamin Edelman, and Tyler Moore (2015): 'Bitcoin: Economics, Technology, and Governance'. In *Journal of Economic Perspectives* 29 (2): pp. 213–38. Doi: 10.1257/jep.29.2.213.

Borup, Mads, Nik Brown, Kornelia Konrad, and Harro Van Lente (2006): 'The Sociology of Expectations in Science and Technology'. In *Technology Analysis & Strategic Management* 18 (3–4): pp. 285–98. Doi: 10.1080/09537320600777002.

Bundesministerium für Wirtschaft und Energie, and Bundesministerium der Finanzen (2018): 'Online-Konsultation Zur Erarbeitung Der Blockchain-Strategie Der Bundesregierung'. https://www.blockchain-strategie.de/BC/Redaktion/DE/Downloads/online-konsultation-zur-erarbeitung-der-blockchain-strategie.pdf?__blob=publicationFile&v=3 (March 31, 2019).

Buterin, Vitalik (2014): 'Ethereum White Paper: A next Generation Smart Contract & Decentralized Application Platform'. http://blockchainlab.com/pdf/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf (March 31, 2019).

——. (2017): 'The Meaning of Decentralization'. *Medium*. https://medium.com/@VitalikButerin/the-meaning-of-decentralization-a0c92b76a274 (May 29, 2019).

Christensen, Clayton M., Michael Raynor, and Rory McDonald (2015): 'The Big Idea: What Is Disruptive Innovation? Twenty Years after the Introduction of the Theory, We Revisit What It Does – and Doesn't – Explain'. In *Harvad Business Review*: pp. 3–11.

Church of Bitcoin (2019): 'Church of Bitcoin.' *Church of Bitcoin*. https://churchofbitcoin.org/ (May 29, 2019).

Davidson, Sinclair, Primavera De Filippi, and Jason Potts (2018): 'Blockchains and the Economic Institutions of Capitalism'. In *Journal of Institutional Economics* 14 (4): pp. 639–58. Doi: 10.1017/S1744137417000200.

De Filippi, Primavera (2017): '"In Blockchain We Trust": Vertrauenslose Technologie Für Eine Vertrauenslose Gesellschaft', Jakob Augstein (Ed.) *Reclaim Autonomy: Selbstermächtigung in Der Digitalen Weltordnung*. Berlin: Suhrkamp, pp. 53–81.

Dodd, Nigel (2018): 'The Social Life of Bitcoin'. In *Theory, Culture & Society* 35 (3): 35–56. Doi: 10.1177/0263276417746464.

DuPont, Quinn (2017): 'Experiments in Algorithmic Governance: A History and Ethnography of "The DAO," a Failed Decentralized Autonomous Organization', Malcolm Campbell-Verduyn (Ed.): *Bitcoin and Beyond: Cryptocurrencies, Blockchains and Global Governance*. Routledge, pp. 157–77.

Elish, M. C., and danah boyd (2018): 'Situating Methods in the Magic of Big Data and AI'. In *Communication Monographs* 8 (1): pp. 57–80. Doi: 10.1080/03637751.2017.1375130.

Espejo, R. (2009): 'Performance Management, the Nature of Regulation and the CyberSyn Project'. In *Kybernetes* 38 (1/2): pp. 65–82. Doi: 10.1108/03684920910930277.

Galati, Francesco (2018): ‘Blockchain as a Process: Ideologies and Motivations behind the Technology’. *Medium*. https://medium.com/coinmonks/blockchain-as-a-process-ideologies-and-motivations-behind-the-technology-c25219d87881 (May 29, 2019).

Garcia, José Luís (Ed.) (2016): 27 *Pierre Musso and the Network Society*. Cham: Springer VS. http://link.springer.com/10.1007/978-3-319-45538-9 (May 29, 2019).

Garrod, J.Z. (2016): ‘The Real World of the Decentralized Autonomous Society’. In *tripleC: Communication, Capitalism & Critique* 14 (1): pp. 62–77.

gedor (2017): ‘Re: Decentralised! Really?’ *bitcointalk.org*. https://bitcointalk.org/index.php?topic=2157167.20 (May 29, 2019).

Golumbia, David (2016): *The Politics of Bitcoin: Software as Right-Wing Extremism*. Minneapolis: University of Minnesota Press.

——. (2018): ‘Zealots of the Blockchain’. *The Baffler*. https://thebaffler.com/salvos/zealots-of-the-blockchain-golumbia (May 29, 2019).

Van den Hoven, Jeoren, Johan Pouwelse, Dirk Helbig, and Stefan Klauser (2018): ‘The Blockchain Age: Awareness, Empowerment and Coordination', Dirk Helbig (Ed.): *Towards Digital Enlightenment: Essays on the Dark and Light Sides of the Digital Revolution*. Cham: Springer VS, pp. 163–66.

Hsieh, Ying-Ying, JP Vergne, and Sha Wang (2017): ‘The Internal and External Governance of Blockchain-Based Organisations: Evidence from Cryptocurrencies’. Malcolm Campbell-Verduyn (Ed.): *Bitcoin and Beyond: Cryptocurrencies, Blockchains and Global Governance*. Routledge, pp. 48–68.

Jasanoff, Sheila (2015): ‘Future Imperfect: Science, Technology and the Imaginations of Modernity’. Sheila Jasanoff and Sang-Hyun Kim (Ed.): *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*. Chicago: University of Chicago Press, pp. 1–33.

Kane, Ethan (2017): ‘Is Blockchain a General Purpose Technology?’ In *SSRN Electronic Journal*: pp. 1–27. Doi: 10.2139/ssrn.2932585.

Kelly, Brian (2015): *The Bitcoin Big Bang: How Alternative Currencies Are about to Change the World*. Hoboken: Wiley.

Krishnakumar, Arun (2019): ' IBM World wire – the inevitable rise of Centralized Blockchains'. *Daily Fintech*. https://dailyfintech.com/2019/03/22/ibm-world-wire-the-inevitable-rise-of-centralized-blockchains/ (March 31, 2019).

Keys, Andrew (2019): 'Welcome to the Fourth Industrial Revolution — 19 Blockchain Predictions for 2019'. *Medium*. https://media.consensys.net/welcome-to-the-fourth-industrial-revolution-19-blockchain-predictions-for-2019-8b2e542bf86a (March 31, 2019).

Kikovic, Mirko (2018): ‘Blockchain Centralization: Is That the Future of Decentralized Network?’ https://medium.com/altcoin-magazine/blockchain-centralization-is-that-the-future-of-decentralized-network-5d95c6f89de6 (May 29, 2019).

Kow, Yong Ming, and Caitlin Lustig (2018): 'Imaginaries and Crystallization Processes in Bitcoin Infrastructuring'. In *Computer Supported Cooperative Work (CSCW)* 27(2): 209–32. Doi: 10.1007/s10606-017-9300-2.

Malcom, Jeremy (2013): 'Internet Freedom in a World of States'. http://www.intgovforum.org/cms/wks2013/workshop_background_paper/64_1367863304.pdf (March 29, 2019).

Metry, Mark (2017): 'Blockchain Technology Is the Most Significant Invention since the Internet and Electricity'. *Medium*. https://medium.com/@markymetry/blockchain-technology-is-the-most-significant-invention-since-the-internet-and-electricity-f2d44a631ef6 (May 29, 2019).

Nakamoto, Satoshi (2008): 'Bitcoin: A Peer-to-Peer Electronic Cash System'. https://bitcoin.org/bitcoin.pdf (March 31, 2019).

Pfotenhauer, Sebastian, and Sheila Jasanoff (2017): 'Panacea or Diagnosis? Imaginaries of Innovation and the "MIT Model" in Three Political Cultures'. In *Social Studies of Science* 47 (6): pp. 783–810. Doi: 10.1177/0306312717706110.

Redshaw, Tom (2017): 'Bitcoin beyond Ambivalence: Popular Rationalization and Feenberg's Technical Politics'. In *Thesis Eleven* 138(1): pp. 46–64. Doi: 10.1177/0725513616689390.

Rousseau, Jean-Jaques (2013): *The Social Contract*. Ware: Wordsworth Editions Ltd.

Sarrouy, Olivier (2019): 'Aragon Nest'. *Aragon*. https://aragon.org/project/grants/ (May 29, 2019).

Savage, Mike (2009): 'Against Epochalism: An Analysis of Conceptions of Change in British Sociology'. *Cultural Sociology* 3 (2): 217–38.

Schrape, Jan-Felix (2019): 'Technology and the Promise of Decentralization: Origins, Development, Patterns of Arguments.' In *Stuttgarter Beiträge zur Organisations- und Innovationsforschung, SOI Discussion Paper* 1: pp. 5–24. Doi: http://hdl.handle.net/10419/194289.

Schumpeter, Joseph A. (1991): *The Economics and Sociology of Capitalism*. Princeton: Princeton University Press.

Scott, Brett (2013): 'So You Want to Invent Your Own Currency'. *Aeon*. https://aeon.co/essays/so-you-want-to-invent-your-own-currency (May 29, 2019).

Seguin, Patrick (2018): 'Back to Basics: Decentralization and Society'. *Medium*. https://hackernoon.com/back-to-basics-decentralization-and-society-df3154d30928 (May 29, 2019).

Seward, Zachary M. (2013): 'Real Money Starts to Pour into Math-Based Currencies like Bitcoin'. *Quartz*. https://qz.com/73379/real-money-starts-to-pour-into-math-based-currencies-like-bitcoin/ (May 29, 2019).

Sharma, Toshendra Kumar (2018): 'Is Blockchain Comparable to "the New Internet"?' *Blockchain Council*. https://www.blockchain-council.org/blockchain/is-blockchain-comparable-new-internet/ (May 29, 2019).

Sitrin, Marina (2012): *Everyday Revolutions: Horizontalism and Autonomy in Argentina*. London; New York: Zed Books. http://site.ebrary.com/id/10603026 (May 29, 2019).

Moritz BECKER
DOI: 10.3217/978-3-85125-668-0-02

Swan, Melanie (2015): 'Blockchain Thinking: The Brain as a DAC(Decentralized Autonomous Organization'. In *IEEE Technology and Society Magazine*: pp. 41–52.

Swartz, Lana (2016): 'Blockchain Dreams: Imagining Techno-Economic Alternatives After Bitcoin', Manuel Castells (Ed.): *Another Economy Is Possible: Culture and Economy in a Time of Crisis*. Malden: Polity, pp. 82–105.

Tapscott, Don, and Rik Kirkland (2016): 'How Blockchains Could Change the World. Interview with Don Tapscott'. *McKinsey&Company*. https://www.mckinsey.com/industries/high-tech/our-insights/how-blockchains-could-change-the-world (May 29, 2019).

Tapscott, Don, and Alex Tapscott (2016): *Blockchain Revolution: How the Technology behind Bitcoin Is Changing Money, Business, and the World*. New York: Portfolio Penguin.

Tomasicchio, Amelia (2018): 'Ethereum Block Reward Will Be Halved'. *The Cryptonomist*. https:/ /cryptonomist.ch/en/2018/08/31/ethereum-block-reward/ (May 29, 2019).

Tozzi, Christopher J. (2017): *For Fun and Profit: A History of the Free and Open Source Software Revolution*. Cambridge: The MIT Press.

Tschorsch, Florian, and Björn Scheuermann (2016): 'Bitcoin and Beyond: A Technical Survey on Decentralized Digital Currencies'. In *IEEE Communications Surveys & Tutorials* 18 (3): pp. 2084–2123.

Turner, Fred (2006): 'How Digital Technology Found Utopian Ideology: Lessons From the First Hackers' Conference'. In *Critical Cyberculture Studies: Current Terrains, Future Directions*, eds. David Silver and Adrienne Massanari. New York: New York University Press, 257–69.

Vidan, Gili, and Vili Lehdonvirta (2018): 'Mine the Gap: Bitcoin and the Maintenance of Trustlessness'. In *New Media & Society* 21 (1): pp. 42–59. Doi: 10.1177/1461444818786220.

Volpicelli, Gian (2015): 'Smart Contracts Sound Boring, But They're More Disruptive Than Bitcoin'. *Vice*. https://www.vice.com/en_us/article/pgaxjz/smart-contracts-sound-boring-but-theyre-more-disruptive-than-bitcoin (May 29, 2019).

Wagener, Andreas (2018): 'Politische Disruption: Die Digitalisierung der Politik und die libertäre Technologie der Blockchain', Andreas Liebhold, Tom Mannewitz, Madeleine Petschke und Tom Thiene (Eds.): Demokratie in unruhigen Zeiten: Festschrift für Eckhard Jesse. Nomos, Baden-Baden, pp. 387-398.

Winner, Langdon (1997): 'Cyberlbertian Myths and the Prospects for Community'. http://homepages.rpi.edu/~winner/cyberlib2.html (May 29, 2019).

Wüst, Karl, and Arthur Gervais (2018): 'Do You Need a Blockchain?' In *Zug: IEEE*, 45–54. https:/ /ieeexplore.ieee.org/document/8525392/ (May 29, 2019).

Xu, Hitters (2018): 'Decentralization Is the Essence of Blockchain'. https://medium.com/nebulasio/decentralization-is-the-essence-of-blockchain-ccc9e7ba839c (May 29, 2019).

Yermack, David (2015): 'Is Bitcoin a Real Currency? An Economic Appraisal', David Lee (Ed.) *Handbook of Digital Currency: Bitcoin, Innovation, Financial Instruments, and Big Data*. Amsterdam: Elsevier/ AP, pp. 31–43.

Zemel, Josh (2018): ‘An Explanation of DAOstack in Fairly Simple Terms’. *Medium*. https://medium.com/daostack/an-explanation-of-daostack-in-fairly-simple-terms-d0e034739c5a (May 29, 2019).

Zook, Matthew, and Joe Blankenship (2018): ‘New Spaces of Disruption? The Failures of Bitcoin and the Rhetorical Power of Algorithmic Governance’. In *SSRN Electronic Journal*: pp. 1–20. Doi: 10.2139/ssrn.3155378.

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

Temporalities and Care: Gendered Tensions in Scientific Practices

Ester CONESA

Interdisciplinary Internet Institute, Universitat Oberta de Catalunya, Spain

Abstract[1]

Changes in science organization connected to new management and evaluation regimes have activated a set of studies working, on the one hand, on the effects of the acceleration of the working pace on academics (Ylijoki & Mäntila, 2003; Müller, 2014; Walker, 2014; Mountz et al., 2015; Vostal, 2015), and on the other, on effects and shifts in epistemic practices (Anderson et al., 2007; Burrows, 2012; Fochler et al, 2016; Horbach & Halffman, 2019). Broader reflections on temporalities and science under neoliberalism are slow science initiatives (Stengers, 2011; Müller, 2014; Mountz et al., 2015), chronopolitics (Felt, 2017) or dominant temporalities neglecting aspects of care in technoscience (Puig de la Bellacasa, 2015). Based on this, I develop an argument that relates time, care, gender and neoliberal regimes in science following feminist care approaches developed by Tronto (1993; 2017) and Puig de la Bellacasa (2015). Through a qualitative analysis of public scientific discourses, researchers' interviews and three focus groups on evaluation practices, I explore five levels: scientific discourses, evaluative practices, knowledge practices, relationships between colleagues, and personal lives. Tensions and dysfunctions in the relationship between time and care are shown to affect not only researchers' lives and their relationships in gendered ways, but also their practices, (dis)connected from quality or 'excellence', and furthermore, the direction of science. A diversity of temporalities is defended as a way of promoting care time and practices of care in science. The notion of care is also discussed as a possible guiding principle for a better and more inclusive and diverse science.

1. This paper is a partial elaboration of the last part of the doctoral thesis.

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

1 Introduction

In European countries, in the last few decades, science and academia have experienced important changes that relate to more global economic changes such as the knowledge economy. The Lisbon Agreement pushed Europe to enhance international economic competition through science, technology and innovation, modifying the role of universities and creating top research centres in the name of excellence (Conesa and González, 2018a). New management (Deem, 1998; Shore and Wright, 2000) – usually called new managerialism or new public management (see Deem and Brehony, 2005) – redefined the rules of the scientific organization by applying the logic of the private sector to the public (Deem, 1998) through the application of the principles of productivity and competitiveness, secured with the audit culture (Shore and Wright, 2000). Research production moves to the fore through publication in high impact journals owned by big editorials. Funding achievement – through demonstrable scientific production and networks around the globe – also becomes central within a system of fierce competition, and in some institutions, it is now the only way to receive payment in an environment of uncertain and precarious labour (Vayreda et al., 2019). Connections with industry through patents and other collaborations have also been fostered (Conesa and González, 2018a).

2 Work intensification and changes in knowledge practices

These movements have produced different consequences, among which, on the one hand, is the intensification of work, and on the other hand, changes in the knowledge practices.

The acceleration of the pace of work has been noted in terms of conflicts that occur in temporal structures related to daily working time, writing time, contractual time and personal time (Ylijoki and Mäntylä, 2003). Müller (2014) highlights the academic race to produce a higher quantity of output in shorter periods of time. This engenders individualist and instrumental strategies of careerism and future anticipation in an endless effort to secure a position (Müller, 2014; Clarke and Knights, 2015; Ylijoki, 2010). Fast academy produces harmful affective states and distress in terms of lack of time for personal, familial and social lives, as well as for the house work, which is still gendered and mostly shouldered by women (Conesa and González, 2018b; Mountz et al., 2015; Gill, 2009; Acker and Armenti, 2005). However, while many feel constrained by time pressures, others may experience it as thrilling, as shown in a study of senior academics of an elite British university (Vostal, 2015).

On the other hand, some studies point to how new management and evaluative culture have produced effects in knowledge practices. First of all, metrics have led academic value to determine career continuity (Burrows, 2012). In this logic, the race to publish in high-pressure rhythms has brought on dubious practices and academic misconduct toward colleagues and research itself, such as cutting corners, self-plagiarism or refusing to share knowledge within the same group or work environment (Anderson et al., 2007; Horbach & Halffman, 2019). Epistemic practices are influenced by productive goals that disregard social and ethical issues in science (Fochler et al., 2016). Finally, among other consequences, metrics have also impacted the creation of local knowledge in local language journals, which are not as valued as English-language, high-impact journals (Hicks et al., 2015).

3 Time, Care and Science

Both lines of studies can lead to questions on time, care and science: is it possible to say, under a feminist care approach, that we are experiencing a lack or undermining of care and care practices at the personal level and the level of colleagues, while also at the scientific level, in order to gain time for our productivity and for the survival of our careers? Does the connection between time and productivity result in *careless* practices? Broader reflections on temporality and science in new management regimes can shed some light that will help frame this question.

Slow science initiatives have appeared in the last years to demand time to think and read, in some cases through disembodied and simplistic claims – as for example the manifesto of The Slow Science Academy (2010) – and others in more reflexive ways (for a review see Conesa, 2018). Personal repercussions, critiques of new management techniques, the race to publish in order to have a competitive edge, and the need for time to engage with students and university life have been cited as arguments in favor of a ‘slower’ science (see for example, Gosselain, 2011; O’Neill, 2014; Müller, 2014; Mountz et al., 2015). Among these heterogeneous voices, Isabelle Stengers appeals to slow science in a critique of the *knowledge economy* that has transformed science into “privileging disembedded and disembedding knowledge and strategies, abstracted from the messy

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

complications of this world" under "fast science and industry" (Stengers, 2011, p. 10), thus pointing to the content and the way in which science is produced.

Ulrike Felt (2017) approaches the question of time in science using the term chronopolitics: "Chronopolitics refers to the politics of time governing academic knowledge generation, epistemic entities, and academic lives and careers" (Felt, 2017, p. 54). For example, knowledge production is compressed into predefined time units determined by the length of projects funded, governing academics' everyday life amidst other demands (Felt, 2017). This framework opens up the politics of time to the different levels of scientific governance. Another meaningful reflection in more theoretical or philosophical terms is developed by Maria Puig de la Bellacasa (2015) when analysing technoscientific dominant temporality, taking as a case the field of soil science. She describes science as driven by productivist timescapes:

> Perhaps more than any other modern social practice, science is actively and performatively embedded in the dominant progressive, promissory, productivist epochal timescape" (Puig de la Bellacasa, 2015, p. 697).

In this way she argues how this dominant temporality in technoscience neglects care aspects, as for example, the *care time* needed to "maintain, repair and 'foster soil's liveliness" (p.702). The futuristic and linear orientation to an increasingly productivist soil science has been translated into exhaustion and loss of diversity of the elements of soil, disregarding the *care time* vital for human and non-human entities.

This reflection brings us to the relationship between time, care and productivity. In Western societies time has been transformed into an exchange value in order to be instrumentalised (Adam, 2004). In this sense, acceleration or time compression is "an unquestioned economic and political goal as it increases profit" (Adam, 2004, p.128-129), since the more we can compress time the more we can produce. These considerations function within a very specific framework, where "inequities remain invisible" (Adam, 2004: 125). In other words, in Western economic terms, the time of the unproductive is not valued and rendered invisible (Adam, 2004). It is usually the time for care and caring practices that goes unnoticed; therefore, the time involved in these activities usually undertaken by the "least well off members of society", that is, women, racialized people, and other groups marked by class, age or ability (Tronto, 1993, p. 113). With all this in mind, can an approach to care inform us and be used as an analytical tool applicable to

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

academia and science? I draw on a broad definition of care, a definition developed by Fischer and Tronto in 1990:

> "On the most general level, we suggest that caring be viewed as *a species activity that includes everything that we do to maintain, continue, and repair our 'world' so that we can live in it as well as possible* [*sic*]. That world includes our bodies, our selves, and our environment, all of which we seek to interweave in a complex, life-sustaining web" (Fisher and Tronto, 1990, p. 40; Tronto, 1993, p.103)

As framed, this definition does not essentialise care as a natural activity for women. It dismantles the idea of care as a (merely) private issue, restricted to the personal sphere, beyond the dyadic relationship (cf. Noddings, 1984). It also helps us understand care as a basic need without which we cannot live – which is close to what Spanish feminist economists refer to when they talk about *the processes that sustain life* when dealing with the notion of *care* (Carrasco, 2001; Pérez-Orozco, 2014). Feminist approaches to care aim to place care at the centre of the political life as a way of disrupting broader social inequalities (Tronto, 1993; Pérez Orozco, 2014; Carrasco, 2001).

Now, how can we apply such an approach to academia? Puig de la Bellacasa also draws on this definition in her account of time for (soil) science (2015) and in her elaboration of "matters of care" (2011) in Science and Technology Studies (STS), as a reformulation of "matters of concern" as developed by Latour (see Latour, 2004). Puig de la Bellacasa (2015) feminist approach "engages with care as a way to draw attention to the significance of practices and experiences made invisible or marginalized by dominant, 'successful', forms of technoscientific mobilization" (p.692). In this application, she approaches time for care or *care time* in an in-depth and meaningful way in order to counteract the futuristic and productivist temporalities in technoscientific endeavours of soil science. This can be read as an application of a care approach to the content of science itself.

Other accounts of care have been applied to academia in organizational literature to highlight a highly gendered workplace, in particular due to total dedication to work but also to internal hierarchies and discriminations (Lynch, 2010; Conesa and González, 2018b; Ivancheva et al., 2019). Heijstra et al. (2017) have used the term "academic housework", drawing a parallel to housework as a way of referring to the undervalued chores of academia (i.e. student supervision), usually undertaken by women and early-career academics. However, care has not been applied as an analytical concept to the different

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

levels of academic and scientific endeavours (in terms of content, organization, work relationships, the personal sphere) in ways that could provide an interesting account on how science is evolving and on ways to improve internal tensions and exclusionary practices highlighted in the aforementioned literature.

This paper, therefore, is an initial, in-progress attempt to apply the lens of a care feminist approach in academia and science to the different levels of scientific governance. It asks what it would look like to look at science through the lens of care in terms of its relationships with time and productivity. It also provides evidences in the context of Spain, adding to previous literature on the topic from other countries.

4 Methodology and Context

This study is based on twenty-five semi-structured biographical interviews with academics and scientists based in Spain, three focus groups and the analysis of web discourses and documentation on hiring processes. They are complemented by notes taken in institutional settings and an analysis of scientific reports by the European Commission.

Part of this research was generated within the GENERA project where I conducted eight interviews in one research centre of excellence and eight in one university department in an equal number of men and women academics at different points in their career (from postdocs to senior positions) working in Biomedicine and Humanities, respectively. Focus groups on evaluative practices were conducted in two Biomedicine and Environmental Sciences research centres and in one Humanities university department, with three-four participants in each group. Nine further interviews were conducted with women working in different university settings and fields following a snowball strategy, covering the fields of Social Sciences, Humanities, Environmental Sciences, Engineering and Biology. A qualitative analysis using content analysis tools developed by Corbin and Strauss (1990/2015) rose tensions around issues of time, productivity, gender and care.

New management techniques have been applied in Spain since the implementation of the 2001 university law of crafted to fit to the European guidelines of the Lisbon agreement (Conesa and González, 2018a). The academic Spanish context has also been and still is affected by harsh cutbacks, especially from 2011 to 2014, with replacement rates in public universities being frozen and funding for research activities curtailed (Conesa and González, 2018a). The application of narrow research metrics by new national and

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

regional quality agencies have toughened already-complex accreditation process (a highly bureaucratic process to be accessible for a position, before a position opens). All in all, this situation has led to a bottleneck situation of accredited academics in precarious conditions waiting for the opening of permanent positions and/or facing stricter academic merits and demands.

4 Findings

In this analysis, productivity-, time-, and care-related tensions are organized into five levels (although some of them overlap): scientific discourses, evaluative practices, knowledge practices, relationships between colleagues, and personal lives.

4.1 Scientific Discourses: Fast Science as a futuristic promise

The EU frames knowledge as “the currency of the new economy” and research in a “(…) global R&I marketplace, [where] Europe has to compete with other regions (…)”, as reports on research of the European Commission usually read[1]. This type of discourses normalise science as a commodity in which outcomes introduced into the productive system are the most valued items. In this context, promissory and futuristic linear temporality rhetoric (Puig de la Bellacasa, 2015) permeate certain slogans, especially those found in STEM research centres or campuses of excellence, where leading, global competitive research is being developed: “the science of the future”, “advancing the edges of....”, “pushing the frontiers of...” or “accelerating research”. Science needs to be fast and future-led, like in a carrot-and stick logic in the search for never-ending productivity. Thus, it would seem the time and care needed to think and work on social and environmental problems is disregarded. Temporality also emerges in motivational speeches in institutional settings, in which researchers and academics are exhorted to “run as fast as you can”, and “to be the best in your field” together with a mantra on the indicators importance[2], as if the aim of science were not the scientific content itself but personal

---

1. Both expressions are found in EU Commission communication and report: the first “A Reinforced European Research Area Partnership for Excellence and Growth” (2012, p.2) and the second “Structural change in research institutions: Enhancing excellence, gender equality and efficiency in research and innovation” (2012, p.13).

2. To preserve anonymity, the institutional settings and the people who voiced these discourses have not been identified.

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

success surreptitiously translated into an improvement in institutional rankings. When explaining the time and effort devoted to projects that have been prepared and will not be funded, the testimonies of interviewees contrast with this fabled temporal imaginary, such as in the case of the male group leader of a very successful lab in Biomedicine: "Out of thirty proposals we have written, twenty are nos, and 10 have been yeses, so we develop these ten". Scientific temporalities have other rhythms that do not fit with time compression driven by projectification (Felt, 2017) or other newly norms in science. For example, in Spain the average duration of the PhD has decreased from 7 years in 2010 to 4.4 years in 2017 due to a Royal Decree implemented in 2011 that determined a maximum length of three years (with extensions under exceptional circumstances)[1]. Narrow and restricted time spans for researchers in training – whose labour conditions could be very diverse (i.e. supervision, working environment, resources, etc.) – point to risks in the care dedicated to the content and development of the research. Productivism – in the form of articles – and the individualist rhetoric of 'being the best' (see also Conesa and González, 2018b) to 'accelerate the future', diverges from views such as those of this group leader woman: "The content of *Nature* is not what advances science but the knowledge we each contribute. This is what society can benefit from, not your personal success". In her view, science is a collective process of knowledge generation that is unrelated to journals, impact factors or personal achievement.

From a care approach we could say that discourses of speed and productivity foster individualism and *fast science* that possibly endanger the time needed to care for the content and development of scientific endeavours. In time-compressed jobs, more complex activities are left out (Sabelis, 2002). In this case, for example, the time and care that would be devoted to the in-depth activities needed to attain a certain degree of quality or commitment (i.e. to read books or complex texts – that many scientists admit they cannot do anymore – to develop in-depth research, write high complex papers or engage in some concerns).

1. Source: Ministerio de Ciencia, Innovación y Universidades, Estadística de tesis Doctorales.

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

4.2 Evaluative practices: Extreme devotion and narrow metrics that neglect "sustainability of a life"

Evaluative practices are not only an important time in an academic career, they also point to the assimilation of certain formal and informal criteria, having constitutive effects. Three focus groups were conducted around evaluative practices. Due to spatial constraints, I will refer to only one of them. The focus group simulated an academic selection process as a way to discuss evaluative criteria with reference to two fictional curricula, one belonging to a man and another to a woman, both searching for a second postdoctoral contract. The focus group was comprised of two male group leaders (junior for A and senior for B) and two human resources personnel of the Biomedicine research centre.

They began the discussion with the number of papers each had published, per the candidates' curricula, and in which journals (searching for impact factors). This was followed by an examination of the time frames between academic milestones (i.e. thesis defence, first postdoc contract and publications), which was expressly different for both fictional candidates. In concrete, the woman's longer time gap between positions was of concern. After this, the discussion turned on the importance of the personal interview and what the group leaders looked for in it:

> A: In general, I look for a young person, that comes here with much drive and motivation, and that has this ambition [to become a PI]. I look for this in the interview. But if her profile is more oriented to a stable contract, it is not that powerful and intense drive of a postdoc that wishes to become a PI. (…) I have four women who are pregnant or have children. They leave at 17h00 while a man can stay until 23h00. If they want a stable position there are not many chances. (...)
>
> B: If what they want is to come back because 'I have a family, I'm tired of being in the United States'…
>
> A: (*interrupts B*) Exactly, then not.
>
> B: (*continues*)…I might be interested. That is, if I don't have someone else and this person knows how to do what I need. But this is not usually what we are looking for.
>
> A: Exactly, exactly. In my case I usually wouldn't hire this person. And it's very easy to tell.

DOI: 10.3217/978-3-85125-668-0-03

Junior group leader (A) defines a young person as being someone with a lot of drive and determination. He begins by taking for granted that the woman will want a more stable contract (unlike the man), which is the opposite of what they are looking for in a new researcher. The candidate's profile is also evaluated in terms of age, "someone young", – this re-appears later in the discussion. For both leaders, ambition with respect to the next position – which is something riskier and more difficult to achieve due to the scarcity of positions after postdoctoral stages – will ensure the candidate's constant, non-stop commitment. In other words, the time and willpower which will lead to publications for the candidate and the lab (thereby ensuring the lab's continuity insofar as securing future funding is concerned). Again, they describe a regime of science exclusively driven by productivist goals towards a now labour-related, promissory future that may never materialize. In this way, life stability and the time needed to care for oneself and others is viewed as undesirable and it is undermined in a markedly gendered way. The statement "a man can stay until 23h00" means that science can only be done by those who can devote their time exclusively to work (see Conesa and González, 2018b), and, besides, women will not even be considered or eligible for this. Scientists are thought and construed, therefore, as pieces of a machinery devoid of attachments, affective bonds or personal care. Under the lens of a care-focused approach, the dominant emphasis on productivity neglects life sustainability – the everyday care practices and care bonds needed to sustain life – fostering dominant temporalities of intensity and speed of production. Narrow evaluative systems shape selection processes in the search for a *successful* (masculinized) *entrepreneurial self* (Vayreda et al., 2019) and exclude the necessary care time for other scientific and personal practices and needs, generating exclusionary practices that follow taken for granted gender scripts.

4.3 Knowledge practices in the race "to publish high"

The importance of metrics and the power of indicators in certain journals usually develop into high pressure that in turn grown into feelings of hurt and frustration. But there are also consequences at the level of knowledge creation or epistemic decision-making (Fochler et al., 2016).

DOI: 10.3217/978-3-85125-668-0-03

This scientist, now in a technical position argues that doing good science in accurate ways is not enough anymore. There has to be a “fashion factor” and “sexy” topics must be chosen in order to publish:

> If you have published in *Nature* or *Science* you have accomplished with the 50% to get a job. It’s like the stamp. One can agree or not. One must not agree. (...) And then they select not only on a basis of scientific quality but on the fashion factor, if what you do is sexy or not. (…) I mean, this has consequences in your career, obviously, even if the work is very well-done, rigorous, highly scientific … (…). This is not normal. This is the part of the science that I rejected. (Man, Biomedicine).

We could assert that there is a lack of care for the quality of science itself in favour of a hyped and trendy science (the marketable visible part) that rejects and neglects the complexity of *less fancy topics* however important for the scientific development itself.

There are also consequences for knowledge in other fields. The following researcher claims that humanities and social sciences are adapting to *hard sciences*’s norms of metrics. When there is scarcity of time and resources and high levels of precarity the need arises to prioritize certain kinds of knowledge and specific forms of publication that will provide a competitive edge in terms of securing access to employment. Local knowledges or local relevance and audience become devaluated (Hicks et al., 2015):

> “The rules of the economic academy are written by the hard sciences, and Humanities and Social Sciences we fit as we can (...) We all know that impact indexes in Humanities are ridiculous. Sometimes a book written in a regional language read by 800 people has more impact [because] it has stirred up the way of doing research in this part of the country. And not to have an article about an enormous trifle but very well written that is accepted in a first quartile. But these are the rules of the game and we already know them.”
>
> (Woman, Humanities).

The logics of centre and periphery apply in the valuation system in a way that undermines certain ways of doing science while prioritizing those of the dominant point of view. In constrained timespans, care for the development and dissemination of different knowledges and languages outside the ‘centre’ is neglected.

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

Another interviewee explained a situation in the United States in which she was pressured to sign an article whose hypotheses had not been proven. After refusing to do so, her boss fired her. Fearing legal action, Human Resources maintained her in her position. However, the result of this astonishing situation was that she became technician:

> My dream job! Look how things went! And it was my last chance to pursue science (…). It was very frustrating to find these things in the best place I had ever imagined. (…) It seemed very unfair, and then I wavered between disappointment with science in general – like 'it can't be true that these things happen!' – and the fear of being fired, and feeling very sad. (Woman, Biomedicine).

There are several ways in which we are not caring for knowledge practices due to the productivist, high-pressure temporal rhythm of science that prioritizes fast and publishable research. We could affirm that care time for certain kinds of content, certain languages and audiences (which promotes diversity) out of the centre is lost due to the logic of productivity that stems from neoliberal forms of conducting science. Moreover, in the last example – and in others (see Conesa and González, 2018b) –, there is evidence of a lack of care for colleagues' relationships – especially under power relations in hierarchical structures – for the sake of publishing.

4.4 Care between colleagues and "academic housework"

Other practices that neglect care between colleagues are shown below. In situations where power relations are enacted in abusive ways it is easy to normalize and forget the rights, time, and respect of others (Conesa and González, 2018b), and pretended 'objective' measures in science have not changed these dynamics. Perhaps, on the contrary, high-pressure environments foster them. The following PhD Student explains that she had been devoting the entire time of her thesis grant to her research group work. The last six months before her contract ended, she said she needed to concentrate on her dissertation in order to finish it. Her demand was not well-received:

> Let's see, I'm paid to work on my thesis (...) 'Until now, I've been helping you and I've always said yes. Always.' Until the moment you say 'No, now I need to concentrate on the thesis, for the next six months, and then I'll see if I can help you again or not. But right now, I can't because I want to finish my work. And they didn't take it very well... Since then, our relationship has been tense, I mean our relationship is quite tense. (…)

DOI: 10.3217/978-3-85125-668-0-03

> I felt very bad because they told me that I was missing out on opportunities and it sounded like a threat. The fact that they didn't appreciate everything I've done until now, it's like, 'Come on, what's going on?!' – (Woman, Social Sciences).

This is an example of "academic housework" (Heijstra et. al, 2017): the invisible work done as research support by a PhD student. This kind of work tends to be given to those at the beginning of their career, who usually acquiesce because of the possibility of future job positions through the demonstration of hard work and submissiveness (Gill, 2009; Heijstra et al., 2017). As is the case with care work at familial level, it tends to be gendered. So, an associate professor in engineering explains when she developed the role of pastoral care with students which demanded a lot of time from her. Not only this time was not valued institutionally but also some students considered her a soft and not so serious professor compared to hard and aggressive male engineer professors they were used to. In a way, time for caring relationships inside scientific settings either with colleagues or with students or junior researchers is non-existent or made invisible and unvalued, yet the focus on productivity enacted by a high productive masculinized figure under hierarchical schemes is in the centre. Care is still associated with weakness in front of dominant values of autonomy and competitiveness (Tronto, 1993).

4.5 Gendered care work at personal lives

On a personal level, many interviewees raised the issue of a lack of time for their personal lives, at the social, emotional and familial level (see Conesa and González, 2018b) which turns into a lack of care on themselves, for their mental health and their general well-being. A woman from Social Sciences explained how she put aside her social activism and semi-professional artistic practice due to high demands from her science group, which ended in feelings of emptiness and isolation.

Another woman explained how her partner – who shared child care of their three children equally – was penalized for no time abroad by having his access to a stable position barred.

> He devoted a significant part of his time, like me, to raise our children and this has penalized him to obtain the accreditation. (...) the type of CVs they look for are very homogeneous and the issue of having children… of course... I mean, when they say you lack research stays abroad, it means they do not take into account that you have

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

> children. Because if you have young children you... you cannot nor want to do time abroad. Apart from the fact that in a globalized and technological world we can communicate without being necessarily there. And this means total exclusivity to academic career models and a narrowly-defined trajectory. (Woman, Humanities).

She is talking about the total time availability of academic career models where the basic need of care for personal lives is not taken into consideration, still following the traditional male breadwinner model (see Conesa and González, 2018b). For those men who start to share care work equally, this time regime disrupts the move toward gender equality (Conesa and González, 2018b) since total devotion is expected more from men than from women (as we saw in 4.2 section). The most common situation for men working in the high time-pressured academia is clearly supported by this interviewee: “I have missed my children’s childhood” (Man, Humanities), though men usually do not acknowledge this as loss, due to gender scripts.

Care at the level of personal lives is undermined in neoliberal science because it implies time that is not employed toward productivist goals. In other words, the time necessary for care practices at personal, familial and social levels become devalued, invisible, absent or is constantly under threat.

5 Conclusions/Discussion: Care as a Guiding Principle in Science?

Field work shows tensions and dysfunctions in the relationship between time and care that affect not only researchers’ well-being and personal relationships as well as those between colleagues in gendered ways, but also knowledge practices and epistemic choices that foster a (dis)connection from/to quality or ‘excellence’ under a dominant productivist temporality. We have seen examples at these different levels: scientific discourses, evaluative practices, knowledge practices, relationships between colleagues, and personal lives. We could argue then that in science and academia the time employed in non-productive non-measurable activities becomes secondary or invisible thus eroding practices of care. The care approach functions as a framework that helps us to analyse and make visible exclusionary dynamics in knowledge and science itself (i.e. what is researched, how it is researched), as well as for academics (especially early-career academics and women) in what can be seen as a decline of practices of care at these different levels. Time pressures guided by productivity goals following narrow evaluative

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

regimes lead to the prioritization of some knowledges over others, some practices over others, and finally and consequently, to some temporalities over others, deteriorating *care time* for science, for personal lives and for our colleagues' relationships. An inherited scientific regime of power relations based on hierarchies and full work devotion (the intellectual of the ivory tower), embodied in the traditional male breadwinner model that has no responsibilities at home, seems not only to continue, but also to be exacerbated by the introduction of the new 'objective' norms that put pressure on lives and practices through the imperative of productivity and speed. Furthermore, it shows tensions in the direction of science as a public good guided by ethical values concerning social or environmental issues. A diversity of temporalities (Puig de la Bellacasa, 2015) that cannot be squeezed in standard and closed time frames is shown and should be defended in order to promote care time and care practices in science.

Now, could the notion of care be a guiding principle for a better and more inclusive and diverse science? Locating care at the centre, within a wide care perspective (Tronto, 1993; Puig de la Bellacasa, 2011, 2015; Pérez Orozco, 2014) would affect the organization of science in a very important way.

However, it would be risky and undesirable to try to systematize care for science as a guide or as a norm. First, because the notion of care is not free from problematic issues that we need to be aware of (see Puig de la Bellacasa, 2015 and, for example, Hughes et al, 2005; Murphy, 2015 or Pérez Orozco, 2014); secondly, because it could create a moral normativity easily subjected to power relations (Puig de la Bellacasa, 2011, 2015); thirdly, because in a neoliberal context, care is susceptible to be co-opted – as it is in certain ways in health care (Tronto, 2017) – or misused, stripping its political meaning and subversive potential.

This said, we could rely on care in an ethical way – being conscious of the related problems – through a culture of care and care time that would permeate our worlds and promote more inclusive, diverse and respectful – human and non-human – environments. In science, a culture of care would have the potential to a) displace competitiveness and foster cooperation and stability in scientific careers; b) promote a different work organization where care of personal lives would be shared equally (which would mean, for example, redesign working schedules that disrupt women as principal carers by omission); c) support different rhythms of research productivity depending on the context, resources, research groups, etc.; d) support and value diverse formats of research production and dissemination while valuing other academic practices by making them visible and important e) fears of professional problems – usually the subtext under neoliberal politics – could be compensated with other forms of organization and horizontal styles, in which the power of senior academics is developed differently; and finally, f) all this could result in care for knowledge practices that are not guided by productivist milestones and pressures, except for the aim of doing science with the time and care it demands (see for example ‘matters of care’ in Puig de la Bellacasa proposal previously mentioned).

References

Acker, Sandra, and Armenti, Carmen (2004): Sleepless in academia. In Gender Educ. 16, pp. 3–24. DOI: 10.1080/0954025032000170309

Adam, Barbara (2004). Time. Cambridge: Polity. ISBN 978-0745627779.

Anderson, Melissa S.; Ronning, Emily A.; De Vries, Raymond; Martinson, Brian C.

(2007): The Perverse Effects of Competition on Scientists’ Work and Relationships. Sci Eng Ethics 13, pp. 437–461 DOI: 10.1007/s11948-007-9042-5

Burrows, Roger (2012): Living with the h-index? Metric assemblages in the contemporary academy. Sociol. Rev. 60, pp. 355–372. doi: 10.1111/j.1467-954X.2012.02077.x

Carrasco, Cristina (2001): La sostenibilidad de la vida humana: ¿Un asunto de mujeres? Mientras Tanto 82, 43–70.

Clarke, Caroline; Knights, David (2015): Careering through academia: securing identities or engaging ethical subjectivities? Hum. Relat. 68, pp. 1865–1888. DOI: 10.1177/0018726715570978

Conesa, Ester (2017): “(No) time for care and responsibility: from neoliberal practices in academia to collective responsibility in times of crisis,” in Revelles B;

González A. (eds) *Teaching Gender: Feminist Pedagogy and Responsibility in Times of Political Crisis*. London: Routledge, pp 42–63.

Conesa, Ester (2018): “Academia acelerada, Slow Science y ética del cuidado” in: González A.M. (ed) *Mujeres en la Ciencia contemporánea. La aguja y el camello*. Barcelona: Icaria Editorial, pp. 175-207.

Conesa, E., and González, A. M. (2018a): Neo-gerencialismo y austeridad en en el contexto académico español y europeo. ¿Dos caras de la misma moneda? Polít. Soc. (Madr.) 55, pp. 257–282. doi: 10.5209/POSO.55883

Conesa, Ester; González, Ana M. (2018b): “Accelerated Researchers: Psychosocial Risks in Gendered Institutions in Academia" Front. Org. Psy, 9:1077. DOI: 10.3389/fpsyg.2018.01077

Corbin, Juliet; Strauss, Anselm (1990/2015): Basics of Qualitative Research. Techniques and Procedures for Developing Grounded Theory. Thousand Oaks, CA: Sage.

Deem, Rosemary (1998): ‘New managerialism’ and higher education: the management of performances and cultures in universities in the United Kingdom. Int. Stud. Sociol. Educ. 8, pp. 47–70. DOI: 10.1080/0962021980020014

Deem, Rosemary; Kevin J. Brehony (2005): “Management as ideology: the case of ‘new managerialism’ in higher education”, Oxford Review of Education, 31(2), pp. 217-235. http://dx.doi.org 10.1080/03054980500117827

Felt, Ulrike (2017): Under the shadow of time: where indicators and academic values meet. Engag. Sci. Technol. Soc. 3, pp. 53–63. doi: 10.17351/ests2017.109

Fisher, Berenice; Tronto, Joan C. (1991): “Toward a Feminist Theory of Care,” in E.

Abel and M. Nelson (eds) *Circles of Care: Work and Identity in Women’s Lives*. Albany, NY: State University of New York Press.

Fochler, Maximilan; Felt, Ulrike; Müller, Ruth (2016): Unsustainable growth, hypercompetition, and worth in life science research: narrowing evaluative repertoires in doctoral and postdoctoral scientists’ work lives. Minerva 54, pp. 175–200. doi: 10.1007/s11024-016-9292-y

Gill, Rosalind (2009): “Breaking the silence: the hidden injuries of neo-liberal academemia,” in R. Flood and R. Gill (eds) in *Secrecy and Silence in the Research Process: Feminist Reflections*. London: Routledge, pp. 1–21.

Gosselain, Olivier P. (2011). "Slow Science. La Désexcellence". Uzance, 1: 128-140.

Heijstra, Thamar M.; Steinthorsdóttir, Finnborg, S.; Einarsdóttir, Thorgerdur (2017): Academic career making and the double-edged role of academic housework. Gender Educ. 29, pp. 764–780. doi: 10.1080/09540253.2016.1171825

Hicks, Diana; Wouters, Paul; Waltman, Ludo; de Rijcke, Sarah; Ràfols, Ismael (2015): Bibliometrics: the Leiden manifesto for research metrics. Nature 520, pp. 429–431.doi: 10.1038/520429a

Horbach, Serge P. J. M.; Halffman, Willem (2017): The Extent and Causes of Academic Text Recycling or ‘Self-Plagiarism’. Res Pol. 48 (2), pp. 492-502 https://doi.org/10.1016/j.respol.2017.09.004

Hughes, Bill; McKie, Linda; Hopkins, Debra; Watson, Nick (2005): '*Love's labour's lost*? *Feminism, the Disabled People's Movement and an ethic of care*', Sociology, 39(2), pp. 259–275 DOI: 10.1177/0038038505050538

Latour, Bruno (2004): Why has critique run out of steam? From matters of fact to matters of concern. Critical Inquiry 30(2), pp. 225–248.

Mountz, Alison; Bonds, Anne; Mansfield, Beckye; Loyd, Jenna; Hyndman, Jennifer; Walton-Roberts, Margaret; Basu, Ranu; Whitson, Risa; Hawkins, Roberta; Hamilton, Trina; Curran, Winnifred (2015): For Slow Scholarship: a Feminist Politics of Resistance through Collective Action in the Neoliberal University. ACME Int. E J. Cult. Geograp. 14, pp. 1235–1259.

Müller, Ruth (2014): Racing for What? Anticipation and acceleration in the work and career practices of academic life science postdocs. Forum Qual. Soc. Res. 15:15. http://nbn-resolving.de/urn:nbn:de:0114-fqs1403150

Murphy, Michelle (2015): Unsettling care: Troubling transnational itineraries of care in feminist health practices. Social Studies of Science, 45(5) pp. 717–737, DOI: 10.1177/0306312715589136

Noddings Nel (1984): Caring: A Feminine Approach to Ethics and Moral Education. Berkeley: University of California Press.

O'Neill, Maggie (2014): The Slow University: Work, time and well-being. Forum Qual. Soc. Res. 15:14. http://nbn-resolving.de/urn:nbn:de:0114-fqs1403146

Pérez Orozco, Amaia (2014): Subversión feminista de la economía. Apuntes para un debate sobre el conflicto capital-vida. Madrid: Traficantes de sueños.

Puig de la Bellacasa, María (2011): Matters of care in technoscience: Assembling neglected things. Social Studies of Science 41(1) 85–106 DOI: 10.1177/0306312710380301

Puig de la Bellacasa, María (2015): "Making time for soil: Technoscientific futurity and the pace of care". Social Studies of Science, 45(5) pp. 691–716.

Shore, C., and Wright, S. (2000). "Coercive accountability. The rise of audit culture in higher education," in M. Strathern (ed) *Audit Cultures. Anthropological Studies in Accountability, Ethics and the Academy*. New York, NY: Routledge, pp. 57–89.

Sabelis, Ida (2002): Hidden Causes for Unknown Losses: Time Compression and Management. In Richard Whipp; Barbara Adam; Ida *Sabelis* (eds) *Making Time*: *Time* and Management in Modern Organizations. Oxford: Oxford University Press, pp. 90-103

Stengers, Isabelle (2011): "Another Science is possible! A plea for slow science", 13 December 2011, Inaugural lecture Chair Willy Calewaert 2011-2012. Faculté de Philosophie et Lettres, Université Libre de Bruxelles. http://we.vub.ac.be/aphy/sites/default/files/stengers2011_pleaslowscience.pdf

The slow science academy (2010): "The Slow Science Manifesto" http://slow-science.org/slow-science-manifesto.pdf

Tronto, Joan (1993): Moral Boundaries: A Political Argument for an Ethic of Care. New York, NY: Routledge.

Tronto, Joan (2017): There is an alternative: homines curans and the limits of neoliberalism. International Journal of Care and Caring, 1 (1), pp. 27-43 https://doi.org/10.1332/239788217X14866281687583

Vayreda, Agnès; Conesa, Ester; Revelles-Benavente, Beatriz; González Ana M. (2019): Subjectivation processes and gender in a neoliberal model of science in three Spanish research centres. Gender, Work and Organization, 26 (4), pp. 430-447 https://doi.org/10.1111/gwao.12360

Vostal, Filip (2015): Speed kills, speed thrills: constraining and enabling accelerations in academic work-life. Glob. Soc. Educ. 13, pp. 295–314. doi: 10.1080/14767724.2014.959895

Ester CONESA
DOI: 10.3217/978-3-85125-668-0-03

Walker, Judith (2009): Time as the fourth dimension in the globalization of higher education. J. High. Educ. 80, 483–509. doi:10.1080/00221546.2009.11779029

Walker, Judith (2014): Exploring the Academic Capitalist Time Regime in Academic Capitalism in the Age of Globalization. In B. Cantwell (ed) Academic Capitalism in the Age of Globalization. Baltimore, MA: JHU Press, pp. 55–73.

Ylijoki, Oili-Helena (2010): Future orientations in episodic labour: short-term Academics as a case in point. Time Soc. 19, 365–386. DOI: 10.1177/0961463X10356220

Ylijoki, Oili-Helena; Mäntylä, Hans (2003): Conflicting time perspectives in academic work. Time Soc. 12, 55–78. doi: 10.1177/0961463X030120013

DOI: 10.3217/978-3-85125-668-0-04

Co-producing Gender Equality Knowledge in a European Project Setting

Jennifer DAHMEN-ADKINS (1), Sandra KARNER (2), Anita THALER (2)

(1) RWTH Aachen University, Germany, (2); Interdisciplinary Research Centre for Technology, Work and Culture, Graz, Austria

Abstract

In the Horizon 2020 funded project "CHANGE"[1], tailor-made gender equality plans were implemented in research performing organisations for the duration of four years. In order to make related activities more sustainable, efforts were also made to aim at the initiation of long-term structural changes towards more gender equality in science and research. To accomplish this ambitious goal, we learned from previous gender (equality) projects but also sustainability research, and came up with a new approach, which attempted to tackle the existing *knowledge-to-action gap,* respectively the *research-to-practice gap*. Translation gaps from theory to practice help to understand why identified barriers for gender equality in science and research and the connected recommendations for change have seldom been put into action and/or their actual impact remained marginal. In this paper we describe what we mean when we say we are co-producing gender equality knowledge together in a European consortium of academic and research institutions. The introduction of the underlying ideas of the project, as well as it's architecture, will explain how structural changes inside the institutions will be enabled through integrated knowledge co-producing processes and through the engagement with institutional key players (Transfer Agents).

Keywords: structural change, gender equality, communities of practice, feminist knowledge

1. "CHANGE – CHAlleNging Gender (In)Equality in science and research" received funding from the European Union's Horizon 2020 Research & Innovation Programme under Grant Agreement no. 787177. Consortium members are: Interdisziplinäres Forschungszentrum für Technik, Arbeit und Kultur (IFZ) – coordination, Rheinisch-Westfälische Technische Hochschule Aachen (RWTH Aachen), Universidade de Aveiro (UAVR), Zilinska Univerzita v Ziline (UNIZA), Nacionalni Institutza Biologijo (NIB), Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V. (IFAM) and Beit Berl College (BBC). More information: https://www.change-h2020.eu.

Jennifer DAHMEN-ADKINS (1), Sandra KARNER (2), Anita THALER (2)
DOI: 10.3217/978-3-85125-668-0-04

1 Background of structural change policies

The Horizon 2020 Specific Programme describes the aim of Part V 'Science with and for Society' as follows: *"The aim is to build effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility"*[1]*.* This statement highlights that scientific excellence can no longer be seen detached from a responsible and socially aware institutional culture; a culture which does not regard gender and diversity as differentiating factors but as sources for an inclusive and innovative science with the potential to overcome the current societal and grand challenges within the European Union.

Starting in Framework Programme (FP) 5 to FPs 6 and 7 and now Horizon 2020, the EU has funded actions to identify gender inequalities in different sectors and subjects, always with the aim to set up (policy) recommendations to improve the situation. The focus of funded actions shifted the approach from an individual (“fixing the women”) to an organizational (“fixing the institutions”) approach. Instead of focusing on inequalities from an understanding of socialized gender differences, the current approach questions existing structures and their unjust outcomes for women in science and research.

Today, in the European Research Area (ERA), the advancement of gender equality and gender mainstreaming in research are one of six key priorities. This includes a special focus on 1) the promotion of women’s careers in science and research, 2) the creation of gender equal decision-making boards, and 3) the integration of the gender dimension into research and innovation activities[2]. Furthermore, in the strategy for an innovative Europe 2020 the European Commission declared that the establishment of gender equality in research performing organisations (RPOs) as one of the key success factors.[3] In our

1. https://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society [17.6.19]

2. https://ec.europa.eu/info/research-and-innovation/strategy/era_en [17.6.19]

3. European Commission (2010), EUROPE 2020. A strategy for smart, sustainable and inclusive growth, Brussels: European Commission. 3.3.2010.COM (2010) 2020.

DOI: 10.3217/978-3-85125-668-0-04

experience[1], many past ‘gender in science’-research projects finished by stating current gender in-equalities, naming several barriers for women’s careers, and giving recommendations for gender equality in science and research (cf. Thaler & Wächter 2005; Caprile et al. 2012; European Commission 2012; Carvalho & Machado, 2017; Carvalho et al, 2013; Carvalho & Machado, 2011, Dahmen & Thaler 2017). However, due to knowledge translation gaps these recommendations were rarely put into action. Furthermore, the politics of *feminist knowledge transfer and power issues* (as described by Bustelo et al. 2016) led to a situation where gender equality would appear in nice words on a website, without the real problems being tackled in many RPOs, as well as in research funding organisations (RFOs). From this it is clear that gender experts and scholars have provided enough evidence and knowledge, but we are still lacking strategies to translate this knowledge properly to be useful for the relevant stakeholders to put this knowledge into practice.

1.1 Translation gaps in knowledge production

Such shortcomings are not unique for the field of gender equality (research) but have been described for various other thematic areas as *research-to-practice gap* (e.g. discussed by Roxborough et al. 2007) and *knowledge-to-action gap* (see e.g. Strauss et al. 2009). The research-to-practice gap describes the challenge faced by practitioners, who are often not aware of results from research produced by academia, or that research results are not valued by practitioners as relevant for practice and consequently not used. The knowledge-to-action gap describes a very similar problem, and often these two notions are conflated. However, the knowledge-to-action gap also underlines that it is not only research-based knowledge which does not find its way out from the ‘ivory tower’, but that the uptake and use of knowledge is related to the process of how it was generated. In the context of sustainability research this has described as ‘*discursive dimension of knowledge*’ (Magnuszewski et al. 2010: 24), a notion with wide applicability. What kind of knowledge is considered at which point in time in practice, e.g. in (policy) decision making,

1. The authors have long-standing EU-project experience with explicit gender focus: INDECS (FP5, 2000-2001), WomEng (FP5, 2001-2003), PROMETEA (FP6, 2003-2005), Advance (FP6, 2006-2008), HELENA (FP7, 2009-2011), MOTIVATION (FP7, 2008-2010), GenderTime (FP7, 2013-2016), and now CHANGE (H2020, 2018-2021).

DOI: 10.3217/978-3-85125-668-0-04

may be seen as a discursive or even political act in itself. Although the societal relevance of research, and the exploitation of results in practice and policymaking has been heavily promoted since the mid 1990s, a better integration of research in policy and practice has succeeded only to a limited extent so far. Causes are often attributed to a lack of cooperation and limited exchange of knowledge between the various knowledge holders and relevant actor groups. This is particularly pronounced in the classical disciplinary academic research, while transdisciplinary and action research proved to be useful approaches in tackling these shortcomings. However, even if the same overall goals are pursued by different actors, cooperation, especially co-production, is not an easy task as a multitude of experiences have shown (see e.g. Wiek 2007*, Karner et al. 2011, Goszczyński et al. 2017*).

For instance, in many past gender projects from the EU different types of gender (equality) knowledge have not been used by each participating organisation, and sometimes different types of gender knowledge have been mixed up, leading to conflicts about theories, and an absence of practical implementation possibilities.

1.2 Feminist knowledge conflict

In previous EU-funded structural change projects one reason for problems in institutionalising gender equality in science and research is the so called “conflict of knowledges” (Albenga 2016, p.140). Viviane Albenga argues that the transfer of ‘feminist knowledge’ into gender expertise needs awareness regarding gender equality (ibid.). This is the approach CHANGE considered for implementation. What Albenga calls ‘feminist knowledge’, we have labelled ‘scientific gender knowledge’, drawing upon the gender knowledge concept invoked by Angelika Wetterer (2009), based on the parallels between Albenga’s gender expertise and Wetterer’s ‘gender expert knowledge’. The important rationale behind CHANGE bears a striking resemblance to the findings of Albenga’s ‘EGERA’ project, namely the difficulty of transferring research into practice or knowledge to action. Together with the problem of resistance against gender equality actions, we identify these difficulties as are the main reasons why in the past so many initiatives have chosen the easier way of ‘changing the women’ instead of ‘fixing the system’ (Schiebinger 2008).

The impact of CHANGE lies in tackling those for gender equality in science and research: by involving relevant stakeholders and key actors in research organisations (such as

DOI: 10.3217/978-3-85125-668-0-04

university and research organisation managers, research funding directors, gender equality officers, research policy makers, etc.) and listening to their experiences (Lee et al. 2010) to **co-produce gender equality knowledge together.** This represents the core idea of CHANGE.

In CHANGE, we address the knowledge-to-action gap, by acknowledging the different types of gender knowledge and their producers as legitimate knowledge holders. Wetterer (2009) coined the term ‘gender knowledge’, which Wetterer defines as the knowledge different groups of persons have about gender, gender theories and/or gendered practices. She distinguishes between everyday, expert, and scientific gender knowledge.

1. Everyday gender knowledge

• A property of all humans, learnt informally during the span of their lifetime

• Characterised rarely as reflected knowledge

• Often strongly influenced by media images, gender stereotypes, etc.

2. Expert gender knowledge

• Often a kind of knowledge that gender practitioners like gender equality officers, gender trainers, etc. have

• Comprised of professional knowledge and competences about gender equality

• Based on a limited number of gender theories, which are preferred by the very practitioners

3. Scientific gender knowledge

• A kind of knowledge gender scholars have and produce themselves

• Results in the evolution of gender theories as the knowledge of the gender scholar grows (this sometimes results in increasing levels of complexity)

• Only a percentage of this knowledge is immediately used for practical implementation.

In former projects concerning gender in science and research, the aim was often to involve two or sometimes three different types of actors, or sometimes it ‘just happened’. These actors included:

DOI: 10.3217/978-3-85125-668-0-04

1.) Scientists or engineers, who are supposed to do gender research even though their academic qualification lies within other fields of expertise. Often women have been chosen as they were seen as ‘naturally interested’ or even ‘naturally competent’ for gender issues, which may be a false assumption in many cases. The point is that involving scientists or engineers is important, because their experiences in the field are relevant and important, but it is crucial to keep in mind that their gender knowledge is an everyday gender knowledge. Thus, this group needs support from gender scholars/social scientists, with their knowledge about gender theories, and social science methods (e.g. conducting and interpreting interviews according to the scientific state of the art, etc.).

2.) Gender scholars, who, as gender studies is an interdisciplinary field, stemmed from various disciplines (philosophy, sociology, pedagogy, psychology, etc.) also have different backgrounds of scientific gender knowledge and advocated for different gender theories. In addition, the group of gender scholars could be further divided into two types:

a.) first professors or other university personnel (tenure track),

• who, as Europe is lacking interdisciplinary gender departments, might conduct gender research, but do so in their position which is appointed to a specific discipline (with specific performance indicators, like disciplinary publications, etc., but certainly no acknowledgement for gender equality action implementation),

• and, consequently, publish a lot of papers, even in projects with a heavy implementation character like ‘coordination and support actions’ of the EU; and

b.) party funded researchers (mostly post doc),

• who engage with these gender projects ‘professionally’,

• devote their expertise to interdisciplinary gender research,

• and, therefore, lack a disciplinary performance record, which would be preferred by most university ratings and career systems.

3.) Gender practitioners, such as gender equality officers from universities, who in some projects were also included. Gender practitioners brought practical experience and gender expert knowledge (e.g. about mentoring, coaching, gender budgeting, sexism in academia, etc.) into these gender projects. This type of expert knowledge, and the role of these actors in their organisations, is a very important resource for the implementation of

DOI: 10.3217/978-3-85125-668-0-04

projects. However, when a specific gender project demands gender research and/or managing a larger project or work package within an international group, these national experts sometimes lack language skills and/or research project experience.

Laube (2017) analysed the difficulties for gender equality change based on these three individual positions, and in line with this, Bustelo et al. (2016) describe tensions between academic and practice expertise in the context of gender training. On the one hand, academic work does not pay enough attention to the analysis of practice, while gender training practitioners do not draw much on theory or research outputs (which are considered to be technocratic, and not very useful for “real-life” cases). As a consequence, in order to overcome the separation of academia, policy development and practice, CHANGE follows an **approach of integrated co-production of gender (equality) knowledge**.

2 Architecture of CHANGE

CHANGE tackles the two major problems explained above while aiming at implementing gender equality plans (GEPs) towards structural change in science and research.

1) The knowledge-to-action gap will be closed by integrating relevant actors and stakeholders from the beginning and *co-producing gender equality knowledge together*, in order to come up with practical knowledge, which is relevant for and will be meaningful for the respective actors in RPOs and RFOs.

2) Power issues (‘the politics’) of the feminist knowledge transfer will be tackled by *integrating so called Transfer Agents* (TAs), and later further stakeholders from RPOs and RFOs in the project consortium to build *regional communities of practices* (CoPs). The TA-concept has been tested in the EU-FP-7-project GenderTime (Thaler 2016; Thaler, Karner & Wicher, forthcoming), where Transfer Agents were defined as relevant institutional actors, who are committed to gender equality and structural change and most importantly have a certain authority within their organisation (management level – in the organisation which works on gender equality plans). The idea of co-producing knowledge and building CoPs had been tested in knowledge brokerage and RRI projects as well, where it has proven to be a successful strategy to enable structural changes (cf. Karner et al. 2014; 2016; 2017).

DOI: 10.3217/978-3-85125-668-0-04

2.1 Co-production of gender equality knowledge

Practices of knowledge co-production might be diverse, but the overall goal is to make different types of knowledge more accessible and responsive to each other, to establish a mutual understanding, to learn from each other and come up with more integrated knowledge, and to better align activities. Co-production in CHANGE builds on iterative learning cycles of communicative interaction, action, and reflection, which needs time and an intermediate social space as co-production certainly also involves power issues regarding knowledge hierarchies as well as considering the capacity for organisational change. Such an intermediate social space is created through the CHANGE project, which offers room for tailored interaction and the planning and implementation of gender equality activities over a period of four years.

In CHANGE knowledge co-production takes place on several levels, essentially in line with the scale of the different Communities of Practice. These levels include the project consortium, within the GEP implementing organisations, regional CoPs, and the international expert community through the regular interaction with other projects, such as EU funded sister projects.

At the *consortium level* knowledge co-creation is institutionalised by means of physical meetings every six months. These meetings are conceptualised as interactive workshops, where partners exchange gender equality knowledge, which is as diverse as the scope of team members' expertise is broad, ranging from academic gender scholars to people from administration and newcomers to the field, who started with hardly any gender expertise into the project. The design of the co-creation workshops is tailored for each meeting according to the specific stages in the project. However, the general pattern is similar:

Partners share their knowledge, which so far concerned shortcomings in GE in general, the actual state of the art in partners' organisations regarding GE, specific contextual conditions influencing GE, plans and strategies for improving GE in the participating organisations and the rationales behind it, and already implemented activities, experiences and results. The group then reflects together upon what was shared, partners get inspired by the ideas of others, feedback and advice is collected, and shortcomings are addressed. Finally, plans for the next steps are revised or further elaborated based on the discussions, either at the consortium or at the organisational level. This links to another very central

Jennifer DAHMEN-ADKINS (1), Sandra KARNER (2), Anita THALER (2)
DOI: 10.3217/978-3-85125-668-0-04

level of knowledge co-production, each of the partner organisations have started to establish multi-actor CoPs, of which the core groups are built by CHANGE team members and Transfer Agents (see next section).

This multi-level design allows for knowledge co-production, which is both systematic and standardised where it is possible (to compare and learn from each other, e.g. the structure of GEPs, the institutionalisation of transfer agents, recruitment and retention activities etc.), but also flexible and open where country and organisational specifics require it (e.g. salary schemes, parental leave, work-life-balance measures).

2.2 Involving transfer agents and stakeholders

In order to successfully and sustainably implement gender equality knowledge in a strategic manner, it is necessary to involve individuals in powerful and relevant positions, who are committed to the idea of gender equality in science and research and support the implementation of the gender equality plans. These individuals, in their respective positions, are so called **Transfer Agents** (TAs are a concept created by Anita Thaler in the EU-project GenderTime, see Thaler 2016). Because TAs are relevant actors of CHANGE institutions (e. g. human resources managers, heads of institutions, or equal opportunity officers) and additionally **stakeholders** from science and research (e.g. policy makers, research funding actors) are involved, gender equality changes also go on after the project ends. All TAs have been asked whether they would support the course of this gender equality implementation project and their national teams in the task of sustainably implementing gender equality measures according to the gender equality plans (GEPs). Their commitment was a prerequisite for the institutions to become partners in the CHANGE consortium.

The specific roles and possibilities of support available from the respective TAs were defined separately for each institution, this is due to variations in what each of the TAs were able and willing to do, depending on their position, time and motivation. The commitment of a TA can be moderate (regular involvement on specific occasions like TA workshops, and additional internal meetings) or it can be (ideally) higher and lead to a very active and continuous collaboration also beyond the organisation (networking activities with stakeholders etc.).

Jennifer DAHMEN-ADKINS (1), Sandra KARNER (2), Anita THALER (2)
DOI: 10.3217/978-3-85125-668-0-04

It is important to stress that any kind of support of the involved TAs is welcome and appreciated, the involvement is likely to increase through the process, especially because of the co-production of knowledge approach (see Karner et al. 2011).

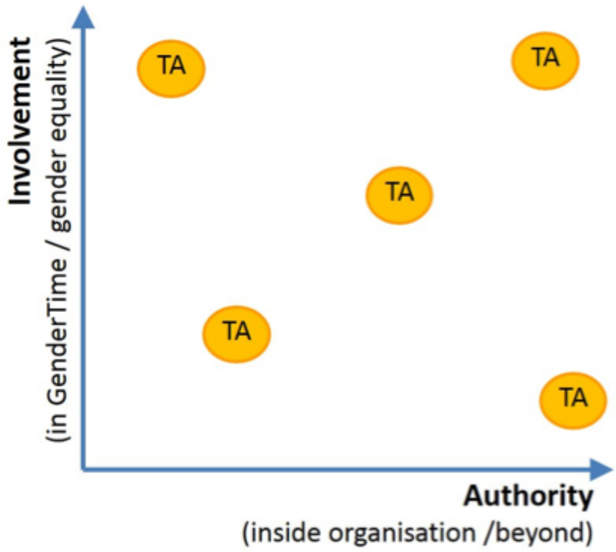


Fig. 1: *Transfer agents with different impacts depending on their degree of authority and involvement (Thaler 2016, p. 19)*

This could be proven for the EU-project GenderTime (2013-2016), where:

> "it could be found out with data collected by project partners about their knowledge transfer activities that the impact of transfer agents (for improving gender equality policies and/or practices) depends on their involvement in the project and their authority. In other words, the involvement means commitment towards gender equality in science and research and authority means power/networks/influence within their own organisation and beyond. It could be observed that a variety of different transfer agents had very different impact on gender equality implementation processes"
>
> (Thaler 2016, p. 18 f.; see also Fig.1 above).

3 Sustainable implementation of gender equality

One main aim of CHANGE is it to support RPOs to implement gender equality plans in a sustainable way. An essential factor for achieving this, is the involvement of the above mentioned TAs. In each organisation they will, together with the core consortium partners, transfer co-produced gender equality knowledge inside their institutions. This innovative approach ensures the promotion and institutionalisation of the GEPs beyond the project duration. Furthermore, through mutual learning and networking with external target groups, the project partners will become regional resource centres skilled to provide gender equality knowledge and expertise to other RPOs and also research funding organisations (RPOs). With such a co-production of knowledge approach, and by building *communities of practice* among RPOs in each participating region, support and mentorship structures will be established and sustained even after the project will be finished. Regular networking and exchange with national and European stakeholders (policy makers, researchers, ministries etc.) ensures a spill-over effect of the project results to other target groups in the respective countries.

3.1 Contextualisation of a project like CHANGE

CHANGE pursues an approach, which connects to the pillars of action research, even if it is an implementation project (as opposed to a research project). Like in an action research project, CHANGE evaluates the current institutional practice (here related to gender equality) and tries to improve it by implementing intervention actions in practice. An action research project demands careful planning and persons involved that can generate solutions to practical problems; further practitioners need to be involved in the implementation and development activities (McNiff and Whitehead 2005). CHANGE fulfils this requirement by pairing newcomers in the field of gender equality with experienced gender scholars and practitioners. TAs and committed management authorities help to assess potential solutions and support their implementation. The evaluation, monitoring and critical reflection on the process and the outcomes of change actions are essential, as well as offering room for reflection for the people involved (Dahmen and Peterson 2017). Monitoring itself is therefore regarded as integrated part of CHANGE and based on monitoring principles developed within the GenderTime action (Dahmen-Adkins and Peterson 2019). Another commonality of CHANGE and action research concerns the generated knowledge, which is very specific based on evaluation and the particular context in which it was gained. Common reflection on underlying processes of change helps to obtain an enhanced organisational understanding, which can lead to an improved and adapted (gender equality) action plan (Reason and Bradbury 2008).

3.2 Five phases of CHANGE

Kotter (2014) developed a model on how to achieve structural change in institutions, including 8 consecutive steps, each of which have to be fulfilled to change the culture of an organisation in a sustainable and inclusive way: 1) Create a sense of urgency; 2) Build coalitions; 3) Form strategic visions and initiatives; 4) Enlist a 'volunteer army'; 5) Enable action by removing barriers; 6) Generate short term wins; 7) Sustain acceleration; and 8) Institute change. The general methodological approach of CHANGE is built up on a condensed version of Kotter's model on how to achieve structural change in institutions. Instead of 8 steps the CHANGE model includes 5 phases (see graph 2), which support achieving structural change in RPOs and RFOs towards more gender-inclusive science and research.

Fig. 2: *Methodological approach of CHANGE*

During the **first phase** the implementing partners undertook an institutional gender equality benchmarking. The main focus here is to get to know the institution better, to talk to organisational key players about gender equality issues, and at the same time to raise awareness for the needs and benefits of gender equality. This phase was also used to communicate the ideas, aims and targets of CHANGE towards the members of the institution. Furthermore, gender trainings were implemented for the project teams in each institution. **Continuous involvement of transfer agents**, who are going to support the institutional acceptance of CHANGE took place right **from the beginning**, as well as an early identification of other potential supporters and allies on department and managerial levels in order to increase the sustainable embedding of gender equality in the organisations (as suggested by Karner et al. 2017).

The **second phase** was devoted to exchanging the collected data, discussing the collected data in their organisations, and also in the consortium as a whole. This step is important for identifying and understanding institutional mechanisms and structures, which can support or hinder the success of the planned GEPs. During this phase, the final GEP were individually designed (while being constantly monitored and, if necessary, revised and adapted/updated during the whole project progress) bearing in mind the institutional and national pre-requisites and circumstances. A roadmap for the implementation of the GEP includes institutional objectives and targets, which will be used for assessing the impact of CHANGE at the end of the project.

So-called quick actions are implemented in **phase three**, which is the current stage. The advantage of the implementation of short-term actions or quick actions helps to increase the visibility of the project within the institution and the awareness of gender equality issues which are already at an initial stage of the implementation. Lessons learned from previous gender equality projects showed that the implementation of short-term actions not only enhanced the commitment of the involved researchers and Transfer Agents, but also immediately showed the involved organisations that this project really changes something (rather than merely speak about change). Another point is the idea of “giving something back” to the involved staff. While many gender projects do research about the involved organisations and ask the staff to answer questionnaires and to take part in focus groups or interviews, quick actions show that the money dedicated for the project is immediately destined to support the organisation in its gender equality efforts and initiates changes, which are visible to the staff. Possible examples for such kinds of actions are inviting experts on the topic of including the gender dimension in research, setting up brown bag sessions to make gender researchers more visible, initiate a women’s peer group, or collecting ideas to improve conditions in the working environment.

Phase four is devoted to the implementation of middle and long-term actions, which are equally important as most of the system changes (not only in the involved RPOs but also beyond in the whole science and research system) need time for planning and implementing actions, which are designed for changing the organisational culture of organisations. Middle-term actions are defined as activities, which will be started and

DOI: 10.3217/978-3-85125-668-0-04

finished during the project life cycle; actions for a long-time implementation will start during the project and will be maintained beyond the funding period.

In the **fifth and last phase** questions about the sustainability of the GEPs or specific actions will be discussed and tackled. For a successful implementation CHANGE takes sustainability aspects into consideration right from the beginning, based on the practical experience made during the realization of actions, modifications, adaptations and changes might be necessary. Another emphasis during this phase lies in the regional, national and international knowledge transfer of the co-produced gender equality knowledge with in CHANGE. Workshops will be set-up as means for dissemination, communication and exploitation.

All the activities in the described five project phases are constantly process monitored. A set of tailor-made qualitative and quantitative monitoring tools including performance indicators is therefore adopted (Peterson and Dahmen 2018). The gathered monitoring knowledge is regularly fed back to the project team and the implementing institutions to improve the project outcomes.

To increase the success and sustainability of the strategic actions, the involved TAs have to be on board from the beginning of the project and are therefore considered as part of the CHANGE team, additionally stakeholders (e.g. from RFOs) are involved in an early stage of the project as well.

4 Conclusion and outlook

CHANGE contributes to closing the research-to-action gap, respectively the theory-to-practice gap by means of a knowledge co-production approach, which follows iterative learning cycles following the action research concept. The co-production activities we implement are tailored and engage various knowledge holders and key actors, who hold a certain power, for change in the participating organisations and beyond, the Transfer Agents, from the beginning and throughout the whole project duration.

This upstream engagement is not only driven by substantive motivations, such as integrating various types of gender knowledge and practice expertise, but also by strategic considerations that support from influential actors and a wider group of key actors, positively impacts the success and sustainability of GEPs in the participating organisations. At the given point in time CHANGE is in its second project year, the results of the institutional gender benchmarking have been analysed and discussed with TAs and the project team. Subsequent activities included the implementation of quick actions within the institutions, and all partners started connecting and networking with relevant key players and practitioners in the field of gender equality in science and research. This is a first step towards the foreseen communities of practice, which will represent one sustainable project output. Changing the culture of an institution is not going to happen in four years' time, we are realistic enough to know that. To reach gender equality in science and research organisations, a common vision is needed, with strategic planning, the knowledge to implement the plans, and the persons who are committed to work on the changes, also after the project ends. It's a long-winding process. However, an intervention action like CHANGE can be an impetus to scrutinize existing structures and to develop new ideas for social gender just organisations in a participatory way.

References

Albenga, Viviane (2016). Between Knowledge and Power: Triggering Structural Change for Gender Equality from inside in Higher Education Institutions. In: Bustelo, Maria, Ferguson, Lucy & Forest, Maxime (eds.). The Politics of feminist Knowledge Transfer. Gender Training and Gender Expertise. New York: Palgrave Macmillan, p.139-156.

Bustelo, Maria, Ferguson, Lucy & Forest, Maxime (eds.). The Politics of feminist Knowledge Transfer. Gender Training and Gender Expertise. New York: Palgrave Macmillan.

Carvalho, T. & Machado-Taylor, M.L. (2017). The exceptionalism of women rectors – A case study from Portugal. In K. White, and P. O'Connor (Eds.), Success in moving forward a gendered agenda in higher education. (pp. 111-131). Hampshire: Palgrave.

Carvalho, T., Ozkanli, O., Peterson, H. & Prozesky, H. (2013). Building academic careers. In B. Bagilhole & K. White (Eds), Generation and gender in academia (pp. 127-168). Hampshire: Palgrave MacMillan.

Carvalho, T. & Machado, M. (2011). Senior Management in higher education. In K. White & B. Bagilhole (Eds), Gender, power and management. A cross cultural analysis of higher education (pp. 90-109). Basingstoke, New York: Palgrave Macmillan.

Caprile, Maria et al. (2012). Meta-analysis of gender and science research. Synthesis report. Brussels: European Commission. Download: https://ec.europa.eu/research/swafs/pdf/pub_gender_equality/meta-analysis-of-gender-and-science-research-synthesis-report.pdf [15.7.2017]

Dahmen-Adkins, Jennifer and Peterson, Helen (2019). The How, What and When of Project Monitoring: Facilitating Successful Implementation of Gender Equality Plans in European Research Institutions.

Dahmen, Jennifer and Peterson, Helen (2017). Monitoring Handbook. DOI: 10.13140/RG.2.2.23894.65603

Dahmen, Jennifer & Thaler, Anita (ed., 2017). Soziale Geschlechtergerechtigkeit in Wissenschaft und Forschung (Social Gender Justice in Science and Research). Opladen, Berlin, Toronto: Verlag Barbara Budrich. Open Access: https://www.researchgate.net/publication/316830144_Soziale_Geschlechtergerechtigkeit_in_Wissenschaft_und_Forschung [15.7.2017]

Ely, Robin J. and Meyerson, Debra E. (2000) Theories of gender in organisations: a new approach to organisational analysis and change. Research in Organisational Behaviour 22, 103-151.

European Commission (2012). Structural Change in Research Institutions: Enhancing excellence, Gender equality and efficiency in research and innovation. Report of the Expert Group on Structural Change. Download: https://ec.europa.eu/research/science-society/document_library/pdf_06/structural-changes-final-report_en.pdf [15.7.2017]

Goszczyński, Wojciech, Stankiewicz, Piotr, Karner, Sandra & Nicoleta Chioncel (2017). Leaving the ivory tower through scientific innovation co-operative research – A social experiment in research on alternative agro-food networks. Acta Innovations 74 (24): 74-86.

Karner, Sandra, Thaler, Anita & Wicher, Magdalena (2017). Wie durch gemeinsame Wissensproduktion in der Gender-Forschung soziale Geschlechtergerechtigkeit in Wissenschaft und Forschung befördert werden kann. (How co-production of knowledge can raise gender equality in science and research). In: Dahmen, Jennifer & Thaler, Anita (Hg.). Soziale Geschlechtergerechtigkeit in Wissenschaft und Forschung. Opladen, Berlin, Toronto: Verlag Barbara Budrich. S. 127-141.

Karner, Sandra, Bock, Bettina B. Hoekstra, Femke, Moschitz, Heidrun, Thaler, Anita, Wiskerke, Han (2016). FOODLINKS: Building communities of practice for learning on sustainable food consumption and production. In: Martinuzzi A., Sedlacko, M. [ed]: Knowledge Brokerage for Sustainable Development. Greenleave Publishing Sheffield 2016.

Karner, Sandra; Bock, Bettina B.; Hoekstra, Femke; Moschitz, Heidrun, Thaler, Anita (2014). Knowledge Brokerage in Communities of Practice. Hands on recommendations. IFZ: Graz. ISBN 978-3-9502678-6-0.

Karner, Sandra, Rohracher, Harald, Bock, Bettina B., Hoekstra, Femke, Moschitz, Heidrun (2011): Knowledge brokerage in Communities of Practice. Synthesis Report on Literature Review. Project Report from 'FOODLINKS – Knowledge brokerage to promote sustainable food consumption and production: linking scientists, policymakers and civil society organisations'.

Laube, Heather (2017). Präsenz, Disruption, Transformation: Feministinnen als Insider und Outsider im vergeschlechtlichten System der Wissenschaft. In: Dahmen, Jennifer & Thaler, Anita (ed.). Soziale Geschlechtergerechtigkeit in Wissenschaft und Forschung. Opladen, Berlin, Toronto: Verlag Barbara Budrich. S. 73-94.

Lee, Lisa; Alemany, Carme & Faulkner, Wendy (2010). Good policies are not enough! The need for “culture change” in achieving gender equality in engineering. In: Anne-Sophie Godfroy-Genin (ed.) PROMETEA. Women in Engineering and Technology Research. Berlin: LIT Verlag. pp. 407-425.

DOI: 10.3217/978-3-85125-668-0-04

Magnuszewski, Piotr, Sodomk, Kristina, Sloob, Adrian, Muro Melanie, Sendzimir, Jan & Claudia Pahl-Wostl (2010). 2010. Report on conceptual framework for science-policy barriers and bridges. Final version 22.12.2010 of deliverable No. 1.1 of the EC FP7 project PSI-connect. EC contract No. 226915. July 2010, Delft, the Netherlands.

(18) (PDF) Report on conceptual framework for science-policy barriers and bridges. Available from: https:/ /www.researchgate.net/publication/230557654_Report_on_conceptual_framework_for_science-policy_barriers_and_bridges [accessed Jul 01 2019].

McNiff, J. and Whitehead, J. (2005) All You Need To Know About Action Research. London: SAGE.

Peterson, H. and Dahmen, J. Monitoring Handbook. Methods and tools for monitoring developed in the GenderTime project. Gothenburg Studies in Work Science, no. 1 2018. Gothenburg: Gothenburg University, (2018)

Reason, P. and Bradbury, H. (2008) The SAGE Handbook of Action Research: Participative Inquiry and Practice (2nd edition). London: SAGE.

Roxborough, Lori; Rivard, Lisa & Russell, Dianne (2009) Knowledge Brokering in Health Care. Published and distributed by CanChild Centre for Childhood Disability Research. Download: http://www.canchild.ca/en/canchildresources/knowledgebrokering.asp [12.7.2016]

Schiebinger, Londa (2008). Introduction: Getting More Women into Science and Engineering – Knowledge Issues. In: Schiebinger, Londa (ed.). Gendered Innovations in Science and Engineering. Stanford: Stanford University Press, p.1-21.

Strauss Sharon. E., Tetroe Jacqueline, Graham Ian (2009) Defining knowledge translation, Canadian Medical Association Journal, 181(34), 165-168.

Thaler, Anita (2016). Learning Organisations in Science and Research: The Role of Transfer Agents in Gender Equality Change Processes. Graz: IFZ Eigenverlag. Download: http://www.ifz.at/eng/Media/Dateien/Downloads-IFZ/Publikationen/Learning-Organisations-Transfer-Agents_Thaler-2016 [15.7.2017]

Thaler, Anita; Karner, Sandra & Wicher, Magdalena (2017). Knowledge transfer agents as catalysts for changing gender policies and practices in research. In: Godfroy, Anne-Sophie (ed.) Proceedings of the GenderTime International Conference, 29-30 September 2016, Paris. https://gendertime.sciencesconf.org/

Thaler, Anita & Wächter, Christine (ed., 2005). Conference Proceedings of the International Conference "Creating Cultures of Success for Women Engineers" , 6.-8. 10. 2005, Leibnitz / Graz. IFZ Eigenverlag, Graz. Download: http://www.ifz.at/Media/Dateien/Downloads-IFZ/Publikationen/Forschungsberichte/Frauen-Technik-Umwelt/International-Conference-Creating-Cultures-of-Success-for-Women-Engineers-Conference-Proceedings [26.7.2017]

Wetterer, Angelika (2009). Gleichstellungspolitik im Spannungsfeld unterschiedlicher Spielarten von Geschlechterwissen. Eine wissenssoziologische Rekonstruktion. In: Gender. Zeitschrift für Geschlecht, Kultur und Gesellschaft, 2009 (2), 45-60.

Wiek, Arnim (2007). Challenges of Transdisciplinary Research as Interactive Knowledge Generation – Experiences from Transdisciplinary Case Study Research, GAIA16/1: 52 – 57.

DOI: 10.3217/978-3-85125-668-0-05

The Circular Character of Building Tradition: Which Challenges for the HUL Approach

Sasa DOBRIČIĆ, Jukka JOKILEHTO, Marco ACRI
University of Nova Gorica, Slovenia

Abstract

The lifespan of buildings čićand open spaces can be radically longer than of other goods. That is certainly one of the reasons why historic buildings have been traditionally associated with heritage value, and thus maintained and protected as part of the future of cities. However, particularly in the current world, buildings and cities are under constant challenge and pressure of changing needs, lifestyles, services of society. Hence, any consideration of circular economy within built environment requires approaches and models that refer to continuity, adaptability, resilience and quality, features that often characterize traditional historic built environments. In the past, urban centers were normally built using sustainable techniques and resources. They were constantly maintained with the intention to make the best use of available materials, by reusing what was possible and thus reducing waste. Consequently, the use of local materials, techniques, crafts and competences has shaped the built environment for centuries, generating testimonies of local cultural identity and authenticity in different forms. Such local culture that characterizes each place has been evolving by being resilient and strictly connected to its environmental context. Indeed, considering the historic urban landscape as an approach to urban conservation and planning through development, we refer to the city in its capacity to represent its development in time, to put in common different urban “facts” in time, as well as the resulting genius loci that made it different from others, but breaking the concepts of identity.

Theoretical framework: circular economy and urban growth

The rise of circular economy as reference in upcoming development strategies reveals a shared urgency to overcome present models that are evidently impotent to tackle the complexity and the “concrete universality” of certain problems, even at local level. The pressure of climate change, environmental needs, global migration phenomena, as well as the need of common financial regulations, is revealing the global, common and shared

DOI: 10.3217/978-3-85125-668-0-05

demand to overcome the linear development paths based on extraction, production and waste. In other words, what chairs over our global productive scenario of depleting local resources to the benefit of a global market is not the figure of the return proper of the cyclical notion of time as dictated by nature, but the figure of target, the problem of how to reach linearly and efficiently the goal. In fact, our western time, at least in terms of production, traditionally addresses linearly the future and not the past. This evidently puts in close relationship the availability of means with the goals to be achieved: when the aims are too far, also the means risk being ineffective. In this perspective, we might say that our time is not simply linear but rather “project oriented”. We eject our arrow (the model, something that does not exist yet) straight into the future. We are future oriented, we simulate future through a project or a model, trying so to give a shape to a “simple” potential: we project (extrude and/or forecast), we pro-eject, we eject in a linear way forward.

In urban contexts though, dealing with heritage and historic places means dealing with the past, in a circular perspective with respect to the cyclical notion of time; in fact, in the cyclical notion of time the future is at the same time the recovery and the revision of the past, which our present calls and demands to reiterate.

Noticeably, in urban historic contexts (and European cities and towns have all the historic dimension), the circular process of reinventing, regenerating, reinterpreting, respecting the past has to be aligned with the linear time of the project: maybe it is exactly the opposite. Like in seasons, that belong to the cyclical behaviour of nature that perpetuates winning regeneration processes, in traditions the transmission is driven by circular reiteration of knowledge, believes and habits: in local traditions time has already revealed its multiple dimension of care and maintenance that challenges the production imperative of the project and its linear development model.

In the traditional, pre-modern world, the community lived in close contact with the environment. Over generations, the choices of economy in a community were based on the human creative capacity to find the most appropriate ways to meet the needs within available resources. While the needs of the society were subject to gradual change over time, it was necessary to develop a habitat that could absorb the desired new requirements without undermining its basic typological characteristics and thus preferring sustainability over radical change. The result was a built environment where components

DOI: 10.3217/978-3-85125-668-0-05

were based on typological variations that together formed a cultural territory, joining urban ensembles with the surrounding rural territories. Due to human creative capacity, such cultural territories had a great diversity, coming to represent the entire humanity over its millennial evolution. Consequently, in such a cultural territory endured the memory of humanity, characterized by elements that represented the cultural-historical authenticity of its local territorial identity. With the modern industrial development, the pre-modern way of living came to face drastic changes. Due to progress in science and technology, as well as better understanding the requirements of healthy living, populations started growing. Partly, this also resulted from an improved management of agricultural activities, and the consequent migration of a part of rural population to towns and cities.

As a matter of fact, realizing the necessity to keep sound and coherent relationship with the past while envisaging the future, is one of the key aspects of the present co-design processes with local stakeholders and citizens, and experts are often impressed by the need of stakeholders to consider past as a circular return of their history which calls to be reactivated again and again. Any lack of the circular dimension of time might indeed return as an ambiguous feature of unreceptivity and hostility that local identity might produce if relationship with the past has not been activated. It is exactly in this effort to balance the linear time of project, with the ticking of circular-cyclic time that nature or tradition impose, that the future projects and production scenarios are called to perform.

Understanding the notion of "circular economy" as an economic system aimed at minimising waste and making the most of resources, we can appreciate that there is similarity with the objectives of integrated urban conservation. The processes that had been traditionally dominant in the pre-modern period, were challenged with the introduction of the strategies of linear economy, namely the mechanization of transport and production, developed so as to eliminate limits in the building sector. The absence of barriers in many senses changed the previous rules and slowly imposed new models for urban regeneration, which included new materials, new technologies, new skills, new competences, and became more and more globalized. The treatments of historic buildings and the development of the built environment were slowly standardized at different scales. Often this resulted in the loss of construction details and of the identity of the place that were an expression of past human creativity and of the genius loci.

The recent trends that have put circular economy at the core of discussions on sustainability are moving in favor of the preservation of historic cities, opening interesting economic and cultural scenarios that will not let "preservation" being considered as a burden. Suddenly, local qualities and resilience are again becoming important and there is a run in giving back to the built environment its partly (or even fully) lost integrity and authenticity. Even tourism is contributing to this trend by developing new models based on experience, balanced judgment and taste.

The historic urban development and the sudden change

As a result of the various developments, cities started growing generating a building industry that also profited from the existing natural resources. Starting from Western European countries, this development rapidly expanded to other parts of the world, partly also due to the colonization of lands in different continents. It seemed that the resources would never finish, and consequently, traditional sustainability came under threat. Particularly in growing cities, the traditional urban fabric was subject to change and the constructing of ever taller buildings. At the same time, the traditional rural landscape started changing, and in many cases, there developed a new form of industrial landscape. In the first part of the 20th century, urban planning was too often aimed at renovation and replacement rather than maintenance. It was proposed that the modern architecture was a "machine", which would have a limited usefulness over time. Thus, it needed to be replaced or drastically renovated about every fifty years. In the same line, modern industrial household products were only designed to last a limited time to be replaced periodically. As a result, also the building aligned to the with the principles of the "linear economy", i.e. economy based on industrial products, which needed periodic replacement, in all types of artefacts.

Modern urban planning developed particularly in the post-WW2 period, i.e. in the 1950s and 1960s, when there was great need of new habitat and when industrial development was diffused into all continents. As a result of the destruction of familiar habitat associated with local identity, people started becoming aware also of the need to reconsider planning policies. In 1945, the Constitution of UNESCO stated that 'culture, and the education of humanity for justice and liberty and peace are indispensable to the dignity of man'. Indeed, one of the principal scopes of UNESCO is to 'Maintain, increase and diffuse knowledge:

DOI: 10.3217/978-3-85125-668-0-05

By assuring the conservation and protection of the world's inheritance of books, works of art and monuments of history and science'. UNESCO became the principal world organisation to promote this task, resulting in the adoption of international recommendations and conventions to guide the Member States, as well as establishing international organisations to assist in this process, including ICCROM and ICOMOS for culture and IUCN for nature. The number of international conferences and workshops have since been organised, including the First International Congress of Architects and Technicians of Historic Monuments took place in Paris, in 1957, and the Second Congress was in Venice in 1964, both under the auspices of UNESCO. The Venice Congress adopted the International Charter for the Conservation and Restoration of Monuments and Sites, which become known as the founding stone for the development of an international doctrine in the conservation of the built heritage.

The question of truthfulness of evidence when dealing with archaeological sites and historic buildings was already established with the development modernity in the 18th and 19th centuries. In the **Venice Charter**, in fact, authenticity was taken as "known", not requiring further definition. The preface of the Charter was written by Paul Philippot, at the time deputy of ICCROM: '*Imbued with a message from the past, the historic monuments of generations of people remain to the present day as living witnesses of their age-old traditions. People are becoming more and more conscious of the unity of human values and regard ancient monuments as a common heritage. The common responsibility to safeguard them for future generations is recognized. It is our duty to hand them on in the full richness of their authenticity*.' With the diffusion of modern conservation policies to the different cultural regions, it was understood that there was need for further discussion about the significance of the notion of authenticity. The opportunity was offered by Japan, in collaboration with UNESCO, ICCROM and ICOMOS, to organize an international conference in Nara in 1994. This was anticipated by a small working group meeting in Bergen at the beginning of the same year.

Speaking in terms of cultural heritage adaptive reuse we should stress that certain circular attitude is, or should be, a common approach within the logic of all intervention phases. In traditional building sites, but also in line with the accredited conservation doctrine that started with the Venice Charter, materials and knowledge are always reused and reconsidered within circular production dynamics. Once, in traditional building sites the reasons were mainly economic, today they are linked to the material characterization (in sense of the dignity of materials that are usually good in aging) and there are also several doctrinal foundations related to the concepts of Integrity and Authenticity. However, this is to say that circular attitude when dealing with tangible or intangible aspects of Cultural Heritage is (at least should be) a rule and not an exception and cultural heritage adaptive reuse should evolve and go beyond its current role of being one of many preservation models or acting as one of many alternative cultures of design practice.

In cultural heritage adaptive reuse what is there left from the past, is never considered as an inert or passive residual of history available for additional repurposing through many categories of reuse, whether it's recycling, up-cycling, down-cycling. These residuals of past speak to us as active fragments of history that are, as they are, already interrelated among them and with many other tangible or intangible features, that make sense only as ensemble. If their reiteration, whatever will be the cause or the form of reuse, does not lack to consider these fragments as a coherent formal, material or functional system only then the operation of use-reuse will avoid the risky to decline into the abuse.

Integrated Urban Conservation and the HUL Approach

The conservation of historic urban areas became the key issues in the 1975 European Architectural Heritage Year, sponsored by the Council of Europe. During this year, there were a series of conferences organized in different parts of Europe in order to examine the policies and methodologies experimented in each case. As a result, the Council of Europe adopted the *European Charter of the Architectural Heritage*, followed by the *Amsterdam Declaration*, which both brought forward the notion of "integrated urban conservation". This was further discussed by UNESCO, who also adopted an international recommendation concerning the *Safeguarding and Contemporary Role of Historic Areas* (1976). This new planning approach was based on the already existing planning methodology, but with a fundamental difference. While the modern urban planning often was targeting newly built areas, the conservation approach was aimed at the identification of the significance and qualities of an existing urban area. Therefore, while the planning norms for modern areas would be based on new design ideas, the planning of existing historic areas needed to be based on the identification and recognition of all the types of buildings and spaces that together formed the urban ensemble. Furthermore, it was necessary to understand such

DOI: 10.3217/978-3-85125-668-0-05

traditional historic areas within the environmental context, involving both nature and more recent urbanised areas. Such approach developed recently into the Historic Urban Landscape (HUL) as developed by many international actors and organisations, merging the tangible and the intangible components of urban built environments.

This is exactly why HUL is important if connected to circular trends. It is through the eyes of landscape and within the Historic Urban Landscape approach, that classification categories of reuse, considered as potential drivers of the future production scenario, shift towards the identification of those forces that perform and guarantee the integration. When it comes to the preservation project, and in particular to the cultures of adaptive reuse, the driving question becomes: how to embrace the full complexity of historic urban landscape phenomena, beyond the empirical, doctrinal or any other accredited approach? What could be represented as an order that make sense rather than the simple extension of space, land, panorama or territory?

How to find the landscape, the glue, to execute the entire montage of past and future sequences, material and formal expressions of heritage and social practices and outcomes, into the circular business or production dynamics?

Prior to HUL, The Landscape approach considers established ideas of landscape like as morphology, panorama or polity/region, but following European landscape Convention it mainly defines Landscape as an area that people share, value and use; Within this framework, landscape is out of the privileged fieldwork of experts or land owners but it belongs to everyone from users to those that are gratified by its enjoyment, and thus all views should be considered when it comes to its preservation, planning or management. Given that in the landscape approach, tangible and intangible components merge, they relate the individual dimension to the public and collective dimension, as well as solidify the relationships between past and future through the present, enhancing the present responsibilities in relating past and future, both at collective and individual domain. As it is asked for natural "heritage", individuals are responsible to transmit urban peculiarities with all their social and cultural layers to the future, reversing the negative impact of the linear pressure of the global market, which tends to the standardization of daily objects.

So, who owns the landscape? Who can claim property over "wealth" that is not quantifiable or exchangeable as an accumulation of things, but based on the quality of the relationship between people and things on Earth and on the nutrition of the culture of complexity this relationship imposes itself?

Through the eyes of Historic Urban Landscape *owning* cultural heritage is related to the right of use, to the adaptation of reuse which never turns out as appropriation, but only as common use. Thus, the protection, management and planning of common goods, intended not as protection of property, of something external (as opposed) to the individual, whether private or public. This situation additionally challenges traditional economy and approaches to governance by reactivating business models that are driven also by the originality and the creativeness of social initiatives and struggles.

Which circular scenarios then within multiple identities that give their voices within historic urban landscapes? How to overcome the "multiple practices of mutual recognition", of the multiple set of knowledge, values, aspirations or collective will, the more complex participation processes are, and finally advance toward shaping a concrete and shared body of mutual identification. In other words, how to advance towards a shared vision that is at the same time a coherent and readable plan of expression, as for example the project is? Moreover, to which extend it is possible to give form to something like historic urban landscape project, that cannot be captured neither within autographic dimension of experts, nor inside multiple individual expressions of community, being at the same time the result of a circular scenario that blurs the crystalline line between cultures of production and the nature of resources?

It is intuitable that the closed bodies of traditional preservation, planning and management categories have to step back and give place to those approaches that are able to embrace the multiple residuals of history and reactivate them again in a process of reuse, where producing is not separate from learning and co-designing with - rather than against – Nature. This means not only greening, but understanding the "ecosystem" values of each part of heritage. Of course, production with residuals might result as an ambiguous process, as it reactivates something that has been as rule left behind, giving at the same time a new impetus to the established thought bringing out its unexpected possibilities.

Sasa DOBRIČIĆ, Jukka JOKILEHTO, Marco ACRI
DOI: 10.3217/978-3-85125-668-0-05

The residual exists and operates within the interstitial space of what has been (past) and what is to be (future), allowing the operation to get out of established formats, categories or, in terms of urban morphology, typologies and reconnect again.

Fig. 3: *Traditional solutions of reusing materials, residuals, as in the Venetian Terrazzo floor*

Fig. 4: *The work of reinventing meanings and uses for the residuals, as made by Carlo Scarpa in the Querini Stampalia museum.*

If we address HUL under this operational condition, it results as an approach that helps us to recover residuals that are “in common” within the heterogeneous and composite spatial and temporal urban stratigraphy. In other words, the residuals make possible (and visible) the relationship between different terms (models, types, etc.) and opens the possibility of dialogue between them instead of falling back on themselves as separate and inert remaining. This approach also sheds a new light on terms such as “cultural identity” (always if there is any such thing), genius loci, integrity and authenticity, leading us to exit the “identity” perspective, by acting divergently, as a “fruitful waste”, that brings out a range of unexpected resources instead of increasing the convergence of identity as the classification of the same.

Sasa DOBRIČIĆ, Jukka JOKILEHTO, Marco ACRI
DOI: 10.3217/978-3-85125-668-0-05

The practice

Relating urban regeneration to tradition in its tangible and intangible components means recognizing the link of different layers and mostly of different scales. As the theory of typological urban conservation highlights, parts of a building (we may add also its interiors, including handmade furniture) talk about the reasons for a certain type of built environment development in time. As we have seen, authenticity and integrity play a role in this. But what do we mean with authenticity and integrity and how much this extends in urban contexts?

Thirty years after the Venice Conference, the Japanese meeting adopted the *Nara Document on Authenticity*, which has since been recognised by the World Heritage Committee and included in the *Operational Guidelines for the Implementation of the World Heritage Convention*. The reason for the organisation of the Nara meeting was to examine the applicability of the notion of "authenticity" in all the world cultures. The question was raised due to some criticism about the European bias in judging authenticity. Indeed, one of the principles established in Nara was referred to the diversity of human creativity: '*The diversity of cultures and heritage in our world is an irreplaceable source of spiritual and intellectual richness for all humankind. The protection and enhancement of cultural and heritage diversity in our world should be actively promoted as an essential aspect of human development*.' (art. 5) Consequently, it is stated that understanding the significance of a resource depends on the truthfulness of the sources of information, i.e. authenticity. We need to understand and judge the meaning of heritage properties within its cultural context. Therefore, the critical question is the identification of the relevant information sources in each case. These can be referred to material testimonies as well as to social and cultural belief systems, such as '*design, materials and substance, use and function, traditions and techniques, location and setting, and spirit and feeling*.' (art. 13).

Fig. 5: *Picture taken in old Gorizia to a traditional local Austro-Hungarian villa's facade*

Fig. 6: *picture taken in Gorizia to a similar building where no attention is paid in preserving both authenticity and integrity of the façade.*

Integrity refers to the structural, material, aesthetic whole of an object, namely how much of its initial fullness remains or is left. This may be clearly true for small objects as well as for urban areas and do not address mainly their tangible components, but also their intangible component. Authenticity and integrity are strictly related but do not always come together. In historic buildings, for example, the concept of maintenance was essential and could include actions of replacements of some parts (this is in itself circular, not only because linked to the use of "natural materials" but to the idea of waste and energy reduction, opposed to the present linear process of substitution of the "whole") reducing the material but maintaining the conceptual authenticity of a work (fig. 5 and 6). Important here to stress that authenticity and integrity applies also to modern built heritage, and their weight should be aligned to the heritage intrinsic values.

Sasa DOBRIČIĆ, Jukka JOKILEHTO, Marco ACRI
DOI: 10.3217/978-3-85125-668-0-05

As we have also noticed above, the concepts of authenticity and integrity are means and represent something to be “transmitted”, as the genius loci. Genius Loci refers to the specific creative inputs that is generated by a specific territory (Fig. 7). Historic development associated to climatic conditions create different, peculiar, place oriented human responses for adaptation. This means that the tangible manifestations of human adaptations represent a proof of the history of a territory. This is true in rural contexts as well as in urban ones. Traditional buildings, as well as traditional crafts and knowledge are expressions of the genius loci, of the adaptation of human beings to specific environments, beyond cultural “contaminations” and before globalization trends that might have reproduced the final effect, but not its intrinsic peculiarities that may be related, for example, to the circularity of maintenance (wood similar ceramic tiles achieve almost perfect final appearance as wood planks, but cannot be either repaired or treated as the original).

Genius loci though must be accompanied by the sense of place (that is often considered as the genius loci) although it should be understood with an additional dimension, the social one. The sense of place indeed refers to the present use of the place in line with its genius loci (Fig. 8). The sense of place reflects the historic development, the peculiarities that made a space place for a specific group of individuals in time. Sense of place refers to the use of the space. Traditional buildings and local traditions give the “tangible” contextualisation of the place and their respect, maintenance, contribute to the preservation of this sense. If a traditional architecture may be considered unique or peculiar, the sense of place makes it even more unique. The sense of place contributes to the quality of life as one is relating to his own environment. Genius loci may be visible in architecture, infrastructural solutions, landscaping, crafts and popular rituals and festivities. At the same time, genius loci may be granted in contexts of absence of the “sense of place”.

Fig. 7: *Venice is a perfect example of genius Loci, displaying numerous solutions of adaptation to local needs and solutions in many of its tangible and intangible components. Pic. From http://events.veneziaunica.it/it/content/ca-farsetti*

Fig. 8: *Venice though is often referred as a place where the sense of place has been lost for the lack of connection between present use and historic development, determining doubts about its authenticity as a city. Pic. From https://veneziaautentica.com/impact-tourism-venice/*

Unfortunately, our ongoing researches within the CLIC project show that the practice so far has not been fully positive in connecting urban preservation with respect of authenticity and integrity and with respect of the genius loci with maintenance of the sense of place, due to numerous factors that could be listed as:

• Lack of knowledge of the preservation theory, namely properly merging heritage preservation, adaptive reuse, urban conservation and regeneration. Such lack belongs both to the political side, the decision makers, that have not been able so far always to design policies or implement tools and practices to make this possible, but it belongs also to the professionals, that have not been either trained properly or capable to achieve the right understanding of the main heritage concepts;

• Lack of awareness by the citizens, the individuals, the traditional heritage owners (important to stress that we are not referring to monuments), who have still difficulties in understanding the importance of their heritage, of their genius loci manifestations, of the sense of place and of their active influence and possible contribution to this.

• The market pressures and logic, that have been both communicating the "better" of new materials and technologies, even when this was not true, and generated a set of

DOI: 10.3217/978-3-85125-668-0-05

standardized products easily available in the linear production chain. As for other goods, also built environment has been suffering of the "intermediate and provisional solutions" in the logic of "this may be changed anytime".

• Inorganic development of the built heritage solutions, that have been growing without the traditional, slow, connections, due to the incredible grows of introduction of new materials and technologies, often produced outside the building sector. This is why, for example, installations of the heating or cooling systems are often added and not integrated in the structural whole of buildings.

• Difficulties in accepting that adaptive reuse of heritage and traditional built environment must be intended as a biunivocal adaptation, of buildings to men and of men to buildings. In this respect, linear economy has played a fundamental negative role.

• The misleading idea of private property has generated a general fall of interest by individuals to accept their responsibility in contributing to the public space. As an example, if it is true that an apartment is considered fully private, with the inclusion of all its parts, on the opposite it has an important public dimension that is both tangible, as the prospect of the apartment on the public road or square, and intangible, as the historic layers in the apartments that are not merely related to the private sphere of the previous owners, but on the relationship the apartment and its building have with the rest of the context.

Conclusions

The paper has been trying to highlight in different forms how much the fundamentals of the heritage and urban preservation theory are related to the fundamentals of the circular economy, opening up an interesting scenario to favor HUL. In reality it is not simply a connection, given that traditional knowledge, built environment and cultural sites have been generated on the cyclical processes of the pre-industrial society, thus related to local resources, materials, techniques, competences and habits.

Nevertheless, highlighting such connection (historical and theoretical) must be accompanied by a clear overview of the practical synergies between adaptive reuse, urban preservation and tradition, as highlighted in the CLIC project, as:

Sasa DOBRIČIĆ, Jukka JOKILEHTO, Marco ACRI
DOI: 10.3217/978-3-85125-668-0-05

• *Respect of integrity and authenticity* – promoting maintenance instead of renewal. Restoration must come as an exception, while maintenance as a rule. Maintenance is cost-efficient.

• *Materials recycling and re-scaling* – generating virtuous mechanisms that reproduce the historic building site in its practice and results. Creativity is not merely expressed by designing new shapes, but also in upscaling residuals.

• *Objects/Finishings/Furniture reuse and re-scaling* - generating virtuous mechanisms that reproduce the historic building site in its practice and results. Creativity is also expressed in up-scaling residuals.

• *Multifunctionality* – giving the urban tissue intensity in use, as in the past where low mobility means were facilitating a full and intense use of the urban environment, during all its daily life. This much refers to the sense of place.

• *Generation of economies based on culture and nature* – new aesthetic or heritage communities are growing, where mutual needs relationships are different than the traditional ones, given the present existence of a virtual sphere and market.

• *Resilience as regenerating force* – the need to refer back to the local knowledge and traditional produces new old-economies and favor both traditions and urban heritage protection

• *Retrofitting* – is not meant anymore as a simply adaptation of buildings tout-court, but as a more complex and protection-oriented approach which involves a mutual adaptation object-man.

• *Community/collectivity engagement or simple awareness* – A clear work of education and awareness raising has to be done to favor the circular economy process in urban regeneration. However such effort is today lighter than some decays ago.

DOI: 10.3217/978-3-85125-668-0-05

Circular economy in urban context must then act at different levels, not only in the buildings adaptive reuse:

• it is about objects – the micro scale (think about the solidarity markets or the repair cafes)

• It is about buildings and their maintenance – the meso scale

• It is about urban ecosystems – the macro scale

Evidently, this is not an individual action, but a more societal movement:

• More than punctual projects, the importance is given to governance, that is how micro-meso and macro are interrelated.

• To reach the micro level awareness raising is needed, as well as acting on the level of commons;

• To reach the meso level awareness raising should be merged to training, given that professionals themselves do not promote the "right thing";

• To reach the macro level, courageous policies should be put in place, recognizing the primary role of culture and nature in the citizens well-being.

Still, even if the conservation movement have been developing the conservation theory for about one century, relying initially on the artistic qualities, lately on the socio-cultural specificities and finally – to convince also the policy makers – on the economic values (we should refer here to the works of Peacock, Throsby, Klamer, etc.), today is the economy itself coming back to help the preservation movement. Although the fundamentals of the circular economy today rely on the environmental and health concerns, they let traditional practice principle re-emerge, together with the need of more sustainable materials, techniques, technologies and procedures.

The real contribution of landscape concept in the EU-CoE Convention and of the Historic Urban Landscape approach in the UNESCO Recommendation has been to re-connect in planning the heritage dimension to the socio-economic dimensions, making the concept of identity not referred to the community, but to the territory. Considering the loss of the traditional concept of community, the territorial identity helps in generating new other communities that are volatile, project oriented and topic focused. The opportunity of European urban context today in terms of tradition and heritage preservation is given by

DOI: 10.3217/978-3-85125-668-0-05

the spread of communities of sustainability that acknowledge the importance of circular economy and renew their interest (direct or indirect) toward local resources that are by definition part of the tradition. Never in the history of the preservation theory the modern school of economy has been so close to tradition and heritage.

Funding

This research was funded under the framework of the Horizon2020 research project CLIC, Circular Models Leveraging Investments in Cultural heritage adaptive reuse. This project has received funding from the European Union's Horizon2020 research and innovation program under Grant Agreement n. 776758.

References

Acri M., Dobricic S. (edited by), Creative *Cities: Which (Historic) Urban Landscape?*, Mimesis, Milan, 2017
CoE, *The European Landscape Convention*, Florence, 2000

Hayden D., *The Power of Place - Urban Landscapes as Public History,* MIT, Cambridge (MA) and London,1997

ICOMOS, *The Venice Charter,* Venice, 1964

Jokilehto J., *A History of Architectural Conservation*, Routhledge, Abingdon and New York, 2018, 2nd edition.

Norberg-Schultz C., *Genius Loci: Towards a Phenomenology of Architecture,* Rizzoli, New York, 1979

Ostrom E., Gardner R., Walker J., (edited by), *Rules, Games, and Common Pool Resources*, Ann Arbor, University of Michigan Press, 1994

Stanley Price N., King J., *Conserving the Authentic – Essays in Honour of Jukka Jokilehto*, ICCROM Conservation Studies, Rome, 2009

UNESCO, *The UNESCo Recommendation on the Historic Urban Landscape*, Paris, 2011

Zumthor P., *Atmospheres,* Birkhauser, Basel, 2006

DOI: 10.3217/978-3-85125-668-0-06

Should Artificial Intelligence be Used to Empower People with Profound Intellectual Disabilities?

M. ENGELHARDT (1), Michal KOSIEDOWSKI (2), T. KRÄMER (1), J. TYRAKOWSKA (3)

(1) Heidelberg University of Education, Germany; (2) Poznan Supercomputing and Networking Center, Poland; (3) Na Tak Association, Poland

Abstract

People with profound intellectual and multiple disabilities (PIMD) often communicate on a pre-symbolic level and use unconventional behavioural signals to express their needs. Hence, the exact understanding of their needs is often not possible even for very familiar persons. This significantly restricts the participation of people with PIMD in all areas of life. However, advanced Information and Communication Technologies (ICT) allow to create smart systems which can, potentially, intelligently interpret these non-symbolic behaviours and translate them into actual needs of people with PIMD. This way, people with this type of disability can be empowered to take actions themselves, especially when their direct support person (DSP) is not available. The INSENSION project investigates if ICT can be employed to create a smart solution capable of supporting people with PIMD and if such a system can be successfully used in practice within the project. This paper discusses ethical issues deriving from the use of Artificial Intelligence (AI) technologies within the context of PIMD. Issues like the target group's inability of giving consent to use these technology-based solutions, which can potentially enable a level of self-determination previously not available to them, need to be addressed. However, not enabling AI for use by people with PIMD would entail refusing them the possibility to benefit from the potential of achieving a certain level of independence. Therefore, a system like INSENSION must be designed and provided.

M. ENGELHARDT (1), Michal KOSIEDOWSKI (2), T. KRÄMER (1), J. TYRAKOWSKA (3)
DOI: 10.3217/978-3-85125-668-0-06

1 Introduction

The INSENSION project focuses on creating and validating an Information and Communication Technologies (ICT) system capable of recognizing the meaningful non-symbolic behaviours of people with profound intellectual and multiple disabilities (PIMD, also referred to as PMLD – profound multiple learning disabilities) and, through putting them into the context of what happens around a specific individual at the time of a given behaviour, allowing the needs of these people to be met with the use of assistive applications. While the primary envisaged application aims to facilitate communication with other people, other uses can be imagined such as turning up the heating in the room when the person with PIMD protests against the cold or playing back their favourite music for relaxation.

The INSENSION platform uses advances in computer vision and audio signal analysis to recognize gestures, facial expressions, vocalizations and psychophysiological states. Further on, similar techniques, additionally extended by readings from ambient sensors, are used to understand the context of the behaviours of people with PIMD. A combination of these methods for automatic analysis of data acquired from the primary end user – the person with PIMD – using cameras, microphones and other relevant Internet of Things devices, constitutes the intelligence of the developed system.

The primary goal of the project is to verify whether creation of the system in question is possible from the technical point of view and whether the system will be smart enough to act accurately on behalf of the primary end user. However, several additional questions arise when discussing real-life usage of such a system. These questions relate, inter alia, to the privacy of the primary end users, the extent to which the system should act on its own once it is able to recognize the meaning of a given behaviour of a person with PIMD, the possibility of allowing the system to act as a prosthesis for verbal communication for a person who is biologically unable to use verbal communication. All these questions are also subject of the research conducted within the project and have been included as important design issues to be solved with the participation of representatives of the secondary users group – direct support persons (DSPs), e.g. relatives or professional caregivers.

DOI: 10.3217/978-3-85125-668-0-06

This paper starts with presenting the characteristics of PIMD in Section 2, leading to the description of the concept and functionality of the INSENSION system in Section 3. Section 4 discusses the ethical issues related to the use of a system based on Artificial Intelligence (AI), like the one to be created within INSENSION. Finally, conclusions are presented in Section 5.

2 Background

2.1 Profound intellectual and multiple disabilities

The group of persons with PIMD is relatively small but increasing in numbers (Bellamy et al. 2010). Proving this statement by means of exact numbers is nearly impossible due to a lack of quantitative data concerning the prevalence of this population (Fornefeld 2004). One of the reasons for that is the challenging task of defining PIMD because of the characteristic heterogeneity concerning the causes, forms and manifestations of the disability within people affected (Axelsson et al. 2014). The *International Classification of Diseases 11th Revision (ICD-11)* provides a first orientation by declaring a “below average intellectual functioning and adaptive behaviour that are approximately four of more standard deviations below the mean (approximately less than the 0.003rd percentile)” (World Health Organization 2019) as characteristic. Typically, the intellectual disability goes along with below average adaptive behaviour, physical or sensory impairments as well as complex health needs like epilepsy (World Health Organization 2019; Nakken & Vlaskamp 2007). In this rather medical perspective, other influencing factors besides the intellectual disability itself are not taken into account. Therefore, the *International Classification of Functioning, Disability and Health (ICF)* – also published by the World Health Organization – offers a consistent and standardized terminology for describing the bio-psycho-social aspects of the consequences of illness. The model of ICF is presented in Fig. 9.

DOI: 10.3217/978-3-85125-668-0-06

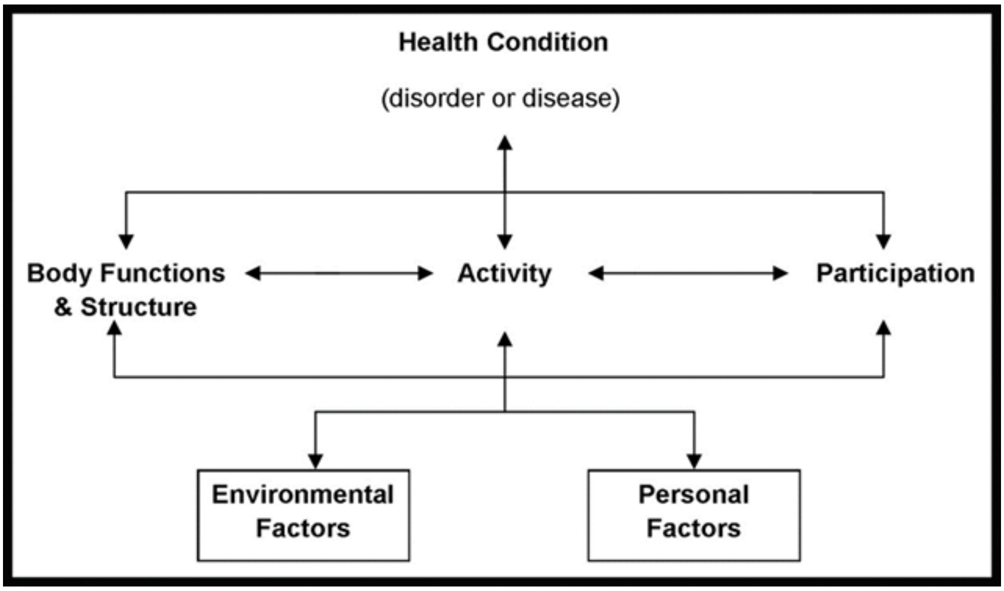


Fig. 9: *The Model of International Classification of Functioning, Disability and Health.*

All of the illustrated factors can have a positive or negative impact depending on the persons' situation. In the ICF conception, the particular disorder or disease (e.g., a genetic syndrome) is seen as a kind of starting point of the reasoning, which does not automatically lead to actual restricted participation. The health condition influences specific body functions and structure concerning, inter alia, motor competencies or intellectual abilities. To what extent these factors lead to a disability depends on personal factors (e.g., intrinsic motivation towards a particular activity) and environmental factors (e.g., support of parents or prevalent politics). Disability itself is also seen as a situational phenomenon, as the severity of the disability depends on the specific activity. In conclusion, the model illustrates the above-mentioned heterogeneity by taking into account contextual factors as well (DIMDI German Institute of Medical Documentation and Information 2017; World Health Organization 2001).

2.2 Communication

People with PIMD often communicate on a pre-symbolic level because they did not (yet) learn the understanding of symbols like pictures or pictograms and usually do not use verbal language due to their intellectual disability or motor impairments (Bellamy et al. 2010; Maes et al. 2007). Hence, their body's own behaviour signals need to be perceived and interpreted by their environment in order to understand their needs. Interaction partners must focus on specific gestures, facial expressions, vocalizations and

DOI: 10.3217/978-3-85125-668-0-06

physiological parameters (Brady et al. 2012; Carnaby 2007) to understand the three reasons of preverbal communication (Rowland 2013; Rotter et al. 1992):

• demanding objects or actions that the person wants

• protesting, when the person does not want a specific object or action

• commenting a social interaction

These signals are highly individual as they usually occur on an unconventional level. Therefore, common conventional signals like nodding or the pointing gesture are not used (or at least not with the same meaning). Since most of the current technological devices for supporting the communication between people with and without disabilities require the understanding of symbols, these forms of Augmentative and Alternative Communication (AAC) are often not suitable for people with PIMD.

The lack of verbal language and the enormous individuality of used behaviour signals lead to restrictions in communication and, consequently, in self-determination and participation. Concerning the satisfaction of their needs, people with PIMD are highly dependent on others(grouped within environmental factors in the ICF conception). This high need for support ranges over their whole life span (Axelsson et al. 2014; Nakken & Vlaskamp 2007). Therefore, individuals with PIMD need to interact with others even to get their basic needs fulfilled, but the number of interaction partners who are actually capable of accurately perceiving and interpreting these specific and highly individual behaviour signals is usually very limited. In most cases, the differentiation between pleasure and displeasure is by all means possible for close DSPs, whereas the exact understanding of more complex needs or specific emotions like fear, disgust, surprise or sadness is often quite difficult even for familiar persons (Petry & Maes 2006).

3 Artificial intelligence supporting people with PIMD

Section 2 described the characteristics of PIMD and the needs of people living with this type of disability in relation to achieving the highest possible quality of life. Like with any other disability, its characteristics define the type of tools capable of enabling a high level of self-determination. The ability of self-determination is an important aspect of living a happy life. Therefore, it is crucial to enable any person with disability, including people with PIMD, to have a level of self-determination as high as possible by using relevant tools.

DOI: 10.3217/978-3-85125-668-0-06

Within the context of other types of disabilities, these tools include for example a wheelchair for a person with motor impairments or a white cane for a person with visual impairments. People with PIMD require the employment of ICT solutions to achieve the same goal.

3.1 The challenge

Looking at the nature of PIMD, it primarily results in limiting people's abilities to communicate with others and to meaningfully interact with their environment. This prevents these people from fulfilling their needs on their own. They need to rely on others, particularly those that can understand their highly individual, usually non-symbolic communication schemes. The caregivers supporting them act as interpreters of the specific non-symbolic 'language' of a given individual with PIMD. This non-symbolic 'language' is composed of facial expressions, gestures and vocalizations, therefore DSPs look and listen to notice a specific behaviour. Since non-symbolic behaviours are reactions of people with PIMD to whatever happens around and/or to the given individual with PIMD, caregivers interpret these behaviours depending on these happenings. Once they understand the particular need expressed with the use of specific non-symbolic behaviours, the DSP can perform an action leading to fulfilling that need.

The way in which the caregivers of people with PIMD work to fulfil the needs of these people directly demonstrates the desired functionality of a solution that could perform similar tasks. This functionality should be related to allowing:

• to visually recognize and distinguish between facial expressions and gestures, and to hear and distinguish between vocalizations,

• to recognize (visually and acoustically) and to understand what is happening around the individual whom the developed solution strives to support,

• to notice the correlation between particular behaviours and particular elements of the situation around the supported individual,

• to interpret all the information mentioned above as a particular need of the supported individual,

• and finally, to fulfil that need.

M. ENGELHARDT (1), Michal KOSIEDOWSKI (2), T. KRÄMER (1), J. TYRAKOWSKA (3)
DOI: 10.3217/978-3-85125-668-0-06

Such a list of abilities defines the general picture of how the technological prosthesis enabling people with PIMD to make decisions on what to do next on their own should be constructed. Since processing of information is heavily involved, this solution should be based on ICT and operate in a cycle as presented in Fig. 10.

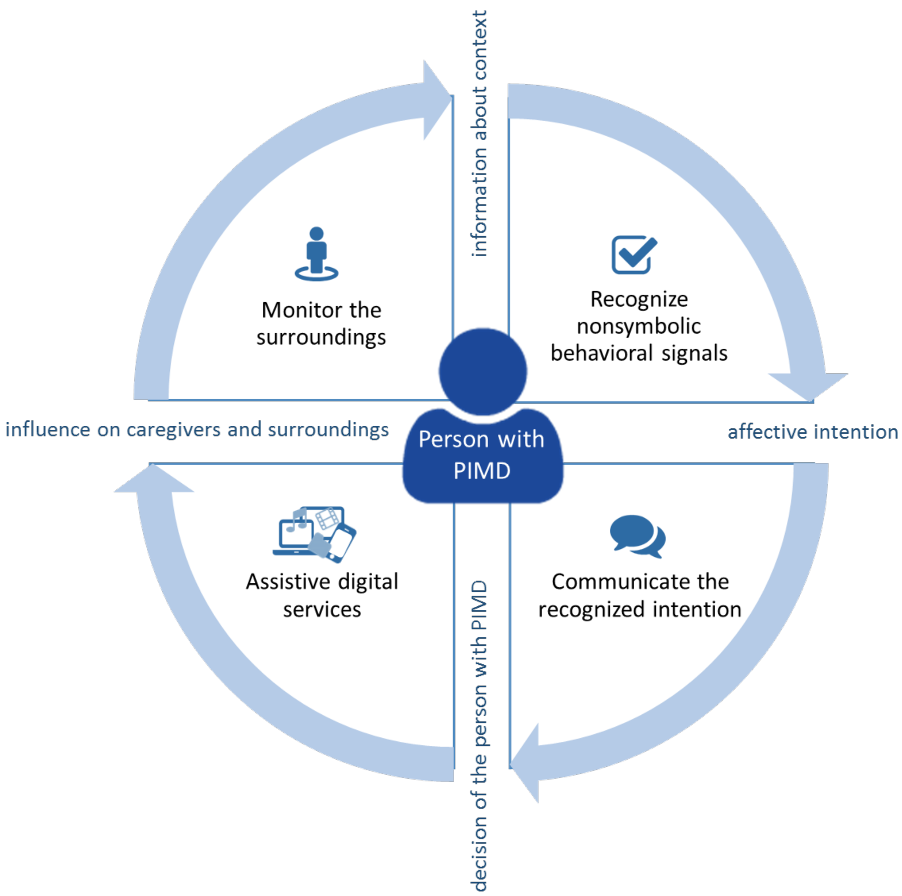


Fig. 10: *The operating cycle of the INSENSION system implementing a self-determination prosthesis for people with PIMD*.

Because the meaningful behaviours of people with PIMD are usually reactions to happenings around them, the ICT system that is supposed to support their self-determination must monitor the environment of the individual it supports. This way, it is able to collect information about the context of any behaviour of that person. The second step is to recognize the facial expressions, gestures, vocalizations and physiological parameters of the supported individual in order to recognize complex non-symbolic behaviours comprised of a number of such signals. Combining the recognized non-symbolic behaviour with information about the context allows to interpret it as an intention

DOI: 10.3217/978-3-85125-668-0-06

of the supported person, for example as a *demand* to prolong a situation that makes them feel comfortable or as a *protest* against a situation that makes them feel uncomfortable. From this moment, the assistive ICT system is ready to communicate the identified intention of the supported individual to the ICT-based assistive services or applications that interpret the affective intention of the supported individual as a decision to perform a specific action with the use of the functionality available within these services. The actions performed on behalf of the supported individual either preserve the situation around them or change it according to their needs, thus influencing their environment.

3.2 The technical solution

The INSENSION system is foreseen as a system working in the close vicinity of an individual with PIMD (Fig. 11). It uses various sensors to collect data from the primary end user and from the environment around them ranging from cameras and microphones to sensors measuring such parameters as air temperature. Afterwards, the collected data is analysed and compared to the behaviour patterns defined based on the human knowledge on the non-symbolic interaction schemes of the user and interpreted as decisions of the user as to what to do next. These decisions are communicated to specialized assistive service or applications, which perform actions aimed at executing the decision of the user. These actions may relate to involving human caregivers to provide the assistance, supply direct support to the user without any DSP, or influencing the environment with the use of relevant actuators.

DOI: 10.3217/978-3-85125-668-0-06

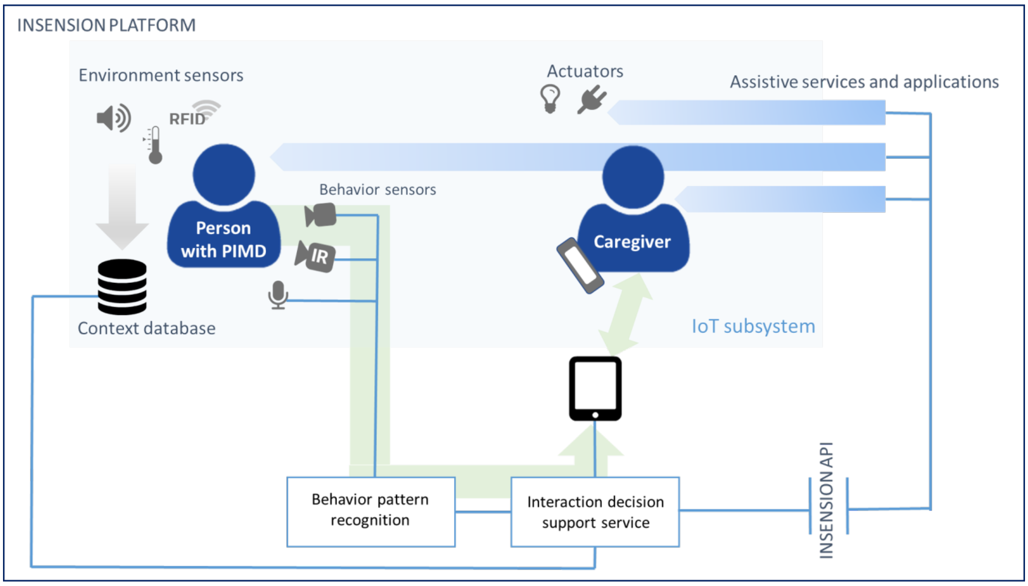


Fig. 11: *The general concept of the INSENSION system.*

On the technical level, this system contains two major types of components that enable it to process and interpret the data collected from the user, i.e. non-symbolic behavioural signals and data on the environment constituting the context of the user's behaviour (Kosiedowski et al 2019). The first type are the so-called recognizer components, which are used to: (1) recognize people's faces and their facial expressions, (2) recognize gestures, (3) recognize vocalizations and sounds, and (4) recognize the affective physiological response of the given individual. The second type of component is constituted by the Interaction Decision Support Service. Fig. 12 presents the placement of these components in the logical architecture of the system.

M. ENGELHARDT (1), Michal KOSIEDOWSKI (2), T. KRÄMER (1), J. TYRAKOWSKA (3)
DOI: 10.3217/978-3-85125-668-0-06

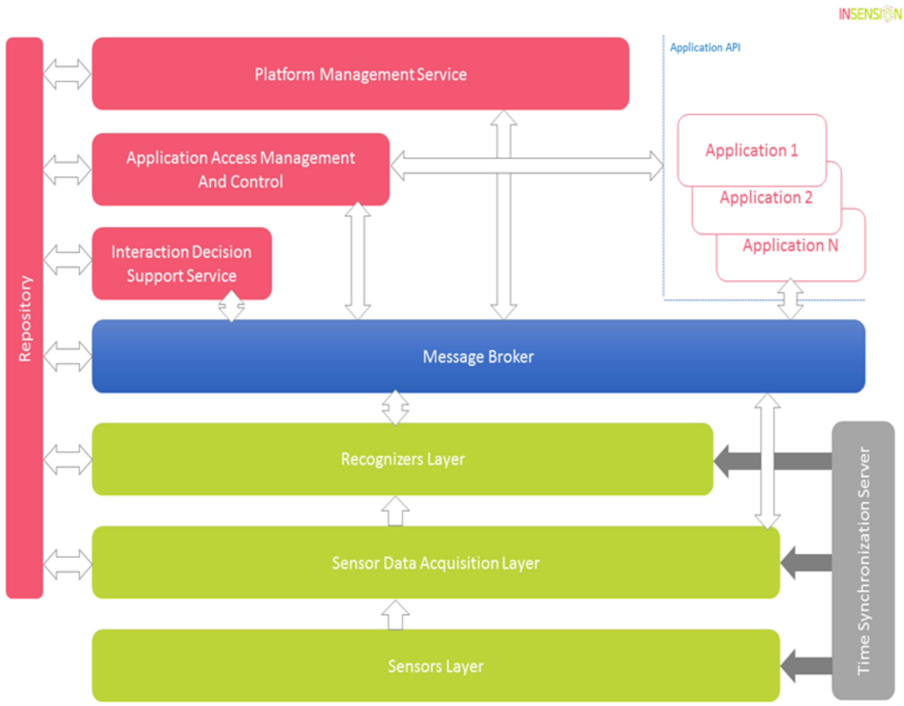


Fig. 12: *The logical architecture of the INSENSION system.*

The recognizers are created with the use of machine learning techniques that allow the specific recognizer components to learn how to notice the required items and events in the video and sound collected with the use of the system's cameras and microphones. This training phase allows to build the relevant numerical models of faces, facial expressions, gestures and vocalizations/sounds. The models are built using real data collected from the users and their environment, i.e. video and sound recorded there. to the system compares the video and sound recorded during actual system operation with these models in order to find occurrences of behaviours fitting those models. Thanks to this, the system is able to recognize visually and acoustically what the user does with their face and body, whom the user sees and what the user 'says' or hears. Fig. 13 presents example facial expressions and gestures recognized by the relevant system components:

M. ENGELHARDT (1), Michal KOSIEDOWSKI (2), T. KRÄMER (1), J. TYRAKOWSKA (3)
DOI: 10.3217/978-3-85125-668-0-06

Fig. 13: *Examples of facial expressions and gestures recognized in people with PIMD by the INSENSION system components.*

In the next step, the Interaction Decision Support Service attempts the interpretation of the recognized behavioural signals. This is done through determining the behaviour state of the user, i.e. whether the person feels ‘pleasure’, ‘displeasure’ or has ‘neutral’ attitude, and through finding out whether the given behaviour was a communication attempt, i.e. whether the user expressed their ‘protest’, ‘demand’ or ‘comment’. This is possible because human experts provide this component with knowledge on how to interpret specific behaviours of a particular individual with PIMD. The next step is to understand the reason of a given behaviour state and/or communication attempt. This is again done based on the knowledge provided by the human experts. Thanks to this, the Interaction Decision Support Service is capable of interpreting for example:

• the presence of a particular DSP near the supported user as causing ‘pleasure’,

• the fact that the temperature is lower than desired by the user as causing ‘displeasure’,

• a digital player playing a particular song as causing ‘demand’ for more of this music or

• the fan being switched off as causing ‘protest’.

DOI: 10.3217/978-3-85125-668-0-06

Being able to recognize behavioural signals, to determine the behaviour states and communication attempts as well as to identify the cause of a given behaviour allows the INSENSION system, on the one hand, to put these three items together as specific intentions of the supported user that should be attended to. On the other hand, the system can create a space for providing ICT-based assistance to the user, thus increasing the level of their self-determination. In this project, this is done with the use of specialized assistive services and applications.

3.3 The opportunities

The ability of the INSENSION system to interpret behavioural signals of people with PIMD as their potential decisions on what should happen around them next opens a wide range of opportunities to deliver specialized assistive applications and services. These assistive applications and services can support the user and the DSPs in a number of life scenarios. In order to define these scenarios, a series of focus workshops took place with the participation of formal and informal DSPs. These workshops were held in Poznan and Krakow, Poland, as well as in Heidelberg, Germany, using Design Thinking (Kelley and Kelley 2013) in combination with the Walt Disney Method (Dilts 1991) to define the INSENSION system usage scenarios.

The scenarios identified by the workshops participants included supporting people with PIMD while transiting from the care of one DSP to another DSP; supporting people with PIMD during the night, particularly when they wake up; enabling people with PIMD to react to external circumstances such as weather that might influence their needs. Scenarios like these can be facilitated using a proper combination of applications and services that can execute relevant actions based on the decisions of the person with PIMD as interpreted by the system. At the moment, three applications that allow facilitating the above-mentioned scenarios are foreseen:

Communication application, allowing the person with PIMD to communicate with other people, e.g. informing them about their current need (‘I need to relax’) or attitude (‘I don’t feel well today, this is probably because of the bad weather’);

Multimedia player, allowing the person with PIMD to decide if and what music or video is to be played in their room, based on feeling ‘pleasure’ or ‘displeasure when no song is played, or on ‘demanding’ or ‘protesting’ when a particular song or type of music is played;

DOI: 10.3217/978-3-85125-668-0-06

Control of room devices, enabling the person with PIMD to switch particular devices on or off, for example switch on the heating device when they feel 'displeasure' caused by low temperature.

An example assistive scenario based on the interviews with DSPs performed during the aforementioned workshops could potentially be realized with the use of the developed system and the applications listed above. It is related to a situation when the person with PIMD stays alone, e.g. during the night in their own bedroom. In this situation, the system, which constantly monitors the behaviours of its user, recognizes with the gesture recognizer that, for example, the person shakes his or her head characteristically. At the same time, the room sensors report that the temperature is slightly lower than usually. Due to the known fact that this particular person has a significant aversion to cold, his or her behaviour can be interpreted by the Interaction Decision Support Service as displeasure caused by low temperature. Such a message is sent to the application controlling the devices installed in the bedroom. As a result, the heating device is switched on and the room temperature can be increased to a level that is not causing displeasure and is accepted by the user. This way, the person with PIMD can control the temperature in his or her bedroom in a self-determined manner, without the need of intervention from a DSP.

While the above-listed scenarios and applications need to be studied during the course of this project, they illustrate how an AI system like INSENSION can use its capabilities to change the situation of people with PIMD, from waiting for the care to be delivered to requesting the care to be delivered, and, where possible, fulfilling a need by themselves.

4 Ethical issues

Human autonomy also includes the ability to decide whether and with whom to communicate. Everyone is familiar with the desire to withdraw or not to communicate to anybody. For people with PIMD, it is much more complex to realise this basic need. As described in Section 2.2, interaction partners often have no choice but to interpret behaviour signals communicatively to get an insight in the person's wishes and needs as well as strengthen their participation. However, this leads to a risk in two ways. On the one hand, it has to be possible for people with PIMD to withdraw or to signal that they do not want to communicate in a specific situation. On the other hand, misinterpretations of the observed behaviour may arise, especially by unfamiliar persons, potentially leading to

DOI: 10.3217/978-3-85125-668-0-06

wrong reactions. Concerning both aspects, a high degree of empathy is required in order to reconcile the necessary caring, communicative attention and respect for autonomy (Klauß 2002).

Therefore, the realisation of the INSENSION project brings forth ethical issues on two different levels:

1) Concerning **research ethics**, attention must be put on the involvement of vulnerable groups without having their explicit consent to participate in the particular research.

2) Regarding **human-machine interaction**, the relation between the human being and the technology – whether it is complementing or replacing – constitutes a crucial point.

Both aspects are part of the project's considerations and will therefore be part of the following discussion.

4.1 Research ethics

Research is never neutral, but it always has a positive or negative impact on the test person. Therefore, research ethics, especially regarding vulnerable groups, have to deal with the questions if the specific interventions of the researcher are acceptable for the test person and how protection of the participating person is provided if it proves necessary (Dederich 2017).

Historically, significant violations of human rights, in particular during the Second World War, have shown that the main component of an ethical approach is the protection of participating persons by ensuring (Calveley 2012; Dederich 2017; MacInnes 1999; Schnell & Heinritz 2006):

• their well-being,

• the voluntary nature of their participation,

• the maintenance of their physical and psychosocial integrity,

• the protection and confidentiality of gathered information (i.e., personal or health-related data).

However, perceiving this protection as the only aspect is a rather short-sighted approach. While medical studies, especially in Europe, are often based on the Declaration of Helsinki, a guideline that has been revised several times up to its current version (General

Assembly of the World Medical Association 2014; Thiel 2013), studies within the field of special needs education can be based on the ethical framework of Beauchamp and Childress (Beauchamp & Childress 1989). The latter focuses on the risks and benefits of participation in comparison to non-participation and identifies four orienting principles: autonomy, justice, beneficence and non-maleficence. These principles have no hierarchy or strict evaluation procedure. In some cases, their implications may be in conflict with each other, which makes it necessary to weigh them in each individual case. In turn, three concrete rules can be derived from this framework (Fuchs et al. 2010):

• The initial focus is on the informed consent, which describes a process of transparent clarification of the research procedure in order to receive an agreement by the involved persons concerning the participation in the research process. An ongoing reflection during the actual research process and well-defined abort criterions are also included.

• The second aspect describes the above-mentioned risk-benefit evaluation in more detail with the question of who (i.e. the test person, the specific target group as a whole or just the researcher) could benefit from this research.

• The third aspect deals with the fair selection of test persons.

4.1.1 Ethical implications concerning research involving people with intellectual disability

In recent years, the amount of empirical research, both qualitative and quantitative, on the lives of people with intellectual disabilities has raised significantly. In order to change the perspective from research about people with intellectual disability (ID) to research with and for people with ID, alternative research approaches, such as the emancipatory research paradigm, have been developed. Although it is clear that this approach is not suitable for all kinds of research, there is a broad consensus concerning the aim of including this group within the research process. However, the informed consent is always a good method of prevention of disadvantages or harm for the test persons. If this cannot be provided on a verbal level, suitable alternative forms of communication for the specific person, i.e. images, pictograms or symbols, are required (Dederich 2017; Mietola et al. 2017).

DOI: 10.3217/978-3-85125-668-0-06

4.1.2 Ethical challenges concerning people with PIMD

Although asking for informed consent in alternative ways such as “emancipatory research paradigm with its emphasis on self-empowerment has made some disabled voices heard, it has not been able to offer alternative approaches to include those who are the most silenced” (Mietola et al. 2017, 264). Due to the above-mentioned difficulties in communication and interaction between people with PIMD and their environment, there is a lack of empirical studies (Maes et al. 2007) and descriptions concerning ethical research approaches.This probably makes people with PIMD the most vulnerable and marginal group in society and research (Mietola et al. 2017).

However, the crucial question is if people with PIMD should be excluded from research due to the mentioned difficulties in finding an ethically correct form of research with this group. Furthermore, how should the fine line between deriving benefits arising out of research findings and considering ethical implications be walked?

4.1.3 Recommendations

In order to make best-interest decisions, some key points should be included in the research process. Due to the incapability of providing direct informed consent by the person with PIMD, close DSPs should be informed about the research approach in terms of the benefits, risks, procedure and their own involvement. They should get the opportunity to ask questions, but they should also be asked questions. Even though the decision to participate is made by the DSPs, the persons with PIMD and their benefit from the research are in focus all the time. Of course, DSPs will always have their own interests and points of view. Although only consent by proxy is possible in many cases, it is particularly important to take the perspective of people with disabilities to the greatest possible extent. This procedure is justified by the fact that an advantage for the DSPs does not per se mean an improvement for the person with PIMD. During the whole research process, permanent and transparent reflection and analysis with possible readjustment should be performed by both the researchers and the DSPs involved to ensure the continuation of the research project. In case of doubt, i.e., if the test person or one of the DSPs involved feels uncomfortable, they should leave the study (Calveley 2012; Coons 2013; Dederich 2017; Mietola et al. 2017).

DOI: 10.3217/978-3-85125-668-0-06

4.2 Ethics in human-machine interaction

Regarding technological assistance within the care over vulnerable target groups, especially regarding the use of humanoid robots, deep-rooted fear of a loss of closeness and affection arises. The increasing humanization of robots and AI implies the risk of a dehumanization of care. A study of Butter et al. (2008) lists these concerns according to their level of security:

• There are slight concerns regarding cleaning robots as well as technical aids like electric beds or wheelchairs capable of avoiding obstacles.

• There are medium concerns regarding robots responsible for tasks where improper execution decreases safety of humans (e.g., service robots managing transport ways).

• There are large concerns regarding the use of care robots in direct interaction with care receivers (e.g., provision of medicine or food).

The closer the technology gets to the person, the bigger the scepticism concerning its use gets. According to Becker et al. (2012) the acceptance towards robots depends on whether their use leads to personnel reduction or whether it implies time savings leading to more time for direct interaction with the care receiving persons.

Another crucial point within the context of technical assistance in care, especially when it comes to people with PIMD, is autonomy: To what extent can technology contribute to more autonomy without restricting the person’s self-determination in an unforeseen manner (Dabrock 2019)? The risk of an abuse of power by technology, connected to a loss of autonomy by the person with PIMD, needs to be considered at any time due to the fluent transition from necessary care to paternalistic care (Falkenstörfer 2018).

The INSENSION system deals with these challenging issues in different ways. On the one hand, the system can support the caregiver by increasing the certainty of having interpreted the behaviour signals of an individual with PIMD accurately, based on the technological analysis of these signals. Furthermore, the system can provide new information by pointing out needs which had not been considered before.

On the other hand, it can enable experiences of self-empowerment for the person with PIMD by means of the connection to assistive applications and services like the ones presented in Section 3.3. In consequence, the experience of being able to have impact on

DOI: 10.3217/978-3-85125-668-0-06

their environment using even slight behaviour signals could potentially initiate further learning processes in the person with PIMD.

5 Conclusions

In this paper, the INSENSION system, aimed at supporting people with PIMD, was presented. These people are often not able to use any type of symbolic communication, hence their ability for self-determination is usually non-existing. However, the recent advances in ICT, which delivered technologies such as AI into the reach of the average person, create an opportunity to build a sort of prosthesis of verbal communication for a person who is biologically unable to use verbal communication.

The INSENSION system, which is currently under development, is an attempt at employing those novel technologies for the benefit of people with PIMD. Designing this system allows to examine not only whether developing such a system is possible from the technical point of view, but also to study if and how such a system can positively impact the lives of people with PIMD. At the current stage of the research conducted within the project, it has been confirmed empirically that AI components to recognize relevant non-symbolic behaviours can be developed (Kosiedowski et al 2019). Further work aims to integrate these components into a coherent system capable of executing full assistive scenarios. At the end of the project, a comprehensive field study is planned on the actual impact of the developed system.

The project investigates the potential of AI to empower people with PIMD to act by themselves, especially when no DSP is around. The benefit that this technology may bring to the person with disability using it, potentially shifting the point of decision from the DSPs to the person with PIMD, must be a strong pro argument when deciding if this technology should be made available to them. Although it is hard to find an ethically correct way of research, it would be even more “unethical to exclude persons with PIMD from research that could provide insights about their subjective experiences, and about how to promote their well-being” (Mietola et al. 2017, 264). The same way of thinking concerning the practical use of the final technological product seems to be the only right choice.

DOI: 10.3217/978-3-85125-668-0-06

6 Acknowledgments

The research presented herewith has been conducted within the INSENSION project which has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement no. 780819.

References

Axelsson, A. K.; Imms, C.; Wilder, J. (2014): Strategies that facilitate participation in family activities of children and adolescents with profound intellectual and multiple disabilities. Parent's and personal assistants' experiences. Disability and Rehabilitation, 36(25), 2169-2177.

Beauchamp, T. L.; Childress J. F. (1989): Principles of biomedical ethics. Oxford: Oxford University Press.

Becker, H., Scheermesser, M., Früh, M., Treusch, Y., Auerbach, H., Hüppi, R. A. & Meier, F. (2012). Robotik in Betreuung und Gesundheitsvorsorge. Zürich: VDF.

Bellamy, G.; Croot, L.; Bush, A.; Berry, H.; Smith, A. (2010). A study to define: Profound and multiple learning disabilities (PMLD). Journal of Intellectual Disabilities, 14(3), 221-235. https://doi.org/10.1177/1744629510386290

Brady, N. C.; Fleming, K.; Thiemann-Bourque, K.; Olswang, L.; Dowden, P.; Saunders, M. D. (2012): Development of the Communication Complexity Scale. American Journal of Speech-Language Pathology, 21(1) 1-24.

Butter, M., Rensma, A., Boxsel, J., Kalisingh, S., Schoona, M., Leis, M., Gelder-blom, G. J., Cremers, G., Wilt, M., Kortekaas, W., Thielmann, A., Cuhls, K., Sachinopoulou, A. & Korhonen, I. (2008): Robotics for Healthcare. [Report]. European Commission, DG Information Society.

Calveley, J. (2012): Including adults with intellectual disabilities who lack capacity to consent in research. Nursing Ethics, 19(4), 558-567.

Carnaby, S. (2007): Developing good practice in the clinical assessment of people with profound intellectual disabilities and multiple impairment. Journal of Policy and Practice in Intellectual Disabilities, 4(2), 88-96.

Coons, K. D.; Watson, S. L. (2013): Conducting Research with Individuals Who Have Intellectual Disabilities: Ethical and Practical Implications for Qualitative Research. Journal on Developmental Disabilities, 19(2), 14-24.

Dabrock, P. (2019). Pflege – Roboter – Ethik. Ethische Herausforderungen der Technisierung der Pflege. Retrieved from https://www.ethikrat.org/fileadmin/PDF-Dateien/Veranstaltungen/jt-26-06-2019-dabrock.pdf [09.08.2019].

DIMDI German Institute of Medical Documentation and Information (2017): ICF. Retrieved from https://www.dimdi.de/dynamic/en/classifications/icf/index.html [31.05.2019].

Dederich, M. (2017): Ethische Aspekte der Forschung an Menschen mit geistiger Behinderung. Teilhabe, 56(1) 4-10.

DOI: 10.3217/978-3-85125-668-0-06

Dilts, R. B. (1990): Walt Disney: The Dreamer, the Realist and the Critic. Dynamic Learning Publications, Ben Lomond.

Falkenstörfer, Sophia (2018). Fürsorge: Alltag in der Praxis – ein blinder Fleck in der Theorie. In Lamers, Wolfgang (Eds.), Teilhabe von Menschen mit schwerer und mehrfacher Behinderung an Alltag, Arbeit, Kultur. Oberhausen, Athena, 167-180.

Fuchs, Michael et al. (2010): Forschungsethik. Eine Einführung. Stuttgart, Metzler.

Fornefeld, Barbara (2004): Einführung in die Geistigbehindertenpädagogik. München: Ernst Reinhardt.

General Assembly of the World Medical Association (2014): World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. The Journal of the American College of Dentists, 81(3) 14-18.

Kelley, T.; Kelley, D. (2013): Creative confidence: Unleashing the creative potential within us all. Currency.

Klauß, Th. (2002). Können Menschen wirklich nicht nicht kommunizieren? – Anfragen zu einem an Watzlawick angelehnten sonderpädagogischen Glaubenssatz. Vierteljahresschrift für Heilpädagogik und ihre Nachbargebiete, 71(3), 262-276.

Kosiedowski, M. et al. (2019): On Applying Ambient Intelligence to Assist People with Profound Intellectual and Multiple Disabilities. Proceedings of SAI Intelligent Systems Conference. Springer, Cham, 2019. p. 895-914..

Maes, B.; Lambrechts, G.; Hostyn, I.; Petry, K. (2007): Quality-enhancing interventions for people with profound intellectual and multiple disabilities: A review of the empirical research literature. Journal of Intellectual and Developmental Disability, 32(3), 163-178. https://doi.org/10.1080/13668250701549427

MacInnes, D. (1999) Ethical Issues in Clinical Research. Nursing Times Clinical Monographs. No. 14. London: NT Books.

Mietola, R.; Miettinen, S.; Vehmas, S. (2017). Voiceless subjects? Research ethics and persons with profound intellectual disabilities. International Journal of Social Research Methodology, 20:3, 263-274. https://doi.org/10.1080/13645579.2017.1287872

Nakken, H.; Vlaskamp, C. (2007): A need for a taxonomy for profound intellectual and multiple disabilities. Journal of Policy and Practice in Intellectual Disabilities 4(2), 83-87.

Petry, K.; Maes, B. (2006): Identifying Expressions of Pleasure and Displeasure by Persons with Profound Multiple Disabilities. Journal of Intellectual & Developmental Disability 31(1) 28-38.

Rotter, B.;, Kane, G.;, & Gallé, B. (1992). Nichtsprachliche Kommunikation: Erfas-sung und Förderung. Geistige Behinderung 31 1–26.

Rowland, C. (2013). Handbook: Online Communication Matrix. Portland: Oregon Health & Science University.

Schnell M. W.; Heinritz, C. (2006): Forschungsethik. Ein Grundlagen- und Arbeitsbuch für die Gesundheits- und Pflegewissenschaft. Bern, Huber.

DOI: 10.3217/978-3-85125-668-0-06

Thiel, C. M. (2013): Experimente am Menschen: Ethische Standards. Erziehungswissenschaft 47(24) 23-28.

World Health Organization (2019): ICD-11. International Classification of Diseases 11th Revision. Retrieved from https://icd.who.int/browse11/l-m/en [31.05.2019].

World Health Organization (2001): International Classification of Functioning, Disability and Health (ICF). Retrieved from https://www.who.int/classifications/icf/en/ [31.05.2019].

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

The Accuracy Paradox of Algorithmic Classification

Fabian FISCHER

Institute for Visual Computing & Human-Centered Technology, Multidisciplinary Design & User Research, Vienna University of Technology, Austria

Abstract

In recent years, algorithmic classification based on machine learning techniques has been increasingly permeating our lives. With their increased ubiquity, negative social consequences have come to light. Among these consequences are ’unfair’ algorithms. This resulted in a large body of research tackling ’fairness’ of algorithms and related issues. Algorithms are frequently considered as unfair if they show diverging accuracies for different groups, with a particular focus on vulnerable groups, indicating a correlation between prediction and information about group membership.

In this paper I argue that, while this research contributes valuable insights, much of the research focuses a quantitative understanding of fairness which creates a very narrow focus. My argument builds on four pillars. First, much of the research on 'fairness' focuses on accuracy as basis for ’fairness’. Even though ’fairness’ can reduce the overall accuracy, this is seen as a limitation, implicitly aiming for high accuracy. Second, this focus is in line with other debates about algorithmic classification that focus on quantitative performance measures. Third, close attention on accuracy may be a pragmatic and well-intended stance for practitioners but can distract from problematizing the ’bigger picture’. Fourth, I argue that any classification produces a marginalized group, namely those that are misclassified. This marginalization increases with the classifier’s accuracy, and in tandem the ability of the affected to challenge the classification is diminished.

Combined, this leads to the situation that a focus on fairness and accuracy may weaken the position and agency of those being misclassified, paradoxically contradicting the promissory narrative of ’fixing’ algorithms through optimizing fairness and accuracy.

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

1 Introduction

As Machine Learning has started to increasingly permeate all aspects of our lives – particularly since the deep learning boom starting in 2012 – a sensitivity for potential downsides to machine learning has set hold in machine learning research and neighbouring fields, but also the wider public.

A particular set of issues has become popular in the past decade in debates of societal impacts of algorithmic systems, namely issues hinging on the terms ’fairness’, ’accountability’ and ’transparency’, frequently combined in the acronym ’FAT’. These topics have taken centre stage in a series of workshops and conferences such as Fairness, Accountability, and Transparency in Machine Learning (FAT ML) since 2014 and the ACM Conference on Fairness, Accountability, and Transparency (ACM FAT*) since 2018. A plethora of papers developing conceptualisations and mathematical formulations of fairness, as well as methods and tool kits to detect and remedy unfairness have been published. The research has a focus on, but is not limited to, machine learning.

Research and debates on these topics has also been noted in a wider public discourse, and by public bodies. This has, for example, resulted in the formation of the High-Level Expert Group on Artificial Intelligence, set up by the European Commission, which also tackles issues of ethics (High-Level Expert Group on Artificial Intelligence 2019). Furthermore, when new algorithmic systems are being introduced, particularly in public agencies and other areas with far-reaching consequences for affected people, these systems increasingly get discussed in terms of fairness, accountability and transparency.

I welcome this sensitivity for societal impacts of algorithmic systems. But in discussions of fairness, an emphasis is frequently put on a very narrow, quantitative understanding of fairness. I will show how this narrow definition of fairness is deeply entangled with notions of accuracy as a quantitative measure for algorithmic classification systems.

In the context of the ongoing digital transformation, algorithmic classification systems are becoming wide spread. In this context, accuracy is often used as a measure for the system’s quality, as exemplified by an OECD report on the use of statistical profiling – a special form of classification – in public employment services, where a lack of accuracy is highlighted as one potential shortcoming of these profiling systems (Desiere, Langenbucher, and Struyven 2019). More importantly, it is stated that "[p]ost-

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

implementation, continuous evaluation and updates of the system based on feedback from all stakeholders will improve the system and its accuracy and will also help to build trust in it" (Desiere, Langenbucher, and Struyven 2019, 3).

This paper aims to contribute to the rich body of work within STS that studies classification and quantification. With Bowker and Star (1999) I argue that classification ist "not inherently a bad thing–indeed it is inescapable. But it *is* an ethical choice, and as such it is dangerous–not bad, but dangerous" (5–6). As I will discuss in detail in section 3, accuracy figures are frequently used as quantifications of quality, a process that abstracts and reduces (context) information to obtain representations (cf. Espeland and Stevens 1998; Porter 1995; Latour and Woolgar 1986).

In this conceptualizing piece point towards issues connected to the strong focus on accuracy, either directly or implicitly by focusing on a narrow understanding of fairness. First, I will introduce the concept of accuracy and some frequently used definitions of 'fairness' and their entanglement. Second I will investigate how the focus on accuracy may have come about. Third I will develop an argument why this focus on accuracy, and fairness in a narrow sense strongly limits the perspective of potential societal impact of algorithmic classification systems. Finally, I will argue that algorithmic classification produces its own marginalised individuals, namely those that get misclassified, and that this marginalisation intensifies with increased accuracy and may lead to a reduced agency of those who are affected. This, I argue, paradoxically contradicts the promissory narrative of improving, or 'fixing' algorithmic systems by optimizing fairness and accuracy.

2 Definitions of accuracy and fairness

Accuracy is a frequently used metric for algorithmic classification systems and often used to assess its quality. In this section, I will go into some detail how accuracy, and some related metrics, are intertwined with many (quantitative) approaches to 'fairness'.

A majority of machine learning systems are, on some level, classification systems. But not all classification systems are necessarily using machine learning. In computer science, an algorithmic classification system can also be called a classifier. Throughout this section I will illustrate the definition of accuracy by a cat picture classification example: An algorithm should classify a picture as either showing a cat, or as not showing a cat.

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

Accuracy in the context of algorithmic classification is a statistical measure that indicates the fraction of correct classifications. It is used to quantify the correctness of classifiers. The generalised calculation of accuracy is as follows

If the classification is binary, such as the cat picture example, the calculation can be reformulated as follows:

Where *True Positives* are in the above example cat pictures that correctly got classified as such. *True Negatives* are pictures that are not cat pictures and correctly got classified as non-cat pictures. *False Positives* are pictures that are classified as cat pictures but are actually not and *False Negatives* are cat pictures that haven't been classified correctly as cat picture.

In some fairness research, other measures play an important role, for example the **true positive rate** (Gajane and Pechenizkiy 2018; Wattenberg, Viégas, and Hardt 2016) that signifies how many have been correctly classified into one class: Sticking with the example of cat pictures, the true positive rate signifies how many of all cat pictures got correctly classified as cat pictures. This measure does not take into account how many non-cat pictures got incorrectly classified as cat pictures or correctly classified as non-cat pictures.

There are additional, closely related measures. While these differ in what they express exactly, they operate with similar concepts such as *True Positives* and *True Negatives*. More importantly, for my argument they are sufficiently close so that their function is interchangeable. All these measures aim to quantify the correctness of algorithmic classification, even though they emphasize different types of sources of misclassification. Common to all these measures is their quantitative nature and the aim to maximize these numbers: A 'good' algorithmic classifier shows high accuracy numbers, or a related metric. In the remainder of this work, I will use use the term accuracy as a shorthand for accuracy and these closely related correctness measures.

In the past decade, a multitude of definitions and formalisations of **fairness** have been used in the machine learning context. Frequently used are individual fairness, group fairness and equality of opportunity.

Individual fairness is when similar individuals get treated similarly (Friedler, Scheidegger, and Venkatasubramanian 2016). How 'similarity' can be defined is heavily dependent on the model used. In the context of college admission, for example, one approach could be

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

to use the performance on standardized tests to measure similarity (Friedler, Scheidegger, and Venkatasubramanian 2016). This approach trusts that the model is adequate and ignores any structural effects that may lead to some groups performing better than others in that model. This formalization of fairness is closely related to accurate classifiers: Only accurate classifiers can treat similar individuals similarly.

Quite different to that is **group fairness**: Here, the population is divided into sub-populations based on some attributes (e.g. gendered or racialized attributes) and all groups are expected to be treated equally (Friedler, Scheidegger, and Venkatasubramanian 2016; Gajane and Pechenizkiy 2018). In the case of algorithmic classification, equal treatment is frequently understood as an algorithm that shows (almost) equal accuracy for each sub-population (corresponding to disparate impact (Friedler, Scheidegger, and Venkatasubramanian 2016)) or the true positive rate (corresponding to equal opportunity (Wattenberg, Viégas, and Hardt 2016; Gajane and Pechenizkiy 2018)). Here, again accuracy or a related metric is the foundation for checking if an algorithm is fair.

There are some additional formalisations with slightly different emphasis. Most operate on a group-level, and frequently groups identified through ’sensitive’ attributes, e.g., gendered and racialized attributes. Gajane & Pechenizkiy (2018) provide a concise overview over many formalizations. The aim of fairness research is, then, to prevent disadvantaging of groups, often explicitly of marginalised groups defined by ’sensitive’ attributes.

What is important to highlight is that narrow, quantitative formalizations of fairness are based on some correctness metric of the classifier that is either accuracy or a close relative. This is the first source of entanglement between accuracy and fairness in the narrow sense. Another way these two quantitative measures are entangled is that this approach to fairness also aims for high accuracy (see, e.g., (Kleinberg, Mullainathan, and Raghavan 2016)), sometimes noting that fairness may negatively impact the classifier’s accuracy, asking for a trade-off between accuracy and fairness (see, e.g., (Kearns et al. 2018)). As a consequence of this, algorithmic fairness discussed on quantitative terms is implicitly also discussing accuracy – reinforcing accuracy as a central aspect in the evaluation of algorithms, an aspect that I will focus on in the next section.

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

3 Accuracy as focal point

As I have described in the previous section, accuracy and a narrow definition of fairness are closely entangled. In this section I argue that this understanding of fairness is dominant in the fairness research, and consequently accuracy gets a strong emphasis in fairness research. In addition to that, I investigate other sources why accuracy and quantitative conceptions of fairness are in focus in many debates about algorithmic systems.

Addressed topic	Number of papers
Fairness	22
Accountability	2
Transparency	6

Number of papers addressing the topics from the FAT/ML 2018 Conference (n = 27)

Table 2: *Topics of FAT/ML 2018 papers*

First, even within the FAT discourse the focus on fairness is much stronger than on accountability and transparency. Table 2 shows the issues addressed in 27 papers presented at the FAT/ML 2018 Conference, showing a strong emphasis on the topic ’fairness’. Further examinations of the papers addressing fairness shows that few go beyond quantitative conceptualisations of fairness. Dobbe, Dean, Gilbert, & Kohli (2018) highlight issues of fairness that go beyond numeric qualities of fairness. Green (2018) provides a fundamental critique of the quantitative nature of machine learning. The increased use of machine learning, Green argues, grants "undue weight to quantified considerations at the expense of unquantified ones." (Green 2018, sec. 2.1, para. 1). Green continues to argue that some "aspects of society resist quantification" (Green 2018, sec. 2.1, para. 1).

Other papers I labelled as ’fairness’ research in Table 1 don’t directly use the term fairness but rather focus on bias or diversity and thus don’t neatly fit the above presented characterisation, either. For example, Ogunyale, Bryant, & Howard (2018) look at different perceptions of robots based on the different colorations of the robot.

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

Even though not all papers work with a narrow, quantitative conceptualisations of fairness, the majority of papers does, mostly by devising techniques and methods to ensure some that the algorithmic systems meets some accuracy-based notion of fairness. Other researches have a similar impression that a narrow, technical, quantitative conceptualisation of fairness prevails in fairness research (Selbst et al. 2019).

I want to identify some reasons why I think this quantitative, accuracy-based notion of fairness is at the focus of debate. They come from a range of directions.

One source for accuracy as focal point is an **optimization logic**. Data and computer scientists may simply be driven by a desire to improve everything (Morozov 2013). And there is hardly any easier way to quantify optimality than to increase a measure expressed in per-cents. This is true even though within computer science it is well known, that exclusively aiming for high accuracy numbers can have unwanted consequences. For example, optimizing for a given data set can mean that the machine learning algorithm is too narrowly learning characteristics of this particular data set and cannot generalise well to new data points. Picking up the cat picture example, if the data set used for learning always shows cats in a particular pose, it may actually learn the pose, not cats more generally. Still, this is seen as a risk to accurately classify new images without questioning the optimization logic itself.

Division of labor and competences within an organisation may also be a reason why data and computer scientists may focus on a rather narrow definition of fairness. Frequently, it is up to the management to formalize the problem at stake. Hence, defining, or questioning, the problem formulation is outside the data scientist's sphere of influence. Similarly, the decision to solve a problem with algorithmic classification is often not up to them. In an attempt to make the best out of this situation, they may attempt to make the most fair system possible given the constraints by optimizing for fairness.

This 'not my department' attitude is also a side-effect of a tendency for modularization and atomization of tasks when building algorithmic systems: Isolated units of work with minimal interaction with other parts of the system ensure on the one hand a divide-and-conquer approach to developing the system, but they also make it hard to assume a holistic view.

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

This also holds to the practice of out sourcing computer science work to external contractors, which can lead to a lack of understanding of the context by the contractor and a lack of understanding of the technical details on the side of the client.

An important source for the focus on fairness is legislation. While the exact definitions vary across countries and by context, compliance with various anti-discrimination laws is one motivator to investigate fairness (Gajane and Pechenizkiy 2018). **Liability concerns** are, then, a reason why businesses, management and public agencies are interested in fairness. Depending on the exact legal definitions, looking at accuracy figures (or closely related measures is a quantifiable way to demonstrate a fair classification system. This also explains why big corporations are paying so much attention to fairness: Being able to provide in this sense ’fair’ algorithmic solutions on the one hands can calm down any criticism and on the other hand makes it easier to enter new business fields where the legislation applies.

This leads to another potential reason why accuracy is getting so much attention: Drawing on a core STS concept, accuracy figures can take the function of inscription devices that provide "the focus of discussion about properties of the substance." (Latour and Woolgar 1986, 51), in this case about the purported quality of algorithmic classification. This is important, because the introduction of algorithmic systems can face resistance, both in the organizations where they are deployed and by those affected by the algorithmic classification. Accuracy as signifier for quality is in line with the practice to quantify qualities (Espeland and Stevens 1998; Porter 1995). Being able to refer to high accuracy is an easy way to **persuade critics** that the new system is doing a good job. For example, the OECD report on statistical profiling in public employment services states that the "usefulness and legitimacy of statistical profiling models hinge on model accuracy" (Desiere, Langenbucher, and Struyven 2019, 15).

At the same time, it is difficult to problematize the algorithmic system in other, more nuanced, more qualitative ways. It would be easiest to provide other kinds of figures to counter arguments based on accuracy or fairness numbers (Latour 1983). Which is then, maybe, one reason why controversies of algorithmic systems often focuses on this kind of figures, effectively establishing discourse coalitions (Hajer 2006) by sharing storylines about the problem at hand: Discrimination and fairness, expressed through figures.

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

Even if the accuracy is not perfectly high, it is easier to **promise accuracy improvements** in the future – a convenient way to take out some steam from the critique. This is, by the way, not necessarily simple rhetoric, but an honest promise. After all, research is making progress in machine learning – and this general progress can indeed lead to improvements in the local setting. These improvements are easily quantifiable, too: If the criticism is aimed at low numbers, presenting higher numbers can silence some of the critique. Contrary to improving this metric it would be much more challenging to attempt to change the system where the algorithmic system is embedded in in more qualitative, deeper ways.

Beyond one algorithmic system, accuracy as common measurement enables **quantifiable comparisons** across sites, and of alternate systems for one site (Desrosières 2010). It is easy to argue that an algorithm with high accuracy is better than one with lower accuracy – and ignore contextual contingencies. As Espeland and Stevens (1998) argue, the practice to transform qualities into quantities "is a way to reduce and simplify disparate information into numbers that can easily be compared" (316). An evaluative statement is much harder to make when comparing different organisational structures, processes, or types of data. By boasting high accuracy scores, one may be seen as a particularly splendid example of how a certain kind of system is done. Exemplified is this by the aforementioned OECD report, that compares several profiling systems using very different data sources and problem formulations, but evaluates them primarily via accuracy, lauding, for example, the Austrian system for its comparatively high accuracy.

4 Accuracy as distraction from the problem formulation

I have already touched how a focus on accuracy may function as distraction from other, maybe more important aspects of the algorithmic classification system. In this section I am going to extend these thoughts.

Focusing on accuracy can, at worst, not at all problematize the underlying data. As research on databases and, more recently, big data has plentifully showed, data are never ’raw’, but always ’cooked’ (Bowker 2005; boyd and Crawford 2012). Data are never ’just’ ’out there’ and ready to be discovered, but are always produced. And this usually with some goal in mind, i.e. what data is left out and what is produced and recorded is decided to support a particular goal.

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

Against this backdrop, a focus on accuracy and quantitative fairness may look at the data at hand and work with whatever is available. This may mean choosing a certain machine learning approach, this may mean taking only a subset of the available data points. The latter is particularly the case if analysis reveals that accuracy is different for certain protected attributes, or that some other variables correlate with protected attributes and using them can, too, lead to unfair classification.

Focusing on this particular perspective on fairness, one quickly looses a sense of the bigger picture. Namely, that any data set is not the same as the messy, contingent and contextual ’real life’ of the affected people. Data are always models, abstractions, or inscriptions. Consequently, any optimization with regards to fairness on this data does not ensure fairness in this messy ’real life’ – it is always an optimization on the model.

In a recent paper, Selbst, boyd, Friedler, Venkatasubramanian, & Vertesi (2019) have pointed out many issues related to this abstraction work done in computer science and assert that most papers dealing with fairness and machine learning "abstract away any context that surrounds this system." (Selbst et al. 2019, 59) The authors then continue to argue, similarly to my argument, that the technical systems are only a subsystem of more complex, contextual socio-technical systems, contributing many insights from Science & Technology Studies to the fairness debate. Importantly, they argue that abstraction is "taken as given and is rarely if ever interrogated for validity" (Selbst et al. 2019, 59)

In a similar fashion, even though not as elaborate, is Green’s argument that not all parts of society can be quantified and that the focus on quantification renders alternative approaches to solve societal issues invisible (Green 2018).

Barabas, Virza, Dinakar, Ito, & Zittrain (2018) tackle the application of risk assessment systems in the justice system. Risk assessment is a particular form of algorithmic classification, attempting to calculate and predict the risk a person may pose to society. The authors argue that debates about these systems’ fairness have hidden more fundamental issues with prediction in the justice system, arguing for the use of machine learning to identify causal "drivers of criminal behavior" (Barabas et al. 2018, 6).

In line with these researchers I argue that concentrating, researching, and debating fairness by means of accuracy and related measures distracts from problematizing the underlying model and problem formulation. I argue that the amount of attention given to

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

research in this area may even be performative in a way to frame fairness as the main issue when discussing the societal impact of algorithmic classification systems. Or, as Barabas et al. have put it, this narrow focus prevents us from "ask[ing] harder questions" (2018, 7).

Continuing this thought further, creating ’fair’ algorithms to socially questionable models and problem formulations may actually stabilise and reinforce them as legitimate. Consequently, even critical data scientists who are slightly uneasy with the task they need to solve and hence set out to develop it in a fair way can eventually actively contribute to this legitimization.

5 Increasing accuracy intensifies marginalization and reduces agency of the misclassified

Until now I have shown that first, fairness research is largely done in a narrow quantitative sense and second, that implicitly or explicitly accuracy (or one of its close relatives) is seen as a quality measure for algorithmic classification and its optimization the goal. And, as I have stated, fairness aims at reducing the disadvantaging of usually marginalized groups. What is, however, not being discussed in fairness research, is that any algorithmic classification is producing its own marginalized group, namely those who get misclassified.

Fairness research tends to focus on well-established sub-populations defined by gendered or racialized attributes, by religion, or by socio-economic status, etc. Some of the fairness research addresses not disadvantaging these populations even if the sensitive attribute of individuals is not known. This can be due to legal issues of collecting these attributes in the first place or simply inability to get this information. Very little research also looks beyond these typical sub-populations and looks, e.g., at "socially meaningful subgroups" (Dwork and Ilvento 2018, sec. 2.2., para. 4) such as mothers. The majority focuses on protected attributes.

The marginalized group produced by misclassification is different to these notions of marginalizations. While the misclassification has to be based on some attributes, it is important to stress that this marginalized group is not necessarily related to the sub-populations defined via protected attributes. Implementing a fair algorithm as discussed above should actually prevent such correlations. The aforementioned work by Dwork & Ilvento (2018) is actually coming close to tackling this issue. Yet, the authors’ focus on

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

’socially meaningful’ groups assumes a pre-existing shared attribute and that these are considered ’socially meaningful’. Different to this, the group of misclassified individuals is produced *by the algorithmic classification system*. This system does, indeed decide on data, and hence attributes. But individuals from distinct ’socially meaningful’ groups may be misclassified on different grounds.

A fictitious example would be a facial recognition system that shows higher rates of misclassification if individuals wear some headwear (e.g. baseball caps), particular style of make-up, or simply have a particular posture which affects the angle of the face to the camera. These cases would hardly be known beforehand and don't relate to any 'socially meaningful' group. These higher rates of misclassification could lead to, e.g., more frequent checks by police, or more frequent denials of access (in case the facial recognition system is used as authentication).

The problem of misclassification is even more troubling if the system is producing predictions about the future, such as the system developed by the Austrian public employment service. This system attempts to predict the chances of job seekers to find a stable job in the future. Job seekers who are predicted to not find a stable job within the next two years will get access to different resources than those that are predicted to succeed. The corollary to this observation is that increasing the accuracy of an algorithmic classification system – which is, as I have outlined above, an overarching goal in machine learning research – is also intensifying the marginalization. The group of misclassified is literally increasingly marginal and the majority of correctly classified individuals is getting stronger. A consequence of this is that it will become harder for misclassified individuals to contest the algorithmic classification.

Let’s do a simple thought experiment: If it is known that the algorithmic system is wrong one third of the time, then it is easy to argue that the decision that affects an individual is incorrect. After all the odds are low. In contrast to this, it is harder to argue why the algorithmic system is wrong in a particular case. The likelihood for this to happen is small. This is why I draw a parallel to the popular claim of big data being superior to ’small’ data. This stance implicitly argues that "the volume of data adds to the weight of evidence" (Kitchin 2014, 135). I argue that, similarly, high accuracy of algorithmic classification adds to the weight to the individual classification.

DOI: 10.3217/978-3-85125-668-0-07

Picking up the term ’evidence’ from Kitchin, there is another problem that may arise if an algorithmic classification system’s accuracy gets close to 100%. What if the algorithmic classification will, at some point, gain proof-like character? What if the algorithmic classification is seen as convincing evidence, if it gets recognized similarly to fingerprinting today (Cole 2009)?

The latter concern is not pulled out of thin air. In a recent media article about facial recognition to be used by the Austrian police, the head of the police records department states that ultimately courts will have to decide whether expert testimonies based on facial recognition will be accepted as evidence (Al-Youssef and Sulzbacher 2019). Even some fairness researchers explicitly point towards the potential usage of algorithmic classification "as evidence in legal proceedings" (Raff and Sylvester 2018, sec. 1, para. 1).

An important consequence of intensified marginalization is that the agency of misclassified individuals is reduced. First, as stated, the position to challenge the classification is weakened if the algorithmic classification system’s accuracy is high. The burden to show why the algorithm is wrong in a particular case is increasingly being shifted to the affected individual, not the operator of the algorithmic system. Second, simply due to fewer people affected by misclassification because the likelihood of getting in contact with other misclassified individuals is lower. This may hinder efforts to form self-help groups and organize from below.

6 Conclusion

In this work I have shown four issues. First, an overarching goal to increase accuracy guides the research of algorithmic classification systems. Second, the majority of research on fairness in machine learning is quantitatively oriented and tightly entangled with notions of accuracy or closely related measures. Third, as other critical researchers have been pointing out, focusing on this quantitative, narrow understanding of fairness renders important aspects beyond technical details invisible. This includes the problem formulation, issues of abstraction and modelling – both practices that reduce the complexity of social life – and the importance of social context. Finally, I have argued that the strong focus on accuracy ignores the issue of misclassification and that increasing accuracy paradoxically intensifies the marginalization of misclassified individuals.

Fabian FISCHER
DOI: 10.3217/978-3-85125-668-0-07

Importantly, there's a frequent narrative in debates about algorithmic classification systems that promises that with increasing accuracy, many issues with algorithmic classifications, e.g. for decision making, will be solved, or at least reduced. A majority of fairness research takes up on this narrative, extending the issue so that algorithmic classification should work with equal or at least similar accuracy, or related performance metrics, across sub-populations. Neither approach focuses on problems that can arise for those that still get misclassified – which will occur even if the classification is close to perfect and 'fair' in quantitative terms.

Additionally, endeavours to improve an algorithmic classification system's accuracy and fairness both signify quality and hence contribute to strengthening its legitimation. This stronger legitimation will, in turn, make it harder for individuals to object the classification.

While some work has started addressing marginalization brought about by the algorithmic classification itself, the vast majority of fairness research is still focusing on well-defined known sub-populations defined by protected attributes.

With my work I want to point to two open questions for future research. First, there's a need to investigate marginalization practices that are done by algorithmic classification systems. This is in contrast to historical marginalization based on, e.g., racialized attributes. Second, the guiding theme in many the debates on machine learning that optimizing accuracy of algorithmic classification has to be problematized. How misclassification can be handled in a meaningful and 'fair' way has to be addressed – this issue cannot be 'optimized away', since all algorithmic classification must operate on a simplified abstraction of a complex and messy 'real world'. One proposition to address this is to focus more on meaningful channels to dissent the classification (cf. Skirpan and Gorelick 2017), and more generally on processes instead of results. Depending on how these processes look, they could provide agency to the affected individuals and could re-introduce context information that got lost in the necessary abstraction of the algorithmic system.

Acknowledgements

I would like to thank Doris Allhutter for extensive feedback to a very early draft of this paper, the participants of the STS Conference Graz for their feedback to my talk that this paper accompanies, and the anonymous reviewers for their valuable reviews.

DOI: 10.3217/978-3-85125-668-0-07

References

Al-Youssef, Muzayen, and Markus Sulzbacher. 2019. “Polizei startet im Herbst Gesichtserkennung mit öffentlichen Kameras.” DER STANDARD. April 18, 2019. https://derstandard.at/2000101679966/Polizei-startet-im-Dezember-mit-Gesichtserkennung.

Barabas, Chelsea, Madars Virza, Karthik Dinakar, Joichi Ito, and Jonathan Zittrain. 2018. “Interventions over Predictions: Reframing the Ethical Debate for Actuarial Risk Assessment.” In *Proceedings of the 1st Conference on Fairness, Accountability and Transparency*, edited by Sorelle A. Friedler and Christo Wilson, 81:62–76. Proceedings of Machine Learning Research. New York, NY, USA: PMLR. http://proceedings.mlr.press/v81/barabas18a.html.

Bowker, G. C. 2005. *Memory Practices in the Sciences*. Cambridge, Massachusetts: MIT Press.

Bowker, G. C. and Star, S. L. 1999. *Sorting things out. Classification and its consequences.* Cambridge, Massachusetts: MIT Press.

boyd, danah, and Kate Crawford. 2012. “CRITICAL QUESTIONS FOR BIG DATA.” *Information, Communication & Society* 15 (5): 662–79. https://doi.org/10.1080/1369118X.2012.678878.

Cole, Simon A. 2009. *Suspect Identities: A History of Fingerprinting and Criminal Identification*. Cambridge, Massachusetts: Harvard University Press.

Desiere, Sam, Kristine Langenbucher, and Ludo Struyven. 2019. “Statistical Profiling in Public Employment Services: An international comparison.” *OECD Social, Employment and Migration Working Papers*, no. 224 (February). Paris: OECD Publishing.

Desrosières, Alain. 2010. *Politics of Large Numbers: A History of Statistical Reasoning*. Cambridge, Massachusetts: Harvard University Press.

Dobbe, Roel, Sarah Dean, Thomas Gilbert, and Nitin Kohli. 2018. “A Broader View on Bias in Automated Decision-Making: Reflecting on Epistemology and Dynamics.”

Dwork, Cynthia, and Christina Ilvento. 2018. “Group Fairness Under Composition.” In *5th Workshop on Fairness, Accountability, and Transparency in Machine Learning*.

Espeland, Wendy Nelson, and Stevens, Mitchell L. 1998. "Commensuration as a social process." *Annual Review Sociology* 24: 313–43.

Friedler, Sorelle A, Carlos Scheidegger, and Suresh Venkatasubramanian. 2016. “On the (Im) Possibility of Fairness.” *arXiv Preprint arXiv:1609.07236*.

Gajane, Pratik, and Mykola Pechenizkiy. 2018. “On Formalizing Fairness in Prediction with Machine Learning.” In *5th Workshop on Fairness, Accountability, and Transparency in Machine Learning*.

Green, Ben. 2018. “‘Fair’ Risk Assessments: A Precarious Approach for Criminal Justice Reform.” In *5th Workshop on Fairness, Accountability, and Transparency in Machine Learning*.

Hajer, Maarten A. 2006. “Doing discourse analysis: coalitions, practices, meaning.” In *Netherlands Geographical Studies*, edited by Margo van den Brink and Tamara Metze, 65–74.

DOI: 10.3217/978-3-85125-668-0-07

High-Level Expert Group on Artificial Intelligence. 2019. “Ethics Guidelines for Trustworthy AI.” Brussels: European Commission.

Kearns, Michael, Seth Neel, Aaron Roth, and Zhiwei Steven Wu. 2018. “Preventing Fairness Gerrymandering: Auditing and Learning for Subgroup Fairness.” In *5th Workshop on Fairness, Accountability, and Transparency in Machine Learning*.

Kitchin, Rob. 2014. *The Data Revolution*. London: Sage.

Kleinberg, Jon, Sendhil Mullainathan, and Manish Raghavan. 2016. “Inherent Trade-Offs in the Fair Determination of Risk Scores.” *arXiv Preprint arXiv:1609.05807*.

Latour, Bruno. 1983. “Give Me a Laboratory and I Will Raise the World.” In *Science Observed*, edited by K Knorr-Cetina and M. Mulkay, 141–70. Thousand Oaks: Sage.

Latour, Bruno, and Steve Woolgar. 1986. *Laboratory Life: The Construction of Scientific Facts*. Princeton, New Jersey: Princeton University Press.

Morozov, Evgeny. 2013. *To Save Everything, Click Here: The Folly of Technological Solutionism*. New York: Public Affairs.

Ogunyale, Tobi, De’Aira Bryant, and Ayanna Howard. 2018. “Does Removing Stereotype Priming Remove Bias? A Pilot Human-Robot Interaction Study.” *arXiv Preprint arXiv:1807.00948*.

Porter, Theodore M. 1995. *Trust in Numbers. The Pursuit of Objectivity in Science and Public Life.* Princeton: Princeton University Press.

Raff, Edward, and Jared Sylvester. 2018. “Gradient Reversal Against Discrimination.” In *5th Workshop on Fairness, Accountability, and Transparency in Machine Learning*.

Selbst, Andrew D., Danah Boyd, Sorelle A. Friedler, Suresh Venkatasubramanian, and Janet Vertesi. 2019. “Fairness and Abstraction in Sociotechnical Systems.” In *Proceedings of the Conference on Fairness, Accountability, and Transparency*, 59–68. FAT* ’19. New York, NY, USA: ACM. https://doi.org/10.1145/3287560.3287598.

Skirpan, Michael and Gorelick, Micha. 2017. "The authority of "fair" in machine learning." In *KDD'17 FATML Workshop*.

Wattenberg, Martin, Fernanda Viégas, and Moritz Hardt. 2016. “Attacking Discrimination with Smarter Machine Learning.” *Google Research* 17. https://research.google.com/bigpicture/attacking-discrimination-in-ml/.

DOI: 10.3217/978-3-85125-668-0-08

Circular Economy Strategies in the Historic Built Environment: Cultural Heritage Adaptive Reuse

A. GRAVAGNUOLO (1), R. DE ANGELIS (2), S. IODICE (1)

(1) Institute for Research on Innovation and Services for Development, National Research Council (IRISS CNR), Italy; (2) Exeter Centre for Circular Economy, University of Exeter Business School, UK

Abstract

Circular Economy (CE) is currently promoted through policy, urban and regional strategies as well as emerging as a relevant research sector. Within this context, circularity in the built environment is attracting attention with applications in many design and urban projects. The general principles of CE are applied to existing and new buildings, focusing on the “end-of-life” stage and developing sustainable innovative solutions to optimize dismantling and reuse of materials and technological parts of buildings. However, in historic urban areas the principles of dismantling and reuse of materials remain barely applicable (end-of-life), as well as the application of standard renewable energy systems (usage), due to cultural heritage unique characteristics and heritage regulations oriented to its preservation, conservation and transmission to future generations. As a consequence, adaptive reuse of cultural heritage seems to be the one of the most viable solution to apply CE in the historic built environment. In this article, we aim to identify CE solutions and to lay the foundation for the future development of a system of indicators able to support circular adaptive reuse choices in the historic built environment. The starting point is the Horizon 2020 “CLIC” project (Circular models Leveraging Investments in Cultural heritage adaptive reuse), which focuses on adaptive reuse as a key strategy for CE implementation in historic cities and regions. The concepts of Circular Economy, Circular Built Environment and Circular Urban Metabolism are explored. Under these perspectives, three representative case studies are described: the first is “De Ceuvel” project in Amsterdam, a second application at a different scale is referred to “Rehafutur Engineer’s House project” (France), and finally, the circular adaptive reuse of a rural village in Spain, within the “ReDock project” in the Altiplano region in Spain, is explored. Conclusions highlight the need of suitable indicators synthesizing theory and practice of CE in historic built environment, starting from the recognition of multiple impacts of cultural heritage adaptive reuse practices.

A. GRAVAGNUOLO (1), R. DE ANGELIS (2), S. IODICE (1)
DOI: 10.3217/978-3-85125-668-0-08

1 Introduction

As a concept with the potential to guide the transition towards more sustainable cities, Circular Economy (CE) is currently promoted through policy, urban and regional strategies as well as emerging as a relevant research sector (Marin & de Meulder, 2018). Within this context, circularity in the built environment is attracting attention with applications in many design and urban projects. This is the case because increased circularity in the built environment offers many benefits such as economic growth, reduced environmental impact and improved quality of life (EMF et al., 2015). The general principles of CE are applied to existing and new buildings, focusing on the “end-of-life” stage and developing sustainable innovative solutions to optimize dismantling and reuse of materials and technological parts of buildings.

Ellen MacArthur Foundations (EMF et al., 2015) defines four domains in which CE can be applied in the built environment, namely: “construction”, acknowledging that 10-15% of building material is wasted during the construction phase; “utilization”, avoiding empty and abandoned spaces; “usage”, in terms of energy consumption; and “end-of-life”, avoiding landfill.

However, in historic urban areas the principles of dismantling and reuse of materials remain barely applicable (end-of-life), as well as application of standard renewable energy systems (usage), due to cultural heritage unique characteristics and heritage regulations oriented to its preservation, conservation and transmission to future generations.

Cultural heritage is ideally projected to an indefinite time horizon, towards eternity. It represents the memory and identity of urban/territorial systems (Fusco Girard, 2018). In the case of cultural heritage, CE models can only be oriented to the conservation of its functionality and “use values” over time, or to the adaptation of the cultural asset to new functional needs, identifying new uses compatible with the conservation of authenticity and integrity as well as the contemporary needs, to the durability and reuse of abandoned areas/buildings and to the preservation of their “embodied energy”. For these reasons, it is possible to state that there are two main alternatives for the application of CE in the historic built environment, the first is the adoption of a conservative perspective towards historic urban areas/buildings and the second is the adaptive reuse of cultural heritage. The latter «is a restorative, regenerative and a sustainable form of conservation that

DOI: 10.3217/978-3-85125-668-0-08

extends the life of our cherished heritage, stimulate civic pride and responsibility, and preserve cultural values for future generations» (Gravagnuolo et al., 2017, p. 186).

Yet, research on the application of CE principles in the built environment has mostly concentrated on construction waste minimisation and recycling (Tebbatt Adams et al., 2017). In this article, we aim to identify CE solutions and to lay the foundation for the future development of a system of indicators able to support circular adaptive reuse choices in the historic built environment. The main reference is represented by the Horizon 2020 "CLIC" project (Circular models Leveraging Investments in Cultural heritage adaptive reuse), that acts as a general framework, focusing on adaptive reuse as a key strategy for CE implementation in historic cities and regions. This is a relevant area of enquiry since the application of circular principles to the historic urban landscape «leads to the ability of maximizing the value of settlements, activating social, economic and environmental synergies» (De Medici et al., 2018, p. 3).

The paper is organized as follows: the first part presents a description of the concept of CE applied to the built environment and the concept of Urban Metabolism (UM), while the second part is focused on the way to assess circularity with reference to the historic built environment, defining a specific methodology.

The third part, presents an analysis of three representative case studies linked to the concept of CE in the historic built environment and to some extent also to circular UM. The first case is represented by "De Ceuvel" project in Amsterdam, focused on the reuse of old boats to create a full "circular" neighbourhood, in terms of materials, energy and even financial resources. A second application at a different scale is referred to "Rehafutur Engineer's House project" in France, an adaptive reuse of a historic villa following CE principles, more focused on building materials. Finally, the adaptive reuse of a rural village in Spain, within the "ReDock project" in La Junquera, will be explored highlighting circular metabolisms of materials, energy and financial resources.

These projects will be analysed to lay the foundation for the future definition of "key performance indicators" that could be used to foster and to monitor the implementation of CE strategies in the adaptive reuse of cultural heritage.

In the last part of the paper, some main conclusions are presented, together with some identified limitations and suggestions for future applications.

A. GRAVAGNUOLO (1), R. DE ANGELIS (2), S. IODICE (1)
DOI: 10.3217/978-3-85125-668-0-08

1.1 Circular Economy, Circular Built Environment and Circular Urban Metabolism

"CE is currently high on the agenda of business leaders, policy makers and academic researchers. Conceptualised as «an industrial system that is restorative or regenerative by intention and design" (EMF & McKinsey, 2012, p.7), CE appears to be a promising vision for inspiring change towards a more prosperous as well as more environmentally and socially sustainable economy. Notably, it is seen as an effective instrument to deal with the rising environmental, social and economic concerns of this particular historical junction. Several practitioners' studies and scholars argue that in a circular scenario, supply and resource price volatility as well as natural resources depletion could be mitigated, and that employment and innovation opportunities will emerge (EMF & McKinsey, 2012; Jones & Comfort, 2017; Kalmikova et al., 2017; Ilic et al., 2018).

As a consequence, several stakeholders (e.g., industries, governments, cities, supranational bodies, non-governmental organisations) are involved in numerous initiatives to promote the implementation of CE principles. The predicted rise in population to 8.6 billion in 2030 (United Nations, 2017) will inevitably translate in greater rates of urbanisation with the resultant increase in infrastructure investments (EMF, 2017). This is worrying because cities already account for 60-80% of greenhouse gas emissions, 75% of natural resource consumption and 50% of global waste production (ibid.). For these reasons, the involvement of cities for a truly transition towards CE is necessary. Cities with their unique concentration of resources are well positioned to lead on the global transition to CE (ibid.). Not surprisingly then, circularity in cities is currently promoted through policy, urban and regional strategies as well as emerging as a relevant research sector (Marin & de Meulder, 2018). According to the Ellen MacArthur Foundation (2017, p. 7),

> "a circular city embeds the principles of a CE across all its functions, establishing an urban system that is regenerative, accessible and abundant by design. These cities aim to eliminate the concept of waste, keep assets at their highest value at all times, and are enabled by digital technology. A circular city seeks to generate prosperity, increase liveability, and improve resilience for the city and its citizens, while aiming to decouple the creation of value from the consumption of finite resources".

A. GRAVAGNUOLO (1), R. DE ANGELIS (2), S. IODICE (1)
DOI: 10.3217/978-3-85125-668-0-08

One of the constitutive elements of a circular city is a circular built environment, which is

> "designed in a modular and flexible manner, sourcing healthy materials that improve the life quality of the residents, and minimise virgin material use. It will be built using efficient construction techniques, and will be highly utilised thanks to shared, flexible and modular office spaces and housing. Components of buildings will be maintained and renewed when needed, while buildings will be used where possible to generate, rather than consume, power and food by facilitating closed loops of water, nutrients, materials, and energy, to mimic natural cycles" (EMF, 2017, p. 7).

Circularity in the built environment is attracting attention with applications in many design and urban projects. This is the case because it offers many benefits such as economic growth, reduced environmental impact and improved quality of life (EMF et al., 2015). However, research on the application of CE principles in the built environment is just emerging and it has mostly concentrated on construction waste minimisation and recycling (Tebbatt Adams et al., 2017) despite the fact that there are several other circular strategies, i.e., retain, refit, refurbish, reclaim, reuse and remanufacturing (Cheshire, 2016), which offer more significant comprehensive sustainability benefits.

Furthermore, the adaptive reuse of Cultural Heritage allows reducing the metabolic flows crossing single buildings as well as the whole city. These flows are represented by the raw material in input, thanks to the use of already existing resources and at the same time by the output flows coming from the construction of new built heritage (especially Construction and Demolition Waste), together with the use of sustainable and compatible technologies that enable to improve the environmental performances of the use phase.

Therefore, each city with all its components can be considered as a living organism crossed by flows of energy and resources allowing its functioning, and for this reason it has its own metabolism. The concept of UM (Fig. 14) in general is a scientific phenomenon based on the principles of conservation of mass and energy, that has been defined as "the sum of the technical and socio economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste" (Kennedy *et al.,* 2007, p.44).

DOI: 10.3217/978-3-85125-668-0-08

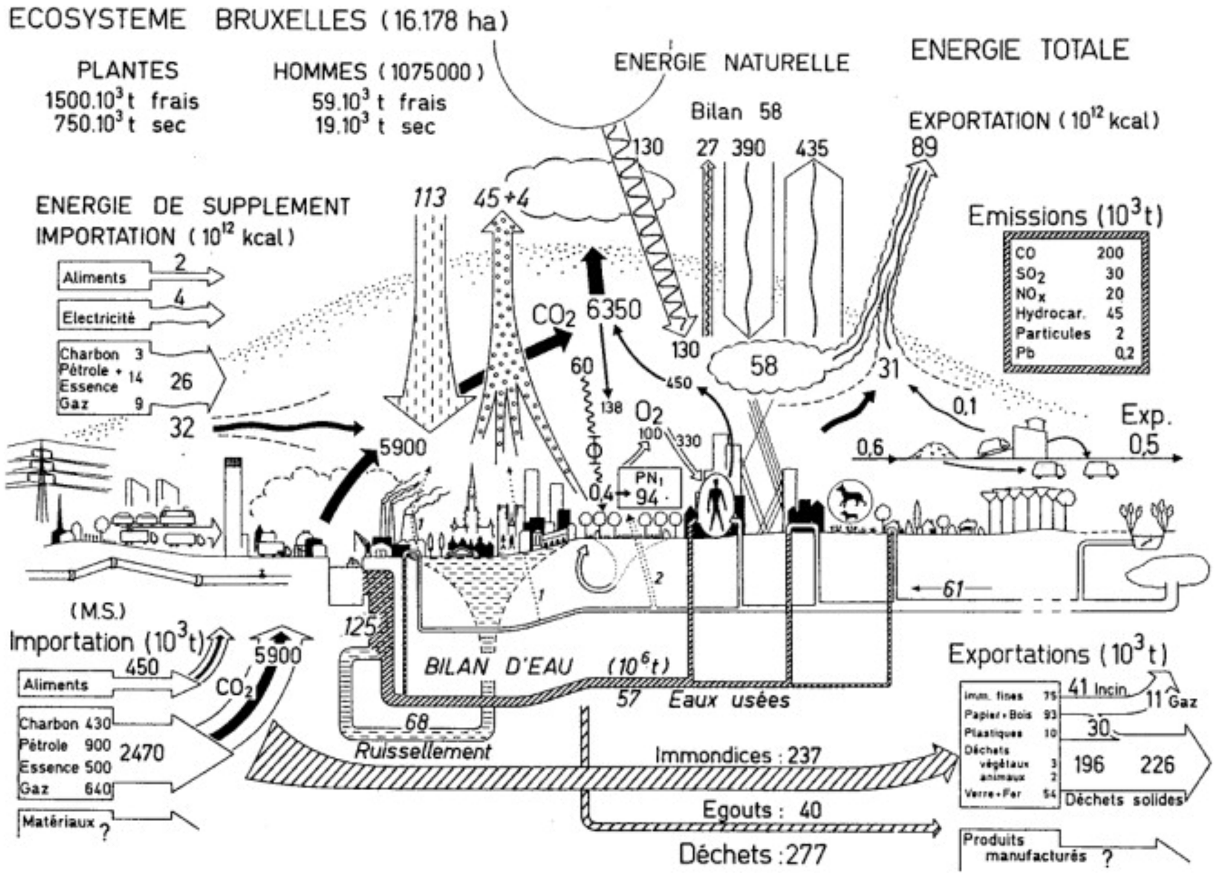


Fig. 14: *The urban metabolism of Brussels (source: Duvignead and Denayeyer-De Smeet, 1977)*

Taking into account the flows of energy, water, nutrients and waste that circulate within a city allows understanding the impacts deriving from the urban development and from the human, social and environmental activities (Mostafavi *et al.,* 2014), making it possible to perform a multidimensional and multi-scale sustainability assessment (Beloin-Saint-Pierre *et al.,* 2017). UM assumes as a fundamental prerogative that cities can be assimilated to living organisms and in order to guarantee the functioning of the various activities at different scales, they need input flows of matter and energy while generating output flows in the form of waste and emissions. Urban Metabolism in cities is actually characterized by a linear development model, where the output flows are not properly reintroduced into the system, differently from what happens in natural systems, characterized by a circular metabolism model.

The concept of circular UM can be found, at different scales and from different points of view, in some of the case studies analysed in the present paper, demonstrating that the adaptive reuse of cultural heritage can contribute to the loop closure.

DOI: 10.3217/978-3-85125-668-0-08

In addition, there are different UM evaluation methods and an example is that of Metabolic Impact Assessment (Pinho et al., 2013) that enables the assessment of a certain transformation on the urban metabolism performance of an urban system.

2 Materials and Methods: Assessment of circularity for the historic built environment

This study aims to lay the ground for the identification of possible circularity indicators for the Historic Built Environment that can be employed in a broader Urban Metabolism (UM) perspective to analyse flows of materials, energy, water, waste, as well as financial resources and socio-cultural aspects, assessing to which extent cultural heritage adaptive reuse can contribute to 'closed' urban metabolisms in a CE perspective.

A hybrid deductive and inductive methodology is applied, starting from theoretical aspects of the CE and circular city models, identifying how cultural heritage contributes to CE implementation, and then analysing three practical adaptive reuse case studies which apply circular economy principles in different ways and at different scales to identify circularity indicators.

According to several studies on CE (Ghisellini et al., 2016, Homrich et al., 2017, Kirkhherr et al., 2018), different frameworks can be adopted to synthesize CE principles: the "9Rs" (Refuse, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover), the "ReSOLVE" framework proposed by Ellen MacArthur Foundation (EMF *et al.,* 2015), are two of the most commonly applied. Moreover, specific studies on cultural heritage adaptive reuse in the context of the CE (Gravagnuolo *et al.,* 2017) argue that heritage reuse contributes in many ways to CE: preventing the use of raw materials, reducing construction waste and landfill, promoting a 'second life' for abandoned heritage assets, also through repairing, maintenance and refurbishment, creating new products from different technological parts of buildings, repurposing buildings through new functional uses, recycling materials wherever possible.

However, CE aspects related to materials, energy, water and waste do not represent a comprehensive approach to CE, considering particularly the 'urban functions' not only related to the availability of materials/goods, water, energy and food, but also to different 'soft' functions related to cultural diversity, identity, relationships, access to financial resources, access to services, etc. Definitely, ultural heritage adaptive reuse can

DOI: 10.3217/978-3-85125-668-0-08

contribute to maintain and enhance urban functions in a circular perspective through three main levels[1]:

• **cultural values conservation/regeneration** (extending the life-time of heritage assets in a circular perspective, including the rights of future generations to benefit of cultural capital);

• **circularity of conservation interventions** (adopting circular building construction strategies such as reusing and recycling of materials, recovering of ancient water management systems, adoption of efficient energy systems and renewable energy sources, nature-based solutions, zero-waste management systems, etc.);

• **circularity of outcomes coming from reuse initiatives** (economic, social, environmental and cultural impacts directly or indirectly linked to the new functions of buildings and sites, including jobs creation, quality and safety of urban environment, enhancement of community relationships, generation of positive revenue flows for long-term self-sustainability, etc.). Here circularity is linked also to avoided costs of abandonment and degrade of buildings and entire urban and landscape areas.

According to the general framework proposed within the Horizon 2020 "CLIC" project, cultural heritage adaptive reuse could be seen as an entry point to circular cities implementation, avoiding the 'waste' of resources by reusing and regenerating buildings and sites which present functional obsolescence, and thus lost their original functionality (e.g. religious uses, productive uses, residential uses). This study adopts a concept of 'Circular Economy 2.0' (Lemille, 2017), considering the implementation of CE principles in a sustainable development perspective which includes necessarily social and 'cultural' objectives along with environmental and economic objectives, overcoming approaches focused only on 'waste', materials, water and energy management. A cultural approach to CE, as adopted in this study, identifies multidimensional and multi-criteria indicators to assess the circular performance of adaptive reuse interventions in the historic built environment, in relation to key urban functions of the circular city/region:

1. The following levels have been developed within the CLIC Horizon 2020 Project. More info can be found at the following address: ***https://www.clicproject.eu/***.

• **self-sufficiency of the city/region** (in terms of re-localization of production-consumption of energy, materials, food, water, and zero-waste strategies);

• **knowledge development and exchange** (towards globally connected, but locally self-sufficient cities and regions);

• **higher density of relationships** (promoting cooperation, synergies, symbioses between stakeholder, as well as between citizens through enhanced places identity).

The theoretical framework adopted is thus based on three levels of circularity in relation to three main objectives of a circular city/region. Once identified the theoretical framework, an inductive approach has been followed for the future identification of possible indicators able to show the relevance of cultural heritage adaptive reuse projects according to their contribution to circular city objectives.

Three representative adaptive reuse case studies have been analysed and are described below: De Ceuvel in The Netherlands, Rehafutur Engineer's House in France, and the Redock project in Spain, which represent different scales of implementation (Table 3). All three cases explicitly present themselves as experimentations of application of the CE model and can be linked to the three levels of circularity proposed above. Moreover, all the three cases focus their attention on the social and cultural impacts of the CE model adopted, and are thus suitable to explore circularity principles from a comprehensive perspective.

Name	**Country, City**	**Scale**	**Cultural heritage typology**	**Sustainability dimensions considered**	**Methodology of analysis**
De Ceuvel	The Netherlands, Amsterdam	Neighbourhood	Old boats, repre-senting Amsterdam cultural identity	Environmental, Economic, Social, Cultural	Desk research and site visit
Rehafutur	France, Loos-en-Gohelle	Building	Historic villa, inside the UNESCO World Heritage Site	Environmental, Economic (savings), Cultural, Social	Desk research
ReDock	Spain, Altiplano Region	Village/ landscape area	Historic rural village	Environmental, Eco-nomic, Social, Cultural	Desk research and Skype interview

Table 3: *Case studies of circular economy implementation in cultural and lanscape heritage contexts*

DOI: 10.3217/978-3-85125-668-0-08

It is necessary to specify that all three cases have been analyzed through a desk research. However, De Ceuvel's knowledge was also deepened through a guided site visit organized within the CLIC project, during which it was possible to interface with the case study managers. Finally, the description of ReDock is also the result of a Skype interview with the manager who allowed to deepen some circularity aspects.

3 Case Studies

1.1 *De Ceuvel[1] case study: an example of metabolic circularity*

De Ceuvel is a former industrial lot located in Amsterdam North that, through a series of transformations, has been turned into a sustainable area, thanks to the use of innovative technological solutions (Fig. 15).

The main peculiarity of De Ceuvel is represented by the use of retrofitted houseboats, linked to the Dutch culture and to the city of Amsterdam in particular, where they are generally used as floating houses. In De Ceuvel, in order to maintain this peculiarity, the boats have been located on the land and used as spaces with different functions for a period of ten years. Among the various uses, there is a floating bed and breakfast and a cultural venue. Furthermore, the area is characterized by the presence of a popular Cafè where there is a separate collection of urine (Roest *et al.,* 2016) and where an ecologically sustainable agriculture is adopted.

As the soil is polluted and it was not possible to create an underground infrastructure, these boats are provided with dry composting toilets, a heat pump, solar panels and biofilters for the treatment of grey water, while the use of phyto-remediating plants helps to clean the soil. The area has also what is called a “Cleantech Playground”, that is an ecosystem in which innovative clean technologies are tested, such as a composting plant, a struvite reactor and a greenhouse where the growth of vegetables is ensured by the use of compost and struvite. In addition, the following targets have been established:

1. The description on this case is based on the Report “TKI Loop-closure Cleantech Playground” and on a direct site visit within the Horizon 2020 CLIC Project.

DOI: 10.3217/978-3-85125-668-0-08

• 100% renewable heating and electricity supply;

• 100% on site wastewater treatment;

• 100% organic waste treatment;

• 100% on-site drinking water supply, if the legislative barriers for this are overcome[1].

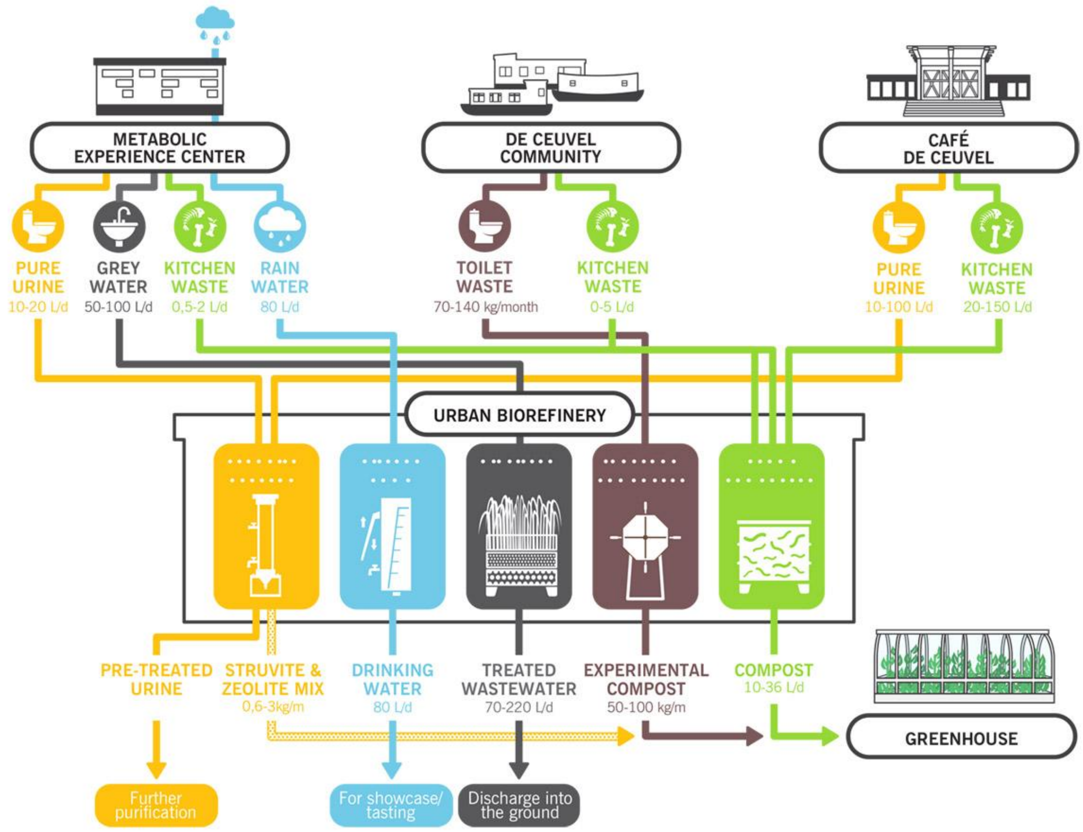


***Fig. 15:** Sustainable technologies at De Ceuvel (source: https://www.metabolic.nl/news/opening-the-cleantech-playground/)*

These technologies have led to the creation of a sustainable workplace for creative and social enterprises, facilitating the development of a real community of entrepreneurs and artists, determining the formation of a cultural urban hub in which art, sustainability and technology coexist in a balanced way. Through the organization of events, workshops and lecture, the community is involved and can learn from De Ceuvel experience.

1. More information can be found at the following website: https://deceuvel.nl/en/

A. GRAVAGNUOLO (1), R. DE ANGELIS (2), S. IODICE (1)
DOI: 10.3217/978-3-85125-668-0-08

The organization of the area allows the existence of different sources of income, like that related to the possibility of renting the site for one-day events. Other sources are represented by the possibility to use the warehouse and the gallery space as a plenary hall, as a workspace and also as a meeting room. Moreover, also the “Metabolic lab” as well as another space known as “Crossboat”, can be hired for the organization of creative events, workshops, courses and masterclasses for the practical learning about the technologies applied in the area, in order to enhance the awareness raising. It is possible to read that the rental price of the Metabolic lab for a full day is 550 € (excl. BTW). As already previously specified, another income comes also from the “Asile Flottant”, a collection of boats retrofitted as hotel rooms. These procedures have increased the involvement of the local community because all are leading actors in the transformation of the space and in the application of circular metabolic principles.

The technologies used are able to facilitate the closure of the cycles and allow the reduction of input and output resource flows, in line with the principles of circular Urban Metabolism (UM).

UM can be applied to different scales, so both to entire neighbourhoods like De Ceuvel, but also to individual buildings; indeed, as stated by Li and Kwan (2017), there are global UM studies as well as studies at the urban local dimension.

UM is currently characterized by a linear development model, causing an intensification of environmental impacts (EEA, 2015). The application of sustainable technologies in De Ceuvel allows the implementation of an efficient use of resources, facilitating the achievement of a circular metabolic model and of a local loop closure. Furthermore, the use of already existing boats with useful functions for artists, volunteers and entrepreneurs, allows reducing the consumption of raw materials for new buildings constructions.

This procedure is linked to the concept of “upcycling”, referred to the use of recycling components and second-hand materials coming from all over The Netherlands, facilitating landfill avoidance thanks to the re-use of sustainably retrofitted discarded houseboats that otherwise would have been demolished. These thirteen boats were taken out of the water and used for different functions, like offices, ateliers, spaces for events, etc. and they can be rent for creative and cultural purposes (Fig. 16). Definitely, the reuse process

DOI: 10.3217/978-3-85125-668-0-08

contributed to many circularity objectives, such as: the enhancement of energy efficiency, the reduction of water consumption, the reduction of raw materials extraction and of Construction and Demolition Waste (CDW) that would otherwise come from the boats dismantling.

Fig. 16: *Some houseboats at De Ceuvel (source: https://deceuvel.nl/en/)*

De Ceuvel is not only based on the implementation of an eco-design model through circular economy practices from an environmental point of view, but also on the construction of a community project with the integration of common knowledge and expert knowledge, demonstrating the possibility to reinvent people relationship with resources and involving future users in construction activities (Metabolic et al., 2014).

De Ceuvel is part of a redevelopment area called “Buiksloterham” located in the northern part of Amsterdam, that is being transformed from an industrial zone into a mixed used area that combines industrial, commercial and residential functions. An UM analysis has been executed in order to understand the functioning of the area from an integrated perspective, taking into account energy and material flows, biodiversity, socio-economic factors, environmental conditions, local stakeholders, policies and strategic plans, as well as the health and wellness of the inhabitants (Gladek *et al.,* 2014). This analysis considers the current state as well as a 20+ scenario and the following goals have been established:

DOI: 10.3217/978-3-85125-668-0-08

• fully renewable energy supply with mostly local production;

• zero waste neighbourhood with a nearly 100% circular material flow;

• rainproof and resource recovery from wastewater (almost 100%);

• regeneration of ecosystems and self-renewing of natural capital;

• flexible infrastructure design and zero emissions local mobility;

• diverse and inclusive culture, and high liveability metrics;

• strong local economy that stimulates entrepreneurship and the creation and exchange of multiple kinds of value (social, environmental, cultural);

• healthy, safe and attractive environment with recreational activity space for all residents.

In order to achieve the above goals, an inclusive governance structure is necessary with the purpose of including both large and small stakeholder through the organisation of bottom-up initiatives. As far as the financial vehicles and the incentive systems are concerned, the following actions are proposed:

• establishment of a rotating investment fund;

• development and implementation of a local incentive system;

• establishment of reverse tenders for challenges and goals.

In general, through the integration of different resource flows and the development of smart financial scenarios, these projects yield a high return on investment and are financially feasible for the communities.

3.2 Rehafutur Engineer's House Case Study[1]

Rehafutur Engineer's House, a historical mining house in the Northern France UNESCO heritage site, is one of the sites included in the EU's project CAPEM (Cycle Assessment Procedure for Eco-impacts of Materials) aimed at assessing the effectiveness of renewable materials for insulation. Now converted into offices, the major intervention realised in the process of adaptive reuse consisted of improving the building thermal

1. The description of this case is based on secondary data (CE 100, 2016; Mangialardo & Micelli, 2018).

DOI: 10.3217/978-3-85125-668-0-08

insulation. Due to its heritage value, the renovation of this building could not affect the external façade, meaning that retrofitting could only involve interiors, and reuse as much as possible of the existing materials was necessary. Using bio-based (e.g., wood fibre, sheep wool), and recycled (e.g., recycled textiles) insulating materials, high standards of energy efficiency have been achieved. In addition, to preserve the heritage value of the original construction, materials were reused. For instance, marble fireplaces have been used as ornaments in public rooms and 18 m^2 of multi-coloured cement tiles were also reused. For the characteristics of the renovation projects, i.e. the use of renewable insulation materials, high energy efficiency standards and reuse of materials, it can be said that Rehafutur Engineer’s House is a pertinent example of the application of CE principles (adaptive reuse) in the construction industry. Several are the environmental, social and economic sustainability advantages resulting from the application of CE principles to this renovation project, which can be summarised as following:

• improved indoor air quality and comfort;

• reduced operating costs in the ‘in use’ phase: prior to the intervention the house needed 1,000 litres of fuel each year whereas after the renovation, the heating demand is very low at 34 kWh/m2 per year with environmental benefits too. In addition, given that the building is located in an area affected by issues of fuel poverty, this project has also a social value as it demonstrates how retrofitting could be effectively used to drastically reduce energy consumption;

• reduced materials costs (thanks to reuse of materials): reusing tiles rather than buying new ones has led to significant savings (8.000 €);

• employment opportunities: reduced materials bill has meant that more funds were available to employ more people, which was another plus of this project;

• the nature of the project kept construction workers motivated and proud to work on the site;

• the project involved a number of stakeholder (e.g., regional enterprises, universities and education centres) and so it had a relevant demonstrative impact.

DOI: 10.3217/978-3-85125-668-0-08

As it is possible to observe in the above information, the solutions adopted are able to reduce the flows of material and energy consumption, stimulating the implementation of a circular UM.

3.3 ReDock Project [1]

ReDock project (Fig. 17) is the transformation of a medieval village into a green and sustainable community, as part of a larger eco-restoration project in the region of the Altiplano, nearby Murcia in Spain. The village aims to become a blueprint for a sustainable future in the countryside and it is planned to be one of a series of green villages worldwide.

The project foresees the reuse and regeneration of the entire village and the surrounding rural area, developing a model of complete self-sustainability, in terms of energy, water, food, and even financial resources to conduct entrepreneurial and commercial activities through a cooperative, mutually supporting model enabling financial independence. Corporates, NGO-employees, government officials, researchers, teachers, start-ups, digital nomads, students and visitors are identified as final users.

The project has been developed by a Dutch company in close cooperation with interested stakeholder such as potential users and investors. An initial investment of 250 K € was granted by private funders, enabling the start-up and detailed design of the 'closed' metabolism and key functions of the village. The functions cover the needs of a self-sustaining community oriented to experiment innovative models and lifestyles in line with CE principles.

1. The description of this case is based on secondary data retrieved from ***www.redock.org*** and on primary data from an in-depth interview with the manager and designer of ReDock, conducted via web meeting in 2018.

DOI: 10.3217/978-3-85125-668-0-08

Fig. 17: *ReDock village design in Spain (source: www.redock.org)*

The regeneration of natural capital, currently extremely reduced in the Altiplano region due to over-exploitative industrial and farming activities, is the key objective of the ReDock project. The Altiplano region, that was in the past a highly bio-diverse and fertile area, presents itself today as a large arid land, requiring 2 Billion Euro to be brought back to natural conditions suitable to life of natural species and human communities. Starting from the recognition of the multiple and complex interrelationships between communities and the ecosystems in which they settle, the eco-restoration of the Altiplano becomes the key objective: the regeneration of land and other natural resources that enable and support human activities. The adoption of multifunctional farming systems enables thus not only local production and consumption of food, but it also aims to regenerate soil fertility over time, as well as conserving and increasing freshwater sources.

The medieval village is recovered enabling new functions that respond to contemporary needs, avoiding the 'nostalgic' idea of the traditional village functions and enabling a contemporary way of living in the countryside. This means to generate new use values for abandoned buildings and sites, which can be transformed into market values re-generating local economies. The plan foresees the realization of Hotels, a School of eco-restoration, an Info-center for visitors and residents, Start-ups co-working spaces, Offices distributed in the entire village and even open-air, Sports facilities, Services such as cultural and social activities (Workshops, Events). The adaptive reuse strategy applies to all parts of the village: churches will be transformed into schools, stables into offices, etc. Temporary living is actively promoted, opening the village to a larger international

DOI: 10.3217/978-3-85125-668-0-08

community of innovators, who may find a place to exchange knowledge and experiment different ways of life and work. Circular flows of materials, energy and water are designed as part of the 'closed' metabolism of the village. Food is grown in the local area, a photovoltaic park connected to the village own energy grid has been designed. Every wasted material is reused to become resource for other productive processes.

The research of ReDock project is focused on providing opportunities for healthy and flourishing life. Decent and attractive work conditions are at the core of this strategy: offices are designed to ensure comfort, flexibility, and to enhance creative work enabling strong connection of people to nature. Healthy food is grown locally and served in the restaurants, which establish agreements with local farmers. Health, creativity, innovativeness, wellbeing, are key concepts of CE that are applied in the ReDock project.

This model of self-sustainability should not be intended as a tentative of 'isolate' the local community through 'off-the-grid' technological measures. On the contrary, the village aims to be connected through physical and digital means, particularly through high-speed internet connection serving the whole area. Data collection on different metabolic flows represent a key source of knowledge to continuously improve the functioning of the village.

Considering the features of the ReDock project, it is possible to recognize three main aspects that enable a CE model in the reuse of historic rural villages:

• a cooperative and mutually supportive financial system;

• a business model based on re-localization and synergic/symbiotic value chains in the area;

• a self-sufficiency objective and the regeneration of natural capital, built capital, human and social capital.

The next section synthesizes the key aspects of circularity that can be recognized in the experiences analysed, applying the three-levels framework previously proposed.

4 Discussion: Key aspects of circularity in the analysed case studies

The three levels of circularity (Gravagnuolo et al., 2017, 2018) that have been proposed in chapter 2, are now associated to the three analysed case studies, in order to understand how they reach the circularity objectives:

DOI: 10.3217/978-3-85125-668-0-08

• **cultural values conservation/regeneration**

In **De Ceuvel** this happens because the boats in their configuration are linked to the Dutch cultural values. Furthermore, the organization of events like interactive workshops, concerts and conferences, and the rent of the boats for different functions help improving the communications of the sustainability values that De Ceuvel wants to reach. In **Rehafutur** this happens because the reuse process has contributed to the conservation of tangible and intangible heritage values and finally in **Redock** because the reuse project regenerates natural and cultural heritage and landscape, providing also additional educational and demonstrative values.

• **Circularity of conservation interventions**

In **De Ceuvel** this is clearly evident in the healthy UM that has been achieved thanks to the combination between urban agriculture, small-scale renewable energy technologies, local urban food production, biological water purification systems, and so on (Gladek and Monaghan, 2013). It is possible to state that the reuse process contributed to many circularity objectives. In **Rehafutur** this is achieved thanks to the technical choices of adaptive reuse and finally in **Redock** through the development of a self-sustainable energy and food system recovering traditional agricultural farming techniques mixed with efficient technological solutions (e.g. renewable energy grid, digital technology).

• **Circularity of outcomes coming from reuse initiatives**

This third level in **De Ceuvel** is achieved through the development of smart financial scenarios (Roest et al., 2016). First, among the sources of income, there is the activity related to Cafè De Ceuvel and also that related to the boats rental. In addition, among the key features of the project, there is also a fast return on investment thanks also to the use of Do It Yourself (DIY) approach. Moreover, the project enhances the creation of jobs, the attractiveness for innovative start-ups and companies, for cultural and creative industries as well as commercial activities, improving also the whole attractiveness of the area, that has become a popular example of tangible sustainability. In **Rehafutur** this is achieved thanks to the increased attractiveness and to the employment opportunities and finally in **Redock** through the attractiveness for creative and innovative entrepreneurs, new jobs in rural areas, new jobs in digital technology and the regeneration of rural ecosystems at a larger scale.

DOI: 10.3217/978-3-85125-668-0-08

Table 4 summarizes the CE impacts in the three analysed cases, providing insights for the subsequent identification of possible indicators of circularity to assess adaptive reuse interventions in the historic built environment.

Case study	Cultural values conservation/ regeneration	Circularity of conservation interventions	Circularity of outcomes coming from reuse initiatives
De Ceuvel	Educational activites; Demonstrative actions (awareness raising); conservation of manufactured goods related to the Dutch culture (boats); communication of heritage values.	Closed cycles of energy, water, materials, organic materials and waste.	Attractiveness of the area for creative and innovative entrepreneurs/firms; social activities; community-building; circular financial system (local currency, Buikslotherham incentives and revolving fund), etc.
Rehafutur	Tangible heritage values conservation; demonstrative project (awareness raising); Pride.	No waste of materials; reuse of materials and objects; energy efficiency systems; recycled and renewable materials.	Attractiveness of the experience as demonstrative project; example for local owners and community; employment opportunities.
ReDock	Landscape heritage regeneration; traditional farming conservation; recovery of abandoned heritage buildings.	Own renewable energy grids; water and materials reuse; digital infrastructure.	Attractiveness for residents (even temporary), visitors, creative and innovative entrepreneurs, digital workers – through natural and cultural heritage regeneration; healthy environment and lifestyle; sustainable financial system and business model, etc.

Table 4: *Comparison of circular impacts in the three analysed case studies, applying the three-levels methodological framework*

5 Conclusions

The three case studies show that experiences of cultural heritage adaptive reuse from CE and UM points of view are already in place and can inspire the development of an emerging sector of implementation within CE applied to the historic built environment. However, a monitoring and performance assessment framework is still lacking in this

DOI: 10.3217/978-3-85125-668-0-08

sector. Building construction industry metrics still do not monitor the "circular" performance of interventions in existing and historic buildings, while CE is recognized as an opportunity for construction industries (ECSO, 2018; EMF, 2016; ARUP, 2018; Bruxelles Environment, 2018; Gravagnuolo et al., 2019). Moreover, it is still controversial to identify common indicators able to show the circular performance in multiple dimensions: social, economic, environmental, and cultural. The three case studies show a high variability of impacts, which suggests that a common ground for the assessment of 'best practices' and the orientation towards CE should be found through exploration of theoretical concepts together with concrete experiences, in order to develop evidence-based knowledge of the real impacts of CE-led interventions in heritage contexts.

The three levels of circularity described in this paper have been identified in the Horizon 2020 CLIC project in order to develop a matrix of indicators for the multidimensional impact assessment of adaptive reuse of cultural heritage projects. This matrix is part of Work Package 2, that has the aim to evaluate and compare the impacts of systemic adaptive reuse in the environmental, cultural, social and economic dimensions through the identification of suitable criteria and indicators in the CE perspective. In addition, some more indicators will be introduced with reference to the specificities of the cases under analysis. The concept of Urban Metabolism and Metabolic Impact Assessment lends itself well to being used for the implementation of a methodological framework for the assessment of urban performances in the perspective of CE. This metabolic analysis could be able to combine the multiscalarity that inevitably characterizes the impacts of adaptive reuse of cultural heritage.

Indicators in general are essential tools as they allow to summarize complex information on the territorial functions and to represent certain aspects concerning the state of the environment (built or not) from a multidimensional point of view, monitoring and analysing the territorial flows (Fry et al., 2009). Future developments, in line also with CLIC advances, will consist in the identification of a set of core indicators to guide the impact assessment of cultural heritage adaptive reuse at different geographical scales (micro, meso and macro) and from different points of views (manager organizations/local governments).

DOI: 10.3217/978-3-85125-668-0-08

Definitely, only through the development of scientific measures, it is possible to monitor and identify common rules able to close the loops and to reduce the input and output metabolic flows.

Authors contribution

The authors have worked in strict collaboration to develop the concepts and methodological approach to this study. Specifically, Antonia Gravagnuolo designed the work and developed the introduction, the methodological framework expressed in Section 2, the case study of ReDock and the overall analysis of circular impacts in Section 4. Roberta De Angelis developed the literature review on circular built environment and circular business models in the building construction sector, as well as the case study of Rehafutur. Silvia Iodice developed insights on Urban Metabolism and the case study of De Ceuvel. The authors have contributed equally to the development of discussion and conclusions.

Funding

This research has been developed under the framework of Horizon 2020 research project CLIC: Circular models Leveraging Investments in Cultural heritage adaptive reuse. This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 776758. This work is specifically developed within the Work Package 2 on "Creating evidence-base of cultural heritage impacts".

References

ARUP (2018) BAM. Circular Business Models for the Built Environment—Arup. Available online: https:/ /www.arup.com/perspectives/publications/research/section/circular-business-models-for-the-built-environment.

Beloin-Saint-Pierre, D., Rugani, B., Lasvaux, S., Mailhac, A., Popovici, E., Sibiude, G., Benetto, E., Schiopu, N. (2017). A review of urban metabolism studies to identify key methodological choices for future harmonization and implementation. *Journal of Cleaner Production*, *163*, S223–S240.

Bruxelles Environnement (2018). Le Secteur de la ConstructionàBruxelles Constat et Perspectives: Vers une EconomieCirculaire; Bruxelles Environnement: Brussels, Belgium.

CE 100. (2016). *Circularity in the built environment*. Retrieved 2018 August from https:/ /www.ellenmacarthurfoundation.org/assets/downloads/Built-Env-Co.Project.pdf

Cheshire, D. (2016). *Building revolutions: Applying the circular economy to the built environment.* Riba Publishing.

Creative Community Network (2012. Cultural Indicators: Measuring Impact on culture. Information Paper prepared for the LGA by members of the CCN, July 2012.

De Medici, S., Riganti, P., Viola, S. (2018). Circular economy and the role of universities in urban regeneration: The case of Ortigia, Syracuse. *Sustainability, 10,* 1-26.

Duvigneaud, P., & Denaeyer-De Smet, S. (1977). "L'Ecosystème urbs: L'Ecocsystème urbain Bruxellois", in Duvigneaud, P., Kestemont P., Productivité Biologique en Belgique. Editions Duculot, Paris, pp. 581-597.

ECSO (2018). European Construction Sector Observatory. Country profile Belgium. Retrieved May 2018: https://ec.europa.eu/docsroom/documents/30662/attachments/1/translations/en/renditions/native

EEA. (2015). Urban sustainability issues — what is a resource-efficient city?. Technical report No 23/2015, Copenaghen, Denmark.

EMF (Ellen MacArthur Foundation). (2017). *Cities in the circular economy: An initial exploration.* Retrieved October 2018 from https://www.ellenmacarthurfoundation.org/publications/cities-in-the-circular-economy-an-initial-exploration.

EMF (2016). CE100 Circularity in the Built Environment: Case Studies. A Compilation of CaseStudies from the CE100. Available online: https://www.ellenmacarthurfoundation.org/assets/downloads/Built-Env-Co.Project.pdf.

EMF, & McKinsey. (2012). *Towards the circular economy: Economic and business rationale for an accelerated transition*. Retrieved 2013 May from http://www.ellenmacarthurfoundation.org/business/reports

EMF, McKinsey, & SUN. (2015). *Growth within: A circular economy vision for a competitive Europe*. Retrieved 2018 July from http://www.ellenmacarthurfoundation.org/business/reports.

Fry, G., Tveit, M. S., Ode, A°., Velarde, M. D. (2009). The ecology of visual landscapes: Exploring the conceptual common ground of visual and ecological landscape indicators. *Ecological Indicators*, *9,* 933-947.

Fusco Girard, L. (2018), "Linking past and future", Retrieved January 2019 from https://www.clicproject.eu/linking-past-and-future-discourse-of-prof-luigi-fusco-girard/.

Ghisellini, P., Cialani, C. and Ulgiati, S. (2016) 'A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems'.

Gladek, E., Monaghan, C. (2013). Cleantech Playground. A cleantech utility in Amsterdam North. February 2013.

Gladek, E., van Odijk, S., Theuws, P., Herder, A. (2014). Circulair Buiksloterham. Transitioning Amsterdam to a circular city. Metabolic, Studioninedots & DELVA Landscape Architects.

Gravagnuolo, A., Angrisano, M., Fusco Girard, L. (2019), Circular Economy Strategies in Eight Historic Port Cities: Criteria and Indicators Towards a Circular City Assessment Framework. Sustainability, 11(13), pp. 3512-3536.

Gravagnuolo, A., Saleh, R., Ost, C., Fusco Girard, L. (2018), Towards an evaluation framework to assess

Cultural Heritage Adaptive Reuse impacts in the perspective of the Circular Economy. Urbanistica Informazioni – INU, 278 s.i., pp. 28-31.

Gravagnuolo, A. *et al.* (2017) 'Evaluation criteria for a circular adaptive reuse of cultural heritage', *BDC Bollettino del Centro Calza Bini*, 17(2/2017), pp. 185–216.

Homrich, A. S. *et al.* (2018) 'The circular economy umbrella: Trends and gaps on integrating pathways', *Journal of Cleaner Production*. Elsevier, 175, pp. 525–543.

Ilic, D., Eriksson, O., Odlund, L., Åberg, M. (2018). No zero burden assumption in a circular economy. *Journal of Cleaner Production, 182,* 352-362.

Kirchherr, J., Reike, D. and Hekkert, M. (2017) 'Conceptualizing the circular economy: An analysis of 114 definitions', *Resources, Conservation and Recycling*, pp. 221–232.

Lemille, A. (2017) *Optimizing Circular Value*.

Jones, P., Comfort, D. (2017). Towards the circular economy: A commentary on corporate approaches and challenges. *Journal of Public Affairs, 17,* 1-5.

Kalmykova, Y., Sadagopan, M., Rosado, L. (2017). Circular economy – From review of theories and practices to development of implementation tools. *Resources, Conservation & Recycling*, https://doi.org/10.1016/j.resconrec.2017.10.034.

Kennedy, C., Cuddihy, J. Engel-Yan, J. (2007). The changing metabolism of cities. J*ournal of Industrial Ecology*, *11*, 43–59.

Li, H., Kwan, M.-P. (2017). Advancing analytical methods for urban metabolism studies. *Resources, Conservation and Recycling*, *132,* 239–245.

Mangialardo, A., Micelli, E. (2018). Rethinking the construction industry under the circular economy: Principles and case studies. In Bisello, A., Vettorato, D., Laconte, P., Costa, S. (2018) (Eds.) Smart and sustainable planning for cities and regions (pp. 333-344). Cham, Switzerland: Springer

Marin, J., de Meulder, B. (2018). Interpreting circularity. Circular city representations concealing transition drivers. *Sustainability, 10,* 1-24.

Metabolic, Waternet, KWR, AWWS (2014). Cleantech Playground. Research Quarterly Report #2, August 2014.

Mostafavi, N., Farzin Moghadam, M., Hoque, S. (2014). A framework for integrated urban metabolism analysis tool (IUMAT). *Building and Environment*, *82*, 702–712.

Pinho, P., Oliveira, V., Santos Cruz, S., Barbosa, M. (2013). Metabolic Impacts Assessment for urban planning. Journal of Environmental Planning and Management, 56(2), 178-193.

Roest, K., Smeets, P., van den Brand, T., Cortial, H., Klavrsma, E. (2016). TKI Loop-closure Cleantech Playground. Local water and energy solutions. KWR 2016.081 | September 2016.

Tebbatt Adams, K., Osmani, M., Thorpe, A., Thornback, J. (2017). Circular economy in construction: Current awareness, challenges and enablers. *Waste and Resource Management, 170,* 15-24.

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

Effects of Metrics in Research Evaluation on Knowledge Production in Astronomy | A Case Study on Evaluation Gap and Constitutive Effects

Julia HEURITSCH

German Centre of Higher Education Research and Science Studies (DZHW), Humboldt Universität zu Berlin, Research Group “Reflexive Metrics”, Department of Social Sciences, Berlin, Germany

Abstract

For this case study nine interviews were conducted with astronomers from Leiden University. The interviews were complemented by a document analysis on relevant institutional (self-) evaluation documents, annual reports, and CVs of the interviewees. The aim was to perform a qualitative study about what astronomers define as research quality and how that related to their perception on what is measured by metrics used in research evaluation. The research shows that astronomers are realists who define scientific quality on the basis of “truth” and are driven by curiosity. These two factors make up their intrinsic values and motivation to perform Astronomy. Publication pressure, arising from the requirements of “the system”, creates an extrinsic motivation to perform. This is perceived as resulting in low readability and replicability, risk aversion and a focus on quantity rather than quality. Hence, indicators do not merely describe quality, but also co-constitute what counts as good research. While such constitutive effects of indicator use on research behaviour and content are observed, there is no indication that the astronomer's intrinsic values are co-constituted. This gives rise to a discrepancy between what is being measured by indicators and what astronomers define as scientific quality; the so-called ‘evaluation gap’. Consequently, astronomers try to manage a balancing act between their intrinsic values and the requirements of the system. Findings on constitutive effects and the evaluation gap in Astronomy lay out the conceptual groundwork for further empirical research and for policy advice on alternative evaluation practices and innovative indicators with the aim of bridging the ‘evaluation gap’.

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

1 Introduction and Literature Review

The quality of scientific production is currently measured and evaluated by a set of quantitative metrics, so-called indicators. This practice has become ever more controversial as insights from the sociology of quantification and the sociology of evaluation show that numbers which quantify quality, do not only describe, but also prescribe. Indicators are performative insofar that they do not merely measure whether science is performed well, but that they also affect what is valued as good research. Reflexive metrics is a relatively new field in science and technology studies, which combines the two strands, the sociology of quantification and the sociology of evaluation, in order to study what effects indicator use has on research and researchers themselves (e.g. Stephan, 2012; Fochler & De Rijcke, 2017). Given that metrics are non-detachable from a social context, reflexive metrics will provide theories about the meaning, reliability and effects of indicator use in evaluation procedures. It is important to question the use of quantitative measurements in evaluation processes as an established practice in order to inform policy makers what effects their policies have on science and what they need to consider to encourage quality research and motivated researchers. This paper will first give a brief introduction to the topic of reflexive metrics, which roots in the sociology of quantification and (e-)valuation in *Section 1*. This includes two concepts developed to explain what effects indicator use has on knowledge production processes, the *evaluation gap* and *constitutive effects*, and how they could be reconciled. The introductive section ends with explaining why this study chose Astronomy and Leiden Observatory as the field and institute under investigation. *Section 2* outlines the methods. *Section 3* contains the results where we first depict the astronomers' definition of quality. We then describe the evaluation gap in Astronomy and what constitutive effect we could observe and finally, how those concepts can be reconciled. This paper will end with its final *Section 4*, the conclusions.

1.1 Sociology of Quantification and (E)-Valuation: Insights into the different characteristics and meanings of numbers

The question how to measure and ensure high-quality of knowledge production has become controversial and challenging. "*Accountability*" and "*transparency*" are becoming ever more closely associated with producing and monitoring metrics (Espeland &

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

Vannebo, 2008). This is because quantification is one means to constitute social entities as things that last and are comparable. Categorising and numbering reduce the complexity of phenomena, which makes them easier to grasp and talk about. As such, the goal of quantification is to enable objectification and to master uncertainty. Through objectification, both a political space and a measuring space, are co-constituted in which things can be compared (Desrosieres, 1998). “It permits scrutiny of complex or disparate phenomena in ways that enable judgment” (Espeland & Stevens, 2008). Hence, quantification offers a shared language and replaces trust in people with “trust in numbers” (Porter, 1995).

Indicators serve the purpose of accountability, which is why they are relevant in science evaluation systems. Indicators *commensurate*, which is the act of using numbers to rate and rank, “creating a specific type of relationship among objects” (Espeland & Stevens, 2008). They are argued to measure and compare the output and performance of researchers and research fields. According to Godin (2006), this is also the reason why psychologists used bibliometrics as forerunners in the early 1900s. Their aim was to contribute to the advancement of psychology by demonstrating its usefulness and productivity quantified in indicators. Advancement of a research field is possible due to more positive attention from funders and policy makers, achieved by trust in numbers. That is how indicators may acquire the power to influence how funding is allocated. They are political means, solidifying categories “by means of which society seeks to manage itself and thereby represents itself and its values” (cited from Dahler-Larsen, 2014; referencing Vestman and Conner, 2006 & Rosanvallon, 2009).

Commensuration is one of the “most consequential uses of numbers” (Espeland & Stevens, 2008). Commensuration turns describing numbers into prescriptive ones. Commensuration attributes meaning to numbers. “Measures that initially may have been designed to describe behaviour can easily be used to judge and control it” and hence, “numbers can also exert discipline on those they depict” and “disciplinary practices define what is appropriate, normal, and to what we should aspire” (Espeland & Stevens, 2008). Foucault (1977 & 2003) links statistical practices to “*governmentality*”, a term to describe how the government uses numbers to influence citizens so that they fulfil those government’s policies. He describes discipline as “a mode of modern power that is continuous, diffuse and embedded in everyday routines” (Espeland & Stevens, 2008).

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

1.2 The Evaluation Gap

The fact that indicators commensurate, where “all difference is transformed into quantity” (Espeland & Stevens, 2008), leads to the argument that their use to assess scientific quality gives rise to an “*evaluation gap*” (see Fig. 18). This is a term coined by Wouters (2017) to acknowledge a discrepancy of what is being measured by indicators and the quality of the scientific content, as perceived by the researchers of the field. The researcher holds a different notion of quality than the indicator serves. The evaluation gap can lead to a number of questionable practices, such as goal displacement, gaming or information overload (Laudel & Gläser, 2014; Rushforth & De Rijcke, 2015). Because “measures can also alter relations of power by affecting how resources, status, knowledge and opportunities are distributed” (Espeland & Stevens, 2008), researchers may need to comply with the concept of quality implicit in the measurement (goal displacement). To reach the target set by the indicator the researcher may then take short cuts (gaming), which possibly undermine research quality, but fulfil quantitative requirements to publish (causing information overload). Negative effects of the evaluation gap on research practices are called “*unintended consequences*” of indicator use. This term is found frequently in literature on effects of performance measurement (for a list see Dahler-Larsen, 2014) and it draws back to the notion of “unanticipated consequences of purposive social action” (Merton, 1936).

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

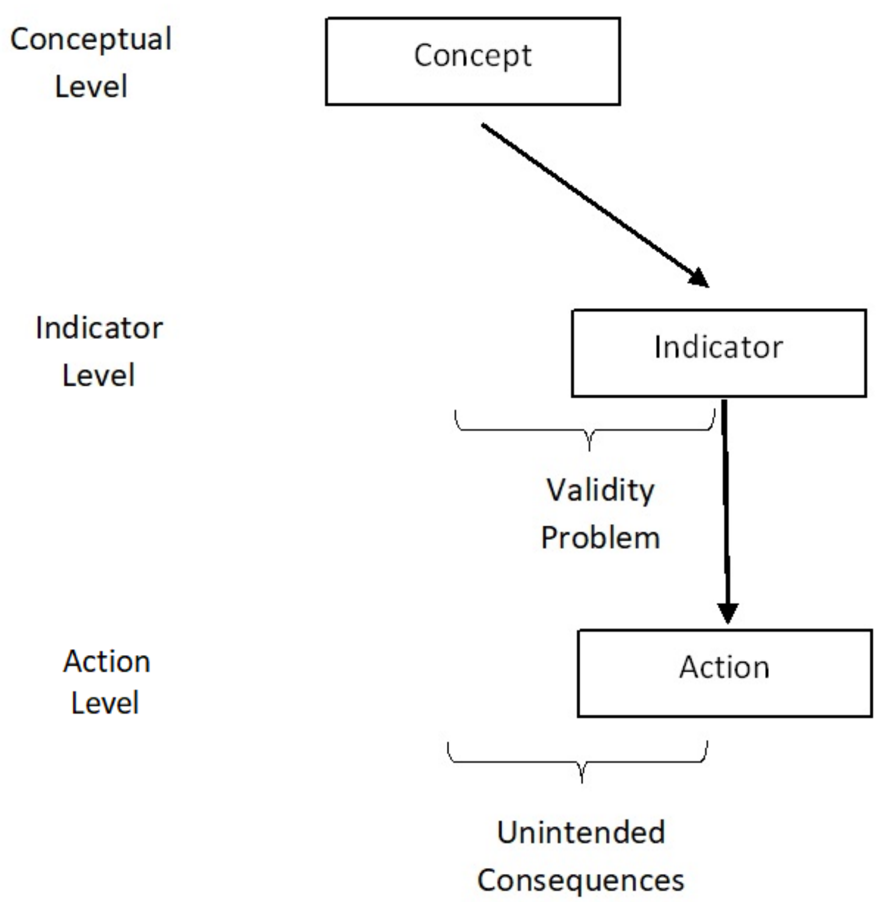


Fig. 18: *The evaluation gap as depicted by Dahler-Larsen (2014). In his paper it is called "Trivial Measure Fixation", where "the indicator is an imperfect measurement of the concept [in this paper: research quality] that is intended to measure. Despite the "validity problem" the indicator guides the action of the researchers. Due to the validity gap unintended consequences occur on the action level; the requirements of the indicator are trying to be satisfied instead of the scientists' concept of research quality.*

1.3 Constitutive Effects of Indicators

Numbers have authority and objectify, however "doing things with numbers" (Espeland & Stevens, 2008) entails a performative element. Austin's "speech act theory" ([1962] 1975) describes a specific type of utterances, so-called speech acts, that relate saying something with performing an action as such. Hence, speech acts do not simply evaluate the truth content of a statement, but they constitute an act. Analogous to that, to quantify something is always to do something, when meaning is attributed to the resulting numbers, rather than simply stating their truth content. This opens up the dichotomy between the prescribing and describing function of numbers (Desrosières, 1998). The term

DOI: 10.3217/978-3-85125-668-0-09

performativity of numbers was established in the economic sociology and in the sociology of finance (Callon, 1998; MacKenzie, 2006) to convey that statistics may not only describe social realities, but also co-constitute them. The process of turning “qualities into quantities creates new things and new relations among things” (Espeland & Stevens, 2008). “Measurement intervenes in the social worlds it depicts”, as measures are *reactive*; “they cause people to think and act differently” (Espeland & Stevens, 2008).

Dahler-Larsen (2014) suggests to depart from speaking about “unintended consequences” of indicator use and using the term “*constitutive effects*” instead (see Fig. 19). On the one hand, this conceptual move avoids the “dependency on a valid identification of intentions behind the indicators” and on the other hand it acknowledges the performative character numbers can entail. Effects of indicator use are constitutive insofar that indicators are not merely representative measures of scientific quality, but they rather shape what is considered to have value in knowledge production and therefore may exert an effect on research behaviour and content. They constitute a “reality that is put on stage so that it can be acted upon” (Desrosiéres, 1998; in Dahler-Larsen, 2014) and indicators become “the way through which the world is defined” (Dahler-Larsen, 2014). For research this means that “indicators and rewards introduced by policies shape the process of the practices they seek to describe” (Dahler-Larsen, 2014). Hence, one may assume that indicator use affects research agendas, knowledge production processes and research behaviour.

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

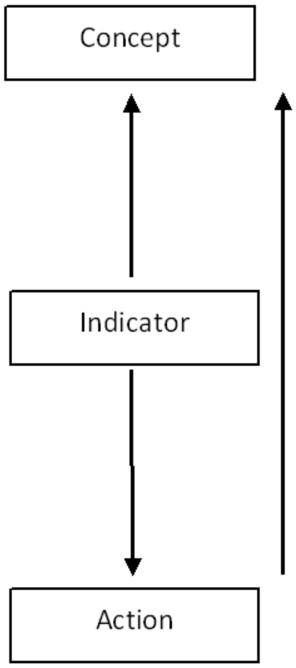


Fig. 19: *Constitutive effects as depicted by Dahler-Larsen (2014). In his paper he calls it "Advanced Measure Fixation", where indicators stand in "a constitutive relation to the reality they seek to describe". As compared to Fig. 18 there is no gap as the indicator-guided action re-shapes the concept of quality the researcher holds.*

1.4 Reconciling the Evaluation Gap and Constitutive Effects

Intentions always play a role in the processes of defining indicators and deciding on which ones to use, no matter whether they are explicit or implicit and whether they are applied in the intended way or not. By avoiding problematic assumptions about intentions, Dahler-Larsen describes constitutive effects as something that occurs to passive actors. While the evaluation gap can be criticised for not accounting for the reactivity of indicators and their potential effects on the researchers' concept of quality, the concept of constitutive effects does not leave any room for divergent notions of quality. Analysing the usefulness of both concepts raises the question whether they are necessarily alternatives or whether those two concepts can be reconciled. Dahler-Larsen (2014) recommends that "constructivists may be immediately comfortable with the idea [of constitutive effects], while rationalists and functionalists may still find value in the idea of unintended consequences." We question whether the decision which concept to use really "hinges on paradigmatic foundations" and rather propose that, when studying the reflexivity of metrics we might find

DOI: 10.3217/978-3-85125-668-0-09

value in reconciling both concepts. That reconciliation may take into account that indicator use can co-constitute concepts and values (about quality), but at the same may also set targets which diverge from intrinsic values (about quality). Testing and conceptualising this hypothesis will be part of this paper.

1.5 The case study: Why Astronomy and why Leiden Observatory?

Despite Reflexive Metrics being a relatively new field, there have been quite a few studies discussing the effects of indicator use on scientists, especially in bio-medicine and the life sciences (e.g. Hammarfelt & De Rijcke, 2014; De Rijcke et al., 2015; Rushforth & De Rijcke, 2015; Fochler et al., 2016; Kaltenbrunner & De Rijcke 2016). While life science is a more applied research field, for this study we chose a field that conducts mainly basic research in order to study effects of indicators when applications don’t play a significant role.

Astronomy (synonymous with Astrophysics) is one of the oldest sciences and according to Heidler (2011) there are 15,000–20,000 active professional astronomers worldwide. The author characterises Astrophysics as “a paradigmatic, established, basic, hard knowledge field with relatively clear disciplinary boundaries”, often following Karl Popper’s ideal of trying to develop theories that can be falsified. Paradigmatic and hard science fields typically are strongly reputation oriented, but nevertheless reflect on bibliometric measures of reputation, like the h-index (Heidler 2011). The reputation system in Astronomy is still based on individual achievements, while an increasing collaboration culture puts pressure on that system. At early career stages, decisions about who to fund and to hire, are “essentially predictions about an individual’s future achievements” (Kurtz & Henneken, 2017).

Astronomy is an interesting field to study from a meta-perspective. Astronomy asks highly fundamental questions which inspire both scientists and the public at large. It is dedicated to basic research, involves large collaborations on expensive instruments such as telescopes, and the use of (open) archives and huge datasets. The access to telescopes is generally not exclusive, although the builder (and collaborators) of the telescope usually get a share of guaranteed telescope time. Instead, the access is regulated by a peer-review system, which evaluates the prospective quality, originality and success of the project (Heidler 2011).

DOI: 10.3217/978-3-85125-668-0-09

According to Heidler (2011), the social structure of a field is influenced by both, its knowledge content and its “historically grown organizational and cultural preconditions”. While Heidler (2011) performed a study on “cognitive and social structure of the elite collaboration network of astrophysics” and Kurtz & Henneken (2017) performed a “40-year longitudinal cross-validation of citations, downloads, and peer review in astrophysics”, showing the capabilities and limitations of each measure, no study has been performed on what effects the use of metrics in research evaluation has on the knowledge production process in Astronomy.

We chose to study evaluation processes at Leiden Observatory (Sterrewacht; Leiden Astronomy institute), since it is viewed as one of the largest and top astronomical research institutes in the world. In 1998 the national Astronomy proposal “Astrophysics: unravelling the history of the universe” was rated first by the Netherlands Organization for Research (NWO). This proposal was submitted under the umbrella of the Nerderlands Onderzoekschool voor Astrononomie (NOVA). It is the alliance of the four university Astronomy institutes in the Netherlands – the Universities of Amsterdam, Groningen, Leiden and the Radboud University Nijmegen – and was rated as top research school in 1998. As a result of the proposal NOVA was guaranteed baseline funding from the Dutch Ministry for Education for 1999 to 2005. Since then this “NOVA grant” has been renewed every 5 years. The grant has been the basis for support of “normal” research activities and the participation in numerous programmes for the construction of astronomical instrumentation. This enabled Leiden to build on its long tradition of radio-interferometry, by getting heavily involved with instrumentation for European Southern Observatory’s (ESO) facilities, securing priority access for conducting observations. Additionally, Leiden hosts the world famous Sackler Laboratory that bridges Astronomy, physics, chemistry and biology. Leiden Observatory is an international environment; many students, postdocs and staff come from abroad. The institute has close collaboration ties with other Astronomy institutes in Europe and the U.S. and hosts visitors from across the globe.

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

2. Methods

The use of metrics to evaluate science opens up a whole series of topics that have found attention in the sociology of quantification. From the way how indicators can provide accountability and enable governmentality to different notions of reactivity, such as unintended consequences or constitutive effects. Espeland & Stevens (2008) point out that "the capacity of measures to discipline" is another "distinctive form of reactivity". Performativity of numbers with attributed meaning is the reason why studying the effects of indicator use is relevant in the social sciences. This paper studies the extent of the indicators' influences on knowledge production processes and research behaviour in Astronomy, including the following research questions: What (perceived) effects do indicators have on the quality of knowledge content? Can the influences be described as unintended consequences or rather constitutive effects? Or must those two concepts be reconciled? What is the relationship between the evaluation gap and constitutive effects?

In this study we classify "research evaluation" as any kind of evaluative process or situation that an astronomer is faced with, which is important for them to continue their research or their career. The career system, funding system and publication system are regarded as different aspects of the evaluation system.

The research questions were tackled by conducting interviews and a document analysis at the Centre for Science and Technology Studies (CWTS) under the supervision of Sarah de Rijcke. Since it regards itself as an elite institute and is listed among the best astronomy institutes in the world, the Sterrewacht makes a good case study of what effects research evaluation has on the knowledge production process and research behaviour. The author graduated from Leiden Observatory in 2015, so she had easy access to the institute. Ten researchers were invited to be interviewed for this study via email. This sample was selected such that it includes scientists in different career stages and from a variety of nations. The Master programme at the Sterrewacht is very research intensive, requiring the students to write two Master theses in total, which is the reason why they are also interesting subjects for this study. From the ten researchers, nine replied positively, which led to semi-structured interviews with four faculty members, two postdocs, one PhD candidate and two Master students.

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

In order to investigate a potential evaluation gap, questions were developed such that an astronomer's definition of quality versus what is measured by indicators can be studied. Topics included career steps, project funding, exposure to assessments, research evaluation, the publication and funding system, different stages of the knowledge production process – from planning, via doing the research to publishing – and the meaning of quality. Each topic was introduced by one overarching question, followed by several potential follow-up questions.

Subsequently, all names were pseudonymized. All interviews, 80-100 minutes in length, were fully transcribed into electronic form, coded and summarised. These codes represent themes which emerged by combining sensitivity towards existing literature on constitutive effects of indicator use with insights from our data. As for the investigation of the astronomers' notion of quality bottom-up coding was applied. To study what constitutive effects indicator use has on Astronomy, top-down coding was done on the basis of five domains of constitutive effects which Dahler-Larsen (2014) carved out. The interview questions and codes can be found in *Table S-1 & Table S-2* of the supplementary material.

The interview data were complemented with a document analysis of materials collected online or made available via the informants, including CVs of the interviewed researchers, annual reports and (self-) evaluation reports of the Dutch Astronomy institutes and their umbrella organisation NOVA. The annual public reports were authored by the respective director of the institute and the collection used in this research comprises those written for the years 1998 to 2015 (hereafter; Annual report[1998]- Annual report[2015]). Institute evaluation protocols for the evaluation period 2010-2015 (hereafter, Evaluation protocol[2010-2015]) were authored by an external committee and self-assessment protocols (same period; hereafter, NOVA self-assessment[2010-2015] & LU self-assessment[2010-2015]) were written by NOVA and the institute as a preparation for the evaluation. Those (self-)evaluation reports are particularly interesting as they compare the Sterrewacht with their national and international counterparts and explicate by which standards successful research is measured in Astronomy. Comparing the official documents with the interviews gives insights into what is valued by evaluation practices as compared to what astronomers value in doing their everyday research. Hence, evaluation documents can help identifying an evaluation gap and constitutive effects.

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

This article summarises the results while the complete report of this project can be found on ArXiv[1]). Direct quotes of the interviewees will be given between double quotation marks.

3 Results

3.1 What is scientific quality for an astronomer?

In order to understand the extent of a potential evaluation gap and how indicators shape knowledge production in Astronomy, we must investigate the intrinsic values and general motivation of astronomers and compare this with what is required by the evaluation system. Only if we know what research quality means for an astronomer, we can investigate whether indicators have constitutive effects on quality.

Our document analysis gives insights into various strategies on how Leiden Observatory maintains its "success" and how that success is evaluated and measured, both in qualitative and in quantitative terms. What we are missing from the reports is an answer to the question who defines quality and if the described measures can satisfy that definition. NOVA claims "*the first part of its strategy [to ensure a front-line role in Astronomy] is to foster an intellectually rich and vibrant scientific atmosphere which allows astronomers to pursue their ideas and push scientific boundaries, and in which young scientists can develop and grow*." This sounds great in theory, but we question, whether individual researchers feel that "success" as defined in the evaluation protocols actually allows such a "vibrant scientific atmosphere" and out-of-the-box thinking in practice.

The study found that astronomers generally conduct science for the sake of "curiosity" and "pushing knowledge forward" (e.g. PhD Candidate, Faculty Member 4), that is searching for the truth and discovering structures of nature. Astronomers are realists, who assume a reality independent from the observer, arising from (physical) causal laws. As Astronomy is the study of the universe and its building blocks, it seeks to answer the most 'fundamental' questions to set a basis for the 'truth of everything'.

1. *https://arxiv.org/abs/1801.08033*

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

> "But that moment of – you know – mystery, that is a scientific experience in the sense that there is only one thing that you accept in that moment, that's the *truth*, you want to know the *real answer*. And no excuses, only the real answer matters. And that is what *drives science*; we only want to know the real answer." (Faculty Member 1)

The notion of truth and the quest to push knowledge forward both result from the astronomers' curiosity to understand the universe, which all interviewees uttered as their motivation to become an astronomer. Astronomer's intrinsic motivation is to "know and to understand better" (Postdoc 1).

> "I mean [my driver is] the journey and not the arrival, basically. […] It's just simply that it feels good. And in German they have a word for that, they call it the 'Aha-Erlebnis', the 'Oh, is that so'-feeling." (Faculty Member 3)

From the astronomers' notion of truth and their motivation to discover follows that high quality in research means that there is a correspondence between reality and the scientific theory (also compare with citation of Faculty Member 1 above). For a realist, truth and scientific quality are 'objective' and it implies scientific integrity.

> "I think in terms of what constitutes *good science* and what is *academic integrity*, all those things don't change – they are pretty close to *absolute values* I would say." (Faculty Member 2)

However, what does an astronomer define as a discovery? The research has to "be something new" (Postdoc 1) to push knowledge forward. This ranges from "trying to solve a problem, no matter what the problem is" (Postdoc 1) to "asking an important question" (Faculty Member 1) and having the means to solve the problem. Solving those problems doesn't only serve the astronomer's intrinsic motivation, but also, in their view, has a high relevance for society and other academic fields.

> "The inspiration that Astronomy brings and the fundamental questions it raises about the nature of everything and the place of humanity in the universe, makes it natural for us to engage with fellow intellectuals in seeking connections between arts, humanities, and science." (NOVA self-assessment[2010-2015])

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

"Science that drives the [knowledge] forward, is science that serves society." (Faculty Member 3)

The interviewees display consensus about the importance of Astronomy with respect to this mission. However, when asked for a more objective definition of what an "important question" is, the astronomer admits controversy:

"That is […] difficult to answer, because if you have 5 referees, they will all have different preferences for what is important and what is not important." (Faculty Member 1)

However, astronomers do agree that there is a difference between "making progress on an important issue" and "valorisation":

"Well, academic quality I think has always been relatively clear. It has to be verifiable and clear, unbiased etc. I think that is academic quality. But there is these days … a tendency to look at the value of science in terms of economic output, it's called 'valorisation'. And I am totally uninterested in that I have to say. It is nice if you can […] use some things… It is always nice if you find applications that are useful and that can actually make you profit even. Why not? But that's not why we do it. And the importance of that is overstated these days. And I don't think that is actually productive." (Faculty Member 1)

Here we can see again the high value of "truth" for an astronomer. Truth matters for its own sake. Applications are opportunity driven, but not the goal of the research. Hence scientific quality in the eyes of the individual researcher is independent of its potential to lead to applications for industry. Societal relevance however, in the eyes of an astronomer, arises self-evidently from the fundamental questions Astronomy gives answers to.

The last quote hints at another aspect of scientific quality, which follows from the astronomers' demand of good correspondence between discovery and reality: using sound scientific methods.

"I guess [good quality research is] if you followed the methods as best as you can – like to the best ability and take everything into account and thoroughly test your results and outcomes to make sure that they are as concrete and solid as they can be before even throwing them out to the general populous … Part of it also is, if you have high quality data, it can be easier to do high quality research, so erm, that too." (Master Student 2)

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

Hence, for good quality research “important questions” need to be answered by robust and careful research. This involves thorough methods, which ideally take all possible factors, assumptions and biases into account and sufficient testing of the methods and results before publishing. However, those criteria are yet not enough to satisfy an astronomer’s account for high quality research: Conclusions that push knowledge forward must not only describe ‘reality’ but must also be “rememberable” (Postdoc 2) and communicated well:

> “And you have written a paper which demonstrates you have answered that question […] And you have written it in such way that a non-expert in that field can read it and understand what you have done. They may not understand the details, they may not understand the algorithms, but I think high quality research is: You can pick up – a good paper – any Astronomy paper, read the abstract, read the introduction, read the conclusions and know what they did. And why they cared. And you may not know the shear statistics of galaxies of redshifts 2, but good quality research will give you the background and give the context which you should be able to understand. As a scientist you understand it. If it’s a crap written paper, then that’s crap research – I don’t care how brilliant the answer is, if they can’t communicate it through a paper or through a presentation, then that’s bad research. […] Yeah, I’d say that means high quality. They are able to write and present a compelling scientific argument from start to finish, that any reasonably trained human being can read and think about, you know.” (Faculty Member 4)

In summary, the study found that the astronomer’s definition of high quality research is based on three criteria:

1. Asking an important question for the sake of understanding the universe better and to push knowledge forward.

2. Using clear, verifiable and sound methodology.

3. Clear communication of the results in order for the community to make use of them.

As obvious as that definition may seem to an astronomer, interviewees admit that there is no easy answer to the question how it can be measured, whether those quality criteria are fulfilled. After all, “scientific quality is hard to measure, and numbers are easy to look at” (Benedictus & Miedema, 2016). That is why indicators serve as proxies to evaluate scientific quality and performance. In order to compare criteria applied in evaluation

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

procedures with astronomers' intrinsic motivation and what they value as quality research, the study investigated what the funding, publication and career systems value and which indicators are used, according to the astronomers. These findings will be explicated in the following section.

3.2 The Evaluation Gap in Astronomy

The former section presented the study's results of what an astronomer values in research quality. Now we will look at what astronomers perceive that is valued in the evaluation system. Only when we know more about the extent of the overlap we can investigate what effects indicator use in evaluation has on knowledge production and scientific quality, which is the aim of this study. We will start this section by giving insights into what our document analysis reveals about the Sterrewacht's strategies to maintain its success, since they likely affect targets that Leiden astronomers need to strive for. Leiden Observatory is ranked among the best Astronomy institutes in the world (Evaluation protocol[2010-2015]). The Sterrewacht is keen on maintaining that status by following NOVA's objective to "*ensure a front-line role in the next generation of astronomical discoveries*". NOVA intends to fulfil this objective by following its mission, which is to "*carry-out front-line astronomical research, to train young astronomers at the highest international levels, and to share discoveries with society.*" Leiden Observatory has three missions, which are well-aligned with NOVA's overarching one:

1. The Sterrewacht's educational mission is to "*to provide excellent education at the bachelor and master level, not only to prepare students for PhD projects, but also for the general job market.*"
2. Research at the forefront of modern Astronomy, including collaborations with Dutch partners such as TNO Delft, Dutch Space and the Sterrewacht's vicinity to ESA's ESTEC (Technical facility of the European Space Agency), enabling "*astronomers [to be] among the first to use the instrument, thus reaping the hottest early science harvest.*"
3. The Sterrewacht follows an outreach & education mission. Since "*Astronomy has a strong appeal to the general public*" (LU self-assessment[2010-2015]), all staff and students "*spend considerable time and effort to explain the exciting results of Astronomy to the general public, in the form of lectures, press releases and newspaper articles, courses, public days and tours at the old observatory complex, and input to television and radio programs.*"

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

Institute evaluations take place every five years by an Evaluation Board (EB). The committee's review is part of the assessment system for all publicly funded Dutch research organizations, according to the Standard Evaluation Protocol (SEP). The SEP consists of three criteria: (i) Research quality, (ii) Societal relevance, and (iii) Viability. The scope of the assessment is set by the Terms of Reference (ToR), which in this case is the information provided by the self-assessment documents of the individual Astronomy institutes and NOVA as a whole. These documents are a description of the institute's mission, objectives and results. In addition, the EB conducts interviews with management, the research leaders, staff members, and PhD candidates.

In addition to the self-assessments prior institutional evaluations and those evaluations, Leiden Observatory measures its scientific productivity with certain "performance indicators" measuring the productivity of staff members and students: "*During the reporting period 2010-2015 Leiden Observatory thrived; its scientific production, measured in terms of number of papers, citations, PhD candidates and postdocs and the amount of grant money awarded, has never been so large*" (LU self-assessment[2010-2015]). The Sterrewacht calls them "objective" as they are quantitative and they include:

• **Publications:** Total number of refereed papers.

• **Citation rates:** including 24 citation parameters (e.g. number of citations, number of normalised citations, number of normalised first author citations)

• **PhD theses**

• **External grants and prizes**

• **Outreach activities:** The performance of its outreach programme is measured by the large numbers of press releases, articles, attendees, teachers and children reached through its various activities.

• **International leadership:** International visibility of Leiden Astronomers and their leadership roles in organisations and committees.

• **Instrumentation programme:** A key indicator of the success here is the on-time, on-budget and within specification delivery of instrumentation (co-)built by NOVA. Another positive measure is the frequent invitations for international collaborations and the number of successful spin-off projects.

In addition to the performance indicators, “excellence” is a rising buzzword to measure the success of institutes and researchers (Sørensen et al., 2015). The Sterrewacht “*believes that their success in winning international research funding demonstrates that their staff is of* high calibre *and has the drive and commitment to continue excelling. […] Their staff and the faculty board agree that excellence will be the most important hiring criterion.*”

The Sterrewacht commits itself to the missions and strategies described above, because the institute’s key goal is to “*maintain the present high level of achievement and to continue to score very well in international competitions for observing time at space observatories and on the ground, as well as for research grants.*”

The funding that the institute receives is comprised of baseline-funding from Leiden University and from NOVA. How much money the university allocates to each institute depends on a formula, which is called *“Allocatie Eerste Geldstroom”* (AEG):

> “So what we get from the university is determined by how well we have done over the last few years in terms of how many grants, how many PhD candidates, how much teaching we have done. It’s kind of an arrhythmic model that determines how much you get over the next year, it’s kind of a 3 year average.” (Faculty Member 2)

The amount of money that the university receives from the government is based on a similar formula. This model makes the institute very autonomous, but at the same time responsible for paying their staff. In addition to baseline-funding, the Sterrewacht vaunts the high number of external research grants acquired by individual staff members. The main funding agencies include the NWO and the EU European Research Council (ERC). The observatory reported already in 2009 (Annual report2009) that

> “*university funding is changing as a result of external pressures. There is more and more emphasis on temporary, project-based funding, threatening the structural long-term funding that is needed as the basis of a healthy scientific institute. Keeping up our success in funding applications is therefore vital.*”

This will become especially true during the next years when the continuation of the NOVA grant is running out in 2023 and NOVA needs to find a different source of funding. Outside grants are also “needed to fund graduate students” (Faculty Member 4) who are the ‘working horses’ of the system:

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

> "[…] if you have money that means that you have also, that you have labour, that you have the effort available. And of course in exchange we need to define a little piece of science that that student can do as part of his PhD." (Faculty Member 1)

Grants are limited and very competitive. Money available for research is finite and so proposals need to fulfil certain criteria in order to be successful in acquiring grants. Advertising the so-called *"sexy topics"* are highly valued when the government and funding agencies decide which research proposal to fund. The interviewees frequently report that "the funding system is very much oriented towards the fashion of the day" as opposed to also "extremely important" topics that are "more pedestrian/ basic" (Faculty Member 1). Promising "impact" is important to acquire external funding and improving the AEG:

> "So the impact is very important, because if [the evaluation committee] had said that we are doing so-so or it is a field in decline or an institute that are not doing things right the university can start reallocating their priorities [as in funding]." (Faculty Member 2)

The potential impact of a research project is often estimated on basis of the recognition a scientist has gained, due to the common assumption that past achievements determine future outcomes (e.g. Kurtz & Henneken, 2017; Merton, 1968 & 1988). Achievement is measured in terms of quantitative indicators, such as publication- & citation rates, impact factors and the number of acquired grants or other "performance indicators" as described above. Given that such achievements determine an Astronomer's recognition and that recognition is needed to acquire more funding, we observe a *Matthew effect* in in Astronomy. This effect, the "Chicken-or-egg problem" (Faculty Member 1), means that past output determines future success (Merton, 1968 & 1988). The prevalence of the Matthew effect is frequently reported by interviewees, for example:

> "The funding system is mostly … Mostly looks at your *past achievements*, right? So much of what determines whether you get your next grant is what you did with the previous one, so … how that's evaluated or viewed, or judged, or measured is key." (Faculty Member 2)

> "Erm … the funding agencies have a tendency of – where the money follows the reputation. And strangely enough, it's not totally inappropriate that money follows

> reputation. Erm, it is in a sense *Darwinian*, I mean something has success and therefore you should feed it, you should support it." (Faculty Member 3)

While serving the "fashion of the day" and promising impact seem to be the basis criteria for a successful grant application, the selecting process isn't very transparent and often depends on luck. According to Faculty Member 3, a career in Astronomy is "90% luck and 10% hard work" and this is partly because receiving funding depends on chance.

> "But … I think the biggest problem of the funding system how it is now, is that there is so little money available, that the selection problem is … I would say almost random, not completely random, but you could have a very good project and very robust project but not been given the money, because there are just too many." (Postdoc 2)

> "So you are good enough, that you know it's a good proposal. And you are now rolling the dice. You are just waiting for …. It will come down to: One person didn't have their chocolate biscuit in the morning and they are grumpy and they dinged you for not being concise enough." (Faculty Member 4)

This randomness in allocation of funding is what astronomers call the "TAC-Shot-Noise" (Faculty Member 4), which stands for "Time Allocation Committee"-Shot-Noise. The word 'time' here instead of 'funding' indicates that committees that grant observing time base their decisions on the same criteria as funding agencies. The interviewees make no difference between grants in terms of observing time and research money when talking about the funding system. In Astrophysics, having been granted observing time is generally as prestigious and important for one's career as funding. That grants are often based on luck generates a lot of (psychological) stress for applicants. Other consequences of this "rolling the dice" technique include tense competition and risk aversion to not lose out on impact. These (constitutive) effects of indicator use will be discussed in the next section. Despite the luck aspect, prestige and reputation are vital for receiving grants/ telescope time and career advancement due to the Matthew effect. The most prominent form of output are *first-author publications*, which are the capital of every astronomer. When an interviewee talks about "having a paper" or "publishing a paper" it is generally implied that that person is first author on that paper. Interviewees emphasise not only the importance of publishing, but also the "emergency" to do so, which results from a pressure to publish, another (constitutive) effect of indicator use, discussed in the next section.

> "Before you have a tenure job, you've got to make an impression and demonstrate that you can produce papers in a reasonably rapid fashion." (Faculty Member 4)

> "You always want to be the fastest and want to have your results out. But it's not really a deadline, it's more an *emergency*." (Postdoc 2)

While some astronomers claim that "everything that is not obviously wrong is publishable" (Faculty Member 1) other interviewees relativize this: "It's not sufficient to be true. It has to be true and pushing knowledge" (Faculty Member 4). This still matches with the astronomer's values, as generating output in the form of disseminating knowledge, including informing the public, is important for an astronomer. As elaborated in the former section, discoveries matter for their own sake and resulting applications are merely a bonus. However, the EB criticizes that "*valorisation seems to be opportunity driven, rather than to derive from pre-determined strategy.*" Hence, while the evaluation system demands for more directly applicable output to demonstrate society relevance of the research, astronomers do not intrinsically strive for such output.

Furthermore, what fulfils that criterion of 'being publishable' is often open to interpretation, so lies in the eye of the reviewer. Often it also depends on the research field. In the field of exoplanets, a detection with the right method (e.g. direct imaging as opposed to radial velocity) can be enough to publish already without interpretation or analysis. In the field of Radio-Astronomy that is the same case, as detections through long wavelengths are extremely difficult. Hence, in some observational Astronomy fields a *sole detection* is highly valued by journals and reviewers.

However, in observational Astronomy, *non-detections* are much more frequent than detections and about 90% cannot get published (Postdoc 1). Unless the non-detection can 'add to new knowledge' by having been able to calculate upper limits or demonstrate anomalies, they are not publishable:

> "[Negative results are not publishable], unless you have a very good, as in for example the way we sort of explained the upper limits with the non-detection. […] *The problem is how to tailor it, right?* […] So, yeah, unless you have … like a good way, I mean there is some research that published non-detection – for exoplanets sometimes they publish it when they didn't detect it, because sometimes you sort of predict that it should be there … […] And it's an anomaly or something like that …

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

> […] So there are some ways to publish this, but I think it's very … like 10%. There is a whole 90% that doesn't get published and sometimes, like for example, if you just had bad weather, then it's very difficult, right?" (Postdoc 1)

In summary, to survive the climb up the career ladder, an astronomer has to acquire recognition on basis of quantitative indicators and publish enough first author papers. The ranking of the universities of previous job positions influences further career development. The Matthew effect leads to a "Golden Child Trajectory" (Faculty Member 4), where the 'ideal' career in Astronomy is a straightforward climb of the tenure track. This often involves committing to a professional life in the hamster wheel of the "cycle of observing, analysis and publishing" (Faculty Member 1).

From this investigation of values two opposite notions of science emerge. The first is the astronomer's "ideal" image of science (e.g. Postdoc 2), where astronomers are driven by their curiosity and the search for truth, limited only by epistemic restrictions such as technical possibilities, which was described in *Section 3.1*. The other notion is the image of a "system" of science, constituted by evaluation practices, such as indicator use, with values that are not in line with the astronomer's intrinsic values.

> "You [wouldn't be] bothered with the raw numbers. I have [*number taken out in order to assure anonymity*] refereed publications and [this] would probably be a lot smaller if your publication rate wasn't so important. […] Yeah, I have my doubts about the usefulness of that *system*." And: "Well, once again, I am not that happy with that cycle. It can put a lot of pressure. And I am trying to ignore that pressure now. I mean I am [above 50; *number taken out in order to assure anonymity*], so my career is established, let's put it that way, so I don't need to prove myself anymore, so I can safely ignore that pressure. But I think that younger people who still have to make that career have to work according to that *system* and I am not quite sure that that is actually a good thing." (Faculty Member 1)

> "The problem is – this is the main thing, right – if you wanna have a job later on, you are gonna a have to have papers, because that's how it works. Even though I don't like the *system*, I don't like the way it is, it is what it is and you have to adapt to it." And: "It's the same issue, it's the same thing … It's a *system* problem I think. Erm, I try to do quality research, but I do feel sometimes that I end up publishing because I have to publish." (Postdoc 1)

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

The discrepancy between those two notions of science gives rise to the evaluation gap. Therefore, we can say that constitutive effects of indicator use generate the evaluation gap; indicator use leads to a concept of quality which is not the same as astronomers would define it. In turn, the presence of the evaluation gap has shaping consequences on the research behaviour and knowledge production in Astronomy. Fig. 20 illustrates the evaluation gap and its constitutive effects on motivation and identity. Those effects are outlined in the following section.

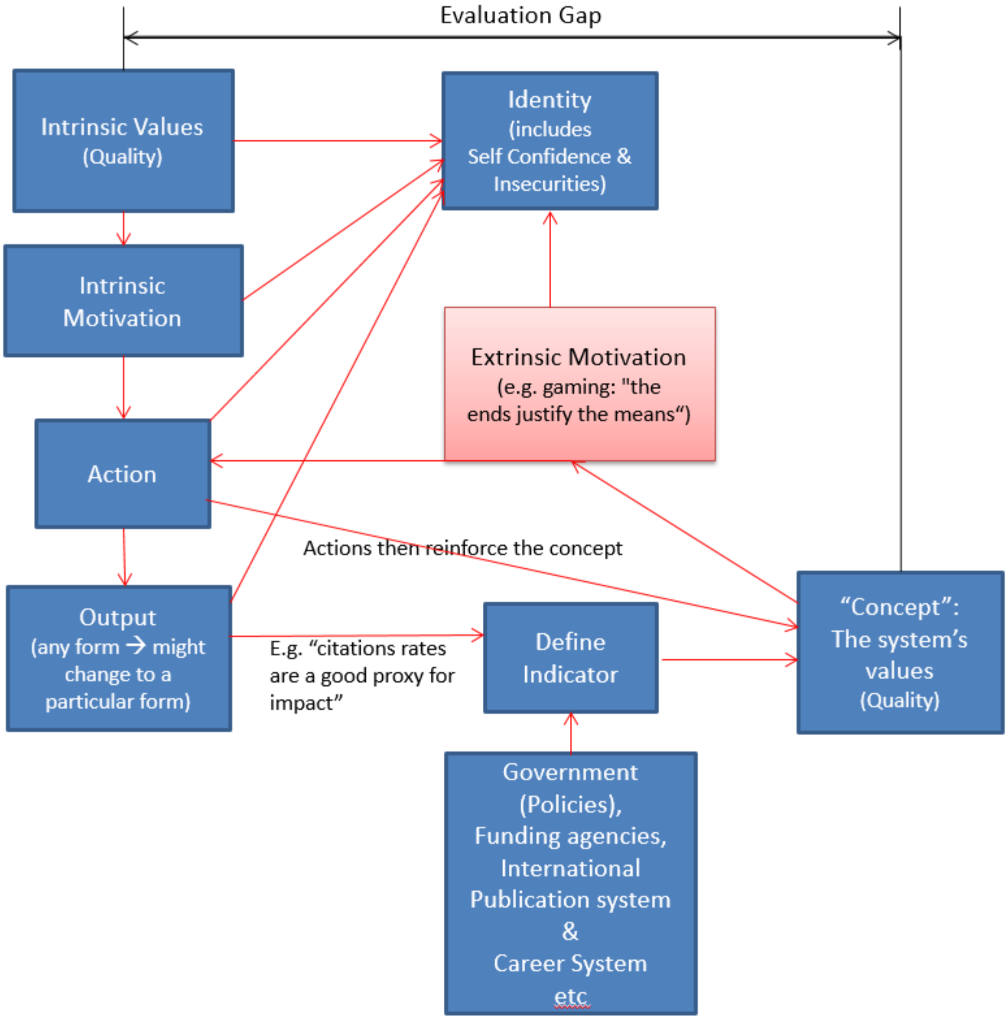


***Fig. 20:** This figure illustrates the evaluation gap and constitutive effects in Astronomy. The cycle starts with the astronomer's intrinsic values and shows what constitutive effects (red arrows) each element has. Because the system does not have constitutive effects on the astronomer's intrinsic values, it also does not influence their intrinsic motivation. The evaluation gap between what an astronomer values and what is actually measured has constitutive effects on the astronomer's identity in form of psychological effects, for example feelings of unworthiness, as outlined in the next section.*

3.3 Constitutive effects of indicators on knowledge production in Astronomy

We have found that performance indicators in research in Astronomy do not reflect the astronomer's definition of research quality. That gives rise to an evaluation gap, which, as we found, have consequences (i.e. "formative effects"; Dahler-Larsen, 2014) on research behaviour and knowledge production. Because those consequences are formative, they are *constitutive in their effects*. The indicator then stands in "a constitutive relation to the reality it seeks to describe" (Dahler-Larsen, 2014). Meaning is being constructed (e.g. citation rates equals impact) and practices are being established ("pushing publications"; e.g. Postdoc 1 & Faculty Member 4). Without being exhaustive, Dahler-Larsen (2014) distinguishes between five main categories of constitutive effects of indicators: indicators define interpretive frames and world views (*A*), social relations and identities (*B*), content (*C*), time frames (*D*) and change in their meaning as a consequence of their use (*E*). This section will portray constitutive effects arising from the evaluation gap in Astronomy and relate them to one or more of those categories (performed by top-down coding).

According to this study's interviewees, output in the form of papers and its quality assessment through quantitative indicators such as publication & citation rates, defines the value of an astronomer (*B*). The increasingly limited number of jobs the higher up the career ladder, introduces a highly competitive "rat race" and "postdoc circus" (Faculty Member 2 & Faculty Member 1). Astronomers need to need to acquire recognition in the form of quantitatively measurable output to establish themselves in the community.

> "It's just because there is so much competition, that the first filter you go into is how many papers you have. Doesn't matter how good or bad «laughing» they don't check this that much." (Postdoc1)

The need for this kind of output to survive "filters" on the career ladder ("publish-or-perish" e.g. Master Student 2 & Faculty Member1), however, causes pressure (*D*).

> "And I don't know … I think also if there was less pressure … Financial pressure to conduct research, people would not have to resort to stupid tricks. And trying to make themselves appear more … high quality researchers than they are by for example publish too many papers or publishing wrong things or hasty or too

> quickly without taking too much care. I think indeed, the lack of funding is … is hurting the research quality. Not really in the sense that we don't have enough money to do all the research that we want, but it's affecting the research that is being done, by *sacrificing quality for efficiency*." (Postdoc 2)

Publication pressure is always "at the back" of an astronomer's mind (Postdoc 1) and the pressure may increase when one or more of the following factors are present, because they define the time-frame of publishing (*D*):

• First, when the astronomer faces head-on competition, there is a *race for priority*, which pushes the researcher to "publish as fast as I can … as soon as I get the data" (Postdoc 1).

• Second, timescales of projects and publishing are "tied to the *timescale of [PhD] students and postdocs*" (Faculty Member 2), because "they need to get their thesis chapters out. They need to be ready for the job application season".

• Third, *telescope application deadlines* are perceived as "natural" deadlines (e.g. Faculty Member 2) for publications, as performance indicators such as the publication rate are part of the assessment criteria for observation time allocation.

Publication pressure may have psychological effects, such as demotivation, discouragement and feelings of unworthiness, on the researcher (*B*) and constitutive effects on the (quality of the) content (*C*). The latter may include cutting up publications in order to publish more ('salami slicing'), premature publishing, and non-replicable papers (*C*).

> "From looking at people who are doing PhDs, erm, you know there is still, they are in on weekends, they are doing more than 8 hour days, they are doing more than 40 hour weeks. You know, they don't take the full amount of holidays allocated to them, which I didn't realise. […] As much as I have been told, that this university really encourages you to have a life outside your PhD, I see very few examples of that. And the examples of that, that I see, are people who […] basically don't let themselves be *bullied by their supervisor* into feeling that they have to do all of this additional work. Some people are happy with this, but I don't want my entire life to be one thing …because it causes me *too much stress for my entire life to be in academia*. […] I think I figured out that it would be *constantly proving that I was good enough*. Constantly proving that I was worth the money, constantly proving that, you know, I

DOI: 10.3217/978-3-85125-668-0-09

was worth the time and the energy and all of that and that sounded exhausting before I even started it. And sounded like I would constantly be battling with feeling I am not good enough, while trying to tell other people that I was good enough. And I kind of went 'No' – and I am not – I know, there is gonna be an element of that in jobs as well, but I feel a little bit, in a job, at least there should be a break, like this is 9-to-5 or whatever. And then I can go home and I can leave it there. Whereas with academia, it's kind of like, yeah you can go home, but then you are getting emails, until maybe 20:00 or 21:00 in the evenings and still doing things." (Master Student 2)

"I think sometimes yes, the pressure to publish has forced us to sometimes push out results, where having another observation or two would make a significant improvement on the current results." (Faculty Member 4)

"[…] they would skip some tests, obvious tests, that they could have done, but that maybe take a bit of time, or that they use a method without properly characterising the biases or the assumptions that are used behind this method. " (Postdoc 2)

"As an observational person you should be able to publish all your data reduction scripts from start to finish. It spits out the output files, which you see in the paper and then somebody else can come along. And I know the reason why is that: There is a fear that, because you made it easy for other people to check your code, other people can find your bugs more easily and so you may get criticized for having buggy code over somebody who never publishes their code and bugs are hidden for years and years and years. There is no incentive at the moment to publish the code."(Faculty Member 4)

"And to be fair, it's mainly because if you want to have a paper, it has to be something new. Sort of. So you are not going to be publishing, checking that someone else's work is fine. That's not gonna give you a paper. You have to either find that something is wrong on the paper or you have to find the same and something more, right? Like, adding to it. So I don't know how much gets checked. I don't think a lot. But I do think if you read a paper and try to reproduce it, it's not very easy from a paper." (Postdoc 1)

In most cases, according to the interviewees, those effects have a negative effect on research quality. Publication pressure however, can also have positive effects, focusing and confining the research question. Salami slicing can be beneficial for good communication and readability of research results. The interviewees, however, remarked that often results are difficult to replicate. This is because of the lack of incentives to

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

publish information needed for replication, such as code used for analysis and a lack of incentives for reviewers and no dedicated time frame for the reviewing process (*D*). Prematurely published information or insufficiently reviewed papers make output even less readable and reproducible, reducing content quality (*C*).

Quantitative indicators define the landscape of success and its inverse: the landscape of failure (*A*). The interviewees have a hard time defining ‘failed research’, due to the very risky nature of research. They are only confident to describe what bad research is – the opposite of good quality research according to their definition (i.e. the three criteria). In contrast, the community and the system do have a definition of failed research, viz. the opposite of successful research as measured by indicators. The use of indicators then causes a shift in what counts as new discoveries in the community, from “anything new” (e.g. Master Student 1 & Postdoc 1) to “publishable results” (e.g. Master Student 1, Faculty Member 2 & 4). Hence, as long as negative results (e.g. non-detections) can’t be put in a context (“tailoring”; Postdoc 1) where they become publishable, they are regarded as worthless: the research project failed and the researcher feels like a failure (*A, B*). This is despite the fact that in many fields in Astronomy non-detections are far more common than detections. Because those are hardly made public, astronomers express their frustration with the ‘wheel being reinvented’ and hence resources wasted. Especially young researchers can’t afford to take on too risky research projects, which causes risk aversion (‘playing it safe’; Stephan, 2012) and a tendency to prefer sexy topics to equally important non-sexy ones. This again has effects on research agendas and content (*C*).

> “These young folks are scared! They are afraid! […] And you know what, that is ultimately bad. This is ultimately bad, because in such a science where you know, ignorance is so big, being scared is not the right thing to be. […] You get results by your brains, your hands, by the collaboration with your colleagues and stuff, but you have to have a sort of courage. And it is *bread out of the young people*. Because they are not rewarded for their courage. And I find that very, very, *very bothersome*. That generation – people growing up like that. How are you ever, ever, ever going to understand the universe if you don’t have courage?” (Faculty Member 3)

DOI: 10.3217/978-3-85125-668-0-09

Thus, the evaluation system undermines astronomers' values by putting a (too) strong focus on quantitative indicators. As a consequence, an astronomer's motivation also shifts to an output orientation where safe and accessible projects become the driver. While "the publication is not the aim – [it] is a means to showing what your methodology is" (Faculty Member 2) it does become an aim. Producing high quality research "to know and understand better" and communicating this knowledge to the community is what makes up an astronomer's intrinsic motivation to conduct research. However, the need to survive the climb up the career ladder gives an extrinsic motivation to perform research, which is oriented towards hitting the required targets (*B, E*).

> "And ahh … if [publishing] was not so important [to keep your standing] … I mean I would still publish my papers [but] it *gives a different motivation* to it, right? As a scientist you just want to publish your papers, because you are a scientist and you think this is important for science: 'This is the result, this is what defines the process of science'."
>
> (Faculty Member 1)

The Sterrewacht as an elite institute is such a compelling case since its mission to maintain its success, which is largely measured by indicators (as listed above) provides the right conditions for an evaluation gap. A higher pressure to achieve targets may lead to astronomers adapting their definition of quality to what the evaluation system measures in order to survive in the system. That is why it is all the more interesting that, even under the conditions set by an elite institute, we found that the astronomer's definition of quality remains unchanged. In other words, the results also show that, while indicators give an extrinsic motivation to an astronomer to perform, their constitutive effects do not reach as far as to affect an astronomer's intrinsic values to a noteworthy extent (see Fig. 20). This is the reason why the "ideal" and the "system" accounts of science do not conflate and astronomers try to serve both – evaluation gap remains.

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

3.4 The Balance Act – Reconciling the concepts ‘Evaluation Gap’ and ‘Constitutive Effects’

In the previous sections, we outlined how the discrepancy between what astronomers value as scientific quality and what they perceive what indicators measure constitutes an evaluation gap. This evaluation gap, in turn, has constitutive effects on researcher’s motivation and the knowledge production process, including the resulting research quality. However, since the interviewees try to serve both imperatives, the “ideal” and the “system” one, at the same time, we could not observe any substantial constitutive effects of indicator use on the astronomer’s intrinsic values and motivation. As a consequence, the two notions do not conflate and indicators are not the only “way through which the world is defined” (Dahler-Larsen, 2014). This is the reason why, at least in the case of Astronomy, it makes sense to use both concepts, the ‘evaluation gap’ and ‘constitutive effects’ in order to reflect on the effects of indicator use.

One particular constitutive effect of the evaluation gap is the advent of a third notion of science: coping with the system. Astronomers try to manage a balancing act between their intrinsic values and the requirements of the system. According to Dahler-Larsen (2014) indicators “define a strategic landscape in which practitioners must navigate”. In the case of an astronomer, the strategic landscape is situated between the astronomer’s intrinsic values and those defined by evaluation practices and the Sterrewacht’s missions. That is where the balancing act takes place.

In particular early career interviewees struggle with the balancing act between performing high quality research according to their standards and fulfilling the requirements of the system. Because success in science or in the scientific career is not only dependent on quantitative indicators, but also on luck (e.g. Faculty Member 3; “90% luck and 10% hard work”), especially young researchers have psychological struggles with this uncertainty. Van der Weijden (2017) elaborates on this further. For some researchers, this discrepancy is unacceptable. As a consequence, they wish to leave academia:

> “Yeah [I don’t want to stay in academia], partly because there is this ‘publish or perish’ thing, where it seems to be like ‘pump it out’.” (Master Student 2)

However, astronomers may also accept “the system” as a “fact of life” (Waaijer et al., 2017) and decide to “deal with it”. The third notion can be described as a synthesis or mix

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

between the other two notions – the “ideal” and the “system”. When astronomers master the balancing act between staying true to their own value’s, while at the same time fulfilling the quantitative requirements, when they are being practical with respect to their work, they find a middle ground where psychological struggles are minimised as the astronomer accepts “the system” and adapts to it. We can observe this in interviews, where especially tenured astronomers describe how they practically “deal with the system” (Faculty Member 1) in terms of getting funding, telescope time and publishing. They emphasise how their science is observation-driven (e.g. Faculty Member 1 & 4) and explain how artificial deadlines, such application deadlines for telescope time, are “natural” deadlines to them (Faculty Member 2). Because of managing the balancing act, tenured astronomers feel that their work is generally in line with their criteria of quality. While having to “adapt to the system” which they do not like (Postdoc 1), early career researchers also declare that they would not personally compromise on quality too much, because research quality “is more important than ultimately [their] career” (Postdoc 2).

Almost all interviewees – even those tenured astronomers, who feel that their research is in line with their notions of quality – acknowledge problems of the “publish-or-perish-system”. Master Student 2 observes that “people talk about the publish-or-perish thing and how it hurts. And then other people seem not to have much of an issue with it.” On the one hand, astronomers know they need to play along with the system. On the other hand, they know what “really matters” (Faculty Member 2).

> Annual report[2014]: “With 16 PhD theses and 318 refereed papers, the scientific 'production' was fantastic. However, in 2050 it will not be those kinds of facts that count, it will be the *true discoveries that have stood the [test] of time that will be remembered*.”

As we observed that in practice research quality is harmed in many respects, either the amount of astronomers who manage the balancing act without sacrificing research quality is extremely low, or there is a fine line between working according to the third notion of science and a bouncing between the “ideal” and the “system” notion of science, where quality is sacrificed at least occasionally and justified by having to survive in the system. More research will be done on this matter.

In any case, whether astronomers manage the balancing act and work according to this third notion of science, or they flip between the two other notions, the majority of astronomers seem to indeed accept the pressure to publish as a “fact of life”. Waaijer et al.

DOI: 10.3217/978-3-85125-668-0-09

(2017) find that being able to cope with the system enhances the early career researcher's sense of autonomy and independence. In addition to their intrinsic motivation, this is probably why so many early career interviewees state that they "try to stay in academia for long as possible" (PhD Candidate) and why pressures can even be party self-enforced (Waaijer et al., 2017):

> Postdoc 2: "If at all possible, yes, I would like to continue in academia. And in a way this rule I have – 1 paper per year – is the standard I have posed on myself in order to have a good chance to continue."

On the one hand, this would be consistent with Waaijer et al. (2017) who claim that, while many PhDs (from different fields) state that publication and grant pressure is too high and had made them hesitant to choose a career in academia, it has not been a decisive factor in their actual job choices. On the other hand, early career interviewees are aware of the fact they might have to leave academia and are working on accepting that. Thus, to what extent a third notion of science, can be held by astronomers in practice, and early career researchers in particular, is subject to future investigation. It would be interesting to see whether or not such a third notion implies a bias towards perceiving the positive aspects of "the system" in order to guarantee one's survival on the career ladder, which would give justification for sacrificing scientific quality. I suggest to employ the Rational Choice Theory to investigate the workings of the balance act and how it is related to individual situations, since that approach sheds light on the factors that go into decision-making processes of individuals. Those could be classified as different typologies of coping. The logic of aggregation will then show what the different coping strategies, as part of the balance act, mean for the quality of science.

4 Conclusion

We have analysed 9 interviews with astronomers from Leiden Observatory and a collection of (self-) evaluation documents and annual reports from that institute and the Dutch astronomy umbrella organisation NOVA. We have elaborated on what values drive an astronomer to enter academic research and how they perceive the values of the publication, funding and evaluation system. We then analysed how the astronomers' values relate to the system's values and what constitutive effects a discrepancy – the evaluation gap – has on knowledge production in Astronomy.

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

We found that astronomers are driven by curiosity, truth-finding and "pushing knowledge forward". During discussions of the interviews with CWTS's group for Science and Evaluation Studies[1], the question was raised of whether these values are based on a folk theory based on the public's *enchanted view*[2] of how science works. A folk theory is a belief based on received wisdom, rather than concrete evidence and facts. However, while especially young astronomers are likely to hold an enchanted view about science and may become disillusioned by their experience in academia (e.g. Postdoc 2), we have observed that the astronomer's intrinsic values hardly change due to this disillusion. Therefore, we conclude that the astronomer's values are based on the realist account that astronomers generally hold, rather than on a folk theory about scientific quality. Astronomers derive scientific quality from their values, and define quality as 'objective' when it meets those values. We found that the astronomers' account for scientific quality is based on three criteria:

Quality-Criterion 1: Asking an important question for the sake of understanding better and to push knowledge forward.

Quality-Criterion 2: Clear, verifiable and sound methodology.

Quality-Criterion 3: Clear communication of the results in order for the community to make use of them.

While astronomers agree on what quality is, they do admit that it is difficult to measure. Because resources such as funding and positions are limited, proxies for scientific quality – the quantitative indicators – help decide whom or what to fund. Those indicators include bibliometric measures such as H-indices, citation and publication rates. They also include the amount of funding acquired and how much observation time an astronomer has been granted. The more prestigious the affiliations a researcher had, the better their profile and chance to climb up the career ladder.

In order to survive in the current science evaluation system, which includes the funding, publication and assessment systems, the astronomer needs to fulfil the requirements of what is valued in "the system", as constituted by quantitative indicators. The discrepancy

1. *https://www.cwts.nl/research/research-groups/science-and-evaluation-studies*

2. Science in Transition, Position Paper 2013, *http://www.scienceintransition.nl/*

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

between the astronomer's and the system's values gives rise to an evaluation gap (Fig. 20). We found that the evaluation gap in turn has a variety of constitutive effects on knowledge production, ranging from research agendas, researcher's behaviour and identities to research content.

There is a shift of focus from high quality science to publishing a high number of papers, presenting research that is less robust, replicable, and transparent than aspired. Risk aversion discourages creativity in the scientific process which inhibits innovative ideas, while valorisation gains ever-growing importance.

Interestingly, we observed that the astronomer holds two opposing notions of science: the "ideal" one which corresponds to their intrinsic values and the "system" notion. This means that, while in their daily research life an astronomer adopts an extrinsic motivation to perform science, their intrinsic values and motivations remain as their ideals. Hence, while indicators give an extrinsic motivation to an astronomer to perform, their constitutive effects do not reach as far as to affect the astronomer's intrinsic values to a noteworthy extent. However, constitutive effects of indicator use may not shape the realist's notion of reality, but they do shape research agendas and have epistemic implications on day-to-day research practices. Man-made deadlines become "natural" deadlines. As a consequence, the evaluation gap remains and a third notion of science arises: coping with the system. The astronomer always tries to manage the balancing act between their intrinsic values and the requirements of the system. In order to do so, astronomers must accept "the system" as a "fact of life" Waaijer et al. (2017), serving to quantitative indicators, while at the same time not sacrificing research quality. Unsurprisingly, we found a difference between early career researchers and established faculty members, where the former struggle with the uncertainty ahead, often considering to leave academia and the latter being more confident that they are managing the balance act. However, providing a typology and different 'coping strategies' is subject to further research.

We conclude that Leiden observatory's goal of "*fostering an intellectually rich and vibrant scientific atmosphere which allows astronomers to pursue their ideas and push scientific boundaries, and in which young scientists can develop and grow*" is not compatible with its strategy to ensure a front-line role in Astronomy if this front-line is defined by quantitative indicators. Instead, we propose to find alternative indicators, whose constitutive effects could be utilized such that the evaluation gap is minimized. By means of "innovative use"

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

of indicators (Fochler & De Rijcke, 2017), positive constitutive effects could alter researchers' behaviour and to regulate the knowledge production process to privilege scientific quality. In such a scenario, the institute’s goal could be met as the astronomers could act upon their intrinsic motivation, while at the same time being extrinsically motivated to perform at a high level. While there is currently little literature on the topic, future investigations into alternative evaluation practices (Duffy, 2017) and innovative indicators (“*re-configuring evaluation*”; Fochler & De Rijcke, 2017) have been proposed. As this study demonstrated, for this kind of future research it makes sense to consider using both concepts, the ‘evaluation gap’ and ‘constitutive’ effects in order to describe the reactivity of indicator use.

References

Annual report1998- Annual report2015: Annual public reports, authored by the director of the institute (1998-2015), https://www.strw.leidenuniv.nl/research/annualreport.php

Austin, J.L. [1962] 1975, “How to Do Things with Words”, [Cambridge, Mass.], Harvard University Press

Benedictus, R. & Miedema, F. (2016), “Fewer Numbers, Better Science”, Nature, Vol 538, p.453-455

Bourdieu, P. (2004), “Science of Science and Reflexivity”, The University of Chicago Press, ISBN: 9780226067377 & ISBN: 9780226067384

Bouter, L.M. (2008), “Knowledge as Public Property: The Societal Relevance of Scientific Research”, OECD, http://www.oecd.org/site/eduimhe08/41203349.pdf

Callon, M. (ed. 1998), “The laws of the market”, Oxford: Blackwell

Dahler-Larsen, P. (2014), “Constitutive Effects of Performance Indicators: Getting beyond unintended consequences”, Public Management Review, 16:7, p.969-986

De Rijcke, S., Wouters, P., Rushforth, A., Franssen, T. & Hammarfelt, B. (2015), “Evaluation practices and effects of indicator use – a literature review”, Research Evaluation, 25(2), p.161–169

Desrosières, A. (1998), “The Politics of Large Numbers – A History of Statistical Reasoning”, Harvard University Press, ISBN 9780674009691

Duffy, D. (2017), http://blogs.lse.ac.uk/impactofsocialsciences/2017/08/14/rather-than-promoting-economic-value-evaluation-can-be-reclaimed-by-universities-to-combat-its-misuse-and-negative-impacts/

Espeland, W.N. & Stevens, M.L. (2008), “A Sociology of Quantification”, European Journal of Sociology, Volume 49, Issue 03, p. 401 – 436, https://doi.org/10.1017/S0003975609000150

Espeland, W.N. & Vannebo B. (2008), “Accountability, Quantification, and Law”, Annual Review of Law and Social Science 3, p. 21-43

Julia HEURITSCH
DOI: 10.3217/978-3-85125-668-0-09

Fochler, M. & De Rijcke, S. (2017), “Implicated in the Indicator Game? An Experimental Debate”, Engaging Science, Technology, and Society 3, p.21-40

Fochler, M., Felt, U. & Müller, R. (2016), “Unsustainable Growth, Hyper-Competition, and Worth in Life Science Research: Narrowing Evaluative Repertoires in Doctoral and Postdoctoral Scientists’ Work and Lives”, Minerva, Doi: 10.1007/s11024-016-9292-y

Foucault, M. (1977), “Discipline and Punish: The Birth of the Prison”, London, Allen Lane

Foucault, M. (2003), “The Subject and Power”, in Rabinow Paul and Nicholas Rose, eds., “The Essential Foucault” (New York, The New Press, p. 129-144)

Godin, B. (2006), “On the origins of bibliometrics”, Scientometrics, Vol. 68, No. 1, p.109-133

Hammarfelt, B. & De Rijcke, S. (2014), “Accountability in context: effects of research evaluation systems on publication practices, disciplinary norms, and individual working routines in the faculty of Arts at Uppsala University”, Research Evaluation (2014), pp. 1–15, doi:10.1093/reseval/rvu029

Heidler R. (2011), “Cognitive and Social Structure of the Elite Collaboration Network of Astrophysics: A Case Study on Shifting Network Structures”, Minerva (2011) 49:461–488, https://doi.org/10.1007/s11024-011-9184-0

Kaltenbrunner, W. & De Rijcke, S. (2016), “Quantifying ‘Output‘ for Evaluation: Administrative Knowledge Politics and Changing Epistemic Cultures in Dutch Law Facilities”, Science and the Public Policy, p.1-10

Kurtz, M. J. & Henneken, E.A. (2017), “Measuring Metrics - A 40-Year Longitudinal Cross-Validation of Citations, Downloads, and Peer Review in Astrophysics”, Journal of the association for information science and technology, 68(3):695–708

Laudel, G. & Gläser, J. (2014), “Beyond breakthrough research: Epistemic properties of research and their consequences for research funding”, Research Policy 43, p.1204-1216

LU self-assessment2010-2015: Self-evaluation Document University Leiden, Leiden Observatory (2016). Period 2010-2015

MacKenzie, D. (2006), “An engine, not a camera. How financial models shape markets”, Cambridge, MA: MIT Press

Merton, R. (1936), “The unanticipated consequences of purposive social action”, American Sociological Review, Vol. 1, No. 6 (Dec., 1936), p. 894-904

Merton, R. K. (1968), “The Matthew effect in science”. Science 159: p.56–63. Page references are to the version reprinted in Merton (1973).

Merton, R. K. (1988), “The Matthew effect in science, II: Cumulative advantage and the symbolism of intellectual property”. Isis 79: p.607–623.

NOVA self-assessment2010-2015: Self-evaluation Document NOVA (2016), including NOVA’s evaluation of its four institutes and a joint appendix. Period 2010-2015

Porter, T. (1995), “Trust in numbers”, Princeton University Press

Rosanvallon, P. (2009), “Demokratin Som Problem”, Hägersten: Tankekraft Förlag.

Rosenberg, N. & Nelson, R. (1994), “American Universities and technical advance in industry”, Research Policy 32, p.323-348

Rushforth, A.D. & De Rijcke, S. (2015). “Accounting for Impact? The Journal Impact Factor and the Making of Biomedical Research in the Netherlands”, Minerva 53, p.117-139

Sørensen, M.P., Bloch, C. & Young, M.(2015), “Excellence in the knowledge-based economy: from scientific to research excellence”, European Journal of Higher Education, https://doi.org/10.1080/21568235.2015.1015106

Stephan, P. (2012), “How economics shapes science”, Harvard University Press

Van der Weijden, I.C.M., Meijer, I., Van der Ven, I., Ali, R.F. & De Gelder, E. (2017), “The Mental Well-Being of Leiden University PhD Candidates”, https://www.cwts.nl/download/f-x2q213.pdf

Vestman, O. K. & Conner, R. F. (2006) “The Relationship Between Evaluation and Politics” in Shaw, I. F., Greene, J. C. and Mark, M. M. (eds), The Sage Handbook of Evaluation 225–42. New York: Sage Publications., in Dahler-Larsen, P. (2014)

Waaijer, C.J.F., Teelken, C., Wouters, P.F. & Weijden, I.C.M. (2017), “Competition in Science: Links Between Publication Pressure, Grant Pressure and the Academic Job Market”, High Education Policy, https://doi.org/10.1057/s41307-017-0051-y

Supplementary Material

1. Interview Questions:

Topic	**Research Question**	**Interview Question**	**Type Respondent (Faculty, Postdoc, PhD, Master)**
Introduction	Background	E.g. How did you get this position, which career steps were necessary?	All
	Topic (How much does the choice of the research topic depend on the need to get funding? (avoiding risk taking?))	What is the topic of your research?	All
Project funding	Conditions of funding	How did you received funding for this project?	All
	Institutional conditions of funding	How is funding allocated in your institute in general?	All
Exposure to assessments	What role do assessments play in an astronomer's (daily) life?	What role do assessments play in your work?	All
		> Do you have yearly appraisals/ R&O talks with your supervisor? Peer review for funding applications & mid-term reviews for projects?	All
		Are you held accountable to the founder/ review panels on a regular basis?	All
Knowledge pro-duction – Plann-ing research	What is the choice of topic dependent on (e.g. preference of supervisor/ funding/ own interest/ riskiness)?	How do you decide on a topic for your research?	All

DOI: 10.3217/978-3-85125-668-0-09

		What do you advise PhD students when they ask about how to select a research topic?	Senior – Faculty
		How do you give priority on topics if you have more than one to work on?	All
		Is the journal agreed upon before writing? So, does the choice of the research topic, methodologies and content of the paper depend on that choice?	All
Knowledge production - Doing research	What are the effects on choices about the research process? (e.g. Effect on methodologies used?)	What needs to be taken into consideration for designing a Methodologies Project Design?	All
		Do you feel restricted in the research process?	All
		Have you heard about "responsible research methods"? And what's your stand towards it?	All
	Does the evaluation system foster collaboration or lead to competition?	How is collaboration organised in your project/institute/field?	All
Knowledge production - Publishing research	Is publication pressure a result of the evaluation system? And how does it influence the publications (e.g. premature publishing/ salami slicing)?	What are the most important factors in your field for deciding on when to publish research results?	All
		What are the most important factors in your field for deciding on what to publish [sexy results etc]?	All
		Do you perceive publication pressure?	All
		> Have you observed that people publish before the research has reached a more matured stage?	All
		> Have you observed that people cut up your research just to produce more papers of it?	All
	Does the evaluation system influence content?	Do you feel like you need to concentrate more on quantity than quality of your work?	All
		> Would one write up results differently if it weren't for the specific requirements measured by indicators such as impact factors and citation rates?	All
	How to deal with unexpected outcomes and "failures"?	What do you define as 'failed' research?	All
		Have research lines you have been engaged in ever failed?	All
		> If yes, what were the consequences in terms of funding, publishing etc?	All
		> If no, do you sometimes worry about not delivering the expected outcome due to a threat of not receiving further funds?	All
		Do you report "negative results"? Can they be published? Do astronomers/ you think that they should be published?	All

DOI: 10.3217/978-3-85125-668-0-09

	How does the evaluation system influence replicability?	Do astronomers try to ensure that their published data is replicable or do you feel the necessity to keep information closed off?	All
What is quality in astronomy (value, quality, excellence)	Field: What is quality research in the field?	What is high quality research in your field?	All
	Institute: What is quality research in the institute?	How is high quality research defined in your institute?	All
	Researcher: What is quality research for the individual researcher?	What does high quality research mean to you?	All
	Researcher: What are motivational factors?	What drives you in your research?	All
	How does the funding system relate to good science quality as defined by the astronomer?	Does the funding system encourage good science?	All
	How does the publication system relate to publication quality as defined by the astronomer?	How does the publication system reflect upon quality in science?	All
		(Is the quantity of publications put above quality?)	All
Improving research evaluation & Consciousness	Are there wishes/ways to improve the evaluation system?	What issues do you think need to be improved to guarantee better science?	All
	Consciousness about the evaluation system	Do you feel that you are given the chance to question how science is performed?	All
	How did the system change over time and what did senior researchers observe?	When did you have your first encounter with the way science is performed and assessed? How did that compare with your initial motivation to become a scientist?	Senior – Faculty
		In your experience, did the definitions of value and academic quality change over time?	Senior – Faculty
	Do young researchers perceive that they need to adapt to the evaluation system?	When did you have your first encounter with the way science is performed and rewarded? How did that compare with your initial motivation to become a scientist?	Junior – Faculty, Postdoc, PhD, Master
		Can you pick topics and methods yourself or do you feel like you'll only be free to do that once you reached tenure?	Junior – Faculty, Postdoc, PhD, Master

DOI: 10.3217/978-3-85125-668-0-09

2. These following codes represent themes which emerged by combining sensitivity towards existing literature on constitutive effects of indicator use with insights from our data. The interviews were coded using these codes:

Code	Explanation & Related Keywords
CAREER Clarity/ Expectations	Has the path been clear? What is expected in terms of career steps? Tenure.
Politics	
Prestige	
Output orientation	Both, in terms of output = basis of assessment & what output is expected.
Pressure	Publication/ Funding
Impact	
Competition	
Collaboration	
Riskiness	
Failure	
Negative results	Non-detections
Authorship	
Salami slicing	
Quality	
Curiosity	“Wanting to understand”
Referees	
Matthew effect	
Citation rates	
Publication rates	
Funding	
Gaming	Strategies, Targeting, "Sales men"
Replicability	
Epistemic Subculture	Topic of research, Instrumentation/ Observational/ Theoretician
Sexy topics	
Uncertainty (research)	
Uncertainty (career)	
Integrity	Fraud, Fake, Cheat
Luck	
Indicator	

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

Price for a Life: An Essay on Becoming of Data-driven Market Governmentality

Ilpo HELÉN

Department of Social Sciences, University of Eastern Finland, Finland

Abstract

The topic of my essay is an emerging mode of governing people based on intensive data mining of personal data from public health care, social services and registers and databases. I focus on a proposal, presented in Finland in spring 2018, in which an estimation of the future health care costs of the person based on a personal risk assessment would be calculated for every citizen, with the help of data mining of public register data. I ask what elements of Nordic (post)welfarist health and social policy have made the idea of setting a prospective personal price of life for every citizen possible and reasonable. In particular, I examine the changes in rationales and practices of maintenance of the welfare state data infrastructure, and the relationship between advances in 'datafication' of public health care and the expansion of the neoliberal policy mode I call 'market governmentality'.

1 Introduction

The topic of my paper is a proposal, presented in Finland in spring 2018, to calculate a *prospective* personal price for every potential client of public health services. The idea was that the personal price – an estimation of future costs of the client-to-be – would have been counted by utilizing public health care, social service and population databases. Allegedly, the purpose of this operation would have been controlling the 'market' of public services in the framework of the proposed great reform of public health care and social services. So far, the plan has not been actualized. The grand reform was dissolved before the Finnish parliamentary election in spring 2019, and the proposal to put a price tag on everyone's life was put on hold as the general reform was postponed.

I analyse the proposal as an example of an emerging mode of governing people based on intensive data mining of personal data on people's health, life course, use of health and social services, and education and social factors like age, sex or marital status collected in and extracted from public registers and databases (e.g. Ruppert 2012; 2013). I seek

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

answers to the following questions: How has setting a prospective price of life for every citizen *become possible* to think, plan and (potentially) put into action? What kind of context of political, administrative, epistemic and technical reasoning has enabled presentation and discussion of such a plan as a reasonable, doable and appropriate solution to a key problem of expenditure management in the great health care reform? How has this context come to be?

My effort is based on Foucauldian 'analytics of governmentality' (Dean 1999; Rose 1999; Lemke 2011a; Helén 2016). As is rather well known, this approach unfolds from Michel Foucault's (2000a; 2000b) insight on the specific mode of Western political power that focuses on rationales and arts of governing which attempt to make the conduct and living of populations and individuals governable. 'Government' as a mode of practicing of political power also aligns state authorities with the production of empirical knowledge on people and with expertise in medical, psychological or social interventions in people's lives. Governmentality perspective is particularly relevant for the analysis of the vicissitudes of the Western welfare state (Helén 2016) because it shows the welfare state as a dynamic and dispersed mosaic of 'government of life' (Lemke 2011b; Helén 2016). In addition, it highlights political technologies (Foucault 2000c), i.e. technical and epistemic means to embrace, utilize, control, and intervene in people's conduct in a number of domains of living, ranging from public health to urban planning.

In this essay, I deploy the above concepts and ideas to capture repercussions of the recent trend of 'datafication' (see Mayer-Schönberger & Cukier 2013) in provision of public health care, and to outline an emerging data-driven mode of government of people and their lives (e.g. Ruppert 2012; 2013).

With this topic, my essay is engaged in recent STS discussions on 'datafication' of health care and emerging of a global health data economy (e.g. Prainsack 2017; Ruckenstein & Schüll 2017; Sharon 2016). In addition, it resonates with a wide range of discussions on 'algorithmic power' engendered by compilation of Big Data and its intensive utilization with the help of ever more 'intelligent' ICT devices (e.g. Amoore & Piotukh 2016; Bigo, Isin & Ruppert 2019; Ziewitz 2016). Furthermore, my approach has a close affinity with studies on 'metric power' that emphasize the continuation between the political aspects of current datafication and the historical alignment of population data and statistics with state power (e.g. Beer 2016; Ruppert 2011; Saetnan et al 2011; see also Hacking 1990; Porter 1996).

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

All these discussions concern the question about the relationship between the technologies for data management and political rule over people's lives. In my essay, I approach the theme by focusing on a very specific case. I attempt to highlight that the reservoirs of digital data and algorithms require a context of political and administrative reasoning and practice in which the technique of 'data mining' can become a political technology. Within such a context, then, technical devices and rationales of 'datafication' – or even their potential and expectations concerning their problem-solving capabilities (see Tarkkala et al., 2019) – can have a significant influence on policy-making and the ways in which public authorities and experts govern people and their lives.

I approach the reciprocity between data management technology and political governing from a historical viewpoint and use the key principles of Foucauldian genealogical critique as my guidance (see Helén, 2005). Thus, I look for a cluster of problems in the domain of public health care in which the calculation of a personal price of life with the help of intensive data mining are expected to provide a solution. Then, I outline the context of political, administrative, scientific, and technical reasoning and practices in which first the problematization of these issues and then the formulation of possible solutions emerges. Finally, I follow lineages by which the elements of that context have formed and connected with each other. I trace political, epistemic, and technological lineages of a data-driven political technology in the context of the Nordic welfare state. I pay attention to the tradition and practices of the collection and storage of the personal data of citizens in public national registers and databases, the adoption of advanced digital data management technology in public administration and services, and the transformation of health and social policy in a 'post-expansionist' (Julkunen 2001) Nordic welfare regime. In particular, I focus on the relationship between advances in 'datafication' of public health care and an expansion of a policy mode I call 'market governmentality' (Helén 2016: 167-218).

My essay unfolds as follows. In the next section, I present the historical formation of the context in which pricing the life of every client of public health care services with the help of advanced data mining technology appears as a reasonable and doable policy measure and administrative routine. Then I analyse projects of implementation and experimentation of data-driven practices in public health care. These efforts prepare the policy and administrative environment to support or even nurture the emerging IC technology, and I pay a particular attention to the manners by which these projects formulate problems in

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

public service provision for which digital data and algorithms seem to provide optimal solutions. After that, I move on to analyse in detail the plan and the technology of political governing which it suggests. In the final section, I frame the plan more generally in terms of the current mode of governmental reasoning and practice, and I discuss ‘market governmentality’ more closely.

2 Descent: Five Lines

The proposal did not just appear as a sudden administrative invention. It originated from a governmental health and social service data authority, and it is embedded in both established institutions and practices of the Finnish welfare state and more recent policy developments and trends. Its descent can also be seen as in line with several historical trajectories of the Finnish welfare state. Therefore, it can well be considered just an extension of existing national and local administrative routines and policy measures, as the advocates of the plan claimed. In the following, I present five ‘sources’ for the proposal that are particularly related to the management and utilization of personal data of clients and citizens in public databases.

2.1 The Land of a Thousand Public Databases

Systematic, routine collection of information by public authorities, and the storage of the data in dedicated public institutions so that it is well-ordered and easily available for scientific and administrative uses form a cornerstone of the Nordic welfare state. This includes data about almost everything from ill health to housing. Sweden, Denmark, Norway, Iceland and Finland are famous for having plenty of nationally comprehensive, well-ordered, and electronic health, social service and population databases. These ‘registers’ are maintained by public institutions that have a legal mandate to collect, store and provide access to the data, which consists of personal information about citizens, residents, and clients of public services. In Finland, there are about 70 different nationwide registers on health issues alone, ranging from general health statistics and surveys to disease-specific data collections, like cancer or infectious diseases registers, and the national patient record archive *Kanta*, established in 2010, which consists of copies of patient record documents and drug prescriptions from local public health care providers.

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

Dating back to early 18th century Sweden, the Nordic countries have probably the longest tradition of making systematic *Statistik* for over 250 years. During the heydays of social planning from the 1950s to the 1980s, the fabric of Nordic societies became impregnated with regular collection of data about all aspects of people's lives by public authorities and researchers. The data collection and repositories were connected to building up and maintaining public welfare institutions and services – health care, social assistance, pensions, education etc. – and they were deployed for the purposes of social planning. Consequently, data were collected and databases organized according to administrative needs and rationales (Alastalo 2009). Gradually, the public data collections piled up into comprehensive and routinely sustained population, patient and client registers to the extent that, for example, 95% of its statistics on population, economy etc. maintained by Statistics Finland are today based on register data (Alastalo 2009).

Two technical developments facilitated this shift in Finland: the public databases were transformed into an electronic form between the late 1960s and 1980s, and the personal identity number (PIN) for every citizen and permanent resident was introduced in the 1960s (Alastalo 2009).

Public data were also put into active use. Personal and population data from the registers were deployed in the centralized planning of welfare services, for everyday administrative purposes and the execution of public authority, and for research purposes. The PIN provided a tool which allowed personal data from different repositories to be circulated, combined, and compared among the users (Alastalo 2009). The data were utilized predominantly for national purposes and under the regulation of the state. The latter was based on administrative protection of the persons, so that information passing from one public authority to another was strictly regulated and, in most cases, required the personal consent of the data subject. Public data authorities were also the gatekeepers of the research use of the data, and access to public databases was permitted only to researchers from the Finnish public academic or state-related research institutions.

2.2 From Social Planning to Governance by Information

The power balance between the national government and local municipal authorities is a major factor influencing the ways population and personal data in public databases are deployed for governance and management of public welfare provision. In war recovery

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

efforts during the 1950s and the building up of the welfare state from the 1960s onward, the state took the command. Centralized social planning led the way for the arrangement of public health care, social insurance and services, and education from the late 1950s until the 1980s. The Finnish welfare state was organized so that the law and governmental orders obligated the municipalities to arrange health care, and social and educational services; the state payed most of the cost of the services, and the rest was covered by the municipalities themselves with the revenues of the municipal tax. Pensions, health insurance and other forms of social insurance were centralized in specific institutional arrangements in which the Social Insurance Institution (KELA) played the key role.

In the mid-1990's, a major reform of public expenditure increased the power of regional and municipal authorities. In the new order, the government provided a municipality a certain sum of money based on the amount, age structure, unemployment rate and morbidity of its population, while the municipality put in additional money from its tax revenue, and arranged health, social, and other public services in a manner that local politicians and administrators found appropriate. In health care, the reform resulted in the most decentralized health policy and service provision in Europe (Häkkinen & Lehto 2005). The 1990s reform was implemented at the same time as Finland went through a major economic recession and state cash crisis. Consequently, the new municipal autonomy for arranging public services was recruited to execute the 'austerity policy' associated with neoliberalism and New Public Management all over the world (see e.g. Blyth 2013). With powers to arrange welfare services as they wished, municipal and local authorities focused primarily on cost reductions and cost efficiency, and the 'saving' of public money became the preoccupation of health and social policy on both the national and local levels.

The 1990's reform 'municipalized' welfare policy in Finland. Actualization and success of the national plans was no longer the primary issue; instead, policy-making, composing and executing reform programs, and innovation in, for example, public health care, were now assumed to happen on the regional and municipal levels. Since that time, the government has not given orders to the municipal and regional authorities. Instead, it imposes its rule by financial means and by defining frameworks for service provision, and providing information and guidelines as recommendations. The guidelines are seen as information about appropriate arrangements and standards of public services like health or elderly care. In addition, the government has started to produce statistical information and

DOI: 10.3217/978-3-85125-668-0-10

indicators based on public register data, and share it with local administrators and politicians. For over a quarter of a century, the National Institute of Health and Welfare (THL) and its predecessor have hosted a special unit for producing and administrating hundreds of population, patient, service use and expenditure-related indicators – and attached databases – tailored for administrative and policy-making use on the regional level. Among many things, numbers provided by the governmental data authority indicate to the local authorities what kind of population inhabits their region: age, income, unemployment rate, morbidity, use of public services etc. For decades, local health and social administrators and policymakers have become accustomed to governing by indicators (Hammer 2011; Ruppert 2012), which has prepared the soil for even more intensive data-driven governing.

2.3 Applied Health Economics

Numbers – statistics, indicators, calculation formulas – have also become essential for the everyday functioning of health care organizations. As medicine has become more complex during the past 30-40 years, management in its every aspect has become increasingly central in health care. The more important role of management in health care organizations has made reasoning derived from health economics more pivotal for medicine. A major part of health care management is about directing resources, controlling expenses, and developing more cost-effective practices and organization. The rationale of management of medical organizations is a kind of applied health economics, and health care managers and directors deploy economic and other performance indicators developed for this purpose. In the following, I take a closer look at a widespread instrument called the Diagnostic Related Groups (DRG).

The DRG was developed in the USA in the 1970s to assist hospital management. It regroups patients according to the resources which the treatment of a disease demands and the expenses which this treatment incurs. Thus, ‘diagnostic group’ is a category of health economics. Statistical indicators form the core of DRG, which is both a rationale and a device that induces an epistemic reorganisation of medical practice in terms of costs and organisational efficiency. A common indicator called Nord-DRG is in use in specialized care in all Nordic countries. It is:

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

> '(…) based on the average costs; the visits and the treatment period are divided in the groups that are medically practical and homogeneous in expenses. As a pricing device, Nord-DRG balances the risks between the provider and the [public] buyer of the medical services.' (https://sotetieto.fi/fi/tuotteet/norddrg-tuottaa-erikoissairaanhoidon-potilaskirjon-ja-hoidon-kustannukset, retrieved 20 March 2019)

In Finland, the DRG is institutionalized. The National DRG Centre is a company owned by the association of the Finnish municipalities. The centre maintains and develops DRG classifications as a 'commodification system' on the national level. More importantly, it annually collects DRG data from the hospitals and regional and municipal health care organizations and returns the statistics and indicators back to local public health care actors. As a result, the DRG and similar economic indicators have been routinized as an essential element of the current Finnish health care system. Against this background, it is interesting that the Finnish DRG centre has introduced a national DRG instrument for primary health care that:

> '(…) combines the patients' medical record data (visits, examination and test measures, treatment etc.) with the budget and personnel data of the organization. As a result, the organization receives patient-by-patient data and information about the real costs and service usage.' (https://sotetieto.fi/fi/tuotteet/norddrg-tuottaa-erikoissairaanhoidon-potilaskirjon-ja-hoidon-kustannukset, retrieved 20 March 2019)

2.4 Population Medicine Personalized

An important source for the possibility of considering a prospective personal price for health care is the trend in medical reasoning and practice toward data-driven 'personalized' or 'precision' medicine (see Prainsack 2017). From a historical perspective, personalized medicine is inconceivable without population medicine. The latter refers to the epidemiological paradigm in medicine in which illness and health are approached by studying population data with the methods of statistics and probability calculation. From population data, epidemiology detects factors that contribute to morbidity or the prevalence of a disease in a population or predict its onset in the individuals. The breakthrough of medical epidemiology happened in the 1950s and the 1960s when chronic diseases like cancer and heart diseases became the focus of medicine and health policy across the Western countries (Oppenheimer 2006; Talley et al. 2004), and

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

epidemiological studies pointed out ‘lifestyle’ factors that contributed to an increase of these conditions in the population (Larsen 2011). In this context, medical epidemiology became closely associated with preventive measures and health promotion, and gradually the idea of health risk became a core idea and object of medicine (Rothstein 2003).

Finland has been a model student in the adoption of medical epidemiology, risk medicine, and popular health promotion focused on health-related ‘lifestyle’ factors, especially regarding cardiovascular diseases (CVD) (Jauho 2010; 2017). Finland was among the countries in *The Seven Countries Studies*, a comparative epidemiology study on CVD that started in the late 1950s (Kromhout et al. 1994), and launched a wide public health promotion campaign, with the focus on lifestyle-related CVD risks in the late 1960s. Since then, systematic nationwide health promotion has made the awareness that CVD risks can be reduced by the means of diet changes, quitting smoking, increasing physical exercise and medication part and parcel of public health, primary health care and lay consciousness.

Along with the development by which medical care has become impregnated with risk medicine and prevention, practices and devices to detect and measure personal health risks have emerged, in Finland and elsewhere. Prenatal and cancer screenings of the population (predominantly women) have been systematically carried out for decades in Finland, and primary and occupational health care have familiarized most Finns with CVD, depression and type 2 diabetes risk questionnaires and calculators, today readily available on the Internet. Such personalization of risk has become a routine way of approaching and managing illness and health.

In risk medicine, the individual is defined as always belonging to a population and the data about it, and risk calculation relates her to that population. When this epistemic view is combined with the practices and devices that personalize health risks and with an emphasis of personal preventive health care, a fertile soil for visions of data-driven personalized medicine is well-prepared. Indeed, many advocates present personalized medicine as if it is an extension of risk medicine (e.g. NAS 2011; Swan 2012; Topol 2012). It is based on the calculation of massive amounts of population data, which allows for the precise indication of things to come and to be expected with a certain probability: health change, a disease, cancer, or life expectancy. What makes the difference is the amount, scope and pace of data utilization. When more and more widely ‘health-related’ personal

DOI: 10.3217/978-3-85125-668-0-10

data will be 'data mined' more frequently, medicine based on statistical averages and risk groups can be replaced by 'precision medicine'. The latter is essentially about defining a health-promoting lifestyle and preventive or anticipatory medical measures person-by-person based on accurate predictive calculations. Promotion of these expectations has captured the future of medicine in a sociotechnical imaginary (see Jasanoff 2015; Tarkkala et al. 2019) in which aggregating more and more of all kinds of 'health related' personal data (Weber et al. 2014), with the help of high-speed computers and smart algorithms, will automatically lead to better and more accurate medical care (see Prainsack 2017). Within this imaginary, it becomes possible to think of medicine and health care as an enduring practice of data-driven control of the 'whole life' of a person, and to consider that following the path to such control medicine is desirable and will bring good for all.

2.5 Administrative Hypomania for Utilization of Digital Health and Social Service Data

During the past decade, enthusiasm for possibilities of Big Data and advanced data mining has been contagious among Finnish policymakers, top governmental officials, leading regional public administrators, and academic experts in data analytics who work with innovation policy and health care reforms. 'Health sector' innovation policy in Finland is today impregnated by a passion, almost an obsession, over the 'secondary use' of public database data and the potential of AI, and the mood is spreading to the domain of social services as well. Alex Pentland's (2003, 80) promissory quotation captures well the mindscape of the Finnish innovation advocates and policymakers:

> 'Data analytics can give us stable financial systems, functioning governments, efficient and stable health care, and more.'

In addition, the Finnish enthusiasts are excited about the idea that the Finnish population, public health and social care databases together form a repository of Big Data. In addition to well-ordered and extensive public databases, the PIN for every citizen and permanent resident is seen as an invaluable tool for flexible utilization of the data. Within the landscape of a data-driven future, mining of the digital 'ore' or 'goldmine' of public databases with advanced IT is seen as able to bring all imaginable blessings to Finnish society: resolve expenditure crises of health care and social services; boost innovation in business and the economy; improve administration and policy-making; and make medical treatment and interventions more precise and cost-effective. In a biobank seminar in 2017

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

in Kuopio, a speaker from a regional biobank presented a graphic that exemplifies the vanishing point of this scenery well (Figure 21).

Fig. 21: *Graphic*

The passion has engendered a political and administrative urge to enable and expand utilization of population and personal data in public databases. The advocates of more intensive data usage view see the main problem as the data being stored and ‘stuck’ in administrative ‘silos’ behind legal and regulatory firewalls. They strive for enabling policy and regulation that would allow easier access to public data repositories and encourage ‘interoperability’, i.e. combination of data from different sources. In practice, this would mean removing or bypassing the ‘hurdles’ like legal restrictions, consent practices, or privacy issues.

3 Top Down: Implementing Data-driven Health Care

Passionate visions and great expectations about data- and algorithm-driven betterment of all walks of life and society, health policy and health care included, have been pushed toward actualization in Finland by a number of proposals, strategy papers, ‘road maps’, and pilot projects. Participating are regional and governmental authorities and organizations, ‘visionaries’ from think tanks, and – occasionally – private companies. A salient feature of many projects and plans is the emphasis that more extensive utilization

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

of public health care, social service and population databases should primarily serve the management of public service provision. These endeavours share a rationale to promote ‘knowledge-based’ management, which actually means data-driven management. The objective of many plans and projects is to find ways to make data in public databases on the performance and clientele of public service organizations usable and actionable for top managers, so that they can foresee, plan, and manage in a ‘strategic’ manner and tackle future challenges. As frameworks of problematization, these plan and projects define the problems that extensive data mining of digital public databases would solve in terms of anticipatory, ‘strategic’ health and social care management and in terms of the efficiency of the organizations.

For over a quarter of a century, regional health care and social service organizations have used to austerity policy and New Public Management style of managerial practices. Therefore, it is quite likely that the proposed devices of data analytics will serve management focusing on the improvement of ‘cost-efficiency’ of organizations and practices. In addition, they are likely to become tools of local policy-making focusing on ‘savings’ in public expenditure and supporting such management. As a result, these projects and plans provide support for health and social policy derived from concerns that ‘10% of the clients cause 80-90% of the costs’ (VTV 2017).

As an example of the efforts to implement data-driven public welfare services, I take a closer look at an influential pilot project, conducted in 2013-16, by a semi-public think tank, regional public health care providers, and the Ministry of Social Affairs and Health (Sitra 2014; Sitra et al. 2016). The idea of the project was to construct a model for combining data from the public services providers’ databases – both client and administrative data – and from national registers, and for organizing the data in ‘info packages’ for the top managers and regional policy-makers. Besides the structuring of the data, the info packages consisted of tools for making service demand prognoses, welfare and performance indicators, and the client analysis. In project documents, the latter was pointed out as the most important device.

In the client analysis, the performance data of the public health and social services was combined with the personal data of the clients and inhabitants of a region. In practice, this meant combining patient data and expenditure data in a manner resembling the DRG. This combination was thought to enable an analysis of the clients’ service usage and

DOI: 10.3217/978-3-85125-668-0-10

costs, which had two objectives. First, '(…) to point out the clients who use a lot of services extensively ("the heavy users") ... in terms of service actions and the costs' (Sitra 2014), and to reorganize health and social services according to the service user segments, as well as 'to build data management systems that would provide standard data and indicators about performance, economy, quality and efficacy' (Sitra et al. 2016).

By introducing the info packages, the project did not present anything new in terms of statistical methods, data analytics, or IC technology. Rather, the info packages performed and embodied the view of a future in which the administrative data 'silos' will be opened, and their data will be intensively used in 'interoperable' ways. Congruent with this imaginary, the project presented a rationale, model and devices for data-driven public management: first, IC technology and experts mine data masses in public repositories; data mining provides information for profiling the clientele and calculating the future service demand; then, health and social services can be planned, arranged and managed according to the prognosis. Data and indicators presented in the project reports are almost exclusively about 'economy', i.e. the costs of the services. In graphics, the client analysis looks like this. In Figure 22, the clients are represented in green and the costs in blue, and both of them are divided according to the sectors of public health and social services.

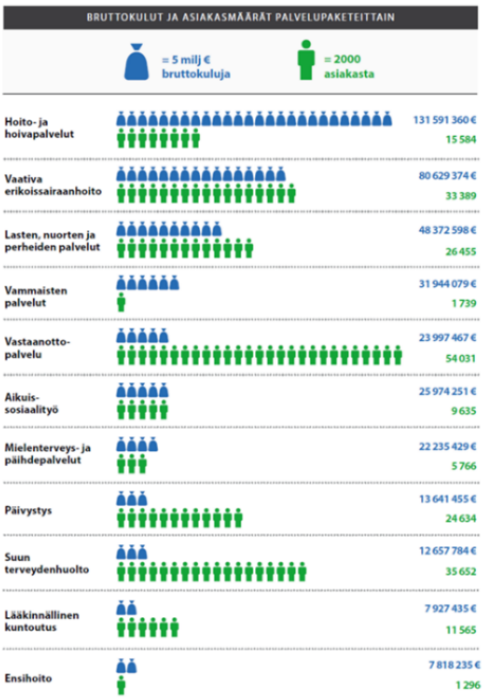


Fig. 22: *(Sitra 2016).*

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

Picture 23 shows a way to calculate an average cost per patient in a certain patient group and compares the cost between regions: in eastern Finland an inhabitant over 75 years costs 9.600 euros a year on average, while the cost is over 11.000 euros in the southern coast town Porvoo.

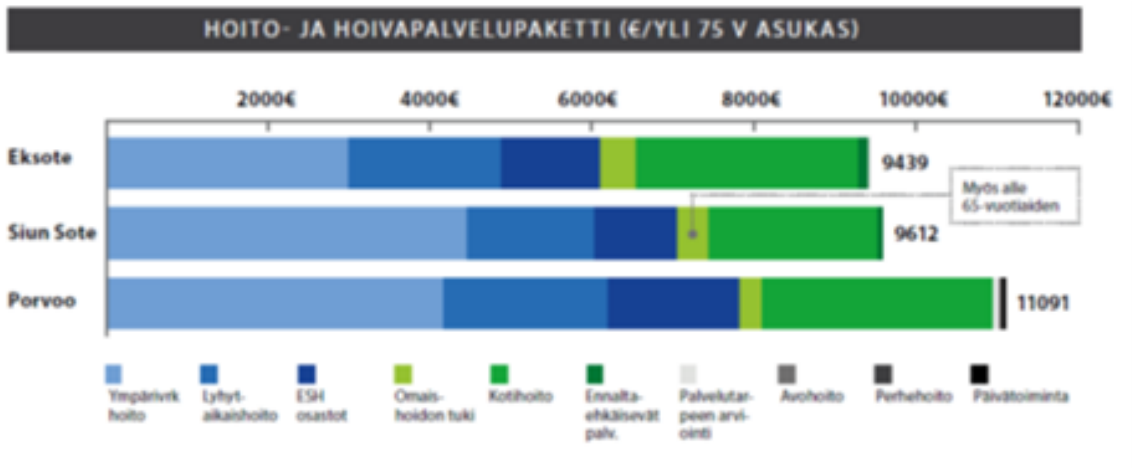


Fig. 23: **(Sitra 2016)**.

The most concrete thing that the pilot project seems to provide for local health managers and policy-makers is a data analytic rationale that segments the clientele of the local public services according to the expenses. Despite this simplicity, the numbers and indicators extracted from the data have important implications. First, the client analysis connects the client, her illness or impairment, and the cost of the service through a single number. This number is an indicator of both the performance of the service organization and the 'vital' condition of the client as a person; consequently, the lives of the people in need of medical and social services and the provision of those services melts together under the client analysis indicators. Furthermore, the functioning of data analytics requires that treatment and care in public services are fragmented into clear-cut 'actions', the cost of which can be defined. Health and social care become commodified and, consequently, illness, impairment, and possibly also health and social risks priced. In this process, the data-driven management devices are congruent with the requirements of marketization of health and social services (see below).

The pilot project proposed a data-intensive client analysis focused on client groups. The idea was that the client analysis would connect the groups and the treated diseases or impairments with the costs, figures which would then direct reorganisation of the services. The same rationale and methods can be used to personalize the calculus, i.e. defining the

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

cost of illness or impairment for every individual client, and it can be extended to health risks, so that the group- or individual-based CVD or depression risks would be related to prospective costs of the treatment. The proposal I will discuss next suggested both extensions.

4 Pricing a Life, in Advance

In April 2018, the main Finnish daily newspaper published an article about a plan to personalize the payment the government pays to health care providers as a part of the health care and social service reform (Helsingin Sanomat 10 & 11 April 2018). The idea was derived from the National Institute for Health and Welfare (THL), a main public data management authority and governmental data service provider. *Helsingin Sanomat* interviewed Timo Seppalä, who was the head of THL Social and Health Economics Unit in charge of preparing the plan. The plan of the great health care reform suggested that the main part of public financing of health services would be organized so that the service providers – both public and private – would be payed according to the number of users they serve. This ‘capitation payment’ per head was planned to cover 2/3 of the payment for service providers, and the rest would be based on the cost of the medical operations conducted. In *Helsingin Sanomat*, Seppälä elaborated that the idea is to refine this model so that every citizen shall have a defined personal ‘capitation payment’. The price will be calculated on the basis of service usage history and risk factors related to the health and life situation of the person, and the data for that will be extracted from public population and health care usage registers, personal medical records excluded. The price for a life will be prospective, a sort of health care derivative, because it designates an estimation of the cost a person may cause.

Furthermore,THL suggested that the citizens would not know the personal prices of their health and illness, and neither would the service providers. The idea was that an automatic system for data circulation and calculation would run public financing of health care, so that when a person chooses her health care provider the ’system’ of the Social Insurance Institution (KELA) automatically picks up her data – with the help of her PIN -- from public databases and calculates the payment to be payed to the service provider. The automated data management would guarantee that nobody would know the citizen’s personal health price, except the data analytics machine at KELA. Seppälä justified the

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

proposal as a 'necessary' means of market regulation. The great reform proposed that all individuals could choose their health service provider freely among public and private providers. Under the 'freedom of choice' banner, the Finnish government wanted to provide a wider and more easily accessible market for private health care companies. The payment to the service providers was originally planned to be based on robust population segments and average costs, which many commentators saw as problematic. THL's proposal was presented to solve one of them. Seppälä commented to *Helsingin Sanomat* that when public health care will be opened to private companies, 'tailoring' the payment person-by-person is needed to prevent the companies from 'skimming' the health care market and making a profit on public expenditure. According to him, personalized pricing would bring 'a just payment based on an accurate risk assessment' (Helsingin Sanomat 10 April 2018).

Above, I discussed sources of data-driven governing in (post)welfare state of Finland: maintenance and utilization of public databases covering the population as a whole; PIN as a flexible 'operator' of data management and usage; government 'at distance' with the help of data; the rationale and devices of applied health economics; a sociotechnical imaginary of data-driven personalized control medicine; and a passionate belief in the blessings of data-mining among the Finnish policy-makers and top governmental officials. These topics conjoin in the proposal to put personalized price tags on peoples' future lives. The proposal also exemplifies a policy rationale and performative that align marketization of health care and deployment of advanced data mining technology. 'Marketization' refers here to governing of public health care provision as if it were a market and a domain of market competition, and to expanding the market by opening public health care to operations of private companies. The government proposal of the reform considered advanced data management and 'digitalization' indispensable for governing and managing marketization in both senses. In turn, the THL proposal shows that marketization directs the deployment of health data and data analytics in an individuating manner, i.e. to serve personalization of the price of health, illness and living.

Thinking of personalization of 'capitation payment' as an instrument of market regulation has certain implications. First, control of health care costs and health risk control will merge epistemically and technically. This resembles rationales and practices of private insurance; in fact, marketization with the help of personalized price tags for health risks

DOI: 10.3217/978-3-85125-668-0-10

may mean that public health care will adopt features of private insurance and move away from the Nordic de-commodification model to insurance.

5 Business as Usual

Public reception of the THL proposal was not very welcoming. The Data Protection Ombudsman was concerned about privacy issues, and a top official of Statistics Finland presented rather sceptical views about personalization. Both of them also reminded the advocates of the plan public that the GDPR is in force in Finland also. However, the main reason why the plan has not been executed relates to the fate of the great reform of public health care and social services. In spring 2019, the grand reform got stuck in a legal, political, and administrative stalemate. Due to this, the time to pass the legislation required by the reform ran out before the parliamentary election, and the government withdrew the reform plan. As the grand reform dissolved, the proposal for personalization of the 'capitation payment' was also put aside. Despite this, the plan was considered and discussed as a reasonable and appropriate solution to a key problem of expenditure management of the grand health care reform. The epistemic and political rationales for execution of the plan exist, and so do administrative and technical means to put it in action. Especially the experts inside the governmental data management and register-keeping institutions tend to consider that defining the price or payment of public health care person-by-person and on the basis of health risk calculation would be business as usual, 'just an extension of normal register research', as Timo Seppälä claimed (Helsingin Sanomat 11 April 2014).

Indeed, defining a personal, prospective price for every potential user of the Finnish health services – citizens, permanent residents and even the new-born – would not make much difference to existing practices. *Technological* prerequisites for personalized health risk pricing are available: existing and expected IC technology has and will advance digitalization, circulation and mining of population and patient data, and there is the PIN as the operator of interoperability between the databases. From an *epistemic* point of view, the introduction of a personalized 'capitation payment' would not bring anything new to the established manners of knowledge production and indicators of health economics, public administration and public health, and neither to the associated practical rationales of using public register data in policy-making and public administration. Technical and epistemic prerequisites for setting a prospective price to a person’s health and illness are complemented by a *political* rationale embedded in the ethos of New Public Management with neoliberal ingredients. I call this policy mode ’market governmentality’. The concept refers to an art of governing that emphasizes the competition mechanism as *the model* of regulation of the state activities and government of people and their lives, uses the market as *a means* to reform and regulate public service provision institutions, and opens up domains of public services to commercial activities and competition (Helén 2016).

The plan for the great health and social service reform in Finland exemplifies these three dimensions of marketization of governing. First, the generative idea of the reform and the basis of the governance model was that market competition will increase effectiveness and quality of public services, health care included. Second, the reform plan suggested the use of the market as the main means to reform and reorganize public health care and social services. In the government proposal, public health care is conceived of and planned to be organized as if they are market relations between public ‘buyers’ that represent ‘demand’ and service providers as the ‘supply’ side. Finally, the reform plan promoted an additional route of marketization of public services by opening public health care as a market for private companies. Regarding the latter two dimensions, digital data management was thought to play a key role. The plan to use intensive data mining for defining ‘capitation payment’ person-by-person is a concrete example of both the importance and expectations of integration of advanced data analytics with the new style of public health care management. Thus, ‘market governmentality’ -- governing *as* and *by* the market – provides a framework in which advanced data analytics technology can function as a political technology … of ‘personalization’.

References

Alastalo, M. (2009): Viranomaistiedosta tilastoksi – rekisteriperusteisen tilastojärjestelmän muodostaminen Suomessa. Sosiologia 46, 173-189.

Amoore, L. (2011): Data Derivatives: On the Emergence of a Security Risk Calculus for Our Times. Theory, Culture & Society 28(6), 24-43.

Amoore, L.; Piotukh, V. (eds) (2016): Algorithmic Life: Calculative Devices in the Age of Big Data. Abingdon: Routledge.

Beer, B (2016): Metric Power. London: Palgrave Macmillan.

DOI: 10.3217/978-3-85125-668-0-10

Bigo, D; Isin, E.; Ruppert, E. (2019): Data Politics. Abingdon: Routledge.

Blyth, M. (2013): Austerity: The History of a Dangerous Idea. Oxford: Oxford University Press.

Dean, M. (1999): Governmentality. Power and rule in modern society. London: SAGE.

Foucault, M. (2000a): Governmentality. IN Power. Essential works of Michel Foucault 1954-1982, vol. 3. New York: Free Press.

Foucault, M. (2000b): “Omnes et signulatim”: Toward a critique of political reason. IN Power. Essential works of Michel Foucault 1954-1982, vol. 3. New York: Free Press.

Foucault, M. (2000c): The political technology of individuals. IN Power. Essential works of Michel Foucault 1954-1982, vol. 3. New York: Free Press.

Hacking, I. (1990): The Taming of Chance. Cambridge: Cambridge University Press.

Hammer, S. (2011): Governing by Indicators and Outcomes: A Neoliberal Governmentality? IN A. R. Saetnan: H.Lomell; S. Hammer (eds.) The Mutual Construction of Statistics and Society. Abingdon: Routledge

Helén, I. (2005): Genealogia kritiikkinä. Sosiologia 42, 93-109.

Helén, I. (2016): Elämän politiikat. Yhteiskuntatutkimus Foucault’n jälkeen. Helsinki: Tutkijaliitto.

Helsingin Sanomat (10 April 2018): Uusi tieto Sote-uudistuksesta: Jokainen suomalainen pisteytetään sen mukaan, miten hän rasittaa terveydenhuoltoa.

Helsingin Sanomat (11 April 2018): Minkä terveystietojen mukaan perusteella maksu määräytyy? Kenellä on niihin pääsy? Viisi kysymystä ihmisten hinnoittelusta, jota ajetaan sote-uudistukseen.

Häkkinen, U.; Lehto, J. (2005): Reform, Change, and Continuity in Finnish Health Care. Journal of Health Politics, Policy and Law 30, 79-96

Jasanoff, S. (2015): Future Imperfect: Science, Technology, and the Imaginations of Modernity. IN S. Jasanoff; S.-H. Kim (eds.) Dreamscapes of Modernity. Sociotechnical Imaginaries and the Fabrication of Power. Chicago: University of Chicago Press.

Jauho, M. (2010): Miten riskitieto alkoi ohjata terveyspolitiikkaa: tilastomatemaattiset välineet ja sydäntautien torjunta Suomessa toisen maailmansodan jälkeen. IM M. Alastalo; M. Åkerman (eds.) Tieto hallinnassa. Tampere: Vastapaino.

Jauho, M. (2017): Contesting Lifestyle Risk and Gendering Coronary Candidacy: Lay Epidemiology of Heart Disease in Finland in the 1970s. Sociology of Health & Illness 39, 1005-1018.

Julkunen, R. (2001): Suunnanmuutos. 1990-luvun sosiaalipoliittinen reformi Suomessa. Tampere: Vastapaino.

Kromhout, D.; Menotti, A.; Blackburn, H. (eds.) (1994): The Seven Countries Study. A Scientific Adventure in Cardiovascular Disease Epidemiology. Bilthoven: The Seven Countries Study.

Ilpo HELÉN
DOI: 10.3217/978-3-85125-668-0-10

Larsen, L. T. (2011): The Birth of Lifestyle Politics: The Biopolitical Management of Lifestyle Diseases in the United States and Denmark. IN U. Bröckling, S. Grassmann; T. Lemke (eds.) Governmentality. Current Issues and Future Challenges. New York & London: Routledge.

Lemke, T. (2011a): Foucault, governmentality, and critique. Boulder & London: Paradigm.

Lemke, T. (2011b) Beyond Foucault: From biopolitics to the government of life. IN U. Bröckling, S. Grassmann; T. Lemke (eds.) Governmentality. Current Issues and Future Challenges. New York & London: Routledge.

Mayer-Schönberger, V.; Cukier, K. (2013): Big Data: A Revolution that Will Transform How We Live, Work and Think. London: John Murray.

Muniesa, F.; Millo, Y.; Callon, M. (2007): An Introduction to Market Devices. IN M. Callon; Y. Millo; F. Muniesa (eds.) Market Devices. Malden & Oxford: Blackwell.

National Academy of Sciences (2011): Toward Precision Medicine. Washington, DC: The National Academies Press.

Oppenheimer, G. M. (2006): Profiling Risk: The Emergence of Coronary Heart Disease Epidemiology in the United States (1947–70). International Journal of Epidemiology 35, 720–30.

Pentland, A. (2013): The Data-driven Society. Scientific American 309:4, 78-83.

Porter, T. (1996): Trust in Numbers. : Princeton: Princeton University Press.

Prainsack, P. (2017): Personalized medicine: Empowered patients in the 21st century? New York: NYU Press.

Rose, N. (1999): Powers of freedom. Cambridge: Cambridge University Press.

Rothstein, W. G. (2003): Public Health and the Risk Factor. A History of an Uneven Medical Revolution. Rochester and Woodbridge: University of Rochester Press.

Ruckenstein, M.; Schüll, N.D. (2017): The Datafication of Health. Annual Review of Anthropology 46, 261-278.

Ruppert, E. (2011): Population Objects: Interpassive Subjects. Sociology 45, 218–233.

Ruppert, E. (2012): The Governmental Topologies of Database Devices. Theory, Culture & Society 29, 116–136.

Ruppert, E. (2013): Not Just Another Database: The Transactions that Enact Young Offenders. Computational Culture: A journal of software studies 3, 1-13.

Saetnan, A. R.: Lomell, H.; Hammer, S- (eds.) (2011): The Mutual Construction of Statistics and Society. Abingdon: Routledge

Sharon, T. (2016): The Googlization of ealth research. Personalized Medicine 13, 563-574.

Sitra (2014): Sosiaali- ja terveyspalveluiden tietojohtamisen käsikirja. Helsinki: Sitra.

DOI: 10.3217/978-3-85125-668-0-10

Sitra et al. (2016): Tiedosta tekoihin. Helsinki: Sitra and Ministry of Social Affairs and Health.

Swan, M. (2012) Health 2050: The Realization of Personalized Medicine through Crowdsourcing, the Quantified Self, and the Participatory Biocitizen. Journal of Personalized Medicine 2, 93

Talley, C.; Kushner, H. I; Sterk, C. E. (2004): Lung Cancer, Chronic Disease Epidemiology, and Medicine, 1948–1964. Journal of the History of Medicine and Allied Sciences 59, 329–74.

Tarkkala, H.; Helén, I.; Snell, K. (2019): From Health to Wealth: The Future of Personalized Medicine in the Making. Futures 109, 142-152.

Ziewitz, M (2016): Governing algorithms: Myth, mess, and methods. Science, Technology, & Human Values 41, 3-16.

DOI: 10.3217/978-3-85125-668-0-11

The Coded Pancreas: Motivations for Implementing and Using a Do-It-Yourself Medical Technology in Type 1 Diabetes Self-Care

Bianca JANSKY (1), Silvia WOLL (2)

(1) Institute of Ethics, History and Theory of Medicine, Ludwig-Maximilians-University, München, Germany

(2) Institute of Technology Assessment and Systems Analysis, Karlsruhe Institute of Technology, Karlsruhe, Germany

Abstract

Type 1 diabetes (T1D) is a severe chronic disease with potentially serious acute and long-term consequences. A technology that adequately replaces pancreatic function is not yet available. Committed people with T1D no longer want to wait for the approval of a commercial system and develop their own systems: Do-it-yourself Artificial Pancreas Systems (DIY APS) automatically adjust insulin delivery through the insulin pump to keep blood glucose levels in a safe range. The question arises why a steadily increasing number of people with T1D relies on a technology that strongly influences their health, but which is not approved by an official body and therefore no-one can be held responsible in case of faultiness. In this article we are drawing upon empirical findings to better understand the motivation behind using a DIY technology for self-care in chronic disease management. We describe the multifaceted motivations of people with T1D engaging in the implementation and usage of DIY APS and how they integrate the new system into their daily practices. Empirically, the article is based on two still ongoing qualitative studies on the lived experiences of people implementing and using DIY APS. We can trace a strong emphasis on community aspects, trust in both the community and the technology, frustration with currently commercially available technical aids as well as actors of the established healthcare systems, and a vigorous dedication from both the users and the developers.

Keywords: Do-It-Yourself Artificial Pancreas System, Type 1 Diabetes, Community, Closed Loop System, Health Technology

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

1 Introduction

Diabetes mellitus is a disorder of the blood glucose metabolism in the body with permanently elevated blood glucose levels. In Germany, an estimated 8 million people suffer from diabetes, 3000.000 of them from type 1 diabetes (T1D) (related to 2016) (Bundesgesundheitsministerium 2019), which is the most common metabolic disease in children and adolescents (Diabetesinformationsdienst 2019). Unlike type 2 diabetes, T1D has no association with lifestyle choices, but rather develops as a consequence of an individual's auto-immune system destroying the insulin-producing cells in the pancreas (Atkinson et al. 2014). Because of its increasing prevalence, T1D is described to be of particular public policy significance (Harries et al. 2019). If not properly managed, the chronic health condition might cause severe long-term effects, such as vision loss and peripheral neuropathy (Harries et al. 2019). So far, the condition is incurable. The disease has serious effects on the entire body, as well as determines the daily lives of those affected. Thus, the task of people with T1D is not only to follow medical instructions for recovery. They have to manage an irreversible condition, which means self-observation and monitoring of symptoms become constant tasks (Bruni/Rizzi 2013). This involves affected people "doing a pancreas" (Wiedemann 2016), for simulating the functions of the organ. T1D requires constant monitoring and recording of i.a. recent and anticipated food intake and activities (e.g. sports) for patients or caretakers of an individual with T1D. Additionally, they have to constantly monitor their blood glucose levels and administer appropriate amounts of manufactured insulin doses via infusion or injection in order to keep blood glucose levels within a required range. This has to be done by patients themselves, after consultation with their physician. Corbin and Strauss (1988) describe this demand for constant care in chronic illnesses, as *work*, which is not reserved to medically trained professionals. This increasing focus on self-responsibility in managing one's own health is a widely researched phenomenon in social sciences, leading to concepts such as “expert patient” (Fox et al. 2005), “active patient” (Rabeharisoa et al. 2014), and, in light of the increasing importance of digitalization in self-care, “digitally engaged patient” (Lupton 2013). These concepts entail the notion that patients can no longer be understood as solely “passive recipients of care” (Lewis/Leibrand 2016), which leads to challenges of traditional hierarchies in healthcare (Kingod 2018).

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

Besides the high level of self-responsibility, T1D is characterized by the fact that the subjective perception of the disease only occurs when the blood sugar level is very high or very low. This means there are no other clinical symptoms that manifest themselves externally, this is referred to as "absence of symptoms" (Hess 2018). Especially while sleeping, this 'absence of symptoms' is problematic, and can cause insecurities for affected individuals. T1D technologies, such as insulin pumps, injection pens or blood glucose monitoring devices aid patients in their everyday life practices to manage their chronic illness and to make the bodily processes more visible, which is why T1D can be described as a highly technologized disease (Hess 2018).

1.1 Technologies for self-care in T1D management

These technological aids for the self-care in T1D therapy have advanced significantly over the last years. While until a few years ago the measuring process was usually carried out by pricking a finger to perform a blood glucose test, it is now possible to measure the interstitial glucose concentration through continuously glucose measuring sensors (CGM). Theses CGMs are placed on the skin with a sensor filament reaching under the skin and can be worn over a prolonged time on the body (Freestyle Libre 2019, Dexcom 2019, Medtronic 2019a, Wiedemann 2016). These sensors also enable constant monitoring of the glucose level (cf. Fig. 24). Thurm and Gehr (2013) compare the difference between traditional blood-based and sensor-based glucose measurements to that of image and film (Thurm/Gehr 2013): while the measurement with blood only shows a single point value and there is no information about the blood sugar progression, sensor-based measurement devices continuously display glucose levels.

Fig. 24: *Freestyle Libre sensor and reading device displaying tissue glucose of the past eight hours. Source: SW*

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

CGM devices constitute a first step towards an autonomous adjustment of the insulin rate. The technological vision, of combining a blood sugar measuring device and an insulin pump in a closed loop system, which is also referred to as Artificial Pancreas System (APS), is not a new idea; it has been subject to research since 1973 (Home 2017). However, at the moment, full closed loop systems are not available at all. There is only one commercially available APS (cf. Barnard et al. 2018): Medtronic MiniMed 670G (Medtronic 2019b, cf. Messer et al. 2018, Cordero et al. 2017), a hybrid closed loop system, which means that insulin for carbohydrate intake still has to be administered manually. So, it is still far from actually simulating the functions of the pancreas. Medtronic MiniMed 670G was FDA approved (for the US market, FDA 2019) in February 2018 and CE licensed (for the EU market, Medtronic 2019c) in June 2018. CE license does not mean that the system is available in all EU countries (Medtronic 2019c); and also, not for any person with T1D even in the countries in which the system is available.

1.2 Vision of an artificial pancreas system and DIY realization

A closed loop system in T1D therapy would connect a CGM and an insulin pump in order for them to communicate with each other, enabling an algorithm-controlled automated delivery of insulin doses adapted to current glucose values (cf. Fig. 25).

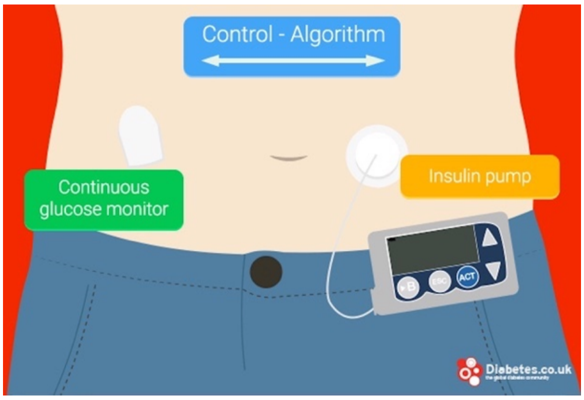


Fig. 25: *An APS linking the data of the CGM and the insulin delivery of the insulin pump. Source: Diabetes.co.uk*

When the sensor reports a low or decreasing glucose level, the pump reacts by delivering less or no insulin. When the sensor reports a high or increasing glucose level, the pump delivers more insulin. As mentioned before, so far only one hybrid closed-loop system (Medtronic MiniMed 670G) worldwide has gained approval from regulatory bodies. As the development of commercial systems progresses slowly, a group of dedicated affected

DOI: 10.3217/978-3-85125-668-0-11

people and their relatives have joined forces and developed DIY versions of an APS in a collaborative effort and made the instructions and source-codes online available for everyone to recreate and further develop (OpenAPS 2019, AndroidAPS 2019, Loop 2019). Users refer to the software as 'the loop', as what the algorithm does is closing the loop between CGM and the insulin pump via a smartphone app. The different DIY systems all have in common that they combine commercially available CGM devices[1] and commercially available insulin pumps with a smartphone app that was developed as a collective endeavor in the DIY community. That part of the community consists of software developers, engineers, as well as medically trained professionals. Previously programming knowledge was needed to use the system, but today with the support of the community and very well documented instructions, programming skills are not a requirement for using a DIY APS, but caution and patience are needed (Braune/Wolf 2019).

These DIY systems are supposed to be precise. Dana Lewis and Scott Leibrand, developers of the first open source DIY APS, OpenAPS, describe it as "far safer than standard pump" therapy and argue that it leads to "remarkable improvements in quality of life due to increased time in range, uninterrupted sleep, and peace of mind" (Lewis/ Leibrand 2016). Currently, at least 1303 people worldwide use DIY APS (OpenAPS Outcomes 2019).

Most of our participants report an increase of quality of life and improvement of their glucose levels, especially more time in range (TIR, the time in which blood glucose is in the target range of 70-180 mg/dl, Danne et al. 2018) and an improvement of HbA1c (mean value of blood glucose over a longer period of time, usually three months, Danne et al. 2018) (cf. Fig. 26). Also, the majority of the interviewed diabetologists and diabetes advisors report improvement of glucose levels of patients using the system.

1. It should be noted that Abbott's Freestyle Libre sensor (Freestyle Libre 2019) has to be enhanced with a transmitter (e.g. BluCon 2019, Miaomiao 2019) in order to function as a CGM.

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

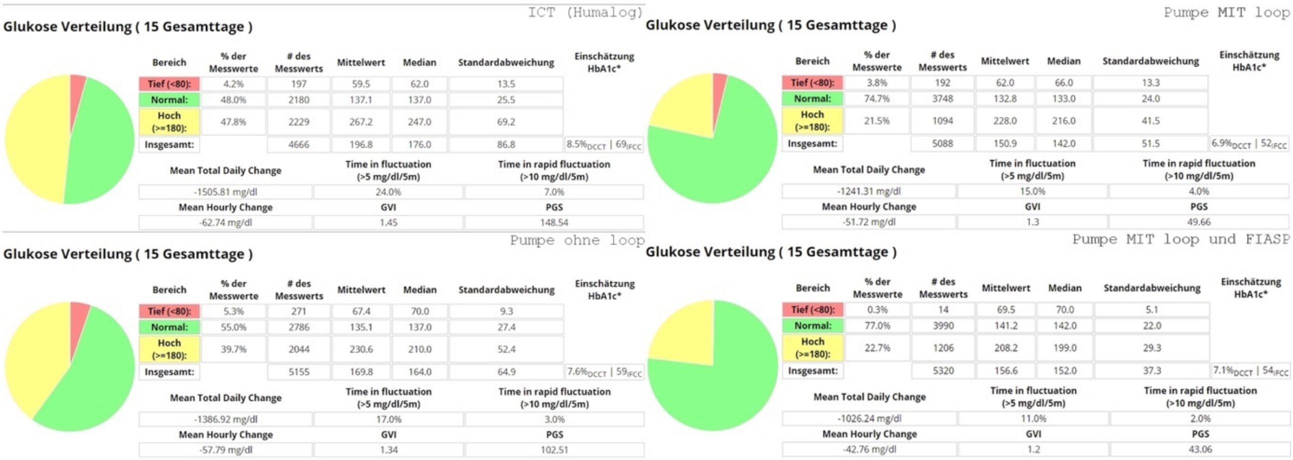


Fig. 26: *Gradual improvements of TIR, depicted by a user: 1) "ICT" (therapy with insulin pens), 2) "Pumpe ohne loop" (therapy with insulin pump without DIY APS), 3) "Pumpe MIT loop" (therapy with insulin pump and DIY APS (AndroidAPS), 4) "Pumpe MIT loop und FIASP" (therapy with insulin pump, DIY APS and a fast-acting insulin). Green area: blood glucose in range; yellow area: blood glucose too high; red area: blood glucose too low. Source: zehn.BE*

This technology comes with many promises, but also changes the self-care for people using the system vastly as they operate in a legal grey area and cannot easily draw upon the advice of medical professionals. Thus, they mostly rely on the help of other users and the information they find online, in the DIY online community. Therefore, the question arises why more and more people with T1D are engaging in the DIY APS and actively advocating the DIY systems, despite the technological obstacle and the lack of approval from a regulatory body. What are the motivations of people with T1D to put a lot of effort and their time in developing, implementing and using a health technology that is situated outside of the sphere of medical development and research?

To better understand the motivation behind using a DIY technology for self-care in chronic disease management, this article describes the multifaceted motivations of people with T1D engaging in the implementation and usage of DIY APS and how they integrate the new system into their daily practices. We explore how patients are using and modifying commercially available technology in innovative ways to improve their daily lives with T1D.

2 Methodology

In light of the anticipated complexity of the study subject, our empirical approach consisted in combining a sociological and a technology assessment perspective to better capture the researched phenomenon. Empirically, the article is based on two ongoing qualitative

DOI: 10.3217/978-3-85125-668-0-11

studies on the lived experiences of people developing and using DIY APS. Bianca Jansky's PhD is mainly focused on aspects of expertise shifts, knowledge production and health and patient activism in the context of DIYAPS; Silvia Woll's PhD examines current technologies for handling T1D with a vision assessment (2.2) approach.

For this article we are combining the data sets gathered parallel by the two authors. For the analysis, both samples where combined and interpreted in light of the mutual research question.

2.1 Situational Analysis

To better empirically understand the complex and dynamic phenomenon that is DIY APS, from a sociological point of view the analysis is oriented at a Situational Analysis (SA) approach as suggested by Adele Clarke (2005, 2015). This constitutes a new conceptualization of grounded theory methodology, inspired by Anselm Strauss' theoretical social worlds and arenas concept, as well as Michel Foucault's emphasis on discourses as analytical framework. With the perception that "[t]here is no such thing as 'context'" (Clarke 2015), the different elements of the researched phenomenon are seen as *constitutive parts* of it, and not as mere surroundings, which makes it possible to situate our analysis deeper on individual, collective, material and discursive levels. This form of empirical approach to our material allowed us to get a deeper understanding of the phenomenon in question, as we can obtain a dense description of both the motivations of people engaging with DIYAPS and at the same time other elements that outline the researched situation.

2.2 Technology Assessment – Vision Assessment

While a SA approach can give us a deeper understanding of the researched phenomenon, with a Technology Assessment (TA) approach, we can examine the benefits and risks of the technology in question, and analyze and judge "trends in science and technology as well as their societal aspects, contributing to the formation of public and political opinion on these aspects" (Ferrari/Lösch 2017). New and emerging technologies (NEST) in many cases come with a visionary character, with a semblance of a potential to change current state of the arts and to improve current unsatisfactory situations. Such technologies' underlying "(guiding) visions have been a research topic at least since the 1980s, when the idea caught on that imaginations about the future, i.e. about future socio-technical

DOI: 10.3217/978-3-85125-668-0-11

constellations, are extremely relevant in the context of socio-technical innovation processes [a]nd that the analysis and assessment of these (guiding) visions might help to better understand the dynamics of innovation processes" (Böhle/Bopp 2014). In 2000, Grin, Grunwald and others developed Vision Assessment (Grin/Grunwald 2000) "as a tool to analyse, to assess and to shape the use of such visions in debates and controversies" (Ferrari/Lösch 2017).

Visions have the potential to "motivate and fuel public debate because of the impact these visions have on everyday life and on the future of areas of society" (Grunwald 2013). On the one hand, positive visions can be seen as drivers for a longing for (societal) change and sometimes also for the use of technologies. On the other hand, "[n]egative visions and dystopias could mobilise resistance to specific technologies" (Grunwald 2013).

In context with our research phenomenon (positive) visions can already be found in the motto of the movement: People are meeting like-minded people under the hashtag "#WeAreNotWaiting" on social media platforms such as Twitter to exchange experiences and knowledge living with the system (OpenAPS 2019, Twitter #WeAreNotWaiting 2019). As mentioned above, the developers of OpenAPS describe their system as safe and leading to improvements in quality of life (Lewis/Leibrand 2016). With such promises, a vision of a less complicated, less exhausting and healthier life emerges. OpenAPS is described as "advanced but easily understandable" (OpenAPS Reference Design 2019) - however, challenges and obstacles of setting up such a system on one's own should also be considered. Combining a SA and a TA approach can, thus, help to both better understand the researched phenomenon on a deeper individual, collective, material and discursive level, and at the same time keep in sight the challenges and obstacles people that are engaging in this innovative new technology have to face when developing, implementing and using the system.

Data

Altogether, the sample consists of 32 in-depth interviews with users and developers of DIY APS systems, caretakers, friends, family members of people with T1D who support them, as well as diabetologists and diabetes advisors. The interviews, lasting from 20 to 120 minutes, were conducted mostly via telephone or Skype and took place from June 2018 to April 2019. In addition to our interview-based material, our sample also consists of

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

fieldnotes from participatory observations, in the context of DIY APS. We joined regular meetings, as well as going to hackathons and larger events.

For maximizing confidentiality, pseudonyms were used where necessary, and all data was anonymized. Interviews were audio-recorded and later transcribed verbatim. Interviews conducted in German were translated for the article.

3 Findings

In what follows, we will trace the main motivations for using and developing a DIY APS that we obtained from the empirical material. We can show a strong emphasis on communal aspect, trust in both the community and the technology, frustration with currently available technical aids as well as actors of the established healthcare systems, and a vigorous dedication from both the users as well as the developers.

3.1 Community - DIY APS as collective endeavor

One of the main findings is that the observed DIY practices can be described as collective endeavors; even though there is an emphasis on *yourself*, our participants all refer in one way or another to the community. The community refers to everyone involved in the DIY APS, including users and developers, and those supportive of or interested in the technology. The community comes together in multiple ways either via social media platforms, such as Facebook or Gitter, or face-to-face on one of the many regular meetups or bigger events. Markus, who is very actively involved in the DIY APS community, describes the division of labor in the community as follows:

> “The community is just people who get involved. There are people who can't program, who can't do anything, but they can speak a language for example that means they can help with translating or supporting newer members, so the developers and the more experienced members don't have to answer the standard questions.”

In the community it is not about being professionally trained in medical technology development, but rather everyone there has a specific skill that they can contribute to the development of the community. At first glance, it would seem that programming would be most needed in the community, but other skills such as the knowledge of multiple languages or even of having a bit more experience in using the system can help. It seems that, as everyone finds their place within the community, everyone can contribute in some

DOI: 10.3217/978-3-85125-668-0-11

form. Without everyone having professional medical or technical knowledge, the division of labor becomes crucial. This observed solidarity in the community can even be the reason to start ‘looping’ in the first place, as Christian states:

> “This community, it's the reason I started looping. I have never experienced so much solidarity, so much support and so much willingness to selflessly give something to others, to do something good, to support other people. I have a problem today and tomorrow I have three answers [...]. That's completely different than when I compare it with any problems I have commercially, I often get answers – from I have no idea, but they are well packaged, and that's what the community really is. So, that's why I did that, because I realized nothing can happen to you because you will never be left out in the rain.”

Christian’s statement can again illustrate the different forms of work, that people in the community take on (in their spare time, without monetary compensation). Christian states that the community IT-support is more reliable than the one he is used to from commercial technology providers, and because of this strong and fast acting community support, he has no fear using the system.

3.2 Trust

Christian’s statement also illustrates the trust in the community and the shared work of the community. In our empirical material we do not only trace the trust in the immediate support of the community, but also the trust in the collectively developed technology: the ‘loop’, the algorithm that connects the sensor and insulin pump.

One issue raised by regulatory bodies, such as the Food and Drug Administration (FDA) is that DIY approaches are unauthorized and could result “in inaccurate blood glucose (sugar) measurements or unsafe insulin dosing, which can lead to injury requiring medical intervention or even death” (FDA 2019a). Especially in the case of insulin treatment, the accurate dosage of insulin is crucial as a wrong dosage can cause severe acute health adverse events, such as hypoglycemia and ketoacidosis. But the FDA statement does not consider that also with conventional pump therapy, “errors of insulin infusion can occur due to pump failure, insulin infusion set [...] blockage, infusion site problems, insulin stability issues, or a combination of these” and “[u]sers are therefore exposed to significant and potentially fatal hazards” as severe hyperglycemia and hypoglycemia (Heinemann et

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

al. 2015). Also, an insulin treatment with pens is associated with risk as a too large as well as too small amount of insulin will always lead to glucose levels out of range. Another issue is "that useful information held by the manufacturing companies is not currently shared in a sufficiently transparent manner" (Heinemann 2015). Developers of DIY APS address this aspect by providing the coding open source, so all is publicly accessible.

As mentioned before, the self-responsibility in T1D, is very noticeable and gives people with T1D in-depth understanding of their disease, in which their knowledge gained in everyday practice is intertwined with medical knowledge. In their everyday life living with the chronic disease, they have been trained to avoid the causes and to recognize the symptoms of the potential adverse events. People with T1D are well-equipped to judge the safety of monitoring systems, considering that these systems' outcomes are people's own glucose levels. When regulatory bodies such as the FDA issue warnings against the usage of the DIY system, the question arises: how is trust built in this context? Our empirical findings show that trust in DIY APS emerges from the experience that using the 'loop' leads to more TIR and to better glucose levels - but also from the knowledge that developers are coding the system for their own children, as Marie states:

> "And most of all, these developers, they have their kids on it. So, if someone like them doesn't work and check carefully, then who does?"

Developing a system and using it on one's own children shows for Marie the trustworthiness of the system. Especially when one's children are involved; she assumes developers would control their designed technology especially careful under these circumstances.

This trust does not only lead to a feeling of safety, but also to more relief of users. This is especially the case when it comes to sleep. One of the main issues for those affected by T1D is the quality of sleep due to fear of too high or especially too low blood glucose levels. Strongly decreasing or increasing glucose levels are problematic especially during the night as it is likely that people with T1D do not notice them. Recent CGM systems with alert functions help the situation, but the quality of sleep still suffers. As reported by its users, looping has an effect on the quality of sleep due to stabilizing glucose levels during the night:

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

> “This was the first time after almost 30 years of diabetes the prospect of sharing a part of this 24-hour task […] with something […] which, for example, guards me for the night. […] For me it was also really a safety thought. Something is watching over me and […] takes some of this 24-hour job away from me.“

Self-care in chronic illness is, as Strauss and Corbin (1988) put it, work for the affected. Marie describes the workload as a 24-hour task, as she cannot just have time off from managing her T1D. With using the 'loop' she feels as if she is not alone, but that “something is watching over [her]”. This shared workload also leads to a feeling of safety during the night for her, as the technology takes some parts of her 24-hour job “away” from her. Similarly, Tim explains his trust in the system and his feeling at ease with the DIY technology:

> “So, when I see the glucose rising, I realize it. I know, the loop, it takes care of it. So, it will take a while. But it'll get it down again.”

Usually, when the blood sugar drops or rises, which can happen several times a day, often unexpectedly and also independent from food intake or exercise, people with T1D have to take care of it by administering insulin or carbohydrates, or by decreasing the amount of administered insulin. With using the DIY APS, Tim can just realize what is happening and does not have to intervene as he knows that the 'loop' will bring his glucose level back in the desired range.

As already mentioned above, safety issues and subsequent fears and concerns are broadly discussed issues concerning the DIY APS, as it is not an authorized and officially regulated health technology. Tim also refers to those safety issues:

> “I see the advantage of this system. It's just much bigger than what might happen. So, the situation you're afraid of with the loop. That doesn't happen because of the loop.“

Regulatory agencies and other actors of the established healthcare system see a danger in shifting some responsibility from the individuals to the 'loop'. However, it is this exact shift in responsibility which allows individuals with T1D to feel less in danger. Their trust in the technology allows for a greater sense of safety living with T1D.

3.3 Frustration with traditional self-care in T1D management

The warning issued by the FDA can be interpreted as an example of the tension between patients, who want to take their health into their own hands and do not want to wait for actors of established healthcare systems to come up with solutions, and regulatory bodies in the public health context. The warning was issued as a reaction to a patient who required hospitalization while using the DIY system - something that could have also happened while using FDA approved commercial devices - but since a DIY system was involved, there was greater public scrutiny. Looking at the media coverage and the public discourse surrounding the DIY APS, two of the main questions are: why are people relying on a DIY system and why is there only one commercially available technology, so far? As we mentioned before, recently, the first commercially developed systems have become available in some countries, but development of a medical device in traditional research and development context is a time consuming and highly regulated practice. This leads to frustration among the affected.

This frustration with pharmaceutical concerns and other actors of the established healthcare system, can also be traced by the use of the hashtag #WeAreNotWaiting. As previously mentioned, affected people did not want to wait for a commercial actor to finally take up the development of a closed loop system, but started to take matters into their own hands, and developed the system open source. Jacob, a father to a six-year-old boy with T1D, explains his frustration:

> "As a computer scientist I was frustrated by the amount of manual management required for diabetes, how many simple calculations you have to make every day and how high the probability of errors is when you have to make these calculations yourself on paper. [...] and we were somewhat frustrated as to why we have to do this ourselves – the data is all there, the pump has the data, the sensor has the data."

In T1D self-care, the focus on self-responsibility of one's health has traditionally been very noticeable: The treatment of the chronic disease requires a demanding regime of self-care for patients, including consistency in diet, as well as blood sugar level monitoring and insulin injections. These practices have to be repeated throughout the day. Referring to his background as a computer scientist, Jacob expressed “frustration" with the lack of automatization in the care of his young child and he turned towards a DIY solution; for him the manual calculations are as much or even more prone to failure than an open source

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

algorithm, as the 'loop'. With this newly gained confidence of people with T1D through their DIY approaches, the traditional hierarchies in healthcare are being challenged. This is especially visible looking at the role of physicians in the context of DIY APS:

> "So, there are doctors, […] who are diabetes patients themselves, who are also endocrinologists, who are totally active in this field. And then, I also had several doctors who don't know their way around. If I tell them about artificial pancreas, they don't know what that is, it is as if I would talk to them in a foreign language."

Marc describes how boundaries of previously defined social roles are blurred by DIY strategies. The healthcare professionals are not seen as omniscient amongst members of this DIY community, but rather, they are perceived either as a member of the community or as or as outsiders without the specific community knowledge.

3.4 Commitment

Our empirical material shows that, using DIY APS seems to come along with a lot of improvements regarding quality of life and glucose levels, compared to the currently very limited commercial alternatives. But on the flip side of the DIY technology is that even with the great solidarity in the community, some things have to be done by every user themselves, for example compiling the app to connect sensor and insulin pump, which is reported to be quite difficult by some of the participants. Marie states:

> "Well, that was difficult with me. But what was even more difficult for me to figure out before that, […] what do I need at all? Well, […] I didn't even know I needed a transmitter. I didn't even know that the thing I needed was called a transmitter. Well, I'd gotten a few words knocked around my ears, like BluCon and an XDrip and Nightscout and APS, okay. But now, what was in charge now, I didn't know. I had to puzzle it out first. Then somehow, I had this Nightscout, I thought: What do I do with it? That this is just a database for uploading […] my values, which I still need somehow, for what I have not yet understood why it is absolutely necessary, an AAPS […]. But it won't work without it. Those were the sticking points where I had a hard time. This linking of apps, […] of XDrip and then XDrip has to communicate with AAPS and Nightscout has to communicate with AAPS to get those links done, that was difficult for me."

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

Setting up a DIY APS can be a challenge without being tech-savvy, so additional to their already very high medical knowledge regarding T1D, users have to acquire some understanding of connecting the respective devices and compiling the app. But since the alternative would be to not use the system at all, people are dedicated to understanding how to do all that.

Achieving to setting up the DIY APS, leads to outcomes beyond improved glucose levels. A feeling that is reported is pride, as Marie expresses:

> “Of course, I'm proud of it. Yes, I am proud of it. Now I'm thinking, why? Yes, because as a mum and housewife I managed to do that. Yes, it also makes me a bit proud. […] That's the way it is. I had to do something for it. “

The commitment of engaging in the setting up of a DIY APS even leads to remarkable outcomes regarding the way parents perceive their diabetic child since using DIY APS. Clara, a mother of a child with T1D, states:

> “I mean for us Sarah is a healthy child, I say. Because we invest so much effort that she has these good blood values.”

Children affected by T1D usually are not considered to be healthy. Their parents’ care includes much more effort than the care of parents of healthy children. Therefore, it is astonishing that Clara considers her daughter a “healthy child” due to effort she takes for her wellbeing. Without DIY APS, this effort might be less (but still much more compared to non-diabetic children) but would never lead to perceiving Sarah as healthy. Engaging in the implementation and usage of a DIY technology for T1D self-care, does lead to some new forms of patients work (Corbin/Strauss 1988) but at the same time takes work away from patients and caretakers and can lead to new notions of what is considered healthy and ill.

4 Conclusion

Motivations for people with T1D to use and implement a DIY APS in their T1D self-care are multifaceted. We can show that a lot of the motivation to engage in the DIY APS context is related to the closely knitted community, and the help people receive through this community. This solidarity throughout the community can in some cases even be the reason for starting using the DIY system. The setting outside of clinical and commercial

DOI: 10.3217/978-3-85125-668-0-11

context also leads to change in the traditional division of labor in medical contexts, where patients follow instructions from physicians. In the context of DIY APS this hierarchy in expertise is no longer stable. Physicians are either part of the community or outsiders, without the community's specific knowledge. People in the community take on new forms of work, that even surpass the notion of patient work of Corbin and Strauss (1988). We can also show that both the community and the collectively developed technology gain much trust from the users and help them in their everyday life. Not only report almost all of our participants better glucose levels using the system but also more trust is put into the (IT) support of the community than in that from commercial actors. We can see this also in relation to the close personal involvement of the developer in the DIY system, as one participant described that her trust derives from the fact that a lot of the developers use the DIY APS on their own children. We can also show that the OpenAPS developers' promise of improvement of sleep quality is confirmed from our participants, they also report a feeling of ease and less fear during the night. Our empirical material shows the frustration of T1D with pharmaceutical concerns and other actors of the established healthcare system, and their dedication to improve their daily lives without waiting for a commercial actor to step in. Our findings show a shift in the conceptualization of 'expertise': they illustrate, how informed patients are successfully engaging in the development process of a medical technology, that improves not only their blood glucose values but also their quality of life. This shows that people living with a chronic illness are experts of their disease and should be included more in the development and research of health technologies and other approaches of treatment.

So far there is little empirical research on the lived experiences of people using and engaging with a DIY system to manage their health condition. We therefore argue for more research on the subject, and we emphasize the importance to engage and involve people with T1D in the research to better understand their experiences and practices using a DIY system for their self-care, as they can be considered experts of their disease.

References

Atkinson, Mark, A.; Eisenbarth, George S.; Michels, Aaron W. (2014): Type 1 diabetes. In The Lancet, 383, (9911), pp. 69–82.

AndroidAPS (2019): url: https://androidaps.readthedocs.io/en/latest/CROWDIN/de/index.html (Stand 25.04.2019)

DOI: 10.3217/978-3-85125-668-0-11

Barnard, Katharine; Ziegler, Ralph; Klonoff, David; Braune, Katarina; Petersen, Bettina; Rendschmidt, Til; Finan, Daniel; Kowalski, Aaron; Heinemann, Lutz (2018): Open Source Closed-Loop Insulin Delivery Systems: A Clash of Cultures or Merging of Diverse Approaches? In Journal of Diabetes Science and Technology, pp. 1-4.

BluCon (2019): url: https://www.ambrosiasys.com/ (last access 27.05.2019)

Braune, Katarina; Wolf, Saskia (2019): Wie alles begann. Diabetes-Forum Schwerpunkt Closed Loop, 4, pp. 14-17.

Bruni, Attila; Rizzi, Carlo (2013): Looking for Data in Diabetes Healthcare: Patient 2.0 and the Reengineering of Clinical Encounters. Science & Technology Studies 26 (1), pp. 29-43.

Böhle, Knud; Bopp, Kolja (2014): What a Vision: The Artificial Companion: A Piece of Vision Assessment Including an Expert Survey. In *STI Studies* 10 (1), pp.155–186.

Bundesgesundheitsministerium (2019): Diabetes mellitus Typ 1 und Typ 2. url: https://www.diabetesde.org/ueber_diabetes/was_ist_diabetes_/diabetes_in_zahlen (last access 25.04.2019)

Corbin, Juliet.; Strauss, Anselm (1988): Unending Work and Care. San Francisco: Jossey-Bass.

Cordero, Toni L.; Garg, Satish K.; Brazg, Ronald; Bailey, Timothy S.; Shin, John; Lee, Scott W.; Kaufman, Francine R. (2017): The Effect of Prior Continuous Glucose Monitoring Use on Glycemic Outcomes in the Pivotal Trial of the MiniMedTM 670G Hybrid Closed-Loop System. In Diabetes Technology & Therapeutics 19 (12). pp. 749-752.

Clarke, Adele (2015): From Grounded Theory to Situational Analysis. What's new? Why? How? In Clarke, A.; Friese, C.; Washburn, R. (eds): Situational analysis in practice: mapping research with grounded theory. Walnut Creek: Left Coast Press. pp. 84-118.

Clarke, Adele (2005): Situational Analysis - Grounded Theory after the Postmodern Turn. Thousand Oaks: Sage.

Charmaz, Kathy (2008): Constructionism and the Grounded Theory Method. In Holstein, J.A.; Gubrium, J.F. (eds): Handbook of Constructionist Research. New York. The Guilford Press. pp. 397-412.

Danne, Thomas.; Kordonouri, Olga.; Biester, Torben; Siegmund, Thorsten; Kröger, Jens; Bramlage, Peter.; Haak, Thomas (2018): "Time in Range": neue Zielgröße in der Behandlung von Patienten mit Diabetes mellitus. In Danne, Thomas,; Ziegler, Ralph (eds): Deutscher Gesundheitsbericht Diabetes 2019. pp. 201-207.

Dexcom (2019): url: https://www.dexcom.com/g6-cgm-system (last access 27.05.2019)

Diabetesinformationsdienst München (2019): Typ-1-Diabetes bei Kindern. url: https://www.diabetesinformationsdienst-muenchen.de/aktuelles/schwerpunktthemen-alt/typ-1- diabetes-bei-kindern/index.html (last access 25.04.2019)

FDA (2019a): MiniMed 670G FDA Approval. url: https://www.fda.gov/medical-devices/recently-approved-devices/minimed-670g-system-p160017s017 (last access 28.05.2019)

FDA (2019b): FDA warns against use of unauthorized devices. url: https://www.fda.gov/news-events/press-announcements/fda-warns-against-use-unauthorized-devices-diabetes-management (last access: 28.05.2019)

Ferrari, Arianna; Lösch, Andreas (2017): How Smart Grid Meets In Vitro Meat: On Visions as Socio Epistemic-Practices. Nanoethics 11 (75). https://doi.org/10.1007/s11569-017-0282-9

Fox, Nick J.; Ward, Katie J.; O'Rourke, A.J. (2005): The "expert patient": empowerment or medical dominance? The case of weight loss, pharmaceutical drugs and the Internet, Social Science and Medicine, 60(6,). pp. 1299-1309.

Freestyle Libre (2019): url: https://www.freestylelibre.us/ (last access 27.05.2019)

Grin, John; Grunwald, Armin (eds) (2000): Vision Assessment: Shaping Technology in Twenty-First Century Society. Towards a Repertoire for Technology Assessment. Springer, Berlin, New York.

Grunwald, Armin (1999): Technology Assessment or Ethics of Technology? Reflections on Technology Development between Social Sciences and Philosophy. In Ethical Perspectives 2, p.170-182.

Grunwald, Armin (2013): Techno-visionary Sciences. Challenges to Policy Advice. In *STI Studies*, 9 (2), pp. 21–38.

Harries, Tim; Rettie, Ruth; Gabe, Jonathan (2019): Shedding new light on the (in)*compatibility* of chronic disease management with everyday life – social practice theory, mobile technologies and the interwoven time-spaces of life, Sociology of Health and Illness, pp. 1–14.

Heinemann, Lutz; Fleming, Alexander G.; Petrie, John R.; Holl, Reinhard W.; Bergenstal, Richard M.; Peters, Anne L. (2015): Insulin Pump Risks and Benefits: A Clinical Appraisal of Pump Safety Standards, Adverse Event Reporting, and Research Needs. A Joint Statement of the European Association for the Study of Diabetes and the American Diabetes Association Diabetes Technology Working Group. In Diabetes Care (38). pp. 716-722. https://doi.org/10.2337/dc15-0168

Hess, Ava (2018): In/Visible Personal Medical Devices: The Insulin Pump as a Visual and Material Mediator between Selves and Others. In Lynch R., Farrington, C. (eds): Quantified Lives and Vital Data. London: Macmillan Publishers. pp. 71-96.

Home, Philip (2017): George Alberti: A Myriad of Contributions to Diabetes and Beyond. Diabetes Care 40 (9), pp. 1154-1158. https://doi.org/10.2337/dci17-0006

Kingod, Natasja (2018): The tinkering m-patient: Co-constructing knowledge on how to live with type 1 diabetes through Facebook searching and sharing and offline tinkering with self-care. Health, pp. 1-17.

Lewis Dana; Leibrand, Scott (2016): #OpenAPS Community. Real-World Use of Open Source Artificial Pancreas Systems. Journal of Diabetes Science and Technology 10(6). 2016. Page 1411. http://doi.org/10.1177/1932296816665635

Loop (2019): url: https://loopkit.github.io/loopdocs/ (Stand 25.04.2019)

Lupton, Deborah (2013): The digitally engaged patient. Self-monitoring and self-care in the digital health era.

Social Theory & Health 11 (3). pp. 256-270.

Medtronic (2019a): Medtronic Guardian Connect CGM. url: https://www.medtronicdiabetes.com/products/guardian-connect-continuous-glucose-monitoring-system (last access 27.05.2019)

Medtronic (2019b): MiniMed 670G url: https://www.medtronicdiabetes.com/products/minimed-670g-insulin-pump-system (last access 28.05.2019)

Medtronic (2019c): MiniMed 670G CE-Zulassung. url: https://www.medtronic.com/de-de/fachkreise/diabetes/produkte/670g-ce-zulassung.html (last access 28.05.2019)

Messer, Laurel H.; Forlenza, Gregory P.; Sherr, Jennifer L.; Wadwa, Paul R.; Buckingham, Bruce A.; Weinzimer, Stuart A.; Maahs, David M.; Slover, Robert H. (2018): Optimizing Hybrid Closed-Loop Therapy in Adolescents and Emerging Adults Using the MiniMed 670G System. In Diabetes Care, 41 (4). Pages 789-796. https://doi.org/10.2337/dc17-1682

Miaomiao (2019) https://miaomiao.cool/?lang=de (last access 28.05.2019)

Mol, Annemarie (2000): What Diagnostic Devices Do: The Case of Blood Sugar Measurement. Theoretical Medicine and Bioethics 21 (1), pp.9-22.

Nightscout (2019) http://www.nightscout.info/ (last access 27.05.2019)

OpenAPS (2019) https://openaps.org/ (Stand 25.04.2019)

OpenAPS Outcomes (2019) https://openaps.org/outcomes/

OpenAPS Reference Design (2019) https://openaps.org/reference-design/ (last access 27.05.2019)

Thurm, Ulrike; Gehr, Bernhard (2017): *CGM- und Insulinpumpenfibel oder bei dir* piept's *ja!* Kirchheim: Kirchheim Verlag.

Twitter: #WeAreNotWaiting (2019) https://twitter.com/hashtag/wearenotwaiting?lang=de (last access 27.05.2019)

Rabeharisoa, Vololona; Moreia Tiago; Akrich, Madeleine (2014): Evidence-based activism: Patients', users' and activists' group in knowledge society. BioSocieties, 92) pp. 111-128.

World Health Organization (WHO): Diabetes. https://www.who.int/news-room/fact-sheets/detail/diabetes (last access 25.04.2019)

Wiedemann, Lisa (2016): "Vom Piksen zum Scannen, vom Wert zu Daten." Digitalisierte Selbstvermessung im Kontext Diabetes. In Duttweiler, S.; Gugutzer, R.; Passoth. H.; Strübing, J. (eds.): Leben nach Zahlen. Self-Tracking als Optimierungsprojekt? Bielefeld: transcript. pp. 293-324.

XDrip (2019) https://github.com/StephenBlackWasAlreadyTaken/xDrip/wiki/Download-Current-Version (last access 27.05.2019)

Bianca JANSKY (1), Silvia WOLL (2)
DOI: 10.3217/978-3-85125-668-0-11

Figures

Figure 24: SW

Figure 25: Diabetes.co.uk. APS how it works https://www.diabetes.co.uk/artificial-pancreas.html

Figure 26: zehn.BE

Overview over cited Interviews

Pseudonym	Description	Interview date
Clara	Mother who uses DIY APS on her diabetic daughter	07.03.2019
Christian	DIY APS user	17.04.2019
Jakob	Father of a child with T1D, uses the system for the child	02.05.2019
Marie	DIY APS user	20.03.2019
Marc	At the time of the interview no user of DIY APS, but actively involved in the community	12.07.2018
Markus	DIY APS user/developer and actively involved in the community	19.07.2018
Tim	DIY APS user	29.03.2019

5 Permissions and Copyright Transfer

We hereby confirm that we obtained the necessary permissions to quote or reproduce material, including figures, from already published works, and to reprint from other publications. We confirm that we obtained the appropriate rights for any image or graphic used in our contribution.

Ute KALENDER, Aljoscha WESKOTT
DOI: 10.3217/978-3-85125-668-0-12

Data Doubles and Control Society: Critical Contentions

Ute KALENDER, Aljoscha WESKOTT

Department of Theatre, Film and Media Studies, University of Vienna, Austria

Abstract

To date, an almost insurmountable number of social scientific contributions have examined digitalisation. However, there is great disagreement about the question which disciplines, knowledges, theories, methods and methodologies, scientific questions, instruments and techniques are adequate to research digitalisation. For example, ethnographic STS studies claim to produce fine-grained pictures of a diversified, multifaceted living in a digitalised society and deem more theoretical-oriented approaches like Marxist as old-school, wood-cut or non-scientific. The latter counter that an encompassing theoretical approach to disparate global processes of digitalisation is still missing. They disqualify diversity approaches as identity politics, descriptive or simply as a-political. As previous technology debates have shown, a problematic effect might be that the different knowledges travel into scattered social fields such as Science and Technology Studies on the one hand and art and social movements on the other hand.

The aim of our theoretical paper is a twofold: Inspired by meta-analyses of recent feminist theory development, we firstly trace some of the investments with which current approaches try to gain sovereignty about interpretations of digitalisation and bring Marxist and diversity approaches into conversation with each other. Secondly, we want to develop an alternative approach that sees the two camps as different modes of data doubles – namely power and exploitation. As such the competing contributions form entrance points and not end points for analysing digitalisation. We claim that *all* approaches are valuable suggestions for conjointly and forcefully researching, intervening, and shaping current processes of digitalisation.

Ute KALENDER, Aljoscha WESKOTT
DOI: 10.3217/978-3-85125-668-0-12

1 Introduction

Wood-cut, old-school, ideological, objectifying, essentialist, anxious, paternalistic, maternalistic, heteronormative, ableist, white supremacist, neo-colonial, non-scientific – ethnographic STS literature continuously uses such labels for theoretical, Marxist oriented approaches to digitalisation. Only descriptive, narrative, subjective, individualistic, singularistic, academic, neoliberal, post-feminist, identity politics or simply techno-capitalism's make up, Marxists respond. Everyone who moves between Science and Technology Studies and critical theory may have encountered these scientific games in one way or the other.

Instead of remaining stuck in this back-and-fourth, we suggest to take these contentions as a starting point for developing a meta-perspective to both Marxist theoretical as much as ethnographic diversity approaches to digitalisation. There are two main purposes for this: Firstly, we claim that Marxist and diversity approaches equally are not only valuable contributions to digitalisation, they also have much in common. Both rely on two key concepts in the debate on digitalisation: control society and data doubles. Secondly, as older debates in STS show, a drifting apart of those knowledges into disparate social fields is problematic. They should be kept in conversation with each other.[1]

The basis of this paper is a literature search on the subject of digitalisation in journals such as Frontiers, Social Media and Society, Television and New Media, Feminist Theory, Theory, Culture and Society, Gender Place and Culture, Feminist Review, The Black Scholar, The South Atlantic Quarterly and Feministische Studien. At the beginning of our new research project on digitalisation and social movements, we started the search with a rather simple question: How from an intersectional, transdisciplinary perspective is digitalisation currently approached in different scientific fields? How do different knowledges, disciplines, research fields make sense of digitalisation? One main finding was that each milieu has a very specific notion of digitalisation, which is hardly surprising,

1. For example in feminist STS debates on reproductive technologies, Marxist and diversity feminisms separated decades ago and took different routes (Franklin 2013, 185–221). Already in 2005 Charis Thompson bemoaned that class and economy had taken a back seat in feminist debates on reproductive technologies (Thompson 2005, 71). Only in 2016, the symposium "Making and breaking families" made diversity approaches and class analyses on reproductive technologies to converse (Smietana, Thompson, and Twine 2016).

DOI: 10.3217/978-3-85125-668-0-12

according to the credo of Science and Technology Studies about the inescapable situatedness and contestedness of *all* knowledge (Davis and Evans 2011; Haraway 1995). However, what struck us was the deep mutual mistrust against each other, the fierceness and eager with which the different approaches try to devalue each other and the ever similar storylines they deploy.

Although we examine journals that might not count as STS journals in a narrower sense, the topic we engage with – digitalisation – is a classical STS subject. Furthermore, our meta-perspective has much in common with an established STS analysis of scientific knowledge production. It is not only the contents of the two fields we engage with, it is also the rhetorical forms in which the arguments are brought forward that interests us.[1] We treat scientific texts on digitalisation not solely as endproducts of a long scientific research process but as "technologies" themselves (Hemmings 2005, 118) – or, to put it in STS jargon, as actants *inside* a scientific praxis (Latour 1987, 40). While scientists *inside the laboratory* carry out research through textual practices, social scientists do that by rhetorical strategies inside their "laboratories" – journals, talks, lectures or seminars. They deploy specific textual techniques of citation, omission, non-engagement, labelling, specific storylines and dramatizations. Both aim at mobilizing allies, gaining power and winning scientific controversies (Wieser 2014, 29).

Due to the limitedness of the space and because all contributions, be they Marxist or diversity oriented, are implicitly or explicitly based on the concept of control society and data doubles, we do not present the argument of the respective positions in its entirety, but briefly sketch the demarcations in order to quickly enter the conversation.

As "diversity approaches" we describe a whole branch of contributions often from an ethnographic oriented STS field such as Postmigration Studies (Borkert, Fischer, and Yafi 2018; Latonera and Kift 2018), Disability Studies (Reeve 2012; Ng 2017), Queer and Transgender Studies (Hansom 2011; Jenzen 2017; Erlick 2018), Feminist/Black Code Studies (Johnson and Neal 2017; Wade 2017) or Xeno- and Glitchfeminism which do not

1. Such interest in the rhetorical forms of scientific controversies partly stems from our own multi-disciplinary background and the tensions that caused. UK has a strong orientation towards sociology, Marxist theory and questions of class and economy. AW is trained in Melodrama Studies and underlines the melodramatization of scientific story telling. Both are united by their interest in so-called identity knowledges, especially in queer approaches on digitalisation.

DOI: 10.3217/978-3-85125-668-0-12

carry out ethnographic STS studies themselves but base their arguments on it (Russel 2013, 2018; Laboria Cuboniks 2015; Hester 2018). Recurring, connecting investments are firstly, the methodological STS postulate of “live subject research”. Secondly, a critique of digital dualism (Jurgenson 2011), which assumes that the on and offline are two distinct worlds, often idealizing the offline world and reproducing existing norms and privileges. Thirdly, a political standpoint and strategy that is not completely hostile towards the digital but aims at repurposing technologies for one's own aims; and finally, a touching upon but not thinking through of key Marxist categories such as accumulation, class, labour, work, or the state.

The Marxist approaches we include, in turn, firstly discuss digitalisation theoretically. They base their arguments on examples and not on ethnographies or extensive empirical work (e.g. Fuchs and Sevignani 2013; Jarrett 2016; Thatcher, O’Sullivan, and Mahmoudi 2016; Couldry and Mejias 2018). Secondly, the rejection of digital dualism is not a matter close to their heart. The authors are not troubled by the normative presuppositions of digital dualism.[1] Their credo, thirdly, is “Resist. Not just repurpose!” Or to put it differently, they do not see any potentials in digitalisation but underline its exploitative until predatory dimensions. The digital is negatively determined. And finally, questions of normalization, identity, difference do not form part of their analysis.

2 Mutual Mistrusts

Between Marxist and diversity approaches there seem to be little overlap, and older front lines in STS, as mentioned above, are repeated. One common strategy of Marxists is the claim that diversity positions lost the big picture – that is a fundamental critique of capitalism in digital times. For example, feminist Marxist Kylie Jarrett is not convinced by diversity positions: “Feminist projects, she [Nancy Fraser] says, became oriented toward the politics of identity instead of critiquing the gendered systems of capitalism” (Jarrett

1. It is not a uniform position towards digital dualism which characterizes Marxist positions. While earlier Marxist works on digitalisation such as Manuel Castells (1999) were based on an obvious digital dualism, in Nick Couldry’s and Ulises Mejias forceful piece on data colonialism a transformational, nearly Latourian thinking of the digital co-exists with dualistic conceptions of the digital. Only Kylie Jarrett (2016, 102) openly discusses the imprecise division into online and offline worlds and understands digital activities as hybrid practices.

Ute KALENDER, Aljoscha WESKOTT
DOI: 10.3217/978-3-85125-668-0-12

2016, 16). They would correspond with a “post-feminist state” and a “mode of feminism that claims power and agency but is robbed of its critical transformative powers” (Jarrett 2016, 16, also 94 ff). By devaluing such standpoints as postfeminist they are posed as non-feminist. Jarrett's historiography of feminism is based on the assertion of a development from a “real radical” feminism that had the big picture in mind to a feminism that has lost its critical edge as it is only interested in ‘individual issues’. Jarrett tells a teleological story of loss and decline, that relies on its very own understanding of contemporary feminism. It wrongly equates diversity feminisms outlined above with identity politics. Jarrett does not even bother to read such so-called identity feminisms. Instead, she brings Nancy Fraser in as a friend. By citing renowned authors the own argument is endowed with power (Latour 1987, 31; Wieser 2014, 27) and a particular narrative is portrayed as widely accepted, as fact rather than an interpretation (see also Hemmings 2005, 129).

Diversity positions in turn also deploy specific devaluing markers. Comprehensive anti-capitalist criticisms of the digital are branded as anxious towards new technologies (Russel 2018). For example, ecofeminism is portrayed as outdated, essentialist, naturalist, even heteronormative. Marxist techno-feminist Maria Mies appears as a killjoy (Hester 2018). Live subject research is brought into play to discredit theoretical positions as woodcut-like ideology: They would be methodologically incapable of dealing with the complexity of living a digital live (Reeve 2012; Jenzen 2017) and by that they are implicitly judged as ableist and transphobic. Here, too, the message is simple: More empirical, ethnographic, diverse knowledge about living in and with digitalisation leads to better and more precise concepts, less objectification and more agency of the researched, which paves the way to digital gender justice. Far from dismissing the everyday completely, we claim that the political scope of such knowledges is also limited. It is a critical knowledge, a theory-driven knowledge and a political knowledge. Nevertheless, the path from knowing to justice is not so self evident as it may seem.

3 Discussion

So far we have shown how Marxist as much as diversity accounts deploy textual techniques in order to position themselves as the better scientific approach to digitalisation. One could say that every story, even the scientific one, is fictional and uses specific story lines, dramatizations, cuts and connections, valuations and devaluations. But to return to the claim we made at the beginning, that a multifaceted approach in formally telling *and* contentwise understanding digitalisation is needed, we suggest to focus on what unites and not what separates these accounts. In other words, a common feature is firstly that all positions deal with questions of a capitalist control society and secondly rely on the concept of data doubles. Both are critical terms developed by theoreticians to understand the social in contemporary digital times. The concept control society was introduced by the French philosopher Gilles Deleuze almost thirty years ago. Deleuze argued that there was a shift from disciplinary societies to societies of control – from societies of total institutions and closed systems to open societies constituted of multiple circulations. For our concern this point is important, because the dynamic, dispersed and delocalised nature of digitally mediated societies comes to the fore. That also means a less static understanding of the social, an understanding of the social as constituted of flows; and as we would like to argue later, it is an approach suitable to grasp different modes of the digital.

Data double was introduced into the discussion of control society later by Haggerty and Ericson (2000). The social scientists understand data doubles in terms of power: Data doubles are on first sight opaque flows of data. Their reassembling serves aims of a surveillance society – governance, commercialization and control (Haggerty and Ericson 2000, 613). While thus Haggerty and Ericson already have a negative stance, we, for a start, stick to a more neutral understanding of data double: Data doubles happen, emerge, are generated at every point when flows are reassembled. Data double is the mere fact that the series of discrete flows that constitute control societies are reassembled into an additional self – be it functional or not. Such selves *can* be used for further social acts such as scrutinizing and intervention, and yet, such selves can also be used for other purposes beyond control, commerce and governance. To begin with such a neutral understanding is important as our goal is to reconcile competing scientific narrations of the digital: Which modes the act of reassembling actually follows – the mode of exploitation, the mode of power, the mode of identification, the mode of disidentification, or even the mode of a new eSthetic of existence – cannot be foresaid entirely.

Ute KALENDER, Aljoscha WESKOTT
DOI: 10.3217/978-3-85125-668-0-12

Control society is the more encompassing, broader, general concept, while data doubles is the concept to fine-grainely grasped the various forms digital selves and digital subjectivation can take on. Therefore, data doubles are a key component of control society. They describe how through generating digital duplicates of our lives a control society is enacted, realized, and comes into being. Data double form the skeleton, the basis, the relais of contemporary control societies in digital capitalism (Haggerty and Erickson 2000): Today each living human being enters the digital by using their iphones, smart watches, computers or other digital devices. By doing so, people willingly or unwillingly generate a virtual data double of themselves.

However, what after the usage of digital devices happens – what exactly the generation of a data double means in social terms – the above discussed approaches interpret disparately. Our point now is that instead of playing whole branches out against each other and delegating one of them to the domain of the ideological or the a-political, we suggest that the contributions deal with different *modes*[1] of data doubles. While firstly ethnographic diversity approaches elaborate on the power aspect of data doubles, secondly Marxist approaches underline the mode of exploitation. Thirdly both modes are interwoven.[2]

1 Data doubles as a mode of power

To understand data doubles as a mode of power underlines that the capture of data and its algorithmic processing is not a neutral act. Data doubles do not merely depict, describe or portray the non-virtual world. On the contrary, algorithms categorize and classify practices according to dominant social ideas – expectations of manhood and womanhood, ability and disability, sexuality, race and class.

The power aspect in this is precisely that they limit the surplus, the diversity, the excess of

1. We understand mode as a specific form of pragmatics and follow Haggerty and Erickson who said: “Rather than being accurate or inaccurate portrayals of real individuals, they [data doubles] are a form of pragmatics: differentiated according to how useful they are in allowing institutions to make discriminations among populations (Haggerty and Erickson 2000, 613).“ Yet we claim that it is not only institutions but individuals themselves, social movements and other non-instituional bodies that produce, circulate and engage with data doubles.

2. We do not claim that data doubles only take on these two modes. For more see Hörl 2018 and Lupton 2014.

DOI: 10.3217/978-3-85125-668-0-12

data that living bodies, minds and environments provide. The statistical models upon which data doubles are produced operate according to specific “cybernetic” forms of social stereotyping. They “define the actual meaning of gender, class, or race themselves**”** (Jenzen 2017, 165). For example, a 23-year-old male friend willingly underwent sterilization. While online he is regularly confronted with adds that show modern versions of fathers. Men in their 20s or 30s holding their kids, feeding them or walking with them through landscapes. Another female friend who is not biologically capable nor socially willing to have children also got displayed guidebooks for mindful mothering or adds for pregnancy clothes. Data doubles here operate through visual suggestions. Such suggestions differ from Marxist understandings of data doubles as the mere fact of classification and the invitations for identifications are not per se an act of exploitation, repression or domination. Such propositions may annoy, they may enervate or bug you, however, to understand them in mere negative terms misses the quality of exerting power in digital times. Such visual suggestions based on algorithmic classifications are a mode of power that works productively and positively through nudging: The algorithm assumes that a 23 year old male is willing to become a father and that every woman has the suitable body and the desire to become a mother.

The newness to older, non-digital forms of power such as Foucauldian normalization is that it does not assume an inner core, truth or authenticity of an individual. The digital is an action on the environment – on environmental variables (Hörl 2018, 155; Foucault 2008). Not inner organic attributes such as genes or blood but situational characteristics are to explain what a human being is: Power operates through behavioural incentives like food intake, movement habits, dating practices. And the preferred media to access such environmental variables is digital media.

Environmental power is also a programme that wants to optimize systems of difference, and such systems of difference are left open for fluctuating processes (Hörl 2018, 159). Consider for example the online dating platform OkCupid. Diversity, perversion, imperfection is appreciated. Similar to Facebook the platform is open to debate, critique and to the expansion and integration of nearly every new form of desire. However, in order to use the platform everybody has to qualify themselves according to specific classifications. One’s own desire still has to be named, labelled and categorized.

Ute KALENDER, Aljoscha WESKOTT
DOI: 10.3217/978-3-85125-668-0-12

The aim of diversity approaches is precisely the struggle *against* such an immobilization of manifoldness in data doubles. They problematize the digital as being part of a world in which identitarian classification is the precondition for political participation and for the access to rights and resources. Identitarian classification is also the precondition for the opposite – for discrimination and exclusion. As such, diversity approaches do not strive, as Marxist feminisms claim, for exhaustively exploring the experience and existence of people situated as black, queer, or disabled in a digital world. The identification of features, characteristics and differences of distinct groups is not at all their goal. An integral part to exploring data doubles as a mode of power is instead the delineation of new eSthetics of existences. These new digital selves undermine, appropriate, and rework dominant ideas of identities and populate queer-friendly platforms such as Tumblr or TikTok.

In sum: Self-portrayal in digital media is a *gentle* compulsion to which people have to succumb, often undeniable with pleasure. It is a soft form of power as the algorithm produces suggestions, offers and ideas. From a Marxist point of view such power is often overlooked as it does not lead to *direct* discrimination, exploitation or capitalization. However data doubles as a mode of power are deeply enmeshed with questions of exploitation. Which leads us to the next point.

2 Data doubles as a mode of exploitation

Marxist approaches deal with the exploitative dimension of data doubles. Their pragmatics function exploitatively when people’s personal data are *repurposed* for the use of others (Lupton 2014). In most Marxist approaches the owners of platforms are defined as such others. Yet, insurances, employers, governments are further examples for others that might profit from data doubles. From this perspective, digitalisation means the creation and opening up of ever more social milieus for data extraction and translation into processes of capital accumulation, which media sociologist Nick Couldry and Ulises Mejias (2018) catchily named data colonialism (on accumulation see also Thatcher, O'Sullivan, and Mahmoudi 2015).

While Couldry and Mejias do not engage with questions of gender, race, heteronormativity or ability, autonomist Marxist media scientist Kyle Jarrett (2016, 2018) formulates a position of exploitation that follows older debates of Marxist feminism. In contrast to Couldry and Mejias, she does not work with the concept of accumulation, but departs from

Ute KALENDER, Aljoscha WESKOTT
DOI: 10.3217/978-3-85125-668-0-12

labour. Social media platforms do not function "without the uploading of content, social interactions and affective engagements of their users" (Jarrett 2016, 2). Their "unquenchable thirst for content" forms the main driving force of exploitation (Jarrett 2018; Couldry and Mejias 2018, 3). Or to put it differently, platforms are the "muscle" of data colonialism (Couldry and Mejias 2018, 6).

In order to make this work around platforms visible and to underline its structural similarity to capitalism with other forms of feminized work, Jarrett introduces the term digital housewife. Housework and digital practices are both unpaid, they are often regarded as voluntary, unproductive labour. Both are often described as pleasurable, but at the same time capitalism heavily relies on it, even more: it is absolutely necessary. While the housewife is indispensable for the reproduction of the worker, for the platform it is the digital worker. Both forms of work support the well-being of others: Liking photos or writing nice comments have a similar positive effect as cooking, touching, or listening attentively. Both types of work can be fun: Playing with children, caring, cooking or having sex can be as pleasurable as uploading photos to Airbnb, giving compliments to friends on Facebook or likes at Instagram. Both works serve the production, preservation, deepening of interpersonal relations or even keep others healthy. While commenting on Facebook photos strengthens a friend's self-esteem, the housewife at home keeps the family together (Jarrett 2016, 2). Finally, both works are still largely carried out by women or are at least devalued as feminine. Who has never experienced the belittling smiles, when one speaks about their facebook friendships?

3 The interwovenness of both modes

The two pragmatics of data doubles do not function separately. Digitalisation is both – power and exploitation. It works positively and productively but also negatively and extractivistly. *Before* data can be repurposed for means which do not serve the giving subject, people have to become users of digital media, and by becoming users of digital media they willingly undergo self-classification or they are unwillingly identified by algorithms. When we enter Tumblr, Facebook or Okcupid, we tick boxes, we display preferences, we follow our sexual, visual, consumerist desires or we have been identified. Our movements have been traced and connected to previous data. And all these processes are not neutral but follow dominant ideas of identity or as John Cheney-Lippold

Ute KALENDER, Aljoscha WESKOTT
DOI: 10.3217/978-3-85125-668-0-12

aptly puts it, “And somewhere, in a database far, far away, you may very well have a gender, a class and a race“ (2011, 165). Only if such classifications have been performed, negative exploitative acts can be exerted. The virtual selves can serve the generation of new products, they can serve health insurances to deny benefits, they can serve governmental restrictions and police repressions. Judges can base their unfair sentencing on that. At airports people can be kept from leaving or entering a country, or they can even be imprisoned.

For this reason, we follow Foucault’s careful and clever distinction between power and domination, and we try to further develop and apply it to questions of digitalisation. From such a perspective, the Marxist approaches to digitalisation follow an understanding of power which is close to a juridical mode: The usage of digital media, then, predominantly subserves bigger entities such as the state, corporations, capitalism, patriarchy, and the epicentres of data colonialism. Marxist approaches are implicitly stuck in an economistic theory of power, which Foucault termed the "economic functionality of power" (Lemke 1997, 102). The problem is the exclusivity with which power is reduced to economic demands and reproduction. Power is only there to maintain class, capitalism and the law of productivity.

Our objections, however, do not negate the importance of economic factors for contemporary digital societies per se. On the contrary, we think that power relations are deeply interwoven with economic relations, that both form a clew, and that they are entangled. Power relations and economic relations, such as the norm to still intelligibly represent “masculinity” or “femininity” online and exploitative data extraction, do not form separate and clearly distinguishable spheres. We suggest to rather ask how exactly they are connected – to explore the form of their interwovenness.

In turn it becomes possible to think the digital self in diversity approaches not as a self-absorbed self but as connected to broader economic, juridical, or state relations. The digital self is then a product and an effect of such relations, and at the same time their carrier, maintainer and producer. In a digital world, gendered and racialised self-relations are for example constitutively interwoven with economic mechanisms of domination. For that reason feminist initiatives such as Black Girls Code, a US-American NGO which introduces girls of colour to technical skills, does not naively idealize a digital diversity self, moreover Black Girls Code’s decisive aim is to overcome the digital divide. They explicitly criticize the fact that access to the digital world and all the economic, social, juridical benefits it entails is still a white privilege. In other word, Black Girls Codes shows that struggles for new digital subjectivities are always also struggles against economic suppression. It also shows that both are interwoven.

With understanding the digital as control society, as a distinct series of flows, the newness of a digitalised society in relation to older technological societies can also be grasped – namely that both processes work simultaneously: Input and output of data are conflated. The digital, then, is a material-virtual arrangement – a space of possibilities that conditions, forces but also enables the synchrony of different social practices beyond immediate territorial proximity and beyond the duty to be present. Deterritorialization and reterritorialization of information streams alternate so quickly that they virtually fall into one. Different modes of the digital continuously take place and can hardly be distinguished from each other (Latonero and Kift 2018, 3; Castells 1999). As soon as one enters the digital realm by self-classification the data might also be used for the generation of profit. For the user of digital media such processes often remain opaque, sometimes labelled as digital Angst.

To consider the interwovenness of both modes rejects a view according to which diversity approaches dismiss a critical analysis of exploitation and idealize a digital subject as an autonomous, creative agent, as much as Marxist approaches are not blind to diversity, to the manifoldness of digital lives. Rather, it is precisely the complexity, the dynamic and the simultaneity of different data pragmatics in a control society that makes it possible to think through the connections between power and exploitation. Such an approach shows how data doubles of diverse qualities emerge in global data colonialism and at the same time function as a constituent moment of these forms of digital domination.

References

Borkert, Maren, Karen E. Fisher, Eiad Yafi. (2018): The Best, the Worst, and the Hardest to Find: How People, Mobiles, and Social Media Connect Migrants In(to) Europe. In Social Media and Society, January–March 2018, pp. 1–11.

Castells, Manuel (1999): Grassrooting the space of flows. In Urban Geography, 20, pp. 294–302.

Cheney-Lippold, John (2011): A New Algorithmic Identity: Soft Biopolitics and the Modulation of Control. In Theory, Culture & Society 28(6), pp. 164–181.

Couldry, Nick and Ulises A. Mejias (2018): Data Colonialism: Rethinking Big Data's Relation to the Contemporary Subject. In Television & New Media 00(0), pp. 1-14.

Davis, Kathy and Mary Evans, eds. (2011): Transatlantic Conversations: Feminism as Travelling Theory. New York: Routledge.

Erlick, Eli (2018): Trans Youth Activism on the Internet. In Frontiers 39(1), 73–92.

Foucault, Michel (2008): The Birth of Biopolitics: Lectures at the Collège de France, 1978–79. Edited by Michel Senellart. Translated by Graham Burchell. Basingstoke, UK: Palgrave Macmillan

Franklin, Sarah (2013): Biological relatives. IVF, Stem Cells, and the Future of Kinship. Durham and London: Duke University Press.

Fuchs, Christian and Sebastian Sevignani (2013): What is Digital Labour? What is Digital Work? What's their Difference? And why do these Questions Matter for Understanding Social Media? In tripleC 11(2), pp. 237–293.

Haggerty, K. D., & Ericson, R. V. (2000): The Surveillant Assemblage. In British Journal of Sociology 51(4), pp. 605–622.

Hanson, Ellis (2011): The History of Digital Desire. An Introduction. In The South Atlantic Quarterly 110(3), pp. 583–599.

Haraway. Donna (1995): Situiertes Wissen. Die Wissenschaftsfrage im Feminismus und das Privileg einer partialen Perspektive. In Die Neuerfindung der Natur. Primaten, Cyborgs und Frauen, ed. Donna Haraway, pp. 73–98. Frankfurt a.M. and New York: Campus.

Hörl, Erich (2018): The Environmentalitarian Situation: Reflections on the Becoming-Environmental of Thinking, Power, and Capital. In Cultural Politics 14(2), pp. 153–173, Duke University Press.

Hemmings, Clare (2005): Telling feminist stories. Feminist Theory 6(2), pp. 115–139.

Hester, Helen (2018): Xenofemimism. Cambridge: Polity Books.

Jarrett, Kylie (2016): Feminism, Labor and Digital Media: The Digital Housewife. New York: Routledge.

----- (2018): Interview. Kylie Jarrett: Feminism, Labour and Digital media. Interviewed by Marc-Antoine Pencolé. http://www.historicalmaterialism.org/interviews/kylie-jarrett-feminism-labour-and-digital-media

Jenzen, Olu (2017):
Trans Youth and Social Media: Moving Between Counterpublics and the Wider Web. A Journal of Feminist Geography 24(11), pp. 1626–1641.

Johnson, Jessica Marie, Neal Mark Anthony (2017): Introduction: Wild Seed in the Machine, In The Black Scholar, 47(3), pp. 1–2.

Jurgenson, Nathan (2011): Strong and Mild Digital Dualism. Post auf https:/ /nathanjurgenson.wordpress.com/tag/digital-dualism/

DOI: 10.3217/978-3-85125-668-0-12

Laboria Cuboniks (2015): Xenofeminismus. In Dea ex machina, eds. Armen Avanessian and Helen Hester, pp. 15–35. Merve: Berlin,

Latonero, Mark, Kift, Paula (2018): On Digital Passages and Borders: Refugees and the New Infrastructure for Movement and Control. In Social Media and Society, January–March 2018, pp. 1–11.

Latour, Bruno (1987): Science in Action. How to Follow Scientists and Engineers Through Society, Cambridge: Harvard University Press.

Lemke, Thomas (1997): Eine Kritik der politischen Vernunft. Foucaults Analyse der modernen Gouvernementalität. Hamburg: Argument.

Lupton, Debora (2014). Self-tracking Cultures: Towards a Sociology of Personal Informatics. Paper presented at the 26th Australian Computer-Human Interaction Conference on Designing Futures, Sydney, Australia, December 2.

Ng, Isla (2017): How It Feels to Be Wired In On the Digital Cyborg Politics of Mental Disability. Atlantis 38(2), pp. 160–170.

Reeve, Donna (2012): Cyborgs, Cripples and iCrip: Reflections on the Contribution of Haraway to Disability Studies. In Disability and Social Theory: New Developments and Directions, Dan Goodley, Bill Hughes and Lennard J. Davis eds., pp. 91–111. London: Palgrave Macmillan.

Russell, Legacy (2013): Elsewhere, after the Flood: Glitch Feminism and the Genesis of Glitch Body Politic.” Rhizome, March 12. Accessed Novemxber 17, 2017. http://rhizome.org/editorial/2013/ mar/12/glitch-body-politic/

----- (2016): An Interview with Legacy Russell: Wandering/WILDING. Eusong Kim and Gelare Khoshgozaran. 13. December 2016. Retrieved from https://contemptorary.org/wanderingwilding/

----- (2018): Glitch Feminism: An Interview with Legacy Russel. In berfrois Von Russell Bennetts. 21. Februar 2018. Retrieved from https://www.berfrois.com/2018/02/glitch-feminism-an-interview-with-legacy-russell/

Smietana, Marcin, Charis Thompson and France Widdanc Twine (2016): Making and Breaking Families – Reading Queer Reproductions, Stratified Reproduction and Reproductive Justice Together. In Reproductive BioMedicine and Society Online, https://doi.org/10.1016/j.rbms.2018.11.001

Thatcher, Jim, David O’Sullivan, and Dillon Mahmoudi (2016): Data Colonialism through Accumulation by Dispossession: New Metaphors for Daily Data. In Environment and Planning D: Society and Space 34(6), pp. 990–1006.

Wade, Ashleigh Greene (2017): New Genres of Being Human: World Making through Viral Blackness. The Black Scholar, 47(3), pp. 33–44.

Wieser, Matthias (2014): Das Netzwerk von Bruno Latour. Die Akteur-Netzwerk-Theorie zwischen Science & Technology Studies und poststrukturalistischer Soziologie. Bielefeld: transcript.

Julius KONRAD, Kay CEPERA
DOI: 10.3217/978-3-85125-668-0-13

Real-Time Governance of Transportation Systems. A Simulation Study of Private Transport

Julius KONRAD, Kay CEPERA

TU Dortmund, Technology Studies Group, Dortmund, Germany

Abstract

For this study we developed a traffic-simulation based on the SimCo simulator tool and ran different governance scenarios regarding the effects of the distribution of real-time traffic data among drivers. The scenarios were based on interviews with experts from diverse fields, including a navigation service provider, the German Federal Highway Research Institute, and public transport providers. We found that a coordinated form of governance between private firms and local authorities benefits all parties. To analyse the impact of such a coordinated mode of governance, two scenarios were implemented. Firstly, drivers would get real-time traffic information and, secondly, they would also receive information on emissions enabling them to change their route accordingly. We found that the use of real-time data does indeed decrease traffic jams, and thus increases network efficiency, but it also increases emissions. This trade-off between network efficiency and emission reduction is prevalent in all our findings.

Keywords: algorithms, governance, self-determination, simulation, traffic

1 Introduction

While not entirely new, algorithmic governance of traffic has become a source of hope concerning the reduction of emissions and improved traffic flow. The increased use of navigation systems (either device, car or app-based) has led to a rise in both real-time traffic data and traffic management opportunities (e.g. by individualised routing suggestions). The resulting combination of centralised traffic management and decentralised decisions, which relies heavily on the real-time distribution of data, is a new mode of governance. To tackle this relatively unexplored issue, we seek to answer the following questions:

Julius KONRAD, Kay CEPERA
DOI: 10.3217/978-3-85125-668-0-13

• How does the interplay of centralised governance and decentralised decisions work?

• How efficient is this mode of governance and can it be deployed to achieve political objectives?

We conducted guided interviews and consulted focus groups comprising representatives of navigation service providers, public transport organisations and the German Federal Highway Research Institute. Based on these interviews, we developed multiple governance scenarios. In one such scenario, drivers are equipped with a *smart navigation* system that shows the best routing option based on real-time traffic data. Another scenario combines this form of commercial navigation with governmental emission regulations in a *coordinated governance mode*. Using agent-based modelling (ABM), we transferred our findings to a simulation model to test various what-if scenarios and compare different modes of governance.

2 Theoretical framework

2.1 Multi-level governance

The underlying frameworks for our analysis are the macro-micro-macro-model and the model of social explanation (MSE) (Coleman 1990; Esser 1993a). In other words, the structure on the macro-level – recommendations that may or may not be followed – sets the frame for an individual's actions and influences them hereby. Interactions between individual actors on the micro-level of a system, e.g. drivers following recommended routes, then aggregate and influence the macro-level which then changes accordingly so, e.g. congestion can be avoided, emissions can be lowered, and net efficiency can be increased.

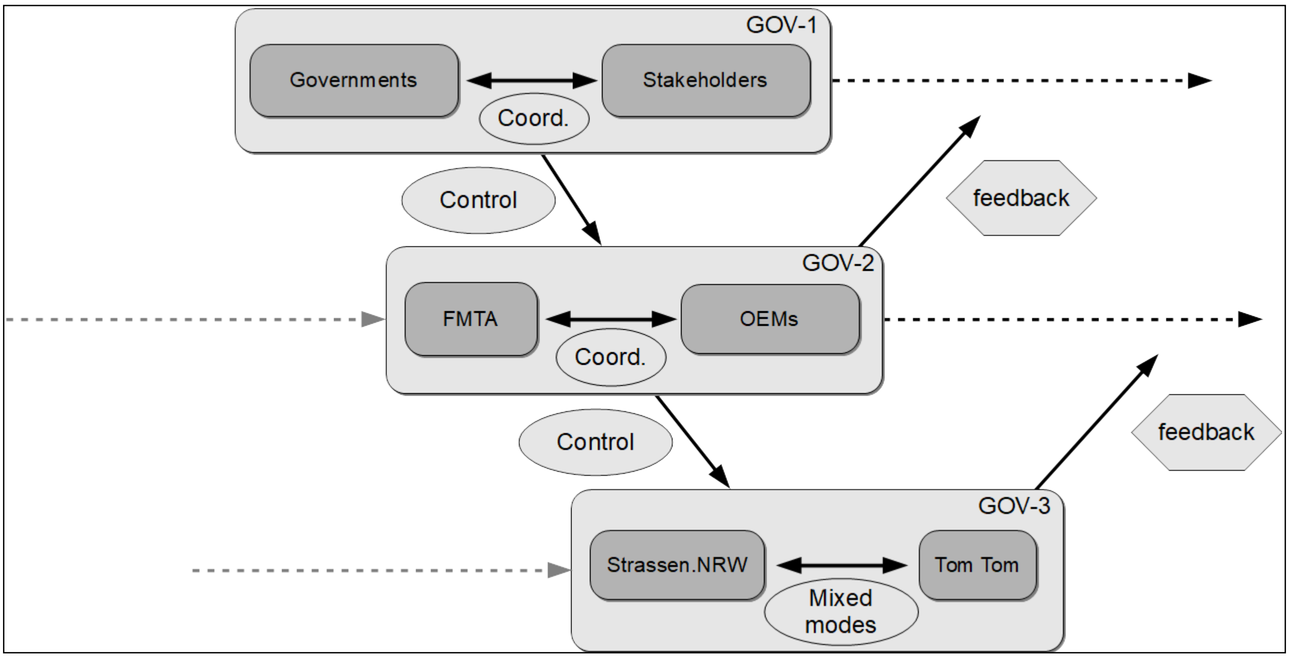


***Fig. 27:** Multi-level governance of traffic (cf. Weyer et al. 2015)*

To include the higher-level governance of the system we use an extended version of this framework (see Fig. 27), where every level of governance follows the logic of the MSE. The traffic system is included at the bottom-level and modelled as the micro-level of this governance system (Weyer et al. 2015). As seen at the bottom-level, private traffic service providers interact with local public authorities and directly affect the traffic. This level is influenced by rules and norms that are decided upon at the middle-level, which is in turn influenced by the top-level, where the government and potential stakeholders shape the path taken by mobility in the long term. For example, the government on the top-level aims to restructure traffic towards more sustainability to meet the demands of stakeholders (the public). On GOV-1 negotiation processes between the government and stakeholders take place in which a concept of the possible changes is established and necessary measures are identified. This concept is then transferred to the level below via control mechanisms. On GOV-2 the Federal Motor Transport Authority (FMTA) interacts with industry actors (e.g. OEMs) to develop subject-specific guidelines and norms. Through these norms control is then exerted on GOV-3, where corresponding institutions are established in order to manage everyday service. Therefore, GOV-1 is the conceptual level, while on GOV-2 this concept is adjusted to the actual circumstances and GOV-3 is the operational level.

DOI: 10.3217/978-3-85125-668-0-13

2.2 Real-Time

In future, the governance of transportation will be even more dependent on data transmitted in real-time to cope with the rising volume of traffic. In this context, real-time means that the behaviour of the system depends not only on collecting accurate data but also on its timely processing (Kopetz 2011). A real-time governance of traffic, therefore, requires reliable data sources and efficient algorithms to exploit traffic management opportunities.

2.3 Agent-based modelling and simulation

The traffic sector is a perfect example of a complex system. Many heterogeneous actors influence the system status. Their individual actions aggregate to socially undesirable effects such as congestions and emissions. Furthermore, control over this system is exercised by many actors on many levels.

With computer simulation in general and agent-based modelling and simulation (ABMS) in particular, the complex reality of a system can be reduced to formalised and simplified rules. In particular, the social interactions among agents, and between agents and the system, can be modelled. In this context an agent is a simulated actor with very simple rules of action and decision making, which nonetheless may lead to very complex emergent outcomes (Kron 2010). Agent-based models allow the analysis of these emergent processes or effects in complex and dynamic structures (Kron 2010). ABMS allows us to consider the choices of a large number of heterogeneous actors. The method also lends itself to the implementation of sociological theories which are highly formalised, e.g. the MSE (Adelt et al. 2014). ABMS is therefore well suited to examine the multi-level governance of the traffic system.

2.3.1 Subjective Expected Utility

The subjective expected utility theory (SEU) is a theory of action which is easily transferable into mathematical equations, making it a great tool to implement individual decision making in a simulation in a simplified way.

It is assumed that an actor acts according to the law where is an objective and is an action. This law does not necessarily mean that the action must lead to the objective, but that the actor has a theory of how the world works and believes that the objective follows

DOI: 10.3217/978-3-85125-668-0-13

from performing the action (Esser 2000). Using this law, the basic principle of action used for the subjective expected utility theory is then defined as (Esser 2000). Translating the principle from propositional calculus, this means: If is the objective of an actor and this objective follows from the action, then the actor will choose this action to achieve said objective.

In most cases there may be different objectives and different actions or combinations of actions to achieve them. To explain how an actor chooses between different alternative actions and possible objectives, the alternatives are weighted by their expected utility (Esser 1993b). Equation 1 shows how these weights are calculated:

$$SEU(A_i) = \sum_{j=1}^{n} p_{ij} \cdot U(O_i)$$

The subjective expected utility of an action is weighted according to the valuation of the possible outcomes. Additionally, the outcomes are associated with probabilities describing the actor’s estimation of how likely the outcome is to follow from the action. In the end all alternatives are compared and the one with the highest SEU weight is selected.

In our agent-based model the agents act according to this theory. Agents decide between different technologies (e.g. car, bike or public transport) and different routes. In the context of the MSE, this would be situated on the micro-level where individuals decide and act in a decentralised way. In combination and through interaction with the system or other agents, the simulated actions of the latter aggregate and enable us to study the emerging effects in a traffic network (e.g. how the modal split is constituted when certain factors such as costs or comfort are changed). Taking the broader perspective of the multi-level governance of traffic, the question arises how changes on upper levels, like shifts in politically motivated goals, changes in the regulation of the traffic sector and new technologies for controlling traffic, affect the emerging effects. Different forms of governance will have an influence on the driving parameters of decisions or on how decisions are made. With ABMS, we are able to study the effects in our model and evaluate a range of interventions, which we simulated in various scenarios (see 4.2).

Julius KONRAD, Kay CEPERA
DOI: 10.3217/978-3-85125-668-0-13

3 State of Traffic Telematics

The term telematics refers to all the information and communication technologies used in the traffic system. The current state of traffic telematics, as we have identified it, is based on the state of research and technologies as well as on the interviews we conducted, hence it is based on the practices of private and public institutions regarding the traffic sector.

In contrast to in-vehicle telematics like Bluetooth hands-free systems for mobile phones or an emergency brake assist, an examination of the governance of traffic relies on the broader definition of telematics including technologies for measuring and controlling traffic. Measurement technologies can be divided into two groups: fixed installations, of which the induction loop is the most commonly known, and floating car (or phone) data, which can be collected throughout a journey. This distinction also applies to the traffic control technologies. In this case fixed installations include variable traffic signs (for speed or routing) while dynamic route guidance systems can be used by means of in-dash systems (i.e. inside the car), navigation devices or smartphones. While firmly installed telematics are superior to floating car data in terms of precision, the latter provide a better coverage.

All of these technologies are ultimately used to manage traffic. The data can be plotted in the basic diagram of traffic (Haight 1963). It displays the flow-concentration curve with which most important characteristics of traffic are measurable (Gerlough and Huber 1975, p. 55-58). According to the observed densities and speeds the travel times can be calculated, the traffic can be managed, or routing recommendations can be made.

4 Simulation and results

4.1 Interview evaluation

Prior to simulation, we evaluated the guided interviews and focus groups with staff from various stakeholders in the traffic sector such as navigation providers, public transport providers, traffic planners, federal traffic offices and local authorities. The aim of these interviews was to investigate the state of development concerning our postulated mode of real-time governance on the one hand and to gain insights about specific demands and probable next steps in the traffic sector.

Julius KONRAD, Kay CEPERA
DOI: 10.3217/978-3-85125-668-0-13

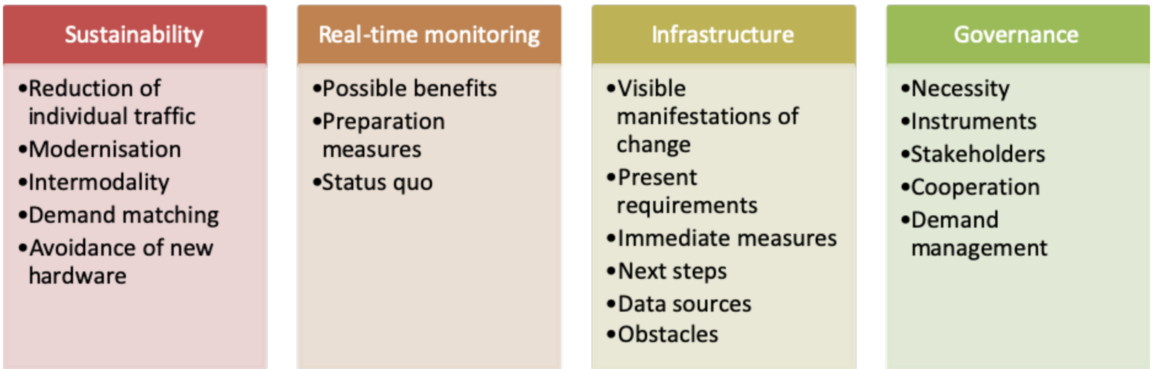


Fig. 28: *Interview categories*

Figure 28 shows the categories and subitems retrieved in the transcripts. It quickly became apparent that, according to our interviewees, future developments in the traffic sector will revolve around the topics of sustainability, real-time monitoring (and influencing) of traffic, infrastructure development and governance.

On the topic of **sustainability**, one of the most frequently mentioned points was a general need for reduction of private vehicles. Furthermore, this should be achieved by optimising existing infrastructure which could lead to an increase in intermodality and efficiency without further investment of resources.

A key technology on this path might be **real-time monitoring** of traffic that allows for an improved prediction of traffic volume in order to use infrastructure more efficiently. During the interviews, it turned out that many steps towards real-time monitoring have already been taken or are currently in progress. Both governmental and economical actors see possible benefits and already have preparation measures in mind that would help to establish real-time monitoring. Additionally, both types of actors expressed willingness to engage in mutual collaboration. This leads to our assumption that real-time governance is a feasible next step. According to our respondents, harmonisation and interchange of traffic data along with an improvement in network technology are vital requirements in order to achieve said goals. In summary, this means that a vast amount of potentially usable data is already being collected while the possibility of processing these data is not yet sufficiently developed.

A similar development is visible in the field of **infrastructure:** While there are already numerous manifestations of change (mostly concerning digitalisation), existing infrastructure needs specific updates to facilitate both real-time governance and

DOI: 10.3217/978-3-85125-668-0-13

intermodal transport. According to our interviews, this is currently being complicated by the sheer size of national transport systems such as Germany's, but also by present bureaucratic structures that hamper cooperation between governments and industry. This problem also appears to be accompanied by differences in focus between public and private stakeholders. For instance, private navigation providers clearly prefer software solutions for the collection of traffic data, claiming that there is very little inaccuracy but a large advantage in expense compared to classic hardware-based solutions. This opinion is vehemently opposed by members of the federal traffic agencies, who claim that only hardware sensors are able to provide data in all the required dimensions. Obviously, this dispute is also accompanied by privacy implications that would increase considerably with the use of mobile phone and in-car data for traffic monitoring. This path would then require additional measures to anonymise data, which have yet to be fully developed.

The last topic frequently brought up by our interviewees concerns different options for the **governance** of traffic. While there is a clear consensus about the point that a stronger governance of traffic will be needed in the future, it is not yet clear who the governing institutions will be and what government instruments and modes will be used. Frequently proposed instruments included soft measures such as route recommendations based on current traffic and emission information, incentivisation of certain transport modes or dynamic route pricing. On this topic, the opinions of our respondents largely coincided insofar as bans are not really considered a preferred option by any of the stakeholders. Also, both public and private stakeholders signalled a general willingness to cooperate in the field of traffic governance (even if there is a need to handle political and commercial conflicts of interest in advance of that). This means that, despite both social protagonists wanting to cooperate, they made it clear that they do not want to be fully controlled by the other party. Regarding the group of involved stakeholders, our respondents agreed that there is a chance of new (tech) companies entering the traffic sector that might then also become involved in the process of real-time governance.

4.2 Scenarios

Based on our interviews, to help understand the best course of action, we developed and tested several what-if scenarios. As a comparison we used the base scenario of our simulator, where agents make self-organised and decentralised decisions, and a fixed routing scenario where agents that drive follow a fixed route which is calculated beforehand. The two most important scenarios, however, are the *smart navigation* and the *cooperative mode*. In the first, 80 percent of the drivers use a dynamic guidance system with real-time traffic information. This proportion is based on the share of 77 percent of drivers in Germany who already use a navigation device or app (Commerz Finanz 2015). With this scenario we test whether real-time traffic information helps to reach the goals of network efficiency and emission reduction. The second scenario, the cooperative mode, is based on the interviews where public decision-makers and private service providers stated that cooperation is in their mutual interest. Following the results of the interviews, we assumed that the intelligent routing can be used to accomplish both goals. Therefore, it is expanded to include not only real-time traffic information but also real-time emission information. To take into account that neither party wants to be fully controlled, the maximum influence of the emission information is capped at 50 percent, meaning the simulated routing algorithm will be equally based on traffic and emission information.

4.3 The SimCo Simulator

The scenarios are tested with the SimCo simulator, which has already been used for traffic simulations (Adelt and Hoffmann 2017; Adelt et al. 2018). In SimCo, the traffic system is formalised as a network of nodes and edges. Nodes are abstract representations of junctions, homes or workplaces. Edges are abstract representations of streets or bike lanes.

4.3.1 Agents

Agents are the representation of actors in the traffic systems and as such they want to reach certain destinations, represented by the nodes. They travel the model by choosing a route to a node they want to reach and a technology. The set of possible actions an agent may take consists of all combinations of possible routes and technologies that can be used on them e.g.: An agent can use the bike to get to the workplace (Adelt and Hoffmann 2017). The agents decide between these possible actions by utilizing the SEU mechanism.

To represent the heterogeneity of road users, different agent-types are included. Their SEU calculations include preferences like how cheap, fast, eco-friendly and comfortable the alternative is (Adelt et al. 2018). Each type of agent has its own characteristic

Julius KONRAD, Kay CEPERA
DOI: 10.3217/978-3-85125-668-0-13

preferences. For example, a convenient agent would prefer comfortable alternatives over eco-friendly alternatives.

4.3.2 Governance

Political instances are not modelled. Governance is instead implemented in the form of scenarios. In each scenario the individual decision making of the agents is influenced in a different way to compare the effects.

4.3.3 Real-Time

For the tested scenarios the real-time information is implemented differently for traffic information and emission information.

In the base scenario agents only have traffic information about the edges that lead to neighbouring nodes. In the smart governance and coordinated mode scenario they have real-time information about the traffic, and therefore the duration of travel, on every edge. The best route to a target node is calculated by the system, considering full information about the system status, so that the agent drives accordingly.

In the coordinated mode the routing algorithm considers an emission factor to calculate the optimal route. The emission factor is based on a rising emission level on an edge. If this level exceeds 60 percent of a limit[1] the emission factor is increased for as long as the emission remains above this level. If emission levels are lower that 60 percent the factor is decreased again. This process happens in real-time. Since the emission factor itself is only changed if certain levels of pollution are reached, it is not based on the real-time status of the system. This leads to a lag in the distribution of emission information that reflects the communication process needed for the coordination.

5 Simulation Results

All four scenarios were run with 6.000 to 12.000 agents to test for the effects of a higher population in the model. To sum up these effects, a higher population resulted in higher emissions and lower network efficiency for all scenarios, although different forms of governance changed the amplitude of the effects. The results shown here are for runs with 12.000 agents only.

1. The limits used are arbitrary numbers suitable for the simulation and not based on emission guidelines.

Figure 29 shows the results for the emissions, the capacity and the agents stuck in traffic. Capacity is a measure for network efficiency. The higher the capacity usage, the better the distribution of traffic, i.e. the network efficiency is higher. The share of agents stuck in traffic is also an indicator for network efficiency. Fewer agents stuck means fewer congestions and indicates a higher network efficiency.

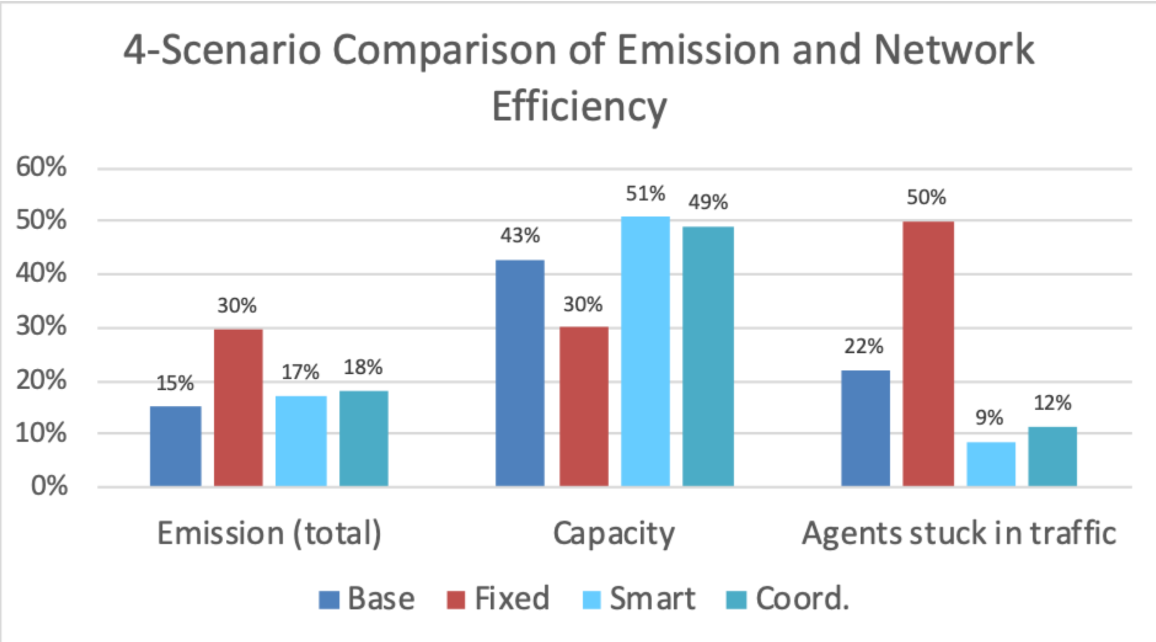


Fig. 29: *Results for emission and network efficiency*

The results show that, compared to the base scenario, fixed routing produces inferior results in every regard. Capacity is lower and more agents are stuck in traffic than in the other scenarios, which shows that network efficiency is low. Also, emission is twice as high as in the base scenario.

For smart routing and the coordinated mode, the results are quite similar. Emission is slightly higher than in the base scenario. The capacity is higher and fewer agents are stuck in traffic, which means network efficiency has increased.

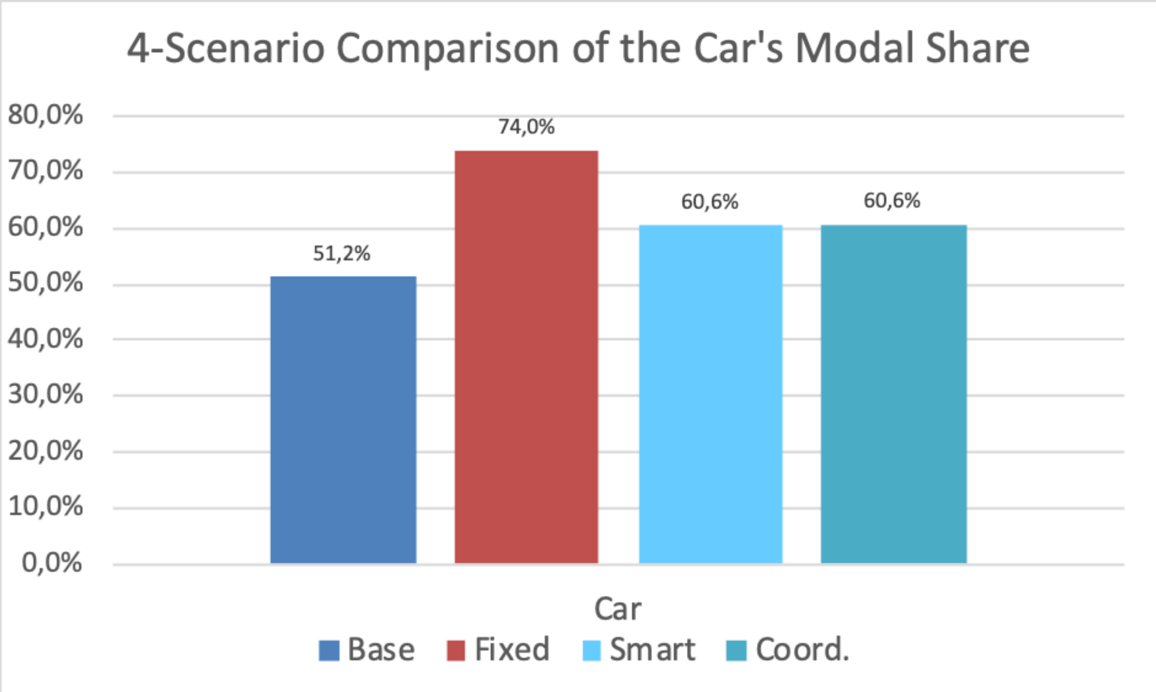


Fig. 30: *Modal Share of the Car*

The share of cars used in the model is depicted in Figure 30. With fixed routes the share of cars is the highest. Again, the smart navigation and coordinated modes show similar results: A roughly 10 percentage points higher usage of cars. These two modes have a higher network efficiency but also a higher usage of cars. This is a result of a typical rebound effect. The higher network efficiency leads to fewer congestions and makes the car more attractive as a mode of transportation. This in turn leads to higher emission. Possible reductions of emission values along with higher network efficiency are impeded by the rebound effect.

Then again, the fixed routing scenario shows a higher percentage of cars in combination with lower network efficiency, which may contradict this trade-off. The very high percentage of agents stuck in traffic may be responsible for this outcome. In the simulation agents can only change their mode of transportation when they reach a home-node, which they are not able to do if stuck in traffic. Therefore, this result is most likely an artefact, caused by the interplay of the governance scenario and the rules of the simulator.

Julius KONRAD, Kay CEPERA
DOI: 10.3217/978-3-85125-668-0-13

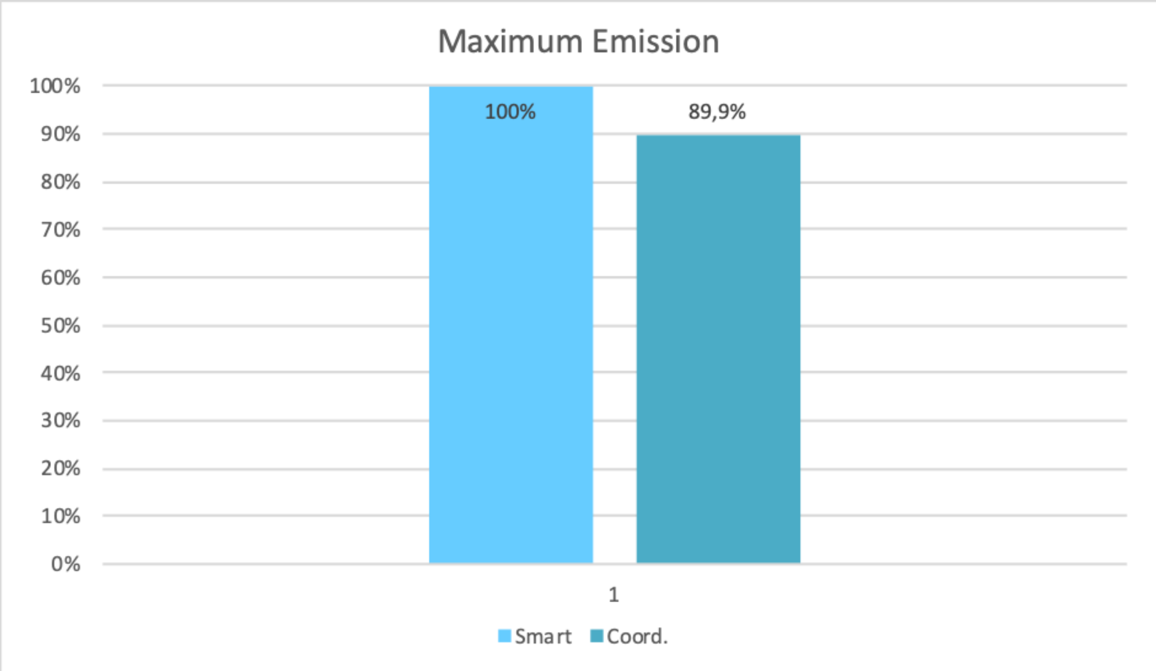


Fig. 31: *Maximum Emission for the Smart Navigation and Coordinated Mode Scenarios*

It is against our expectations that the distribution of emission information in the coordinated mode has no positive effect on emission values. As Figures 29 and 31 show, this is true for the overall emissions, but not for the maximum emissions. Overall emissions are the mean value of emissions of the whole system throughout the whole simulation run. Maximum emissions are the peak value that is reached on the most polluted road during that run. While the reduction of overall emissions is the ecologically more desirable goal, it may also be beneficial to reduce peaks and distribute emissions. This would help to maintain a consistent air quality while relieving busy roads. The coordinated form of governance can help reduce the maximum emissions in the model by roughly 10 percent. Hence, a coordinated mode of governance may help to reach the politically incentivised goal of reducing emission spikes on specific roads, as is mandated by European Union laws.

It is noteworthy that the governance mechanism we installed significantly alters the way the agents move through the system, at least while driving. In the base scenario, agents decide in a self-organised and decentralised way. On every node they can modify their route. With the navigation system in place they must reach a set destination and their route is changed by an algorithm based on the real-time information distributed in the specific scenario. This underlines the fact that the scenarios are what-if scenarios, which may not be easily implemented if agents or actors are not willing to comply with routing recommendations. On this topic, we conducted a second study (Cepera et al. 2019), investigating the influence of trust on users' willingness to change their behaviour on the basis of app recommendations. Following Weyer et al. (2018), this second study assumes that trust is a crucial element of a big data process like the real-time governance that we present here. Only with mutual trust between involved actors and technology will the process be stable and users willing to follow algorithmic recommendations. The results of this second study show that dispositional, institutional and interpersonal trust indeed have a significant influence on users' willingness to modify their behaviour. For the special case of navigation apps, we found that 69,6% of drivers are willing to change their route according to an app-based recommendation while driving (cf. Cepera et al. 2019). This shows that real-time governance of traffic, if implemented, would have a high acceptance rate and a great range via app-based recommendations.

6 Conclusion

Using agent-based modelling (ABM), we compared the scenarios with a status quo base scenario prior to comparing them among each other. Our findings show that smart navigation vastly improves traffic flow and the efficiency of an existing road network. Simultaneously, there are negative effects in terms of an increase of car usage. Due to improved traffic flow, road users are incentivised to use their cars more often, since travel times decrease. In this case, social logics of individual decision-making contradict the goal of emission reduction with algorithmic governance alone. On the micro-level of the model, smart routing recommendations lead to better individual goal attainment (in terms of reaching desired destinations) shown by better network efficiency, while reducing individual autonomy when it comes to routing decisions.

When taking emission regulations into account, the coordinated governance mode can decrease maximum emissions. Either way, the overall decrease of emissions that we hoped for does not occur and is accompanied by a decrease of network efficiency, forming a trade-off between emissions and network efficiency that is prevalent in all our findings.

On the one hand, we can show that algorithmic governance can reduce maximum emissions and increase traffic flow but, on the other hand, it fails to satisfy the ambitious politically installed targets. This shows that the examined algorithmic governance can only be used to its full potential if there is a simultaneous shift in societal prioritisation of different modes of transportation. Assuming that the attainment of political objectives is a condition for the legitimacy of this form of algorithmic governance, our simulation shows that algorithmic governance is indeed an adequate tool. However, societal phenomena (like increased car usage) may contradict these efforts. This shows a need for the incorporation of emergent social effects in the governance mechanism itself.

References

Adelt, Fabian; Hoffmann, Sebastian (2017): Der Simulator „SimCo“ als Tool der TA. In *1* 26 (3), pp. 37–43. DOI: 10.14512/tatup.26.3.37.

Adelt, Fabian; Weyer, Johannes; Fink, Robin D. (2014): Governance of complex systems: results of a sociological simulation experiment. In *Ergonomics* 57 (3), pp. 434–448. DOI: 10.1080/00140139.2013.877598.

Adelt, Fabian; Weyer, Johannes; Hoffmann, Sebastian; Ihrig, Andreas (2018): Simulation of the governance of complex systems (SimCo). Basic concepts and initial experiments. In *Journal of Artificial Societies and Social Simulation* 21 (2). DOI: 10.18564/jasss.3654.

Cepera, Kay; Weyer, Johannes; Konrad, Julius (2019): Vertrauen in mobile Applikationen. Eine empirische Studie. TU Dortmund (Soziologische Arbeitspapiere, 58).

Coleman, James S. (1990): Foundations of Social Theory. Cambridge/Mass.: Harvard University Press.

Commerz Finanz (2015): Anteil der Autofahrer, der zur Vorbereitung der Fahrt oder während der Fahrt grundsätzlich oder gelegentlich Anwendungen wie Google Maps, andere interaktive Tools wie GPS oder Online-Navigationsseiten nutzt. Statista - Das Statistik-Portal. Available online at https://de.statista.com/statistik/daten/studie/579214/umfrage/grundsaetzliche-nutzung-von-online-navigationsdiensten-in-weltweiten-laendern/, checked on 6/25/2018.

Esser, Hartmut (1993a): Soziologie. Allgemeine Grundlagen. 3. Aufl. Frankfurt: Campus-Verl.

Esser, Hartmut (1993b): The Rationality of Everyday Behavior. A Rational Choice Reconstruction of the Theory of Action by Alfred Schutz. In *Rationality and Society* 5, pp. 7–31.

Esser, Hartmut (2000): Soziologie: Spezielle Grundlagen. Soziales Handeln. Frankfurt/M.: Campus-Verl. (3).

Gerlough, Daniel L.; Huber, Matthew J. (1975): Traffic Flow Theory. A Monograph. Washington, DC: National Research Council (Transportation Research Board, Special Report 165).

Haight, Frank A. (1963): Mathematical Theories of Traffic Flow. New York: Academic Press (Mathematics in Science and Engineering, v. 7).

Kopetz, Hermann (2011): Real-Time Systems. Boston, MA: Springer US.

Julius KONRAD, Kay CEPERA
DOI: 10.3217/978-3-85125-668-0-13

Kron, Thomas (2010): Zeitgenössische soziologische Theorien. Wiesbaden: VS Verlag für Sozialwissenschaften.

Weyer, Johannes; Adelt, Fabian; Hoffmann, Sebastian (2015): Governance of complex systems. A multi-level model. TU Dortmund (Soziologische Arbeitspapiere, 42). Available online at http://hdl.handle.net/2003/34132.

Weyer, Johannes; Delisle, Marc; Kappler, Karolin; Kiehl, Marcel; Merz, Christina; Schrape, Jan-Felix (2018): Big Data in soziologischer Perspektive. In Barbara Kolany-Raiser, Reinhard Heil, Carsten Orwat, Thomas Hoeren (Eds.): Big Data und Gesellschaft. Eine multidisziplinäre Annäherung. Wiesbaden: Springer Fachmedien Wiesbaden (Technikzukünfte, Wissenschaft und Gesellschaft / Futures of Technology, Science and Society), pp. 69–149.

DOI: 10.3217/978-3-85125-668-0-14

Designing a Multi-stakeholder Analysis of Trade-offs in the Water-Energy-Food Nexus

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2),
Jasminko NOWAK (3)

(1) European Institute for Participatory Media, Berlin, Germany; (2) Institute of Environmental Systems Research, Osnabrück University, Germany; (3) European Institute for Participatory Media, Berlin and IACS – Institute for Applied Computer Science, University of Applied Sciences Stralsund, Germany

Introduction

The growing urban populations and economies in rapidly-developing countries inevitably lead to increased demand for water-energy-food (WEF) resources. Diverse interests regarding these resources among the stakeholders from different sectors in urban and non-urban areas often lead to conflicts and misunderstandings. The lack of transparency and information concerning the consequences of the different uses of the WEF resources prevent sustainable solutions. Nexus approaches call for cooperation and coordination through identification of interconnections between these resources and developing an understanding of trade-offs between different alternatives, in order to identify solutions that are beneficial for all involved stakeholders (Liu et al. 2018). Effectively implementing such nexus approaches requires novel toolboxes enabling non-technical stakeholders (with differing goals, backgrounds and information asymmetries) to identify and analyze trade-offs in the WEF nexus.

In this contribution, we present an approach that allows a multi-perspective visualization and analysis of trade-offs between the often-conflicting WEF issues and policy options in a way that promotes a more holistic view and cooperative decision-making in multi-stakeholder environments. The approach is informed by the theory of “perspective making and perspective taking” (Boland and Tenkasi, 1995) that demonstrates how interaction and cooperation between members of heterogeneous “worlds of knowledge” can be supported. Specifically, the developed prototype allows different stakeholders to formulate, visualize and compare their perspectives with respect to various alternative solutions and reflected in indicators representing their real-world impact. It provides both a holistic view of the WEF issues, useful for stakeholders with non-technical backgrounds, as well as detailed information on specific issues for stakeholders with special interests. By supporting both a single-sector as well as multiple-sector perspectives the visualization tool allows the stakeholders to identify the interconnections between the different WEF issues, encourages communication and decision-making and also builds trust and increases willingness to use such tools.

The visualization tool has been developed within the DAFNE project (Decision analytic framework to explore the water-energy food Nexus in complex transboundary water resource systems of fast developing countries) funded by the EU Horizon 2020 program. The DAFNE decision-analytic framework provides scientifically-grounded data, models and simulation of different solution alternatives for the WEF nexus in the project's case studies (Zambezi and Omo-Turkana basins). This data is translated and visualized in the multi-perspective visualization tool in a form suitable for non-technical stakeholders and cross-sectoral group interaction. The data and the models underlying the visualization tool have been obtained through the project's participatory integrated planning approach (Castelletti and Sessa 2006), the main aim of which is to involve stakeholders representing various sectors and especially those coming from urban and non-urban areas early on in the design process.

In this contribution, we first describe the theoretical background and the participatory design process for the multi-perspective visualization tool. We then present the design and implementation of the current prototype and a preliminary evaluation of its suitability for supporting and stimulating the analysis of WEF trade-offs from a cross-sectoral perspective, undertaken with stakeholders from the Omo river basin case study.

Theoretical Background for the Design and Implementation of a Multi-Perspective Visual Analysis Tool

The use of computer-based information visualization to derive insights from large volumes of data has been extensively researched. Use of visualization techniques allows individual users to recognize patterns and relationships in data and thereby develop new knowledge (Card et al. 1999). In particular, the collaborative use of shared visualizations is gaining in importance (e.g. Heer et al. 2009). It allows the development of customized visualizations from predefined templates and the storing of specific visualization states (e.g. zoom, filter or time scale parameters). The advantage offered by collaborative use is that these visualizations can then be accessed by others and supported by textual comments and

DOI: 10.3217/978-3-85125-668-0-14

graphical annotations can link the contributions of users to the related views and vice versa (Heer at al. 2009; Willet et al. 2011).

This "social data analysis" (Wattenberg and Kriss 2006) couples visualization with asynchronous social interaction, and thus supports the process of individual 'sense-making' in which people create new knowledge by collecting, organizing and interpreting information from their own stakeholder group but also from other stakeholders (Russel et al. 1993). Sense-making often involves a social process in which the meaning of data and information is socially constructed (Miranda and Saunders 2003) by sharing backgrounds, frames of reference, goals and perspectives (Boland and Tenkasi 1995). The use of tools that support this kind of social data analysis are especially important in heterogeneous stakeholder networks with conflicting perspectives on the meaning of information (Novak 2007).

The approach used in the DAFNE project is informed by the theory of "perspective making and perspective taking" (Boland and Tenkasi, 1995) that demonstrates how interaction and cooperation between members of heterogeneous "worlds of knowledge" can be supported. In line with this theory we propose that there are two processes by which stakeholders can develop new knowledge and establish a shared understanding in heterogeneous stakeholder networks. Perspective making (PM) refers to processes through which stakeholders express, develop and exchange knowledge. By internalizing the meaning of concepts and establishing relationships between them, members of a community develop their own perspective of the subject matter at hand. Perspective taking (PT) refers to the development of an understanding of the knowledge perspective of an unfamiliar community (e.g., stakeholders from a different sector). This comprises developing an understanding of the backgrounds and frames of reference of other community members by internalizing this knowledge within one's own frame of reference and expressing it in one's own way (PM). Therefore, social data analysis for NEXUS-related issues requires both perspective taking and perspective making: understanding "what and how the others know" (Bonifacio et al. 2002), learning how this is related to one's own knowledge and then internalizing this information and thus developing the ability to view the problem from other's point of view.

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2),
Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

Previous research suggests that in order to enable perspective making and taking, specific requirements need to be considered (Novak 2007). In particular, this refers to the need to provide functionality that supports both perspectives: reflecting personal points of view of individual users and shared perspectives of specific user groups. This requires defining the individual and shared perspectives, determining the ways in which they can be best presented and which functionality should be useful in each case. Existing approaches often do not consider the importance of presenting the same information from various perspectives (Watteberg and Kriss 2006; Willett et al. 2011). In subsequent sections, we describe the approach used in the project to design and implement a tool that supports both of these processes: the multi-perspective visual analysis tool.

Design of the Multi-Perspective Visual Analysis Tool

There is often a substantial difference between stakeholders in terms of their affinity with technology, their professional background, and their experience with respect to using data-driven visualization tools that allow them to assess the merits of various solutions to WEF issues. To account for these differences, a user-centred design approach is used that considers the needs of different stakeholders, matches these against technological constraints and opportunities, and subsequently develops a visual analysis tool in an iterative way, alternating between development and stakeholder consultation. The user-centred design process that is adopted in DAFNE is depicted in Figure 32.

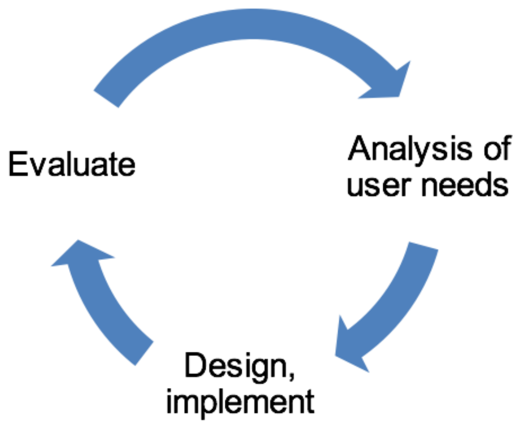


Fig. 32: *User-centred design process.*

In the first step, the analysis of user needs, the outputs of the stakeholder and actor analysis, as well as the results of the kick-off meetings yield insights into the needs of

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2), Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

stakeholders with respect to the visual analysis tool. Future stakeholder consultations will continue to refine the project’s understanding of these needs, which feed into the design and development process.

In the second phase, the design and implementation phase, two processes converge: “user pull” and “technology push”. While user pull reflects the specific needs and requirements of the stakeholders with respect to a visual analysis tool and its usefulness for their decision making in practice, technology push reflects the technological opportunities that the DAFNE project wants to employ (e.g. the Decision Analytic Framework and the underlying modelling approach for the water-energy-food nexus). In the first iteration, the result of these two processes is a conceptual design, a set of visuals resembling screenshots that reflect what the tools could look like (mock-ups), which features it will contain, and how users could interact with it. In later iterations, the outcome of this phase will be the subsequent versions of the tool that is then implemented as working software.

In the third phase, the output of the second phase is evaluated with stakeholders. The evaluation starts a new iteration as the feedback received provides additional information about the needs of stakeholders, as well as input for the design and development of the visualization tools.

The results of the stakeholder analysis distinguish between two types of users:

• Experts from the water, energy, and food domain who seek to obtain an in-depth understanding of solutions, pathways and indicators as well as gain insights into trade-offs between the sectors. Such users sometimes use analytical visualization tools in their daily work;

• Non-expert users who have a stake in the decisions that are made along the WEF nexus, but who are typically not using such visualization tools in their daily work.

Whereas visualization tools for complex geospatial and time series data often require background knowledge to grasp the information conveyed, in this case an easy-to-use, easy-to-understand solution it is necessary that users can:

• visually explore the interrelationships between water, energy and food perspectives and related sectors, based on selected indicators and underlying data;

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2), Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

• familiarize users with the concepts of the Decision Analytic Framework;

• support users in gaining a better understanding of the impact of certain solution pathways on different sectors and associated indicators.

Given these requirements, the main objective of the multi-perspective visual analysis tool is to make the main results of the DAF model available to a wide range of stakeholders in a way that allows them to easily explore, analyse and discuss the trade-offs of different WEF nexus solution pathways. Specifically, the tool allows stakeholders from diverse backgrounds to formulate, visualize and compare their perspectives with respect to various alternative solutions which are reflected in indicators representing their real-world impact. It provides both a holistic view of the WEF issues, useful for stakeholders with non-technical backgrounds, as well as detailed information on specific issues for stakeholders with special interests. By supporting both single-sector as well as multiple-sector perspectives the visualization tool allows the stakeholders to identify the interconnections between the different WEF issues. It supports communication and decision-making and also promotes trust-building and the willingness to use such tools for multi-stakeholder WEF analysis.

Implementation of the Multi-Perspective Visual Analysis Tool[1]

In line with the perspective making and perspective taking theory, the tool has two main modes: “Create your perspective” mode and “Compare perspective mode”. A perspective can be defined as the set of relevant indicators used by each stakeholder to evaluate impacts of each pathway on their sector of interest. As depicted in Figure 33 the tool allows the stakeholders to create one or more perspectives, as well as to compare their perspectives to those of others in order to understand the trade-offs between the effects of different solution pathways on the indicators that each sector considers important.

1. Note that the visualizations presented in this tool use preliminary data and are only used for the purpose of illustration of the functionalities of the tool (and not for deriving conclusions about the NEXUS issues)

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2),
Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

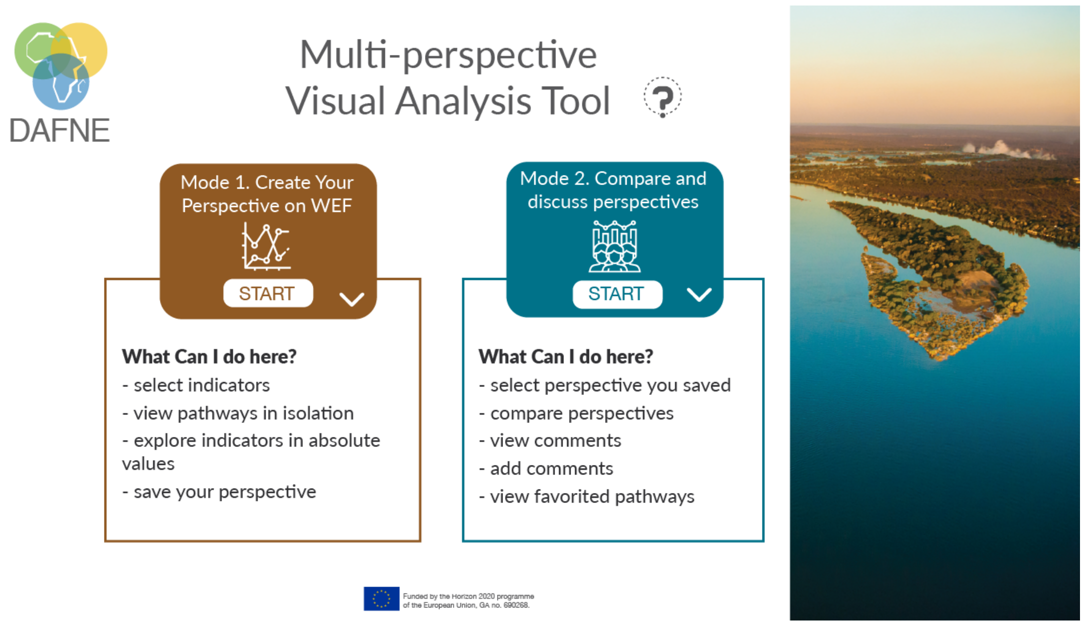


Fig. 33: *The start screen of the multi-perspective visual analysis tool*

The tool can be used in two main ways as illustrated in Figure 34. Normally, stakeholders begin to create their perspective(s) by selecting the indicators they would like to focus on and in the next stage, comparing various perspectives or exploring the perspectives of others (Way 1). However, if the stakeholders want to explore the perspectives of others or they have already created some perspectives, they can go directly to the "Compare perspectives" mode (Way 2). These different views can support two different types of interactions with the tool. "Create perspective mode" can enable sector-specific interactions, whereas the "compare perspectives" allows for multi-stakeholder interactions.

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2), Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

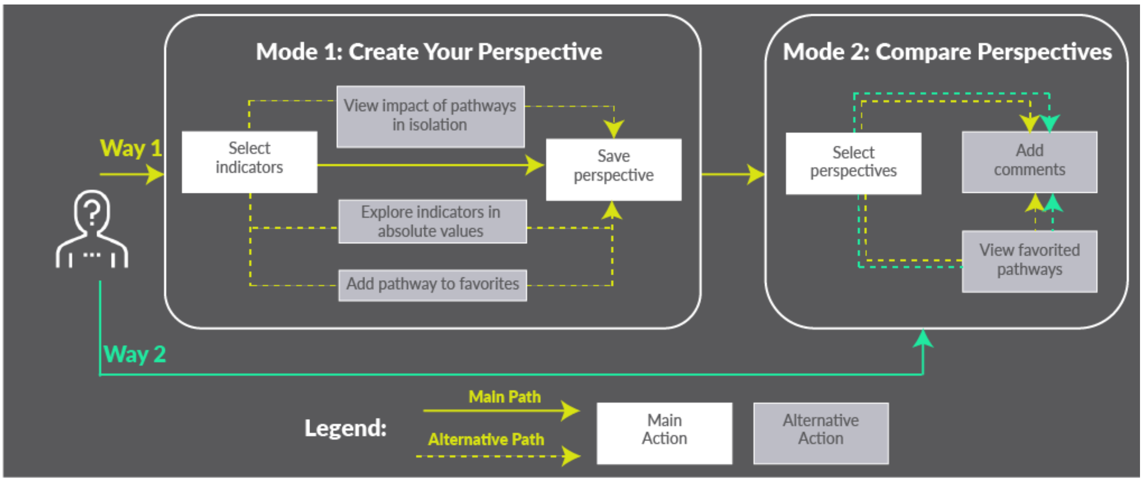


Fig. 34: *Two primary ways in which the multi-perspective visual analysis tool can be used*

In line with the main purpose of the tool, that of enabling the stakeholders to analyse and discuss the trade-offs of different solution pathways, the tool has two primary modes: "Create your Perspective" and "Compare perspectives," which are accessible from the main menu. There is also one supplementary mode, "View impact of pathways and indicators in absolute values," which is accessible through the "Create your perspective" mode. These are explained in this section.

"Create Your Perspective" Mode

In the 'Create Your Perspective' mode (Figure 35), the stakeholders can visually display a set of best candidate pathways. They can view the impact of the pathway classes and pathways on the indicators, create and save the perspective and view indicators in absolute and normalized values. A pathway class is a collection of pathways with the same set of structural actions. Each pathway within a pathway class represents the implementation of the same set of actions under a different (resource) management scenario.

DOI: 10.3217/978-3-85125-668-0-14

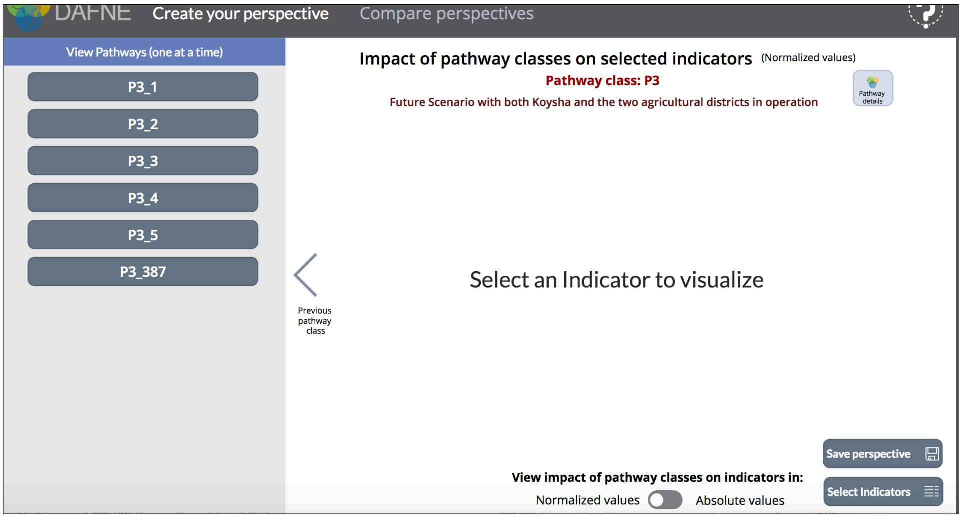


Fig. 35: *Start screen of the "Create your perspective" mode*

To create a perspective, stakeholders first select the indicators that interest them (Figure 36). Stakeholders can create one or more perspectives of the chosen sector by selecting the indicators for which they want to explore the impact through the "Select Indicators" window. Indicators are grouped by sector, but stakeholders can also choose from the complete list of indicators. They can then click on the indicators to select them. By selecting the indicators that the stakeholders want to focus on, either belonging to one or multiple sectors, they can view either the perspective of one sector or a multi-sector perspective, respectively.

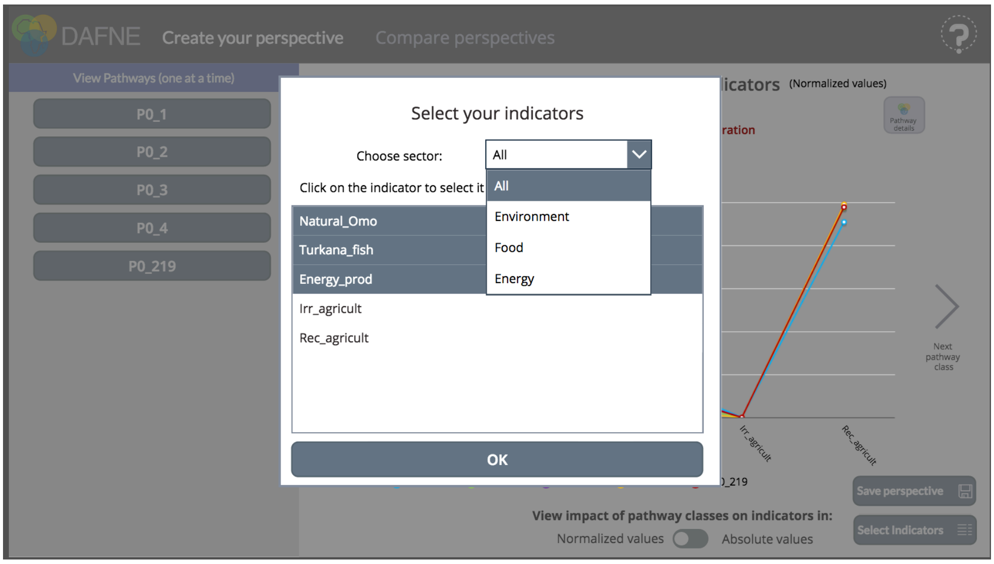


Fig. 36: *Step 1 in creating the perspective: selecting the indicators*

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2), Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

In the next step, the stakeholders can explore the impact of pathways on the selected indicators (Figure 37). They can click through the pathway classes to see the impact of the structural investments on the selected indicators. Stakeholders can view detailed information (e.g. which exact actions comprise the pathway class) by clicking on the DAFNE icon, which will redirect the user to the detailed pathway model.

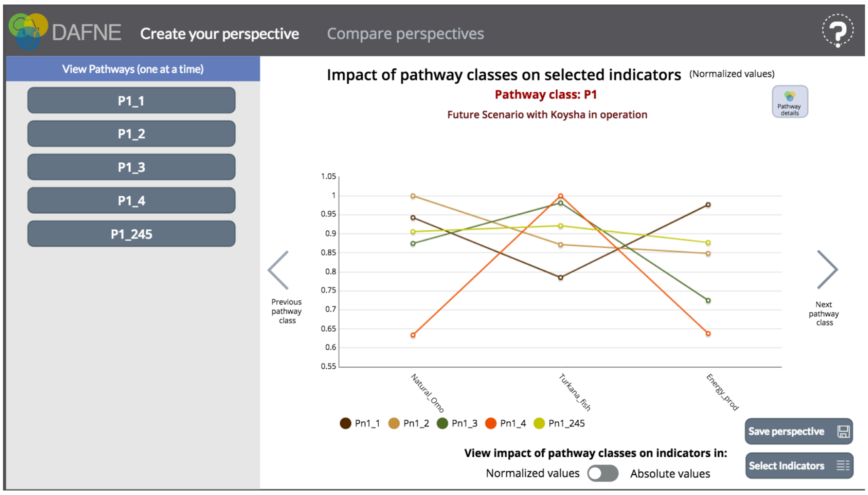


***Fig. 37:** Step 2 in creating the perspective: exploring the pathways*

At this stage, some additional options to explore the pathways include: exploring one pathway at a time and exploring the impact of pathways in absolute values. On the right side of the screen the icon called "View Pathways (one at a time)" can be selected to filter out one pathway from the pathway class and explore its impact on the selected indicators. On this screen, stakeholders can also save one of the pathways to 'favourites' (Figure 38). By saving a pathway to favourites, stakeholders can later see which pathways were preferred by others.

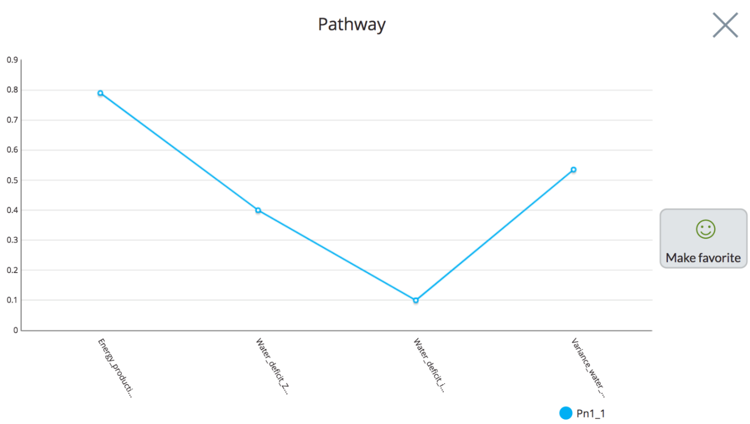


***Fig. 38:** View pathways one at a time and indicate a favourite pathway*

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2),
Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

The indicators which are explored do not always follow the same optimization function. To ensure comparability and to make the analysis easier, the values of the indicators are normalized on a scale from 0 to 1, where 0 represents the worst possible effect of the pathway on the indicator, and 1 – the best possible effect (across all simulated pathways). The disadvantage of the normalization is, however, that the seemingly small differences in normalized values can correspond with large differences in absolute values. If stakeholders would like to explore the impact of pathway classes on indicators measured in absolute values, this can be done by toggling the option at the bottom of the screen "View impact of pathway classes in absolute values". In the 'View impact of pathways on indicators in absolute values' mode, stakeholders can explore the impact of pathways on the indicators in absolute values Figure 39). As the absolute scale is different for each indicator, stakeholders can only explore the impact of the pathways on one indicator at a time. Stakeholders select an indicator they want to explore from the drop-down list. For each indicator, a short description is provided. If stakeholders want to return to explore the impact of pathway classes on indicators in normalized values, this can be done by toggling the option "View impact of pathway classes in normalized values".

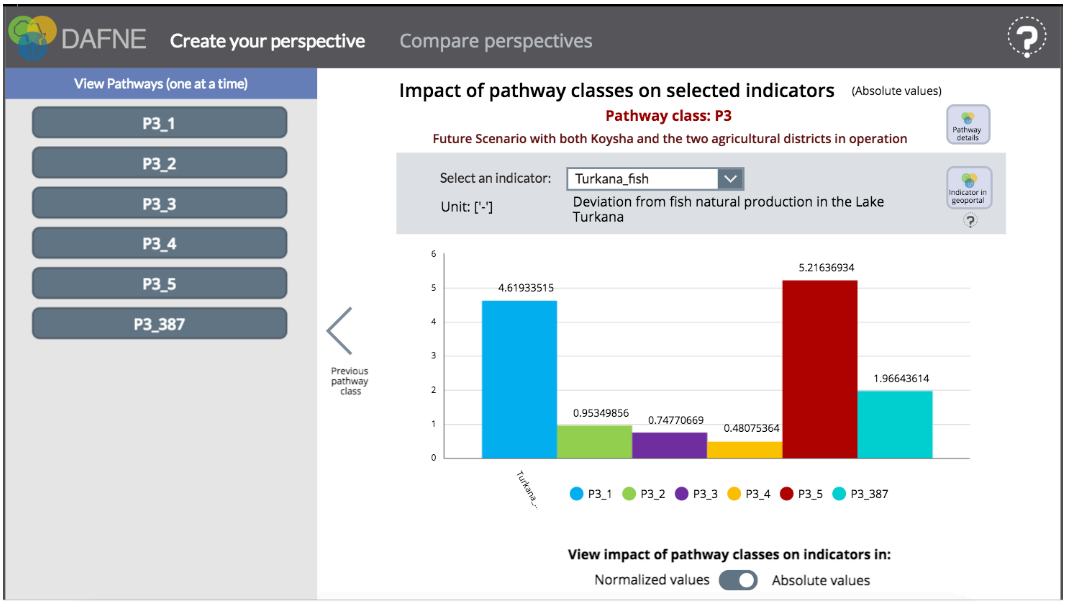


Fig. 39: *"View impact of pathways on indicators in absolute values" Mode*

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2),
Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

Finally, in the third step, the stakeholders can save their perspective by clicking on “Save perspective” in order to compare it later in the “Compare perspectives” mode (Figure 40).

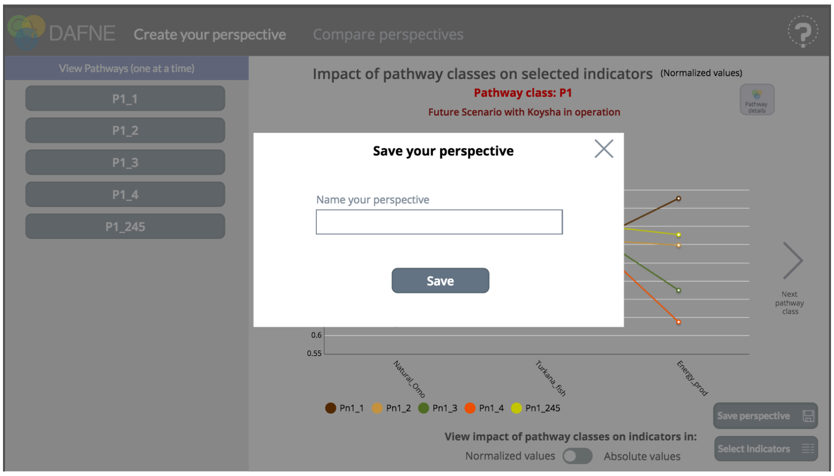


Fig. 40: *Step 3 in creating the perspective: saving a perspective*

“Compare Perspectives” Mode

In the ‘Compare Perspectives’ mode, stakeholders can compare and annotate perspectives as well as view pathways favoured by all other users. In this mode, stakeholders can choose to retrieve two perspectives saved in the “Create Your Perspective” mode and compare them with each other. They can also retrieve perspectives that other stakeholders have saved. In this way, they can take the perspective of other sector and anticipate the pathways that will be preferred by that sector. Additionally, by selecting two saved perspectives stakeholders can analyse and compare them to each other, thus supporting discussions between stakeholders representing different sectors (Figure 41). Stakeholders can annotate the perspectives by writing comments about them and/or reading the comments provided by others. If needed, the user can also make comments privately so that they are not seen by other users.

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2), Jasminko NOWAK (3)

DOI: 10.3217/978-3-85125-668-0-14

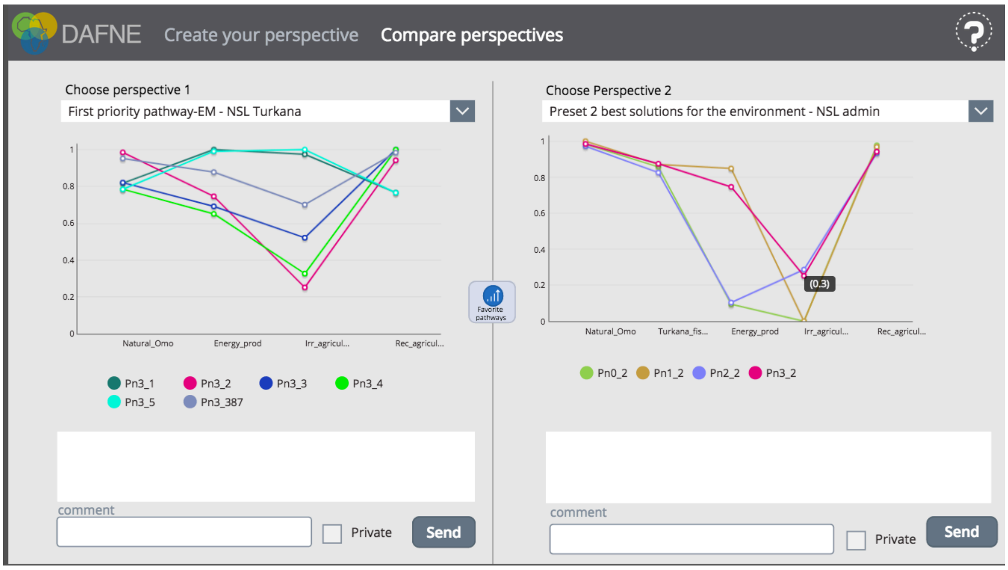


Fig. 41: *Compare perspectives" Mode*

In addition, by clicking in this mode on the icon "Favourite pathways" in the middle of the screen, one can see how many times each pathway was favoured by all the users (Figure 42). In this way, one can see which pathways are preferred by other stakeholders.

Fig. 42: *"View Favourite Pathways" Functionality*

Evaluation of the Multi-Perspective Visual Analysis Tool

A preliminary evaluation of the first prototype of the multi-perspective visual analysis tool was undertaken in February 2019 with the stakeholders from the Omo basin. In total, nine interviews were conducted with stakeholders from various sectors including energy, agriculture, environment, food, economy and tourism. The 45-minute long interviews were conducted in person in Addis Ababa. After a brief introduction to the purpose of the

DOI: 10.3217/978-3-85125-668-0-14

session, the evaluation was performed. In an interactive session, the stakeholders were asked to perform tasks in the multi-perspective visual analysis tool similar to those they would be doing when using the tool on their own. The data used in the tool was preliminary and only for the purposes of illustrating of the main functionalities of the tool. The interviewer asked questions after every interaction. The goal of obtaining this intermediate feedback from the stakeholders was to verify that the prototype developed fits their needs and to identify any issues for further improvement.

As a starting point, the stakeholders were asked about their interests in the project and specific interests for the future of the basin. As expected, the interests of the stakeholders are very different: food security, food productivity, maintaining the livelihood and cultural heritage of communities in the Omo basin, sustainable land management, preserving the environment, preserving forests, promoting investment which complies with environmental requirements, avoidance of floods, good agricultural projects, no conflicts within and between the transboundary countries, etc. In this regard, the stakeholders view the DAFNE project in general and the multi-perspective visual analysis tool in particular, as potentially helping to support a variety of goals such as: optimizing food and water supply; obtaining scientific data to make informed decisions in the nexus; facilitating negotiations between policy makers, negotiating with the government including its ministries, identifying sustainable alternatives for investment, supporting infrastructure planning, promoting good relations with Kenya; and, finally, exploring the effects on culture. The stakeholders are especially interested in the multi-sectoral aspect of the project covering long-term considerations and enabling multi-dimensional analyses exploring the interaction between the various indicators.

Overall, the tool presented to the stakeholders was received positively. The stakeholders were eager to explore the results with the available functionalities of the tool. One stakeholder explained: "*I am fascinated by this tool. It is very interactive. I am very interested in it and also to learn how to use it and interpret all the pathways*". They said that the tool is very useful for exploring trade-offs, making decisions based on evidence, considering the perspectives of other sectors and using it during negotiations. The interaction with the tool was also perceived to be quite easy with one stakeholder mentioning: "*Overall one can see the trade-offs clearly, easy-to-save perspectives, quite good interaction with the tool*". The stakeholders could easily explore all of the

DOI: 10.3217/978-3-85125-668-0-14

functionalities of the tool such as: selecting indicators, saving perspectives, viewing the indicators in isolation, saving a pathway to 'favourites', retrieving and comparing perspectives, and writing comments. The stakeholders were especially interested in the fact that the tool was available online. However, because not all areas of the country are equipped with (adequate) internet access, they asked if the tool would be available offline too. An export function could be very useful in this regard.

The Perspective-making ability of the tool was evaluated through interaction with the "Create your perspective" mode. This mode was perceived as useful and easy to use, with one of the stakeholders mentioning: *"Create your perspective mode is very useful, providing rich and comprehensive information with various options, and it can be used as a negotiation tool by the stakeholders"*. In this mode, the stakeholders selected the indicators they were interested in, viewed the pathways in isolation, and saved their perspective. All these tasks were carried out with ease by at least 80% of the stakeholders. The other 20% needed a bit of additional guidance in using the tool. In this mode, some stakeholders wanted to explore more indicators (which will be possible once the data becomes available) as well as asking about the possibility to 'make a perspective' for interdisciplinary sectors such as tourism and possibly include integrated indicators (value-added indicators) to convince the stakeholders from various sectors.

The Perspective-taking ability of the tool was evaluated through interaction with the mode "Compare perspectives". As with the perspective-making mode, the perspective-taking mode of the tool was perceived as useful and easy to use. As one stakeholder commented: *"Comparison mode is also very helpful, good visualization, can compare easily, to make trade-offs, and to have evidence for negotiation".* The possibility to consider the impact on other sectors and comparing one's own to the perspective of others was regarded as especially useful to the stakeholders. All of the stakeholders could understand and use the functionalities of this mode of the tool such as: retrieving their perspective, making comparisons, identifying their preferred pathways, as well as providing feedback. We found that by putting the perspectives of the two sectors side by side, a trade-off analysis process for a cooperative selection of pathways can be effectively supported.

DOI: 10.3217/978-3-85125-668-0-14

A few aspects were also observed that suggest potential for further improvement. These can be divided into those that relate to the usability of the tool and those related to the general understanding of the results of the DAF model. The former can be addressed when improving the tool for the final version. The latter will be addressed by making sure that enough background is provided for participants. This can be achieved within the context setting for the participants, by including explanatory meta-data in the visual analysis tool in order to aid stakeholders in interpreting the results of the model.

The stakeholders when interacting with the multi-perspective visual analysis tool uncovered a few minor usability issues. First, the stakeholders expected a bit more interaction with the pathways, by clicking on them and selecting them, or clicking on their labels. The ability to select one pathway should be explored in the next versions of the tool, and right now is supported by the extra menu that allows the exploration of the pathway in isolation. Second, when selecting the indicators, the stakeholders were a bit confused when the indicator is selected and when not, and suggested the use of a check box so that the interaction is clearer. Third, some stakeholders could not find the menu to switch between the create and compare perspectives modes, and this might be because the tool is slightly larger than the size of the screen that was used for the evaluation. An easy solution for this is to adjust the size of the tool to fit a screen. These issues require minor adjustments in the interaction design of the prototype and can be tackled in the next version of the tool.

What concerns understanding the results of the model, it was observed that some stakeholders could grasp the results of the model easily, while others required some more guidance into the interpretation of the results. Those stakeholders who required more explanations are the ones with less technical backgrounds who do not deal with a large amount of numbers in their daily work and are not familiar with the technicalities of WEF nexus modelling. Specific points scattered around understanding the concept of a pathway and the meaning behind it. As such, the stakeholders desired more details about the pathways and some simple description as to the actions that comprise it. They asked: "*How can the model be translated into action? What should the stakeholders do?*". Access to the detailed information about the pathways and the indicators was already foreseen: this can be viewed in another tool with a direct link from the multi-perspective visual analysis tool; however, the stakeholder feedback suggests that it would be advantageous

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2),
Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

to include some of this more detailed information already in the multi-perspective visual analysis tool itself. Another point was around understanding the impact on the indicators in absolute and normalized values. Overall, normalized values allowed for an easier way of understanding, but normalization in some cases can be misleading (e.g. in a case where a 0.8 normalized value corresponds to a very low absolute term). Finally, the stakeholders suggested that it would be helpful if there could be an overall simplification of the underlying model so it could be grasped without the detailed knowledge of the DAF model. One of the stakeholders mentioned: ”*There should be a way to simplify it, add more details in the simplified language so that it is understood by many… someone very high level looking at these results will not be interested in the details*”.

There are several possible ways of addressing the issues outlined above. First, in the final version of the tool a short video tutorial will be available that explains how the results of the underlying DAF model can be possibly interpreted and how they are reflected in the tool. Additionally, there could be online and possibly offline training sessions offered for the stakeholders. All of the interviewed stakeholders expressed a wish to have training on how to use the DAFNE tools in general. Second, another idea could be to add another mode showing the impact of the pathways on a higher level, e.g. by displaying the aggregated impact on the sectors, or on the specific aggregated indicators. One of such options was explored with the participants: to include the potential impact of pathways on sustainable development goals set out by the UN (SDG indicators). The interviewees were presented with a mock up displayed in Figure 43, which shows an example of how the potential impact of the pathway could be shown on the SDG indicators (i.e. which ones could be influenced positively and which ones negatively). The stakeholders expressed a high level of interest in including the SDG indicators into the multi-perspective tool. For some of them, the SDGs give the high-level multi-perspective view by displaying the combined impact of various indicators. Others already use SDGs in their work, for example when planning infrastructural investments, so this additional information about the impact on SDGs would be especially important to them. Some of the most interesting SDGs were those relating to cultural and human aspects (such as no poverty, food security, etc.), as well as those that allow achievement of a sustainable ecosystem (e.g. poverty or gender balance) as well as partnerships between the sectors and the countries (Ethiopia/Kenya).

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2),
Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

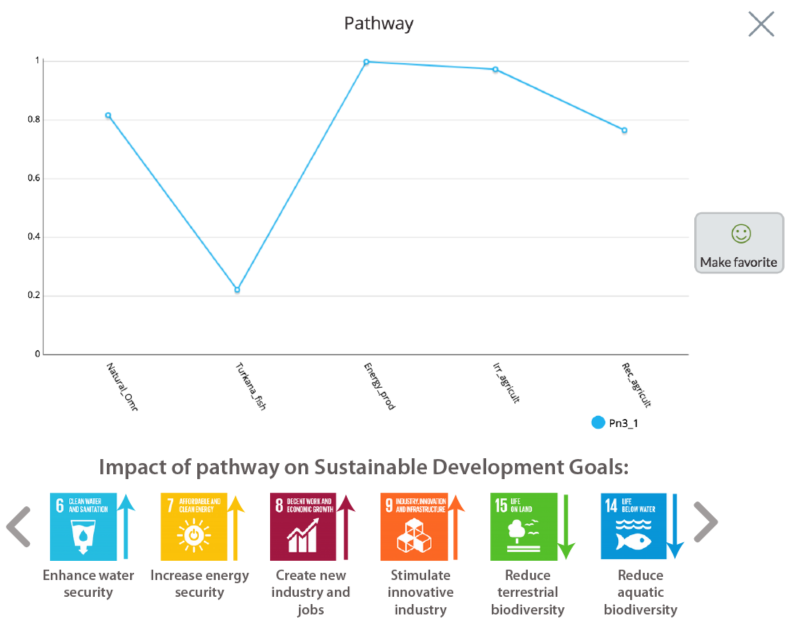


Fig. 43: *Mock-up that illustrates including the impact of pathways on SDG indicators*

Conclusion and Next Steps

Overall, according to the results presented in this article, the intermediate evaluation of the multi-perspective visual analysis tool confirmed its usability and the suitability of its conceptual design, allowing stakeholders to analyze, create and compare perspectives on the WEF issues in order to analyze the trade-offs of different solution pathways. The results suggest that the multi-perspective visual analysis tool the needs of stakeholder and satisfies their expectations on its value and ease of use. The feedback obtained also helped to identify several minor issues to be corrected and possible areas for further improvement.

The option of integrating the UN Sustainable Development Goals (SDGs) into the tool is an interesting avenue for further research. Currently, such a feature is not available in the existing prototype. The panel discussion of a recent *Resource Nexus Policy & Cluster Workshop* hosted by the European Commission[1] identified a number of challenges related

1. http://dafne-project.eu/2018/12/11/resource-nexus-policy-cluster-workshop-27th-november-brussels/

Ksenia KOROLEVA (1), MIRANDA Darien (1), Caroline VAN BERS (2),
Jasminko NOWAK (3)
DOI: 10.3217/978-3-85125-668-0-14

to development such a feature in a reliable way. They pointed to the need for further research projects to specifically addressing this issue. Accordingly, due to the complexity of the underlying challenge, this might be an objective to consider developing into a dedicated follow-up project.

Acknowledgements

The DAFNE project presented in this article has received funding from the European Commission's Horizon 2020 Research and Innovation Programme under Grant Agreement No 690268.

References

Boland Jr, R. J., & Tenkasi, R. V. (1995). Perspective making and perspective taking in communities of knowing. *Organization science*, *6*(4), 350-372.

Bonifacio, M. et al. (2002). Enabling distributed knowledge management. Managerial and technological implications. *Novatica and Informatik/Informatique* III (1).

Card, S.K., Mackinlay, J.D., and Shneiderman, B. (1999). Readings in Information Visualization: Using Vision to Think. Morgan-Kaufmann.

Castelletti, A., Soncini Sessa, R. (2006). A procedural approach to strengthening integration and participation. *Water Resource Planning, Environmental Modelling and Software*, 21(10), 1455- 1470.

Heer, J., Viégas, F.B., Wattenberg, M. (2009). Voyagers and Voyeurs: Supporting Asynchronous Collaborative Visualization, *Communications of the ACM*, Vol. 52, No. 1.

Liu, J., Hull, V., Godfray, H. C. J., Tilman, D., Gleick, P., Hoff, H., ... & Li, S. (2018). Nexus approaches to global sustainable development. *Nature Sustainability*, *1*(9), 466.

Miranda, Shaila M., and Carol S. Saunders. (2003). The social construction of meaning: An alternative perspective on information sharing. *Information systems research*, 14 (1), 87-106.

Novak, J. (2007). Helping Knowledge Cross Boundaries: Using Knowledge Visualization to Support Cross-Community Sensemaking, Proc. of HICSS-40, *Hawaii International Conference on System Sciences*, Hawaii, Jan 02-06, 2007

Russell, D. M., Stefik, M. J., Pirolli, P., and Card, S. K. (1993). The Cost Structure of Sensemaking. *Proc. of ACM INTERCHI'93*, 269-276.

Wattenberg, M. and Kriss, J. (2006). Designing for social data analysis. *IEEE Transactions on Visualization and Computer Graphics*, 12, 4, 549–557

Willett, W., Heer, J., Hellerstein, J.M., Agrawala, M. (2011). CommentSpace: structured support for collaborative visual analysis. In CHI, 3131-3140

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

The Double Understanding of Norms and the Prospectives of Current Socio-technical Developments

Gesa LINDEMANN
Carl von Ossietzky Universität Oldenburg, Germany

Introduction

This paper takes a theory of society perspective on the ongoing digital transformation of society. In current diagnoses of society it is indisputable that the use of digital data collection and analysis technologies will have an influence on people's lives and may even change the entire structure of society (Baecker 2018; Mason 2015; Pohle 2012; Zuboff 2019). This paper takes up this time-diagnostic perspective, and relates it to a contradictory insight from the theory of social differentiation.

The contradictory insight: On the one hand, modern, horizontally differentiated society is characterized by a preference for cognitive, i.e. learning-oriented forms of social control, whereas normative forms tend to lose significance (Luhmann 2005, p. 68ff) . On the other hand, there is also the finding that Western modern societies themselves are based on strong normative foundations that are centered around the institution of the human individual, equal in freedom and dignity (Joas 2011; Lindemann 2018; Luhmann 1999). If the first assumption is correct, one would expect that the development of automated prognosis and control technology would merely reinforce an existing socio-technical tendency. According to this understanding, dramatic crisis scenarios would be inaccurate (Nassehi 2019). If the second finding is correct, the automated generation of estimates and predictions based on digital traces of behaviour could have the potential to fundamentally change societal structures. The implementation of these technologies strengthens the dominance of cognitive-prognostic social control and undermines the normative foundations of modern society.

These contradictory findings have a basis in a double understanding of individuality, which characterizes modern horizontal differentiation. The crucial point is that the human individual is understood as a societal institution (Lindemann 2018) required as precondition of horizontal differentiation. Horizontal differentiation and the institution of the human being, equal in freedom and dignity, secure each other, as Luhmann (1999) puts it

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

in his analysis of fundamental rights. To safeguard the relationship of mutual precondition between horizontal differentiation and the institution of the individual, requires a balance between the knowledge about individuals in different contexts and the protection of the individual from an excess of knowledge about it (Pohle 2012). This means, for example, that the knowledge of an organization about an employee should not include the knowledge about this person in relation to his or her overall economic behavior. Or: The knowledge that is generated about an individual in the context of consumer behavior should not be used to forecast family behavior. The individual is thus understood in a twofold way: it is endowed with freedom and dignity and it is a predictable individual, based on the stock knowledge about it, gathered by other actors or organizations. My thesis is that horizontal differentiation and its institutionalized double understanding of the individual are endangered by current socio-technical developments.

I unfold my argument in four steps. First, I unfold the idea of the individual as an institutional condition of horizontal differentiation (Section 1 and 2). Second, I argue that the double understanding of the individual parallels a double understanding of norms, which steer social processes. I distinguish between functional and moral aspects of norms. This enables us to analyze modern society as a society composed of skinnerboxes (section 3). Third, I investigate whether the development of the new platform technologies and their possibilities of data storage, collection and evaluation have to be identified a) as a threat to the structures of horizontal differentiation or b) as a confirmation of these structures. Herewith, the text provides an in-depth-discussion of the tension in the understanding of the ongoing digital transformation of society: have we to understand these developments as the fulfillment of existing tendencies or as a fundamental threat to the normative structures of modern societies (Section 4).

1 The double understanding of the individual

I understand the idea of the individual as an historical contingent form of sociation. This requires a theoretical starting point, which does not presuppose the idea of the individual. In this respect I refer to the „social undecidedness relation“ (Lindemann 2019). Based on an interpretation of Plessners theory of the shared world (Plessner 1975). According to Plessner lived bodily selves find themselves always already in relationships of touch that is, in a shared world, the members of which affect each other. That is, „lived bodily selves

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

exist as a reflexive turning upon the factual state of existing in relationships of touch." (Lindemann 2019: 101) This opens up different possibilities of understanding social life, each of which has to be institutionally consolidated. One institutionally consolidated possibility is that lived bodily selves experience themselves from the perspective of a third party as a single individual who can enter into relationships with others. If this possibility is institutionally consolidated, a given historical context would be structured by an individualizing form of sociation. The other possibility would be that the aspect of existence in relationships is institutionally consolidated. In this case we find historical contexts, which are structured by a dividualizing form of sociation.

It is common sense that modern societies is characterized by individualization (Dumont 1991). But it is highly disputed what „individualization" means. There are at least two different conceptions of individuality in modernity, which can be understood on the basis of the difference between the particular and the singular. The particular is that which can be grasped by a general knowledge. This aspect is elaborated within the tradition of Foucault (Foucault 1975). According to these studies being an individual is the effect of knowledge and power, the individual is governed by governing itself (Lemke 2002). In this sense, lived bodily selves would be individualized by Google, Amazon or other tech-organizations. They grasp the individual as a particular accumulation of measurable properties. The individual is the intersection of general characteristics. It is expected that the individual will govern itself according to the suggestions a particular tech-organization offer to him/her. In a similar sense, we behave in everyday life when we use our knowledge of individuals to form expectations related to their behavior. The individual as particular is the individual insofar as something is or can be known about it and insofar the individual behaves according to the expected expectations.

The individual as a singular has to be understood in a different way. As a single individual, the individual is that which is not grasped by the particular knowledge about it. The individual as singular is the individual that is not determined to behave in a particular way. The singular individual is the particular individual, insofar as it relates itself to itself. Therefore it is not determined by internal or external causes. Instead, the individual is supposed to be free that is the individual is able to determine itself. This thought can be found for example in Simmel (1983) as well as in Luhmann (1984) – to name only two important sociological theorists. And has been part of modern philosophy since Kant.

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

Luhmann or Simmel take this double unterstanding as general premise of sociality (Simmel) or communication (Luhmann). Following Plessner, I take a different path. Unlike Simmel or Luhmann, I analyze this understanding of individuality as a historically contingent form of the social. The individual equal in freedom and dignity is an institution of modern horizontally differentiated society. Contrary to that Simmel describes the individual and its relations as „aprioric conditions of sociation“ (Simmel 1983, p. 24) in general. Luhmann argues in a similar way, as I will show in more detail. I argue that the institutional form of the modern individual includes two aspects: the individual exists as a particular (the individual characterized by positive knowledge about it) and as a single (the individual, insofar as it relates itself to itself and is not fully determined by its knowable conditions). These two aspects are understood by Luhmann as the general premise of his concept of communication.

“Two irreconcilable possibilities offer themselves to (Alters, GL) self-understanding. As far as information is concerned, Alter must view himself as part of the meaning world in which information is true or false, is relevant, repays utterance, and can be understood. But as someone who utters it, he must have the freedom to speak, to do this or not. In one respect he must interpret himself as part of what can be known about the world, for the information refers back to him (otherwise he could not apply it). In another regard, he controls himself as a self-referential system. Dieter Henrich calls this the “distance between his being a subject and his belongig to the world” … Viewed sociologically, this distance, however is nothing natural, and even philosophy knew nothing of it before Kant. We do not view it as the facticity of a transcendental position, but as the effect of the fact that ego interprets the behavior of Alter as communication and therefore expects Alter to accept this distance.” (Luhmann 1995: 141)

Luhmann describes two ways of Alter Ego to understand him/herself. If Alter Ego is understood as a part of the meaning world, it is possible to gather information about Alter Ego and it is possible that Alter Ego him/herself gathers information about him/herself. Alter Ego is understood as a knowable being about which more or less complete information can be gathered. In this respect Alter Ego is not different from weather and weather forecast. We gather information about everything that may influence the weather tomorrow. Based on such information we try to forecast the weather, as well as we can try to forecast the behavior of Alter Ego. We collect information on Alter Ego, and can improve

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

our predictions by gathering more and more information. If we expect Alter Ego to be determined by the factual knowledge about him/her, we would expect that the more information we have, the better our prediction will be. In this respect Alter Ego is a particular individual.

As a singular individual Alter Ego is described as being a subject. Alter Ego is described as someone who is a self-referential system. Alter relates itself to itself and therefore is not determined by the facts others can know about him/her. Even if actors would have gathered all in informations available about Alter Ego, they would not be able to produce safe predictions, because Alter Ego is not determined by its known factual existence. Luhmann understands the double understanding of the individual as singular and particular as the general basis of his concept of communication. Communication for Luhmann requires to treat each other not only as a particular individual but also as a singular individual. The individual as a particular is the individual as a part of the meaning world. In this respect particular information can be collected about Alter Ego by others and Alter Ego itself. This is the basis for actors to predict each other's behavior. Actors have to treat each other as predictable actors, otherwise structured communication would not be possible. On the other hand, according to Luhmann, actors have to treat each other as beings, who are not determined by the information making them predictable. They have to treat each other as free and responsible individual actors that is as subjects. Beings in a subject-position are individuals as singular.

Luhmann and Simmel grasp the double understanding of the individual as a universal concept of communication or interaction. Following Plessner, this double understanding of the individual has to be understood as a structural element of modern society. It is a structural feature of horizontal differentiation. Taking this perspective allows to understand the development of digital surveillance technologies as well as its critique as elements of modern society. In the following section I unfold this argument in two steps. First I describe how the double understanding of the individual can be analyzed as a structural feature of horizontal differentation. Second, I analyze how the discourse on on digitalization refers to the distinction between the individual as singular and as particular.

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

2 Theory of functional/horizontal differentiation

If one understands the difference between the singular and the particular individual as a historically contingent form of social life, the question arises as to how this form is institutionalized. Here the theory of horizontal/functional differentiation becomes relevant. Modern societies are characterized by functional differentiation (Luhmann 1997) or horizontal differentiation (Lindemann 2018). Horizontal differentiation requires different forms of being an individual, which I have described as the individual as singular and particular. The difference between the singular and the particular individual is institutionally required by horizontal differentiation. Within the institutional order of functional/horizontal differentiation the individual exists on the one hand in particular contexts of action, such as familiy, organizations or societal contexts of communications such as the law, economy, politics etc. (Lindemann 2018, pp. 157ff; Luhmann 1997, pp. 707ff). Within each of these structured contexts of action and communication individuals need to be predictable. Therefore information about the individual is required to make it predictable or calculable. However, such knowledge should always be limited to particular contexts of action, i.e., within different contexts of action the knowledge about the individual should be different. There is a knowledge about the individual related to the family, to the organization in which it works (company) etc. A fragmented knowledge about the individual is the institutional guarantee for the individual not being fully absorbed in the knowledge that exists about him/her in a particular context. Due to fragmentation of knowledge, within no context of action the individual can be predicted with certainty. (Pohle 2012)

At the same time, this institutional arrangement is accompanied by the suspicion that the individual would be completely predictable, if one knew everything about it. This is the suspicion of behaviorism, e.g.: Skinner (1971) , with its predecessors Planck and Meyer (Zuboff 2019). All discourses that describe people as completely determined would fall into this category.

Thus, two levels have to be distinguished for the discursive shaping of the understanding of individuality: the discourse about the reduction to the particular (and predictible) individual and the discourse about saving the single individual.

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

As far as the particular individual is concerned, it would only be a question of knowledge growth until the individual would become completely predictable. In this sense, the institutional structure of horizontal differentiation would be understood merely as an inhibition to the further development of knowledge about the particular individual, which could be much better adapted to the functional rules of society, if these inhibitions were overcome.

With respect to the single individual, the focus is on the difference between the two understandings of individuality. The individual cannot exist as a mere singular (single individual), for as a singular it is always related to itself as a particular individual. The individual as singular describes the self-referential relation to the individual as particular. Every attempt to save the singular emphasizes that it is a general structural condition for communication or interaction. In Luhmann, too, the double characteristic (as single and as particular) does not belong to the individual in the sense of a transcendental assumption, but nevertheless in the sense of a necessary precondition for the practice of communication.

The double understanding of the individual parallels a double understanding of norms. With respect to norms I distinguish between moral norms and functional norms. Whereas moral norms require an understanding of the individual as singular and as a particular, functional norms would require the individual only as a particular. I explain this difference in the next section.

3 The double understanding of norms and the possibility of a skinnerbox-like form of social steering

I analyze norms from the perspective of disappointment of expectations. Actors expect a particular course of events. For example, Ego says “hallo” and expects Alter Ego to greet back, but Alter Ego does not greet back. The expectations of Ego have been disappointed. Ego is somehow affected or even concerned about it. This is the “ipseistic dimension of expectations”: Ego is affected or concerned, whether its expectations will be disappointed or fullfilled (Lindemann 2014, p. 220). If expectations are disappointed, Ego can react in two different ways, it can learn and change its expectations or it can hold to its expectations. If Ego would learn, it would expect cognitively. If Ego would hold to its expections, it would expect normatively. The distinction between normative and cognitive

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

expectations was first made by Galtung (1959) and introduced by Luhmann into sociology (Luhmann 1972). Turning back to the greeting-example: If Ego would expect cognitively, it might say, “I was talking too softly, Alter Ego probably couldn't hear me”. In this case, Ego will not expect any longer to be greeted back in this particular situation. Ego does not hold to its expectations instead Ego changes its expectations. If Ego would expect normatively, it would hold to its expectations. This can be done with respect to different aspects of norms.

3.1 The double understandig of norms

If Ego would expect in a normative way, Ego would hold to its expectations, although they have been disappointed. In this case Ego must show its disappointment to make it socially relevant. Ego could say “hello” in a loud voice, or Ego could ask Alter Ego “why don’t you greet back”. These two reactions refer to different aspects of the norm: the functional and the moral aspect.

Functional aspect: If Ego would greet in a loud voice and if Alter Ego would greet back, the normal course of events would be re-established. Here the focus is on re-establishing the functional order of events. A greeting should be returned. If it has not been returned, actors have to take care that the normal course of events will be reestablished. This is the functional aspect of norms. Norms are explicit or implicit assumptions on how things should happen. In case of a deviation, actors have to find back to the normal course of events.

Moral aspect: If Ego would ask Alter Ego “why don’t you greet back”, it is not about reestablishing the normal course of events. In this case Ego treats Alter Ego as a morally responsible actor, who has breached an expectation, which one should hold to. This is the moral aspect of norms. In this case, Alter Ego is addressed as an actor who can see the meaning of the norm and that he has made a mistake. Ego also implies that Alter Ego could have acted differently. From the perspective of Ego the other actor has freely chosen an action and can be held responsible. Therefore Alter Ego is asked to give reasons for his/her behavior. If the focus is on the moral aspect of norms, it is about treating the Alter Ego as a responsible and reasonable actor. The focus is not on reestablishing the normal course of events.

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

The moral aspect of norms requires necessarily the individual as a singular. As singular the individual is assumed to be free, its actions cannot be understood as the effect of a causal chain of events, about which a more or less complete knowledge exists. Reducing the understanding of norms to functional norms, would have severe consequences for our understanding of social steering. If we would understand norms only as functional norms, society would take on the form of a skinnerbox.

A skinnerbox is a set of functional norms and it is about teaching its inhabitants to follow these norms. The inhabitants need not to understand the rules according to which the skinnerbox is built. Inhabitants of a skinnerbox are not asked, why they follow a norm or not. They simply follow the norm, otherwise they are made to do so by operant conditioning. There is no symbolic representation of the functional rule. Nobody has to give reasons for his/her behavior. There is simply the fact that organisms behave according to positive or negative reinforcements. If an organism in the skinnerbox shows a behavior which does not correspond to a functional rule, this could only be a case of an erroneous prediction. If this behavior is not classified as corresponding to a functional rule, a negative sanction can automatically be imposed so that the particular individual learns to behave differently in the future.

Let us assume that we have identified a typical course of action and that we can predict, whether actors (rats or humans) will follow the expected course of events, or whether they will deviate from the normal course of events. In this case it would be functional to prevent deviating behavior to occur at all. This is, what „predictive policing“ aims at: Predict deviating behavior and prevent it. In this case the practice of law would be changed into a skinnerbox-like mechanism.

3.2 Skinnerbox – different constructions

Behaviorists conceptualize norms only as functional norms. The moral aspect of norms becomes superfluous in this perspective. With respect to behavior in a skinnerbox, it is only a question of the correctness or incorrectness of predictions or of preventing non-functional behavior. But actors are never addressed as a singular that is as actors acting freely and therefore being morally responsible.

Concerning the functioning of a skinnerbox two levels have to be distinguished. Those who build the skinnerbox have to realize that it makes sense to show a behavior that

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

corresponds to the functional norms. If they would not understand what they do, scientists would not be able to design the skinnerbox at all. It follows that there are two positions: The position of those who build the skinnerbox based on insight, and the position of those who act within a skinnerbox. If there is a split between these groups, there are two groups of actors: those who build the skinnerbox and those who live in a skinnerbox, whose actions are predicted and shaped by operant conditioning. It is claimed that the knowledge about those who live in the skinnerbox also applies to those who build it. However, the structure of the environmental relationship of those, who build the skinnerbox is of a much higher complexity, because they do not simply behave, but have to understand what a functional social behavior is. This is not necessary for those who live in the skinnerbox. From this follows: The assertion that the environmental relationship between the builders and the inhabitants of the skinnerbox is equally complex is tantamount to a performative self-contradiction, from which Apel (Apel 1979, p. 301) justifies the emancipatory interest in knowledge (Lindemann 2014, pp. 41ff).

If we take into account the two positions, two different models of constructing a skinnerbox can be distinguished in an idealtypical way:

Model 1: The builders of the skinnerbox do not inhabit it. The residents are subject to the skinnerbox's functional norms. It doesn't matter whether they understand it or not. It is enough that operant conditioning make them to behave according to functional norms.

A variant of model 1 could be called a nudging box. This is a skinnerbox with positive reinforcement only. Here incentives are set to behave in a certain way, but without using negative reinforcement, if the organism does not behave as expected. In this case, the builder of the skinnerbox must learn how to create better positive incentives to achieve the desired behavior. In fact, the nudging box aims to capture the attention of the particular individual so that s/he does not reflect on what s/he is doing. Nudging is a form of behavioral change without insight.

Model 2: In principle it is possible to switch between the groups of builders and inhabitants of the skinnerbox. Every builder knows that he is creating the situation, within which s/he will live. If s/he experiences a sanction as a resident, s/he can understand its meaning, or if s/he does not understand the meaning of this particular sanction, s/he can try in the position of the builder to change the functional norm. The structural complexity of this

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

situation is close to a double understanding of norms. Builders of the skinnerbox can demand reasonable arguments from each other, why it should make sense to construct the box in a particular way. As builders actors have to treat each other as free and responsible actors, who act based on insight. As builders, actors are not subjected to functional norms but they have to establish norms according to which a well functioning skinnerbox should be constructed. In short, as builders actors would not only act according to functional norms, but they would have to address each other as morally responsible actors. The moral aspect of norms of norms becomes relevant again.

Model two reveals the performative self-contradiction of the two positions. As an inhabitant, one is an organism that functions in the sense of operant conditioning. As a builder, one is involved as a speaker in a (scientific) discourse about the validity of functional norms and how they can be applied to concrete behaviour. As builders actors can hold each other responsible and address each other as morally responsible actors. As long as the groups of builders and inhabitants are separated, the performative self-contradiction must not become explicit. But if actors take both positions (builders and inhabitants), they are faced with the contradicting requirements of living in a skinnerbox and building a skinnerbox. In this case it would be harder to claim that that the knowledge about those, who live in the skinnerbox also applies to those who build it. Everybody who inhabits the skinnerbox, has the experience of building it and therefore has the practical experience of a more complex relationship to his/her environment.

I suspect that everyday life intertwines both aspects of Model 2 ad hoc. Actors are not only norm followers, but they also build and change norms. And actors treat each other in everyday life also as responsible actors. The functional and moral aspects of norms are intertwined in everyday life.

4 Conclusions

With respect to societal developments driven by digital technology crucial questions arise. Do socio-technical processes described as digitialization or informatization endanger the structure of horizontal differentiation. Zuboff's (2019) analysis of Google's development suggests this. At first, people used Google’s search algorithm and their search behavior was fed back into the construction of the algorithm. Thus the users became co-constructors of the search algorithm. Then venture capital investors threatened to cut off

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

the money supply to Google, if the company would not make money. Thereupon, Google turned to advertising. In other words, the behavioral traces (e.g.: digital trace of a google-search) of users were turned into money by developing prediction algorithms based on the behavioral traces. The predictions were sold and used to effectively place targeted advertising. Thus, Google produces personalized search results and sells the opportunities to produce personalized advertising offers. Google users are nudged to click and buy according to the presented personalized advertisements. This creates a relationship between Google and its users according to model 1, because everything users contribute to the search algorithm primarily serves to improve the accuracy of advertisements to make users more efficiently to buy things. Google became a nudging box, which was developed further to a skinnerbox, because Google uses increasingly negative reinforcement: One cannot take a service up, if one does not agree into the use of the own data.

There is a self-portrayal (Google, Tesla, Facebook, etc.) that describes users as co-authors of technology development. This is also sociologically affirmed with the concept of the prosumer, which understands consumers as co-producers. This would be an arrangement according to model two. Everyone is working on the construction of the skinnerbox. At the same time, there is a drift to model one when the data of prosumers are used to improve a behavior control, the functional norm of which prosumers cannot influence.

If there are complete enough stocks of knowledge about the individual to reliably predict behavior in different social contexts, the principle of horizontal differentiation would be overruled, at least for those who have the corresponding knowledge. Some organizations like the big tech-companies have enough knowledge to predict the behavior of their users in different social realms. For example, Facebook has enough data to predict behavior in different social contexts, be it the family, politics or consumer behavior. For organizations like Facebook horizontal differentiation seems not to exist any longer, instead there is only the difference between the positions of inhabitant and builder of the skinnerbox. If society would be dominated by such tech-firms, the institution of the individual equal in freedom and dignity would no longer be required.

Nevertheless, there would still be the participants of the scientific discourse within which the functional norms of the skinnerbox are defined. This discursive knowledge is

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

administered by organizations with only a few technology developers. The ones, who participate in building the predictive technologies of the skinnerbox are different from its residents. Perhaps there would be several organizations with different stocks of knowledge and differently constructed skinnerboxes.

From a sociological point of view it is relevant to ask, which form of being an individual is institutionally required to produce and reproduce a society, structured by differently governed skinnerboxes. The decisive factor would be the effective institutionalization of the belief that knowledge about actors is complete enough to predict the behavior of the particular individuals in different fields of action. This development would require the individual to exist institutionally only as a particular individal, which is determined by the knowledge about it. If this understanding of individuals is effectively institutionalized, those ones, who have gathered enough information (like Facebook) are believed to successfully predict the individual's behavior. This institutional understanding of the individual includes an institutionalized belief into the reliability of predictions. If it is institutionalized that there is only an individual as a particular, each failure of prediction will be interpreted as caused by a lack of knowledge. Within such an institutional arrangement one question would not occur: Is a false prediction an indication of the individual as a singular? If the institutional understanding of the individual refers only to the individual as particular, each false prediction has to be treated as an indication of a lack of information.

When the Internet of things is realized, there will be a large amount of additional data sources. This would provide the basis for overcoming the fragmentation of knowledge in an even more efficient way. I have argued, that fragmentation of knowledge functions as an institutional safeguard for the individual not being fully absorbed in the knowledge that exists about him/her in a particular context. Therefore, the internet of things probably has to be interpreted as a further threat to horizontal differentiation.

If knowledge about individuals could not be fragmented efficiently, the socio-technical developments will lead us to one form of the skinnerbox or the other: model one or model two. Even if we would end up in skinnerbox model two, horizontal differentiation and its double understanding of the individual and of norms would be gone. But the necessity to (scientifically) construct the skinnerbox would have its own institutional requirements. Perhaps we would face a new version of the double understanding of the individual and the double understanding of norms. According to model two, there must be a scientific

Gesa LINDEMANN
DOI: 10.3217/978-3-85125-668-0-15

discourse on how to construct the skinnerbox properly. The participants of the discourse have to recognize each other as responsible speakers. Nevertheless, this community would have quasi-totalitarian features. All participants would be transparent to each other because everyone would be in the position of the knowledge generator and the knowledge object. Due to the organizational dependency there would always also be a drift to model one at the same time. Both developments wold be incompatible with the institutional order of horizontal differentiation and its double understanding of individuality. The uncertainties of the "social undecidedness relation" would have to be fixed by new institutions: the responsible scientific constructor of the skinnerbox and the known individual, which needs to be better known – to improve the functional norms and the well-being of us all.

References

Apel, K.-O. (1979). *Die Erklären:Verstehen-Kontroverse in transzendentalpragmatischer Sicht*. Frankfurt/M.: Suhrkamp.

Baecker, D. (2018). *4.0 oder Die Lücke die der Rechner lässt*. Berlin: Merve.

Dumont, L. (1991). Dumont, Louis (1991) Essays on Individualism: Modern Ideology in Anthropological Perspective, Chicago, London: University of Chicago Press.

Foucault, M. (1975, 1979). Foucault, Michel (1975/1979) *Überwachen und Strafen. Die Geburt des Gefängnisses*, Frankfurt/M.: Suhrkamp.

Galtung, J. (1959). Expectations and Interactions. *Inquiry*, *2*, 213–225.

Joas, H. (2011). Joas, Hans (2011) *Die Sakralität der Person. Eine neue Genealogie der Menschenrechte*, Frankfurt/M.: Suhrkamp.

Lemke, T. (2002). Foucault, Governmentality, and Critique. *Rethinking Marxism*, *14*(3), 49–64. https://s3.amazonaws.com/academia.edu.documents/34222326/Lemke_2002_Foucault__Governmentality__and_Critique_Manuscript.pdf?response-content-disposition=inline%3B%20filename%3DFoucault_Governmentality_and_Critique.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20190820%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20190820T102758Z&X-Amz-Expires=3600&X-Amz-SignedHeaders=host&X-Amz-Signature=526866befbd14c910d46cb1cc94565b9971ea17b0ce6ddd350b369e23ba8314b. Zugegriffen: 20. August 2019

Lindemann, G. (2014). *Weltzugänge. Die mehrdimensionale Ordnung des Sozialen*. Weilerswist: Velbrück Wissenschaft.

Lindemann, G. (2018). *Strukturnotwendige Kritik. Theorie der modernen Gesellschaft Bd. 1*. Weilerswist: Velbrück Wissenschaft.

DOI: 10.3217/978-3-85125-668-0-15

Lindemann, G. (2019). The Social Undecidedness Relation. *Human Studies*, *42*(1), 101–121.

Luhmann, N. (1972). *Rechtssoziologie (2. Bde.)*. Reinbek bei Hamburg: Rowohlt.

Luhmann, N. (1995). Social Systems, Stanford: Stanford University Press, Englisch translation of: *Soziale Systeme. Grundriß einer allgemeinen Theorie*. Frankfurt/M.: Suhrkamp, 1984.

Luhmann, N. (1997). *Die Gesellschaft der Gesellschaft, 2 Bde*. Frankfurt/M.: Suhrkamp.

Luhmann, N. (1999). *Grundrechte als Institution*. Berlin: Duncker und Humblot.

Luhmann, N. (2005). Die Weltgesellschaft. In *Soziologische Aufklärung 2. Aufsätze zur Theorie der Gesellschaft* (S. 63–88). Wiesbaden: VS.

Mason, P. (2015). *Postkapitalismus. Grundrisse einer kommenden Ökonomie*. Berlin: Suhrkamp.

Nassehi, A. (2019). *Muster. Theorie der digitalen Gesellschaft*. München: Beck.

Plessner, H. (1975). *Die Stufen des Organischen und der Mensch*. Berlin: de Gruyter.

Pohle, J. (2012). Pohle, Jörg (2012) Social Networks, Functional Differentiation of Society, and Data Protection, in: arXiv, 1206.3027.

Simmel, G. (1983). *Soziologie. Untersuchungen über die Formen der Vergesellschaftung*. Berlin: Duncker und Humblot.

Skinner, B. F. (1971). *Beyond freedom and dignity*. New York: Alfred A. Knopf, Inc.

Zuboff, S. (2019). *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power*. Public Affairs.

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

Reinforcing Intersectional Inequality via the AMS Algorithm in Austria

Paola LOPEZ
Faculty of Mathematics, University of Vienna, Austria

Abstract

This paper examines the so-called *AMS Algorithm* from a mathematical perspective: this algorithmic system constitutes a predictive model that will be used by the Public Employment Service Austria (AMS) starting in 2020 to algorithmically classify job-seekers into three groups, each with different access to AMS support resources, according to their predicted *chances* on the labour market. Since the features gender, age, childcare responsibilities, disability and citizenship are *explicitly implemented* in the model and are thus linked to the availability of resources, this algorithmic system is to be considered very problematic. This paper is part of an ongoing research project, and it identifies three conceptual building blocks of the AMS Algorithm that are all based on human decisions and in which obvious societal bias can be located. Furthermore, this model is used as an illustrative example to address the larger question of what can be expected when predictions are made that are based solely on data that describes the past: If the predictions by these models result in unquestioned and confirmatory measures such as the redistribution of resources, a reproduction and reinforcement of inequality is possible. If these measures are now applied to vulnerable and highly dependent target groups, such as job-seekers, it will be more drastic: In a first step, these predictive models depict the reality of discrimination, then, in a second step, normatively reinforce it as a supposedly objective fact and finally, in a third step, return it to the social sphere by means of the resulting measures.

1 Introduction

Starting in 2020, the Public Employment Service Austria (Arbeitsmarktservice Österreich, in short AMS) will use a predictive model (*Arbeitsmarkt-Chancen-Modell*) to segregate job-seekers into groups with different access to AMS support resources according to their predicted *chances* on the job market. It became known in the media by the name *AMS Algorithm* primarily through the publication of its accompanying method paper. It can be inferred from the paper that the personal data entry *Gender: Female* results in an

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

automatic deduction of points, which means that a woman can be assigned to a group with less access to AMS resources solely on the basis of her gender. Further potential point deductions according to personal data, such as age or nationality, can lead to an intersectionally compounded disadvantage: Figure 44 below shows a screenshot taken from the method paper that was discussed widely in the media.

BE_INT
= f (0,10
– 0,14 x GESCHLECHT_WEIBLICH
– 0,13 x ALTERSGRUPPE_30_49
– 0,70 x ALTERSGRUPPE_50_PLUS
+ 0,16 x STAATENGRUPPE_EU
– 0,05 x STAATENGRUPPE_DRITT
+ 0,28 x AUSBILDUNG_LEHRE
+ 0,01 x AUSBILDUNG_MATURA_PLUS
– 0,15 x BETREUUNGSPFLICHTIG
– 0,34 x RGS_TYP_2
– 0,18 x RGS_TYP_3
– 0,83 x RGS_TYP_4
– 0,82 x RGS_TYP_5
– 0,67 x BEEINTRÄCHTIGT
+ 0,17 x BERUFSGRUPPE_PRODUKTION
– 0,74 x BESCHÄFTIGUNGSTAGE_WENIG
+ 0,65 x FREQUENZ_GESCHÄFTSFALL_1
+ 1,19 x FREQUENZ_GESCHÄFTSFALL_2
+ 1,98 x FREQUENZ_GESCHÄFTSFALL_3_PLUS
– 0,80 x GESCHÄFTSFALL_LANG
– 0,57 x MN_TEILNAHME_1
– 0,21 x MN_TEILNAHME_2
– 0,43 x MN_TEILNAHME_3)

Fig. 44: *. Published f1-coefficients for the base population, screenshot from the method paper (Holl, et al., 2018, p. 11)*

2 Classification

The *AMS Algorithm* uses different types of data (see below) to model the probabilities of the job-seekers to achieve two *goals*, namely the *short-term goal* f1 and the *long-term goal* f3, see below. Using these probabilities, three groups of job-seekers are formed: (Holl, et al., 2018)

DOI: 10.3217/978-3-85125-668-0-16

• **Group A**: Job-seekers who are predicted to achieve the short-term goal with a probability f1 of at least 66% are said to have *high chances* on the job market, according to the model. Therefore, they are less eligible for support from the AMS resources since they are not considered to need much support based on their predicted already high chances. (Kopf, 2018a)

• **Group C**: Job-seekers who will achieve the long-term goal with a predicted probability f3 of less than 25% are classified as having *low chances* according to the model. They should get access to *different* resources in order to prevent *expensive resources* to be used on people with *little output* (Kopf, 2018a): external support formats have been tested in a pilot project in 2018, see below.

• **Group B**: Those job-seekers who fall neither into Group A, nor into Group C, are said to have *medium chances* on the labour market. The AMS plans to focus on this group of job-seekers, they should get full access to the AMS resources. (Kopf, 2018a)

3 The Model

It is therefore essential for job-seekers which of the three groups they are assigned to, hence the prediction model itself will be examined next in order to assess which factors have how much influence on the resources available to jobseekers according to this triage classification.

3.1 Base Population

According to the published method paper, three types of data are relevant for the calculated probabilities f1 and f3, firstly so-called *personal features*, secondly the previous individual employment history, and thirdly the current AMS case. (Holl, et al., 2018, p. 3) Furthermore, a differentiation must be made as to which *model variant* is used in each case - job seekers are first divided into different statistical *populations* (i.e. subgroups of job seekers) with regard to the *quality of information* (i.e. data) available in the respective case, so that a different *model variant* is realized for each *population*. In this context, good *quality of information*, which defines the so-called *base population* of job-seekers, refers to the availability of *continuous* data and employment history with social security status in the previous 48 months. According to the method paper, the calculation of the probabilities f1

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

and f3 is most possible for the base population. (Holl, et al., 2018, p. 4) This corresponds to the statistical principle that predictions are possible with greater accuracy, the more *relevant* information is available and can thus be incorporated into the predictive model. (Hastie, et al., 2008) If less data is available from the past, the method paper speaks of subpopulations which, due to the lack of important data, cannot be estimated as well as the base population. (Harrell, 2015)

3.2 The Coefficients

The probabilities for the *short-term goal* f1 and the *long-term goal* f3 are calculated using logistic regression. (Holl, et al., 2018, p. 7) This means that the model, or more precisely, each *model variant*, is determined by a list of weights of features, i.e. positive or negative coefficients (numbers) that describe the positive or negative influence of different features on the probabilities. The key to understanding the classification of job-seekers into groups is therefore, on the one hand, the features that are included and, on the other hand, the respective weights (coefficients) of these features. As mentioned above, a type of features is that of the so-called *personal features*. These include age, gender, nationality, education, childcare responsibilities and disability. (Holl, et al., 2018) Due to the limited scope, this paper focuses on the personal features, as these are among the explicitly protected features by legal anti-discrimination regulations. (Holzleithner, 2016)

The coefficients for the *short-term goal* f1 of the model variant for the base population were published as example, see Fig. 44. The negativity/positivity of the coefficients for the different features appear here as an (undoubtedly unplanned) intersectional decoding of social inequalities: The coefficients for the data entry *Gender: Female*, for being of an age above 30, for non-EU citizenship and for disability are negative meaning that these features negatively influence the probability of reaching the *short-term goal.* Childcare responsibilities also have a negative coefficient, which, however, is only taken into account if the individual is female, reflecting the statistical finding that having childcare responsibilities does affect women's probability f1 of job placement, but not men's. (Kopf, 2018b) The coefficients were determined by analysing the available data from the past on the basis of the two *goals.* Since it is known in retrospect exactly which persons achieved which goals, the coefficients that encode the impact of each feature on job placement in the past could be estimated. These are used to make predictions about the future.

DOI: 10.3217/978-3-85125-668-0-16

4 Three Building Blocks

From a mathematical perspective, the AMS Algorithm, as well as any other such classification system using logistic regression in an equivalent manner, consists of three basic building blocks: the data, the target variables, and the thresholds. Hence, the coefficients as well as the distribution of all job-seekers to the Groups A, B and C depends on these three components. In the following chapter it will be discussed how any change in one of these building blocks would lead to a different decomposition of the job-seekers, so that the categorization as it is cannot be regarded as a given and neutral one, but in this sense has a certain degree of fragility to it: After all, crucial parts of the building blocks are based on human decisions, which, as will be detailed below, could also have turned out differently.

Each of the three building blocks has a conceptual dimension, as well as a concretely implemented dimension: The (specific view on the) past as a conceptual dimension finds its specific realization in the data; the (particular outlook on) the future is implemented as the target variables, or *the goals*; and the thresholds are the numerical cut-off points that describe the valuations that stand behind the decomposition of the job-seekers.

4.1 The (Specific View on the) Past = The Data

The available data determines both the categories of features that can be statistically (and thus algorithmically) analysed, (Hong, 2016) and the resulting coefficients of the model. (Zheng & Casari, 2018) The data that was used to build the model is data that the AMS has been collecting and evaluating for a long time. The types of data that the AMS is legally allowed to collect are stated in § 25 AMSG, and include personal data, as well as employment history data. The data used was therefore not collected for the purpose of developing the model: Existing data was used to find statistically significant correlations between available features and job placement rates.

The data (in Machine Learning one speaks of *training data* that is used to *train* a model to make correct predictions (Goodfellow, et al., 2016)) is always essential for the model that is to be developed. The probabilities from which the coefficients that form the core of the model are determined on the basis of the data. After assuming a logistic regression-approach and by fitting the model using the maximum likelihood method (which basically estimates coefficients by maximizing plausibility (Hastie, et al., 2008)), the respective

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

impact of the different features is estimated, leading to this degree of impact being reflected in the coefficients. *The available data therefore constitutes the past on the basis of which the future is to be predicted via the model.*

The question that has been investigated is: *Which categories* of people have successfully achieved job placement, *when* and for *how long*? The solution to this question is available within the AMS-internal data concerning past cases, and so the probability of achieving the *short-term goal* and the *long-term goal* was retrospectively assessed. This data – personal data, data on the previous employment history, and AMS-internal case data – thus reflects (to the extent of the model assumptions) how the labour market has reacted to job-seekers that are recorded within the AMS data in the past.

If a person is not sufficiently datafied, for example if the person's employment history is *fragmented* (see below), then there are gaps in the data. Missing data is a common problem in Machine Learning (Harrell, 2015), and here it was dealt with by developing other model variants for these people (see above). The way in which this was done, or more detailed information on the strategies for dealing with data gaps, cannot be found in the method paper.

4.2 The (Particular Outlook on the) Future = The Two Goals

The particular outlook on the future refers to the events for which the probability is calculated by the predictive model. In general, a probability can only be estimated with respect to a specific and very concretely defined event that is quantifiable and included in the training data. It is thus essential to examine the concrete definition of the *short-term goal* and the *long-term goal*.

• The *short-term goal*, which is relevant for f1, is defined as *successful* if the job-seeker in question achieves job placement for at least three months (90 days) within the next seven months. (Holl, et al., 2018, p. 7)

• The *long-term goal* for f3 is defined as successful if job placement for at least six months (180 days) is achieved within the next 24 months. (Holl, et al., 2018, p. 7)

The probabilities are computed accordingly. For example, an output of f1 = 0,59 means that, according to the model, the person is predicted to have a 59% chance of achieving job placement for three months or more within the next seven months, since persons with

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

the same data entries achieved this same goal with a probability of 59% in the observed past data. The method paper did not provide explanatory reasons for these concrete definitions, nor is it explained whether these timeframes and job placement goals are AMS-internal objectives, or whether these timeframes were set by the Synthesis research institute (in the method paper it says that the goals were defined *in coordination with the AMS* (Holl, et al., 2018, p. 4)). According to an AMS-internal definition, a person is regarded as *long-term unemployed* starting from a period of one year (AMS, 2019), so that this notion cannot be used to explain the defined timeframes of seven, respective 24 months.

A different definition of these two objectives with different timeframes for the observation period used (seven resp. 24 months) and/or for the employment objective (90 days resp. 180 days) would imply different coefficients in the implementation of the model and thus a different composition of the groups formed, since the calculated probability always depends on the corresponding definition of objectives. (For example, it is obvious that the probability of achieving employment for at least two months in the next seven months is greater than the probability for at least three months, since all those who achieve the three-month goal achieve the two-month goal a fortiori, and thus the success population is larger.)

Thus, these are acts of definition which are based on human decisions and could therefore have been different. The categorization of job-seekers who are algorithmically classified and the concrete composition of the groups both depend on these human decisions.

4.3 The Thresholds

A logistic regression model a priori does not yet determine a classification into different categories. It initially merely estimates the probabilities of achieving certain goals. The classification of individual job-seekers, and the partitioning of all job-seekers into different groups, is carried out via the introduction of cut-off points. (Hastie, et al., 2008) The threshold value for being categorized into Group A is $f1 > 0{,}66$, the threshold value for Group C is $f3 < 0{,}25$. Thus, the two probabilities are first calculated for the corresponding job-seekers, and then the classification in Group A, B or C is determined along these threshold values.

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

Other thresholds would therefore imply a different decomposition into the groups. If, for example, the threshold value for Group C is higher than 0,25 then, obviously, more people would automatically fall into this group. It is therefore crucial for the configuration of the three groups exactly where the threshold values are set.

In the method paper it is stated that the threshold values 0,25 and 0,66 were chosen *considering the accuracy of the model.* (Holl, et al., 2018, p. 6) This means that these values are intended to make the accuracy as good as possible, so that the rationale behind them is to be able to correctly classify as many people as possible from the available data from the past in retrospect.

In the method paper, there is no indication of the fact that one reason for the thresholds (and, thus, for the specific composition of the groups) could lie in the factual context of the job-seekers' labour market situation and their respective needs, so that it can be assumed that the issue here really is only one of accuracy and not a qualitative assessment of which measures (such as the BBEN, see below) would be suitable for which people.

In summary, the classification of job-seekers along the AMS Algorithm is based on three conceptual building blocks that are designed from specific perspectives and are therefore neither objective nor neutral. The data previously collected reflects to a certain extent the labour market situation in the past (see below), so that bias and unequal treatment on the labour market is naturally present and is inscribed in the model. Behind the definition of the two goals with regard to which the probabilities f1 and f3 are calculated, are specific values and very specific perspectives, which were not further discussed in the method paper. The thresholds are predefined cut-off points that shape and define the group affiliation of each job-seeker.

The algorithmic classification (and thus, the three building blocks) can have a significant impact on the situation job-seekers find themselves in. It is planned that being assigned to Group C will lead to removal from the AMS-internal resource system and a transfer to the external format of the BBEN (see below).

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

5 Group C

The method paper does not provide sufficient information to reasonably assess the implications of the categorization. The coefficients in Fig. 44 above, for example, that were published in the method paper, only apply to the base population of job-seekers who have an employment history that is statistically fully recorded, which means that there are no gaps in their data (see above). Furthermore, these coefficients apply to the short-term goal f1 which only determines whether or not a person will be assigned to Group A. More interesting and important, however, would be the coefficients for the *long-term goal* f3, since f3 is used to determine whether a person is assigned to Group C. Nonetheless, some statistics in the method paper do give an idea about the degree of vulnerability of Group C.

5.1 Fragmented Employment History

Of the sub-population of cases of job-seekers with a *fragmented* employment history and residence in Vienna, the classification algorithm assigns a total of 29% to Group C. (Holl, et al., 2018, p. 15) It says in the method paper that the employment history of a job-seeker is *fragmented*, for example, when it comes to young people (having had no significant employment history), immigrants (having had no employment history in the Austrian job market), or people returning to work after a long period of time, (Holl, et al., 2018, p. 5) so that it may be assumed that women who do not have a continuous employment history due to childcare in the 48 months prior to the start of the respective AMS case belong to this statistical sub-population.

These people are excluded from the *base population* (see above): They form the counterpart to the norm of the continuously employed persons with social security status. This shows another dimension of inequality: It may be assumed that not being "datafied" enough in the past correlates to a high probability of being assigned to Group C. To fully assess this, more statistical data about the actual distribution of the job-seekers via the classification is needed.

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

5.2 Gendered Inequality

Initially, Johannes Kopf, who is in the Executive Board of the AMS, countered the accusations that this algorithmic system with its negative coefficients for the data entry *Gender: Female* is discriminatory by saying that there was a labour market policy goal in Austria anyway of spending 50% of the AMS support resources on women. (Wimmer, 2018) Interestingly enough, the counter-argument is not that the algorithmic classification and its consequences *do not discriminate* against women – instead, he claimed that women were the focus of a 50% support policy quota that interferes in that sense with the redistribution of the AMS resources via the algorithmic classification. However, with the new labour market policy goals set by the Austrian government, this policy goal has now been withdrawn. (Szigetvari, 2019)

Concrete and extensive statistics on gender proportions in Groups A, B and C were not published. Kopf's statement that there are "disproportionately many" women in the most eligible Group B (Kopf, 2018b) does not provide any information on the actual impact of the gender dimension. Model variants implemented once with and once without gender as a relevant feature would have to be compared, and these variants do not exist. Also, since gender inequality on the labour market was statistically found to have a negative influence on women's job placement (reflected by the negative coefficient of the feature *Gender: Female*), a predictive model that does not consider gender would therefore not be as accurate – which points to the dilemma that a high degree of accuracy in predictions that are based on data from the past just translates to the model being as good at discriminating structurally as the labour market is, see below.

The only gendered statistic that can be found in the method paper is the following: Of the fully datafied base population of cases of women, estimated at the beginning of the case at the AMS, 5% are categorized in Group C - which is more than one and a half times the size of the corresponding sub-population of men. (Holl, et al., 2018, p. 15)

5.3 The BBEN

In order to assess the impact of the algorithmic classification of job-seekers it is crucial to identify what exactly happens to those job-seekers who are assigned to Group C. As mentioned above, the categorization of job-seekers into three groups is supposed to be a step on the way to categorize and reorganize the distribution the AMS support resources.

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

Those job-seekers with low chances on the labour market should get access to *different resources* (Kopf, 2018a) that are not provided by the AMS itself. According to § 32 AMSG and § 34 AMSG, the AMS can cooperate with external (non-AMS) institutions (BBE – *Betreuungs- und Beratungseinrichtungen*) when it comes to support services that the AMS cannot provide, the reason being that offering these services would be *unsuitable* or *uneconomical*. (Weber, et al., 2019, p. 5) One such external service format mentioned earlier, the BBEN (*Beratungs- und Betreuungseinrichtung Neu*), was tested in a pilot project in late 2017 and in 2018 in several regions in Austria, and subsequently evaluated externally by a consultancy agency. This document is available online on the AMS research platform *Forschungsnetzwerk*.

It says in the evaluation that the background for the BBEN is the planned segmentation of job-seekers. (Weber, et al., 2019, p. 26) As the AMS will focus its own resources on people with *medium* chances on the labour market, this leads to a need for a new support format for people with especially low chances on the labour market. (Weber, et al., 2019, p. 23) The BBEN's target group are has job-seekers with *multiple job placement difficulties*, and its constitutive purpose is to *preserve the chances of job placement*. (Weber, et al., 2019, p. 15)

In late 2017 and throughout 2018, the BBEN were tested for a specific subgroup of job-seekers (that were not algorithmically classified, as the algorithmic classification was only introduced in 2019): People with a 2-year long unemployment case history at the AMS who fulfill at least two of the following criteria - being at an age above 45, having a low degree of education, and having a disability. (Weber, et al., 2019, p. 15) It says explicitly in the document that the BBEN will be extended to people who have a *probability of less than 25% of achieving job placement for six months within the next 24 months*, (Weber, et al., 2019, p. 16) which is precisely the defining condition f3 < 0,25 for Group C. Therefore, it can be concluded that being assigned to Group C will lead to being removed from access to the internal AMS support resources to the external BBEN resources.

The evaluation assessed, among other things, the satisfaction on the part of the AMS and selected participants of the BBEN. Job-seekers who had participated on one or more offers of a BBEN for six months or longer were interviewed and the result of the evaluation is said to be consistently positive: 83% of the surveyed participants were *very content* with the BBEN. (Weber, et al., 2019, p. 9) However, one characteristic of this external format is

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

voluntary participation: After a single mandatory information event at the beginning, the assigned candidates only participate on a voluntary basis. (Weber, et al., 2019) Therefore, the composition of the surveyed group of job-seekers should be reflected accordingly: If only those candidates are interviewed who have *voluntarily* used the BBEN resources for at least six months, they are naturally satisfied with the BBEN resources, as otherwise they would not have used them. Of 5700 candidates of the pilot project in 2017 and 2018, just under 47% (2675 candidates) took advantage of the BEEN resources for at least six months. (Weber, et al., 2019, p. 16;20)

Furthermore, it is noteworthy that the most frequently cited reason for satisfaction by the surveyed participants is the possibility of one-on-one meetings within the BBEN (Weber, et al., 2019, p. 10), so that the assumption that a one-on-one meeting with somewhat more time capacities within the AMS system could also lead to the same degree of satisfaction is not far off. According to the evaluation, 98% of the interviewed participants took advantage of individual meetings and counselling. (Weber, et al., 2019, p. 10)

The planned segmentation of job-seekers, which is to be introduced, among other things, in order to save internal counselling resources of the AMS and, therefore, in order to reduce the case workers' workload, also encounters a certain degree of reluctance within the system. On the one hand, it was pointed out in the evaluation that the BBEN format leads to a clear relief of the AMS case workers and provides remedy against the pressure to reduce the duration of the AMS cases. (Weber, et al., 2019, p. 34) It can therefore be concluded that admitting a job-seeker to the BBEN leads to the internal ending of the respective case, so that the case workers' success rates in ending cases turn out to be increased. Thus, AMS case workers in fact only have advantages with the introduction of the BBEN. Accordingly, 86% of the interviewed case workers consider it a relief to have this new external resource. (Weber, et al., 2019, p. 71)

Yet on the other hand, a total of 37% believe that the group of job-seekers that are assigned to the BBEN should rather remain within the internal AMS system. The evaluation speaks of "only 37%" (Weber, et al., 2019, p. 71) – but in view of the exclusive advantages of the BBEN for the AMS case workers, this number can also be regarded as very high: Almost 40% of the interviewed case workers are therefore in favour of keeping the BBEN-group within the AMS instead, despite the fact that this externalization clearly relieves them of some of their workload. It is noted at one point in the evaluation that

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

caution is advised at the transition of BBEN-participants returning to “intensified AMS” counselling to avoid the BBEN becoming a “one-way street”. (Weber, et al., 2019, p. 73) This hint is to be read in view of the consistently very affirmative tone and optimistic outlook of the evaluation. While the positive aspects are repeatedly elaborated, the evaluation clearly sees a potential problem here. Being assigned to a BBEN, which, as it is planned, is equivalent to being assigned to Group C, could potentially be a “one-way street”.

6 Intersectional Inequality

Intersectional discrimination occurs when a person experiences discrimination on the basis of several interrelated and compounding dimensions of inequality. (Holzleithner, 2016) (Crenshaw, 1989) (Uccellari, 2008) The algorithm that estimates the probability of achieving the two job placement goals f1 and f3 has been designed in terms of AMS data from the past. In retrospect, it was thus possible to determine *which groups* of people with *which features* (that are, and therefore, *can be* recorded in data) managed to achieve job placement *when* and *for how long*. (All these questions are encoded in the definition of f1 and f3, see above.) The negative coefficients of certain data entries, such as *Gender: Female*, age above 30, disability, childcare responsibilities, non-EU citizenship, show that these factors, under the underlying model assumptions, have had a negative impact on achieving job placement of the people recorded. Although only the concrete coefficients for f1 for one sub-population were published, it can be assumed that the negativity of these coefficients can generally be found in all model variants. (Other coefficients for other model variants could not be found, and a request to Synthesis for even example coefficients for f3 was rejected.)

The underlying assumption behind the development of a model using logistic regression is that the target probability can be estimated sufficiently well by the variables (features) included. (Hastie, et al., 2008) Each coefficient is to be interpreted in the sense that having the corresponding data entry (e.g. *Gender: Female*) viewed on its own (with all other features fixed) has the corresponding influence on the probability (described by the coefficient), in the example above -0,14. (Hastie, et al., 2008)

The statistical finding that the feature *Gender: Female* has a negative coefficient thus shows that there is a *structural* disadvantage in the labour market: Two job-seekers with

DOI: 10.3217/978-3-85125-668-0-16

otherwise completely identical data entries have statistically different success rates with regard to job placement. The feature *Gender: Female* with otherwise unchanged data has a negative effect.

This knowledge could potentially open up an emancipatory moment in the use of such predictive technologies. Indeed, the predictive model does not calculate the individual *chances* a person *has* on the labour market, as from the very beginning these are collective groups formed along datafied (and datafiable) categories. *Rather, the model shows in the form of the negative coefficients how and to what extent the Austrian labour market differentiates and discriminates structurally on the basis of various features.* Precisely this structural dimension of disadvantage, which has nothing to do with the specific individual, is embedded in the statistical significance of the different included features.

The model therefore does not calculate the individual *chances* that a person has, but *reflects* the structural situation on the labour market with which this person will be confronted when searching for a job. As an analysis of the Austrian labour market and its discriminatory tendencies, this model with its coefficients could thus be an insightful tool for distributing support resources using a bottom-up approach, see below. The current use of the model does the opposite, however, in that individuals are subjected to the collective disadvantage of their non-voluntary membership to a group formed via data categories that is discriminated against structurally.

• In a first step, the *AMS Algorithm* depicts intersectional discrimination on grounds of gender, parenthood, age, citizenship and disability that occurs in the job market via the negative coefficients in the predictive model.

• In a second step, the individual facets reinforce each other to create yet another dimension of disadvantage: Being a person at the intersection of different axes of vulnerability can lead to being assigned to the less eligible Group C.

If job-seekers are exposed to structural discrimination on the labour market to a certain (predefined) extent, namely $f1 < 0{,}66$ while at the same time $f3 > 0{,}25$, then they fall into the Group B and have access to all AMS support resources. If, according to the model, their disadvantages exceed the predefined threshold value, so if $f3 < 0{,}25$, for example by cumulation of various *personal features* with negative coefficients, then they fall into Group

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

C, which was defined as less eligible within the AMS resources system according to the "efficiency" criterion.

The fact that people are subjected to discrimination because of their age, gender, care responsibilities, nationality (and thus implicitly because of racism in the labour market), is observed, then confirmed in the statistical model and finally reinforced by means of the classification and the corresponding efficient distribution of AMS resources.

7 Merely a Tool? – Individualizing the Problem

It is emphasised by the AMS that the model is merely a tool for decision-making and is not formally binding, so that the *individual final decision* about the classification should remain with the (human) case worker. (Kopf, 2018a) However, research on the use of automated decision-making tools has long shown that these tools are often neither well-understood nor questioned by users. (Parasuraman & Riley, 1997)

This referral on the part of the AMS to the *individual final decision* of the respective case worker is essential insofar as the planned use of the predictive model in this way escapes the corresponding legal conflicts on equal treatment and anti-discrimination. The AMS is subject to the Equal Treatment Law (GlBG: *Gleichbehandlungsgesetz*), which prohibits unjust unequal treatment based on gender, parenthood, ethnic background, age and several other protected features. Unequal treatment because of higher or lower education, for example, does not fall under the legal definition of discrimination. An unlawful unequal treatment occurs if a less favourable treatment takes place solely because of one or more of the aforementioned *protected* features. These features, however, are *explicitly implemented* in the algorithm via their corresponding coefficients, so that being assigned to a less eligible group due to an intersectional cumulation of *negative* coefficients might be considered to be exactly such an unequal treatment. A normative and formally binding acceptance of the algorithmic classification without referring to the individual final decision could therefore be assumed to not be compatible with this law.

The AMS bypasses this legal conundrum by pointing to the individual case workers. So, if a discriminatory use of this technology can be proven, the case workers will be held responsible, since, ultimately, they are said to make the final decision. It will therefore be required of the case workers that they always make the right decision as to whether or not they follow the algorithmic classification, all that in addition to their increased workload

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

(with which, among other factors, this algorithm was justified). *The issue of structural unequal treatment, which is first reflected by and then inscribed into the model, is being argumentatively reduced to the individual level of the case workers*.

Thus, there is a certain field of tension, so that on the one hand this model was obviously developed in order to be extensively used in practice (otherwise the almost 240.000 Euros spent (Kopf, 2018) would not be justifiable in times of efficiency increase), and on the other hand it is always emphasized that the use will be restricted by the individual case workers to a non-discriminatory level of usage.

The model was designed in order to be able to provide a more *objective* (Kopf, 2018) assessment of job-seekers with *highly complex mathematical models* (Kopf, 2018c) and with more information (data) than the case workers on an individual level could ever have, (Kopf, 2018b) and yet the case workers are expected to have some sort of meta-intelligence to be able to judge whether or not to use the model in specific situations with specific job-seekers.

8 Efficiency

As mentioned above, the rationale for using the predictive model is an accompanying increase in *efficiency*. This refers to an efficiency on two intertwined levels: At a macro level, the overarching objective of this labour market policy measure is job placement for as many people as possible. (Kopf, 2018a) Furthermore, at the micro-level of the operational processes within the AMS, case work is to be transformed to the extent that costly resources, such as one-to-one counselling, can be focused more strongly on Group B. Johannes Kopf speaks of *reducing contact intensity of this group.* (Kopf, 2018a) Thus, valuable resources, such as the above-mentioned counselling resources should be used where they are most *efficient* in terms of maximizing the number of job placements according to the defined *short-term goal* and *long-term goal*.

This labour market policy objective, i.e. job placement for as many people as possible, is to be understood as a *defined* objective. A different conception of objective therefore would yield a different conception of efficiency in relation to this objective. According to a bottom-up strategy, for example, the most important objective of labour market policies could be to support those job-seekers who, for a variety of reasons, have particularly low chances on the labour market. (Crenshaw, 1991) The people of Group C who are currently being

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

handled as almost negligible collateral damage in the current use of the model would thus become the starting point and centre of the AMS labour market policy efforts.

According to Judith Pühringer, Executive Director at *arbeit plus*, a network of over 200 non-profit, labour market orientated Social Integration Enterprises in Austria, efforts along this same bottom-up approach were at least to some extent the focus of the AMS operations until the introduction of the algorithmic classification. In October 2018, when the AMS Algorithm was widely discussed in the media, she said: "*Currently people who have the greatest need receive the most support. Now we are moving away from this logic.* […] *The* [new] *focus is on the middle segment*". (Szigetvari, 2018)

The concept of *efficiency*, which goes hand in hand with the introduction of the categorization of job-seekers via the AMS Algorithm, thus becomes discriminatory in its impact only as a result of the unquestioned fact that the particularly disadvantaged people of Group C can be regarded as negligible with regard to the internal AMS resources, so that they automatically fall outside the labour market objectives, and thus all the more outside the concept of *efficiency*.

Conclusion

This paper has elaborated that the AMS Algorithm is based on three building blocks, each with a conceptual and a concretely implemented dimension: The past to which one refers when making predictions is abstracted and reflected in the data that is available. The outlook on the future that is used to derive measures is found in the target variables, i.e. in the two goals. The cut-off points reflect a valuation along which it is decided who shall belong to which group. These three elements are based on human decisions and are therefore neither objective nor neutral.

The field of STS is well aware that the production of scientific knowledge is a social undertaking that can thus be examined through a social, as well as a political lens, so that the situatedness of the scientists can, and should, always be taken into account. (Haraway, 1988) In the case of the AMS Algorithm, behind the proclamation of these *highly complex mathematical techniques*, which is in line with the currently prevalent Big Data hype (boyd & Crawford, 2012) there are quite clearly visible valuations, decisions and presumptions, as shown above. As intensified data collection and data analysis are to be expected in the future (as well as in the present), and as phenomena are being transformed and reduced to datafiable quantities, (Kitchin, 2014) which has been shown to be much more than just reduction, but a process that impacts ontological dimensions, (Mol, 2002) the epistemological foundations of Big Data guided methods are to be critically examined. (Prietl, 2019) The complex problems that can occur when working with large amounts of data (Busch, 2014), such as missing data or data gaps, (Harrell, 2015) can result in bias that may be prevalent in the data itself, for data cannot be objective, and is always “cooked” (Gitelman, 2013) as well as in implemented algorithms. (Friedman & Nissenbaum, 1996)

The AMS Algorithm is a concrete and therefore an illustrative and instructive example of how and where to locate presumptions in algorithmic techniques. As one characteristic of such technologies is scale, (O'Neil, 2016) meaning that biased tendencies can be easily and efficiently transferred to large numbers of people, inequalities can be reinforced and amplified on a large scale. (Eubanks, 2018) If the algorithmic technique is based on a predictive model (Hofman, et al., 2017) so that socio-political governance measures (Rieder & Simon, 2016) are derived from the prediction, (Jasanoff, 2005) the prediction itself can be highly biased, (Angwin, et al., 2016) and the derived measures can reinforce inequalities as a (literal) self-fulfilling prophecy, or feedback loop, (Ensign, et al., 2018) especially when imposed on vulnerable target groups.

References

AMS, 2019. *Arbeitsmarktdaten und Arbeitsmarktforschung: Fachbegriffe.* [Online]
Available at: https://www.ams.at/arbeitsmarktdaten-und-medien/arbeitsmarkt-daten-und-arbeitsmarkt-forschung/fachbegriffe#langzeitbeschftigungslose
[Retrieved 3 5 2019].

Angwin, J., Larson, J., Mattu, S. & Kirchner, L., 2016. *Machine Bias. There's software used accross the country to predict future criminals. And it's biased against blacks..* [Online]
Available at: https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing
[Retrieved 2 5 2019].

boyd, d. & Crawford, K., 2012. CRITICAL QUESTIONS FOR BIG DATA. *Information, Communication & Society*, Issue 5, pp. 662-679.

Busch, L., 2014. A Dozen Ways to Get Lost in Translation: Inherent Challenges in Large-Scale Data Sets. *International Journal of Communication*, pp. 1727-1744.

DOI: 10.3217/978-3-85125-668-0-16

Crenshaw, K., 1989. Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics. *University of Chicago Legal Forum*, pp. 139-167.

Crenshaw, K., 1991. Mapping the Margins: Intersectionality, Identity Politics, and Violence Against Women of Color. *Stanford Law Review*, July, pp. 93-118.

Ensign, D. et al., 2018. Runaway Feedback Loops in Predictive Policing. *Proceedings of Machine Learning Research*, pp. 1-12.

Eubanks, V., 2018. *Automating Inequality: How high-tech tools profile, polica, and punish the poor.* New York: St. Martin's Press.

Friedman, B. & Nissenbaum, H., 1996. Bias in Computer Systems. *ACM Transactions on Information Systems (TOIS)*, Issue 3, pp. 330-347.

Gitelman, L., Hrsg., 2013. *"Raw Data" Is an Oxymoron.* Cambridge: The MIT Press.

Goodfellow, I., Bengio, Y. & Courville, A., 2016. *Deep Learning.* s.l.:MIT Press.

Haraway, D., 1988. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies*, Issue 3, pp. 575-599.

Harrell, F. E. J., 2015. *Regression Modeling Strategies: With Application to Linear Models, Logistic and Ordinal Regression, and Survival Analysis.* 2 Hrsg. s.l.:Springer.

Hastie, T., Tibshirani, R. & Friedman, J., 2008. *The Elements of Statistical Learning: Data Mining, Inference, and Prediction.* 2 Hrsg. s.l.:Springer.

Hofman, J., Sharma, J. & Watts, D., 2017. Prediction and explanation in social systems. *Sciencs*, 3 2, pp. 486-488.

Holl, J., Kernbeiß, G. & Wagner-Pinter, M., 2018. *Das AMS-Arbeitsmarktchancen-Modell. Dokumentation zur Methode.* [Online]
Available at: http://www.forschungsnetzwerk.at/downloadpub/arbeitsmarktchancen_methode_%20dokumentation.pdf
[Retrieved 4 3 2019].

Holzleithner, E., 2016. EU-rechtliche Bestimmungen zum Diskriminierungsverbot: Grundlagen und Anwendung. In: A. Scherr & A. El-Mafaalani, Hrsg. *Handbuch Diskriminierung.* Wiesbaden: Springer.

Hong, R., 2016. Soft skills and hard numbers: Gender discourse in human resources. *Big Data & Society*.

Jasanoff, S., 2005. Technologies of humility. In: C. Mitcham, Hrsg. *Encyclopedia of Science, Technology and Ethics.* New York: Macmillan Reference, pp. xix-xxvii.

Kitchin, R., 2014. Big Data, new epistemologies and paradigm shifts. *Big Data & Society*.

Kitchin, R., 2017. Thinking critically about and researching algorithms. *Information, Communication & Society*, pp. 14-29.

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

Kopf, J., 2018a. *Der Standard. Interview and Article by András Szigetvari: AMS-Vorstand Kopf: "Was die EDV gar nicht abbilden kann, ist die Motivation".* [Online]
Available at: https://derstandard.at/2000089096795/AMS-Vorstand-Kopf-Menschliche-Komponente-wird-entscheidend-bleiben?ref=article
[Retrieved 17 1 2019].

Kopf, J., 2018b. *JohannesKopf.at: Wie Ansicht zur Einsicht werden könnte.* [Online]
Available at: https://www.johanneskopf.at/2018/11/14/wie-ansicht-zur-einsicht-werden-koennte/
[Retrieved 06 2019].

Kopf, J., 2018c. *Der Standard. Kommentare der anderen: AMS-Algorithmus - von der Ansicht zur Einsicht.* [Online]
Available at: https://derstandard.at/2000091365385/AMS-Algorithmus-von-der-Ansicht-zur-Einsicht
[Retrieved 2 4 2019].

Kopf, J., 2018. *Futurezone. Interview and Article by Barbara Wimmer: AMS-Chef: "Mitarbeiter schätzen Jobchancen pessimistischer ein als der Algorithmus".* [Online]
Available at: https://futurezone.at/netzpolitik/ams-chef-mitarbeiter-schaetzen-jobchancen-pessimistischer-ein-als-der-algorithmus/400143839
[Retrieved 17 January 2019].

Latour, B., 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory.* Oxford: Oxford University Press.

Mol, A., 2002. *The Body Multiple: Ontology in Medical Practice.* Durham: Duke University Press.

O'Neil, C., 2016. *Weapons of Math Destruction; How Big Data Increases Inequality and Threatens Democracy.* New York: Crown Publishing Group.

Parasuraman, R. & Riley, V., 1997. Humans and Automation: Use, Misuse, Disuse, Abuse. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, Issue 39, pp. 230-253.

Prietl, B., 2019. BIG DATA: Inequality by Design?. *Proceedings of the 2nd Weizenbaum Conference on Digital Inequality*.

Rieder, G. & Simon, J., 2016. Datatrust: Or, the political quest for numerical evidence and the epistemologies of Big Data. *Big Data & Society*, Issue 1.

Szigetvari, A., 2018. *Der Standard: AMS bewertet Arbeitslose künftig per Algorithmus.* [Online]
Available at: https://derstandard.at/2000089095393/AMS-bewertet-Arbeitslose-kuenftig-per-Algorithmus
[Retrieved 9 5 2019].

Szigetvari, A., 2019. *Der Standard: Sozialministerium streicht 50-Prozent-Förderziel des AMS für Frauen.* [Online]
Available at: https://derstandard.at/2000098639725/Sozialministerium-strich-50-Prozent-Foerderziel-fuer-Frauen-am-Jobmarkt
[Retrieved 14 3 2019].

Paola LOPEZ
DOI: 10.3217/978-3-85125-668-0-16

Uccellari, P., 2008. Multiple Discrimination: How Law can Reflect Reality. *The Equal Rights Review*, pp. 24-49.

Weber, F., Hager, I., Krüse, T. & Reidl, C., 2019. *Evaluierung des Betreuungsformates für Personen mit multiplen Vermittlungshindernissen (BBEN).* [Online]
Available at: http://www.forschungsnetzwerk.at/downloadpub/2019_BBEN_BBEN-ams_final.pdf
[Retrieved 2 5 2019].

Wimmer, B., 2018. *Futurezone: Der AMS-Algorithmus ist ein "Paradebeispiel für Diskriminierung".* [Online]
Available at: https://futurezone.at/netzpolitik/der-ams-algorithmus-ist-ein-paradebeispiel-fuer-diskriminierung/400147421
Retrieved 8 2 2019].

Zheng, A. & Casari, A., 2018. *Feature Engineering for Machine Learning. Principles and Techniques for Data Scientists.* s.l.:O'Reilly.

DOI: 10.3217/978-3-85125-668-0-17

Students' Vision and Representation of Gender-Inclusiveness in Science

R. ANTOLINI (2), S. AREZZINI (2), S. AVVEDUTO (1), G. DIONISIO (2), Ilaria DI TULLIO (1), S. LEONE (2), D. LUZI (1), M. R. MASULLO (2), S. PELLIZONI (2), L. PISCANE (1)

(1) Institute for Research on Population and Social Policies, National Research Council, Rome, Italy;

(2) National Institute for Nuclear Physics, Italy

Abstract

The contribution presents data and lesson learned on a national high school contest fostering students' critical reflections on the role of women in science. The contest, that involved 120 high schools and more than 830 students, was organized in the framework of the H2020 GENERA project (https://genera-project.com/) and it constitutes one of the outcomes of the first Gender in Physics Day (GIPD) event, organized by the Italian National Research Council (CNR) and the Italian National Institute for Nuclear Physics (INFN). The contest required the candidates to create a project about the issue of gender equality in physics with the aim to explore students' perceptions on the prejudices embedded in dominating culture concerning the role of female scientists in society. The contest produced tales, reportage and videos about gender equality and scientific careers. The results support the idea that meaningful knowledge raises when students are actively involved with learning materials. The outcomes show that school contests could be used as educational tools as well as awareness raising activities for high school students with a relevant impact on group learning dynamics and on teachers' active involvement. Preliminary analysis on the videos produced by students show that 1) students were direct performers/actors of their message, 2) interviews were chosen as main information source by students, 3) 1 out of 5 videos cited gender statistics pointing out that students are reached by relevant statistics source on gender, 4) the most interviewed testimonials were female scientists and the least interviewed were the teachers.

Keywords: gender equality, school competition and school contest, women in science, group learning dynamics

R. ANTOLINI (2), S. AREZZINI (2), S. AVVEDUTO (1), G. DIONISIO (2), Ilaria DI TULLIO (1), S. LEONE (2), D. LUZI (1), M. R. MASULLO (2), S. PELLIZONI (2), L. PISCANE (1)
DOI: 10.3217/978-3-85125-668-0-17

1 Introduction

Social cognitive constructivist theories sustain that knowledge and culture are framed and produced through several dimensions and variables which contribute to construct the meaning of the culture we live in (Bruner, 1966; Vygotsky, 1978). In line with the constructivist theories and within the mass communication scenario, learning theories enhance the idea that the more people are actively connected with learning materials, the more they develop a deeper level of understanding (Hall, 2001; Long et. al, 2016).

Many studies found that students learn better with multimedia messages than with single resources such as text (Goldman, 2004). Alongside previous studies (Buckingham, 2007; Hobbs, 2011; Hobbs e Moore, 2013) that relate critical analysis to students' own concerns, tastes and identities, active learning is more effective than engaging them in the abstract analysis of ideology. Media production activities contributes to developing a greater awareness of media languages as well as encourage learning (Swain et al., 2003) and critical thinking (Ranieri e Fabbro, 2016).

Furthermore, Jenkins' theory (2006) examines how storytelling can contribute to learning process through technology-supported educational environments (Kearney, 2011).

Under a different perspective, there is an increasing interest on the impact that science learning experiences outside of school curricula have on the improvement of science literacy and interest in scientific careers (Miller et al., 2018). These experiences encompass students' participation in science outreach events, fairs, competitions and contests, which have been analysed in different studies showing improvement in both reasoning and communication skills as well as in boosting motivations to take up scientific careers (Cruse, 2006). In this perspective Research Performing Organizations (RPO) are increasingly adopting contests[1] in outreach activities to boost their impact on targeted audiences, including high school students.

Based on these premises the current paper presents data and lesson learned on a national high school contest fostering students' critical reflections on the role of women in science. The "Women and physics" contest involved 120 high schools and more than 830 students, was organized in the framework of the H2020 GENERA project (https://genera-

1. In the current paper the words **contest** and **competition** are used as synonymous

R. ANTOLINI (2), S. AREZZINI (2), S. AVVEDUTO (1), G. DIONISIO (2), Ilaria DI TULLIO (1), S. LEONE (2), D. LUZI (1), M. R. MASULLO (2), S. PELLIZONI (2), L. PISCANE (1)
DOI: 10.3217/978-3-85125-668-0-17

project.com/) and it constitutes one of the outcomes of the first Gender in Physics Day (GIPD) event, organized by the Italian National Research Council (CNR) and the Italian National Institute for Nuclear Physics (INFN). Both these Italian research organizations have a long-standing experience in outreach activities addressing school and university students as well as general public. Within these activities a student competition proved to be one of the best ways to stimulate students' creativity and at the same time fostering their learning on topics not usually addressed within regular curricula.

A further motivation to adopt school contest has been: 1) the possibility to enhance the gender reflection in science careers by a direct students' involvement, 2) the opportunity to explore their vision and representation of gender-inclusiveness in science analysing the contents produced. Our aim was to explore, on the one hand, students' understanding and representation of stereotypes present in the research environment, and, on the other, to test how science outreach activities could be modified to include gender issues. Moreover, in our view the choice of the subject as well as of the media to use, could give students a variety of possibility to be engaged, express their creativity and work in groups. The paper presents the contest design, the analysis methods and steps along with the relevant lesson learned.

2 The competition "Women and physics" within INFN and CNR outreach activities

The Italian Ministry of Education, University and Research (MIUR) guidelines supported RPO to foster media skills development as an essential part of the training program to be offered to Italian students specifically to improve: "the ability to elaborate new messages, offering its own contribution to the media system and therefore being creators of information and communication and not mere passive elements[1]". The contest "Women and physics" followed this vision and was framed within the outreach strategy of the two RPO organizations.

The National Institute for Nuclear Physics (INFN) is the Italian research organisation dedicated to the study of the fundamental constituents of matter and the laws that govern them. It conducts theoretical and experimental research in the fields of subnuclear, nuclear

1. https://www.miuristruzione.it/3087-la-media-education-nelle-scuole-ecco-perche-e-importante/

DOI: 10.3217/978-3-85125-668-0-17

and astroparticle physics. The INFN is fully committed to promoting scientific culture. It takes part in all the main dissemination activities in Italy and yearly organises various exhibitions and events throughout the country. In addition, INFN organizes several activities targeting high school students, with a clear educational focus. Competitions involving students have been proposed over the years both at local (i.e. in the National Laboratories) and national level. At national level, the INFN web site devoted to outreach (called "Scienza per Tutti") promotes each year a competition in which students are invited to present a “product" on an assigned subject (proposed subjects in the past years were: the vacuum, broken symmetries, the light, the time etc.). At local level, both the INFN units, the national centres and laboratories organize outreach activities. The GENERA consortium took advantage on Gran Sasso National Laboratory’s, long-standing experience in disseminating and promoting its activities towards students.

The Italian National Research Council (CNR) is the largest public research institution in Italy performing multidisciplinary activities. Part of the CNR activities are devoted to the dissemination of science, with the aim of stimulating public knowledge. These activities include the organization of scientific travelling exhibitions and events addressed to the public, as well as specific initiatives targeted to schools such as: Science in a box, Kidseconomics, Scienziati e studenti, work-linked trainings/young apprenticeship programme. The goal is to enhance the public interest and involvement towards science and technology, of young generations in particular, so contributing in promoting the advancement of the knowledge.

The INFN and CNR were both partners of the GENERA project that aimed to contribute to overcoming the under-representation of women in physics research and foster gender equality in science in general. The GENERA strategy, beside the adoption of Gender Equality Plans by RPOs, was the integration of gender equality in the outreach activities in the partner organization through public events named Physics Day (GIPD).

3 The experience: methods and techniques

When we started thinking of an Italian Gender day inside the GENERA project we thought of involving students for two reasons: our experience in outreach activities and the consciousness that if we speak of the necessity of a cultural change, we have to start from

DOI: 10.3217/978-3-85125-668-0-17

schools. When it was decided to propose a school contest on the subject of women in physics research and on gender stereotypes, top-down approaches were discarded in favour of initiatives where students could freely express themselves, becoming the leading figures of the actions.

The theme of the competition was "Women and research in physics: stereotypes and prejudices". Students, from high school, were asked to create a product (video, photo report, story, book) on three different subjects: encourage young women to pursue a scientific career; learn about the personality of woman researchers and explore aspects of their personal and professional life; highlight any stereotypes and prejudices that still influence the role of women in research. In this scheme the students become the leading actors: the ‘Gender day’ program was built around their presence, foreseeing enough time to discuss student’s works.

Our aim was to explore students’ understanding and representation of stereotypes in research environment. Furthermore we tested how science outreach activities could integrate gender dimension. Moreover, in our view the choice of the subject as well as of the media to use, could give students a variety of possibility to be engaged, to express their creativity and to work in groups. The only constrain was the length of the videos (no longer than 5 minutes).

The competition advertisement was opened to all typologies of high school. It was advertised on the official CNR and INFN web sites, on the Gran Sasso National Laboratory and on the GENERA project web sites. However, the direct contact with teachers proved to be more valuable. Therefore, for a capillary spread of the information we used the list of teachers with whom we had collaborated in the past and asked for help to the Italian Association of Physics Teachers (AIF). We think that the direct involvement and the encouragement from the teachers were much more effective in conveying the successful adhesion to the competition, than the bare publication of the initiative on a web site.

DOI: 10.3217/978-3-85125-668-0-17

Out of 120 schools participating to the contest, the majority of them were scientific high school (59%), followed by classic lyceum and industrial and technical institutes (Di Tullio, Pisacane, 2019). More than 830 students were involved producing tales, reportage, videos and comics. Videos were the preferred media chosen by students (58%).

Each product has been separately evaluated by three referees on the basis of a grid that considered originality/creativity and communicative effectiveness of the content presentation. Moreover, video technical skills were also taken into consideration. In a final team meeting the collected grid was analysed to reach a common decision toward the award of the three best products. Given the high quality of products received, 6 videos were awarded with special mentions (i.e. best reportage, originality of the expressive mode, technical quality and originality of the contents).

After the successful Gender Day, in which 120 students together with their teachers participated to the event, the INFN-CNR team decided to carry out an in-depth analysis of the videos that constituted the majority of the products received. The aim was to explore whether similar patterns in representing gender issues could be detected both in terms of content construction, stylistic features, images and music chosen.

To achieve this goal, an interpretative tool was developed that analysed the following:

• Structural Data (type of schools, gender and role composition of the team producing the videos, teachers' gender and education subjects);

• Typology of narrative style adopted (interview, use of statistics, acting, biography) including music;

• Woman and man representation (female and male scientists' images, role models, facial expressions, workplace representation);

• The use of language (style of the title, expressions used to describe female and male scientists' traits/characteristics);

• Final Message (whether students had a specific target audience and/or final conclusion deriving from the storytelling).

DOI: 10.3217/978-3-85125-668-0-17

The tool was tested on a selection of videos by the INFN-CNR interdisciplinary team and then randomly assigned to three team components. In a one day workshop all results gathered were discussed to align divergences.

4 Preliminary Findings

The interpretative tool was then used to analyse the 58 videos selected as the information universe of the study. Preliminary findings are presented in this paper focusing in particular on the narrative style adopted by the students in the videos that represents just one section of the interpretative tool.

A first result showed that, among the possible narrative styles, the students choose to be direct performers/actors of their message. In 31 out of 58 videos female students were acting and in 15 of those, they were acting as scientists. The direct acting in the video represents a strong involvement approach of the students and proves how the “gender and science” topic could emotionally involve students (see Figure 45). This results shows how the contest was able to mix aspiration, biography, expectation and a self-identity process, especially for young girls that put themselves into the shoes of future women researchers.

A second result showed that students used interviews as the main information source in structuring the narrative messages within the videos. In 21 out 58 videos interviews to female scientist were displayed. The interviews mainly targeted female scientists and were performed both in-person (on the workplace as laboratories, research facilities, offices) and via Skype. Both the options required the students working group to prior design a number of questions to be asked and gave the opportunity to visit a number of research facilities, at least in the case of an in-person interview. The large use of interviews in the videos can be interpreted as strong students’ willing to explore the “woman in science” topic from the leading actors and to collect direct opinions from female researchers on their careers and their motivation behind the will to become a scientist.

In third place a relevant use of gender statistics raised as the narrative style in the videos, 1 out of 5 videos cited gender statistics (see Figure 46 as an example). This aspect is particularly relevant because it shows how pervading the “data issue” became on the gender in science discourse. The most cited statistics were from the National Statistical Office, but also from the OECD or the European Commission. It is not known through

DOI: 10.3217/978-3-85125-668-0-17

which channels the students collected the information (websites, publications, reports, direct research on databases) and which was the teachers' contribution towards the use of statistics.

Finally, the most interviewed were the female scientists and in very few cases the interviews also collected male colleagues' opinions (1 out of 3 cases), this in line with the subject of the contest. More relevant is the data of the interviews with the teachers. They were, in fact, the least interviewed figures, probably because they supported the students' work to be open to the outside world rather than to the school context. In any case, the relevant teachers' contribution was unfortunately somehow invisible to the analysis, because it was not possible to detect whether they supported, orient or informed the student's work.

Fig. 45: *Students performers/actors of their message – Source: Screenshot from the video "Fisica allo specchio", IVD Liceo Statale "G. Galilei" di Dolo (Venice).*

R. ANTOLINI (2), S. AREZZINI (2), S. AVVEDUTO (1), G. DIONISIO (2), Ilaria DI TULLIO (1), S. LEONE (2), D. LUZI (1), M. R. MASULLO (2), S. PELLIZONI (2), L. PISCANE (1)
DOI: 10.3217/978-3-85125-668-0-17

Fig. 46: *Videos cited gender statistics – Source: Screenshot from the video "Refrigerator Ladies", VB Liceo Statale Duca degli Abruzzi, Treviso*

In the video analyses, a frequency counting of female scientists was performed to identify the most represented and cited. The count encompassed both women represented (in the cases where the students performed as actors) and the cases were woman scientists were cited. Figure 47 shows a word cloud dig out from the mentioned name's frequency. The most cited was by far Marie Curie followed by the Italian physicist Gianotti, the astrophysicist Hack and the neurologist Levi Montalcini. Marie Curie's role is linked to the great role model she played in the European Commission communications and outreach activities on women and science. The following two cited scientists are famous Italian researchers: Fabiola Gianotti with a renowned international career, and Margherita Hack, who is also well-known for her commitments in science dissemination activities. This result shows how important and pervasive are the female role models in science and how strategic they can be in inspiring the younger generations.

Fig. 47: *The most represented and cited woman scientists – Source: Word cloud from the most represented and cited woman scientists in the videos. Produced with WordArt software*

DOI: 10.3217/978-3-85125-668-0-17

The analysis also considered the use of music in the videos. The music was detected using the Shazam application and player and style were reported in the interpretative excel sheet. The videos have then been divided into two macro categories: 1) piano music, instrumental and slow rhythms and 2) rock, upbeat music. The first group of videos used the music mainly as background to narrate woman difficulties in earning the right credit in science. The music in these cases was associated with biographies of female scientists, who gained no recognition in their life time or with an intimate description of wishes and aspirations of many young girls depicted in the videos.

In the typology rock, upbeat music the video used the sound as a background for an enthusiastic approach to the topic “gender and science”. In many videos, the music was used as part of a positive and encouraging message as “yes we can!” or “science is open to everyone”.

5 Conclusion

The school contest organised by the INFN-CNR team within the GENERA project prompts some reflections on the lesson learned when promoting science outreach along with gender awareness. This twofold aim was accomplished taking advantages of pre-existing experiences in outreach activities as well as in gender issues, and was based on a fruitful long-standing collaboration with schools. These were the ingredients that made the school contest a successful event, in terms of number of students involved and high quality of the products received. In particular, videos production, even if facilitated by the current available technologies, implies a close team work in the selection of topics to address, in the construction of the storytelling, in the choice of music and additional technical and narrative features. This certainly stimulates students’ creativity in the learning process providing the opportunity to address topics, such as gender issues, which are generally not often addressed in curricula.

The analysis of the videos, whose preliminary results are reported in this paper, shows a variety of narrative styles chosen by students to explore gender issues in science and in particular in physics. Their active involvement is evident in particular when they choose to have a performer/actor role in the videos, in many cases as women scientists, outlining a self-identity process, especially for young girls. Moreover, the choice of making interviews indicates a strong personal commitment in carrying out a “field work” to find out directly

DOI: 10.3217/978-3-85125-668-0-17

woman scientists' motivations and experiences and explore the environment where they work. A common feature in the construction of content was the frequent mention of well-known past and present women scientists that convey role models that may encourage girls in taking up scientific careers mitigating gender stereotypes. An additional result, with a direct policy implication, has been the frequent use of gender statistics as information source in the videos (in more than 20% of the works appeared statistics). This aspect is particularly relevant because it shows the "data issue" pervasiveness in the gender in science discourse. The importance of data evidence to guide gender equality policies influenced many videos that described the state of art using gender statistics from different sources (both from national statistical office and EU/OECD databases). This results is an outcome on years of public and institutional information outreach on gender inequality in RPO grounded on data evidences and data driven polices that need to be further supported and boosted for the benefit of future researcher generations. A final consideration to these preliminary results concerns improvements that may be introduced in future school contests, such as the possibility to have a feedback from the teachers, who supported students' activities offstage, or from involved students afterwards, so to get deeper insight of content design and ideas' developments in the team.

References

Bruner, J. S. (1966): Toward a theory of instruction. Cambridge, Mass: Belkapp Press.

Buckingham D. (2007): Beyond Technology. Children's' learning in the age of digital culture. Cambridge: Polity press.

Cruse E. (2006): Using Educational Video in the Classroom: Theory, Research and Practice. M.Ed., Curriculum Director, Library Video Company

Di Tullio I., Pisacane L. (2019): Women and science: outlook from an Italian School Competition in "Co-creation. Competences, responsibility, reflexivity": Ed. Springer "SpringerBriefs in Research and Innovation Governance series". ISSN: 2452-0519

Goldman, R. (2004): Video perspective meets wild and crazy teens: a design ethnography: Cambridge Journal of Education. 34(2), 157-178

European Commission (2015): She Figures

Hobbs R. (2011): Digital and media literacy: connecting culture and classroom. Thousand Oacks, CA: Corwin

R. ANTOLINI (2), S. AREZZINI (2), S. AVVEDUTO (1), G. DIONISIO (2), Ilaria DI TULLIO (1), S. LEONE (2), D. LUZI (1), M. R. MASULLO (2), S. PELLIZONI (2), L. PISCANE (1)
DOI: 10.3217/978-3-85125-668-0-17

Hobbs R.; Moore D.C. (2013): Discovering media literacy. Teaching digital media and popular culture in elementary school: Thousand Oaks CA: Corwin/Sage.

Long, T., Logan, J., Waugh, M. (2016): Students perceptions of the value of using videos as a pre-class learning experience in the flipped classroom: Tech Trends, Springer 60:245-252

OECD (2015): The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence: Paris: OECD Publishing

Kearney, M. (2011): A learning design for student-generated digital storytelling: Learn media technology 36(2):169-188

Swain, C., Sharpe, R., & Dawson, K. (2003) : Using digital video to study history: Social Education 67(3), 154-157

Jenkins H., (2006): Convergence Culture: where old and new media collide: NYU press

Miller K., Sonnert G., Sadler P. (2018): The influence of students' participation in STEM competitions on their interest in STEM careers: International Journal of Science Education, Part B, 8:2, 95-114, DOI: 10.1080/21548455.2017.1397298

Ranieri M., Fabbro F., (2016): Questioning discrimination through critical media literacy. Findings from seven European countries: European Educational research journal. Vol.15 (4) 462-479

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

Smart Spaces | Towards a Smart-Spatial-Nexus in Urbanism The Example of Smart City Quarter Waagner Biro in Graz and Hunziker Areal Zurich

Radostina RADULOVA-STAHMER

Institute of Urbanism, TU Graz, Austria & Institute of Urban and Landscape Design, Department of Urban Neighbourhood Planning, Karlsruhe Institute of Technology, Germany

Abstract

One of the most frequently declared objectives in Smart City (SC) vision agendas across Europe is the objective of raising the quality of life for the citizens. The quality of urbanity and more precisely the quality of urban design and public space would thus appear to be crucial for pursuing and achieving the goal of the Smart City urban visions. The aim of this paper is therefore to investigate the spatial particularities of SC projects in order to find out how architecture and urban design can contribute to the quality of Smart City developments by proposing spatial principles for design. In this context, there is a lack of spatial engagement with the process of urban digitalisation and the need for a connection between spaces and technologies has become evident. The hypothesis is pursued that Smart City neighbourhoods differ spatially from conventional developments of urban quarters. This article explores a pair of urban quarters – one SC and one conventional – through which Smart City spatial particularities are rendered visible. One Austrian city that is a prominent site for smart urban development, Waagner Biro in Graz, is analysed and compared with a similar development Hunziker Areal in Switzerland. The results contribute to the establishment of spatial smartness as an additional dimension of the Smart City concept in order to enable spatial design strategies to contribute to the physical materialisation and implementation of Information and Communication Technologies (ICTs) in urban space.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

1 Introduction

ICTs are used in cities around the world to meet current urban challenges such as global warming, environmental pollution or scarcity of resources. Concurrently the demand for new, modern, urban quarters is growing. They are intended to do many things: conserve resources, be energy-efficient, socially accessible, cost-efficient, resilient and generally improve the quality of life for citizens.

The technological advances of the past two decades have brought about spatial modifications at the neighbourhood level. Smart City concepts are increasingly impacting urban space. But first global Smart City pilot projects like Songdo or Masdar City show that the one-sided orientation towards technological solutions can improve the efficiency of the city, but does not increase the spatial qualities of the city and thus the quality of life of its citizens. The opposite is frequently the case. The spatial interaction between physical urban space and digital technologies thus needs to be examined in order to prevent a purely efficiency centred use of urban technologies. The aim is thus to investigate the spatial particularities of urban technologies in SC projects with a focus on mobility and environment at the neighbourhood level in order to find out how spatial design can contribute to the SC concept and its declared aim to improve the quality of life for citizens.

This is why SC neighbourhoods are only smart if they can achieve the declared goal of not only improving the systemic efficiency in the district but also and primarily that of improving the quality of life of citizens if the technology applied in the urban context is spatially integrated and spatially designed with the urban surrounding and not only attached to it as an additional layer.

1.1 Literature overview and understanding

The term Smart City (SC) together with related concepts such as Digital City or Creative City, (See Fig. 48) have been appearing with increasing regularity in scientific articles and reports for the past two decades. Municipalities, politicians and service providers use these terms to convey an idea of a city in which technologies help in meeting the wishes and needs of city dwellers (Hollands 2008). But in addition the challenges of increasing urbanization, such as traffic load, energy consumption, pollution, or waste management, also point to the need to find possible solutions for dealing with these urban problems (Caragliu, Del Bo, and Nijkamp 2011).

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

Two major school of thoughts dominate the literature: the technology-led (Batty et al. 2012, C. Harrison 2010) and the socially-led (Hollands 2008, Caragliu and Del Bo 2018, Caragliu, Del Bo, and Nijkamp 2011, Giffinger 2007b) approach to Smart City, leaving a gap in the discussion on space and the spatially-driven approach to the topic.

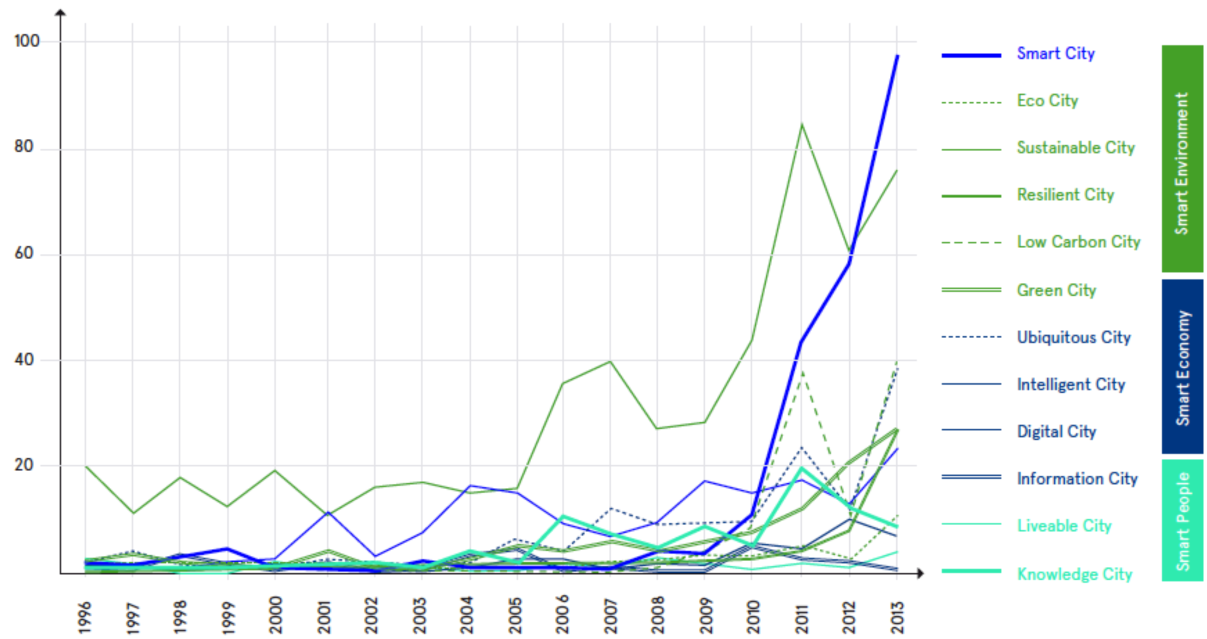


Illustration by Author: Development of the related concepts and replacement by the Smart City concept (based on SCOPUS article de Jong et al. 2015, (scientific publications in scopus 1996-2013)

***Fig. 48:** Development of terms related to Smart City*

While part of the literature focuses on new technologies, such as ICTs, and perceives the city as a functional system that optimizes operational processes with the help of large amounts of data, another part of the literature focuses on soft factors, such as quality of life, human capital, or a city's ability to innovate.

Looking at the technology-oriented understanding of SC, which is characterized by different digital data collectors, the increase of productivity and smooth functionality of urban systems turns out to be a main goal of the advocates. Large volumes of real-time information are collected, transmitted, interpreted and processed in order to optimize processes and inform the relevant administrative bodies in the event of problems or dangers (Hall 2000, Marsa-Maestre, Lopez-Carmona, and Velasco 2008, Jaekel 2015, Greenfield 2006). By this means the processed data can help ensure that traffic runs smoothly, despite rush hours, or that energy consumption is distributed more evenly, thus

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

reducing energy costs. But the use of ICTs alone cannot lead to a move towards a SC that improves urban living conditions. This includes soft factors such as human experience, knowledge, skills and innovation.

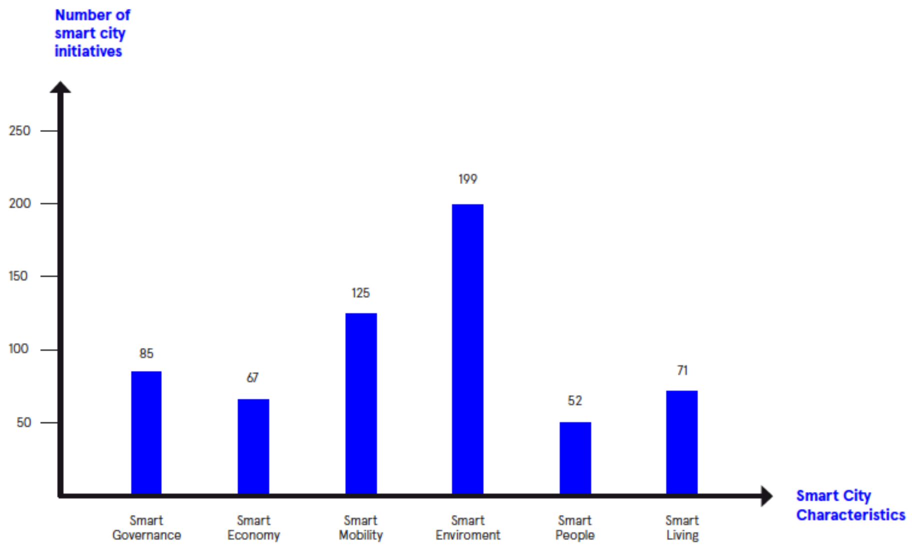
The other essential part of the literature deals with quality of life, educational opportunities, or employment opportunities in cities. Here, the self-determination and skills of urban dwellers come to the fore in order to improve the quality of the city or to establish forward-looking business models (Caragliu, Del Bo, and Nijkamp 2011, Giffinger 2010, Hollands 2008, Giffinger 2007a, Townsend 2013).

In between this spectrum, other areas of SC understanding are appearing, such as the "smartness" of the municipality or the administration. Their ability to make services, information or communication available to the local population in an innovative way is an important pillar of the SC model under the term e-Governance (Sangeetha G 2016, Luciano 2014, Hollands 2015).

The SC model developed by the research group at Vienna University of Technology (Giffinger 2015), is based on a total of six core areas: Smart Mobility, Smart Environment, Smart People, Smart Living, Smart Governance and Smart Economy. Twenty-seven fields of application were defined and 90 indicators were determined in order to quantitatively evaluate the degree of efficiency of a city and thus enable a Europe-wide ranking. According to Giffinger, a city is smart if it offers good performance in the combination of these six areas. The core areas include detailed application areas such as Smart Mobility: local transport systems, international accessibility/networking, ICT infrastructure and sustainability of means of transport.

The EU report “Mapping Smart Cities” shows the highest numbers of initiatives in the smart mobility and smart environment characteristics. (See also Fig. 49) This is why I chose those two characteristics as the focus for the article.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18



Source: European Commission, Report „Mapping Smart Cities in the EU" 2014, p. 38

Fig. 49: *Relevance of Smart City characteristics*

The spatial dimension aspect of SC, however, remains disregarded. Adam Greenfield offers a critical view of the SC model. In his book "Against the Smart City" (Greenfield 2006), he discusses the concept, which is predominantly recruited by technology providers and service providers, and formulates critical questions in with the context of the purpose, benefits and need for such a concept. To this end, he examines prototypes of SC - Songdo City in South Korea, Masdar in Abu Dhabi and PlanIT Valley in Portugal - and filters options for defining the term SC from the perspective of globally leading ICT companies. His investigations do not, however, address aspects of SC's spatial design and perception. Furthermore the spatial dimension was not considered at the conference Digital Clouds - Urban Spaces - City as Information System, organized by the magazine Dérive and the World-Information Institute in Vienna (2014).

Some scholars are describing how urban technologies and ICTs are affecting urban planning and space even when this is not in the SC context (Mandeville 1983, Nijkamp and Salomon 1989, Grentzer 1999, Ogawa 2000, Sohn, Kim, and Hewings 2002, Talvitie 2002, Sassen 2011, Comin, Dmitriev, and Rossi-Hansberg 2012, Zawil 2017), but none of the literature engages with technologies from an urban design perspective. Thus in order to be specific a narrow spatial definition of the term Smart City is useful for understanding the scope of the paper.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

1.2 Operational definition

Although there is still no global definition of the term Smart City many scholars try to locate the meaning at least from an academic perspective and discuss it from different angles and viewpoints (Caragliu, Del Bo, and Nijkamp 2011, Anthopoulos 2017, Albino, Berardi, and Dangelico 2015, Mosannenzadeh and Vettorato 2014, Lazaroiu and Roscia 2012, Hollands 2008).

What all definitions have in common is the ICT-driven development. These new technologies promise to change the cities both as systems and as society. Some scholars describe the SC concept as an multilevel system consisting of multiple categories such as natural environments, hard infrastructures both ICT-based and non ICT-based, soft infrastructures and smart services for example (Anthopoulos 2017). Despite all the significant amount of research that has been conducted in the last two decades on SC it is lacking in a significant spatial understanding of the concept (Hall 2000, Marsal-Llacuna and López-Ibáñez 2014, Picon 2015, Roche 2016).

In order to be able to discuss the concept from an urban design perspective we need to focus the understanding it brings on space. In my understanding, an SC is a territory with system boundaries of any size, in which ICTs are not only implemented in urban space but are physically thought-through and designed together with the urban space, hence ICTs are design embodied in space. This SC process is integrated in urban design and follows specific key objectives in order to improve people’s lives by presenting spatial-technological solutions to current social, ecological and economic challenges. I suggest referring to the resulting physical reciprocity between technologies and space as a “smart-spatial-nexus”.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

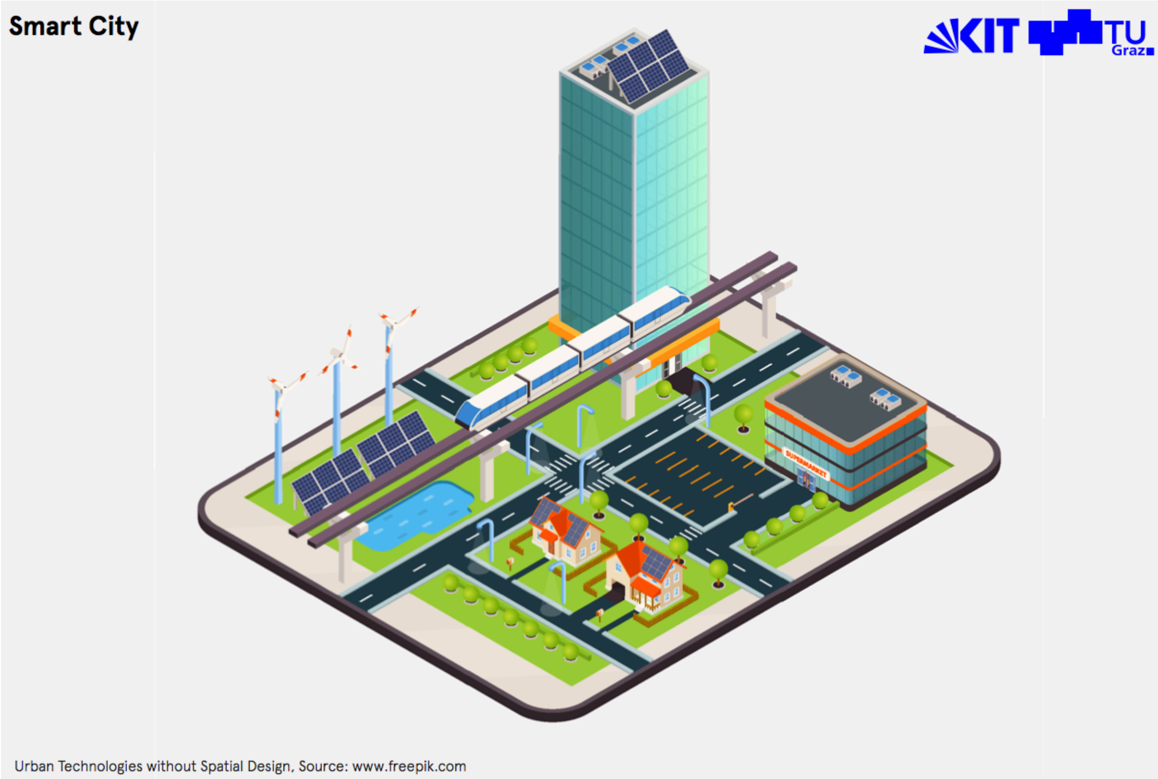


***Fig. 50:** Spatial Production of Smart City Approach*

***Fig. 51:** Smart Spatial Design, Approach ICTs Design Embodied in Space (Smart Spatial-Nexus)*

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

Against this background, it remains unclear whether and, if so, how the concept of a SC is spatially represented. Finally, if the city is the research object, then the concept of the SC needs to have a three-dimensional, spatial, or even atmospheric consequence. In order to be able to assess the development of the SC holistically, an intensive examination of the spaces created within this concept is necessary.

1.3 Research approach

As mentioned in the abstract one of the most frequently declared objectives in Smart City vision agendas throughout Europe is the objective of raising the quality of life for the citizens (Albino, Berardi, and Dangelico 2015, Ballas 2013). The quality of urbanity and more precisely, the quality of urban design and public space would appear to be crucial for pursuing and achieving this goal. The integrated and extended design approach presented in this paper enables the qualifying of the city and its urban space instead of only improving the technological efficiency of cities as systems. But first we need to study the spatial particularities of SC projects and differences between those and conventional quarter project in order to tackle the question of the spatial consequences of ICTs.

To do so an analysis matrix of SC and conventional city districts in the German-speaking area is elaborated with 24 quarters in the German speaking area along seven mobility criteria. These criteria have been chosen to narrow down the possibilities and choose the most adequate case studies in order to indicate the characteristic of smart mobility, as it is one focus area of the research. (See Fig. 53) A good accessibility on foot influences the mobility behaviour of the inhabitants in the neighbourhood.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

Thus, the investigation is carried out on the basis of isochronous maps with 10 minute walking distances. The polygon deflections are set concave[1] in order to map the traffic space and accessibility as accurately as possible. The uses are shown only within the isochronous map and are recorded independently of the quarter boundaries.[2] (See Fig. 52)

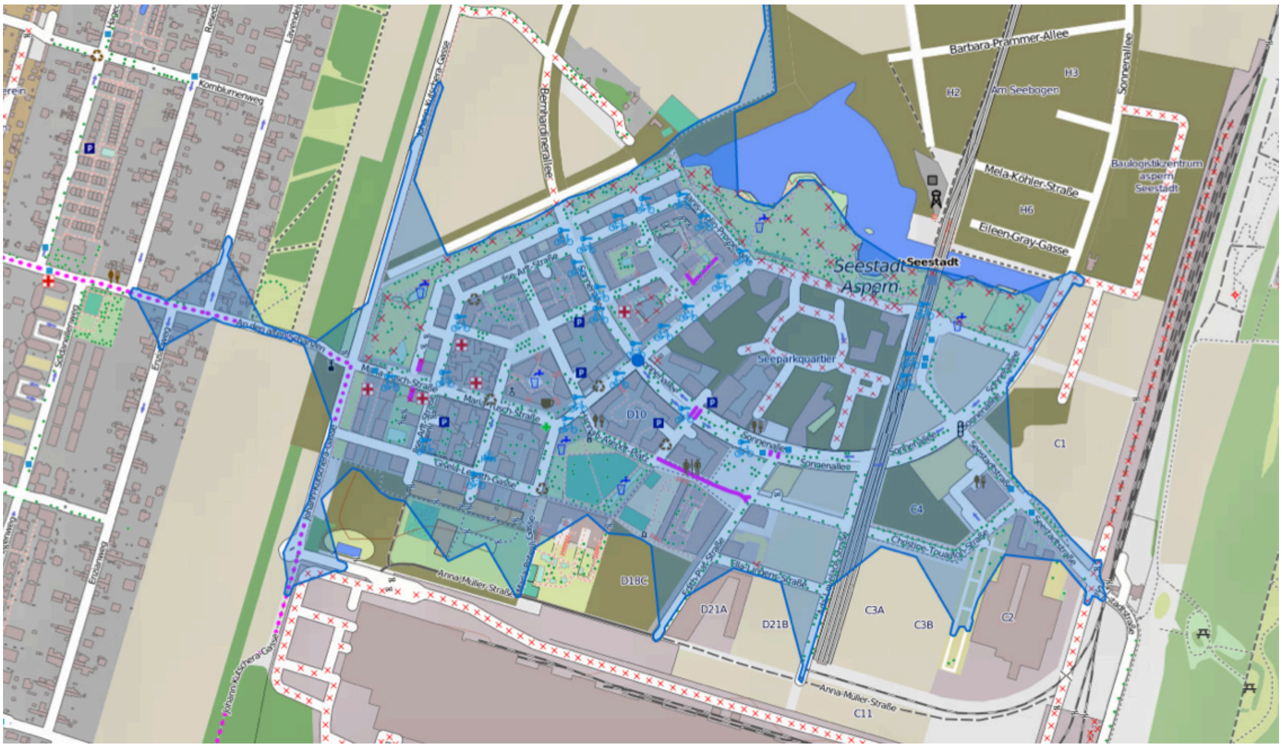


Fig. 52: *Example of GIS Isochone Map of Parking Garages in Seestadt Aspern Vienna*

1. at level 8 (at 0 convex, at 8 concave)

2. All data are based on Open Street Maps (OSM). In the case of districts that have not yet been completed, some building structures and uses have not yet been entered in OSM, so that the representations do not correspond to the current state of construction. These data are used for the first phase of the evaluation and assessment in the criteria matrix. In the event that a neighbourhood does not yet have any data on OSM, the respective project website is used to collect information.

DOI: 10.3217/978-3-85125-668-0-18

	Accessibility	Public Transport Links	Multimodal Hubs	Cycling Infrastructure	Mix of uses	Collective Parking	e-Mobility	Location in the City	Location Favor	Development Process	Size of Area	Type of Development	Possible Case Studies
Waagner Biro Str./ Alte Poststr. (Graz)	1	3	1	3	3	0	0	zentrumsnah	Bahnhof	Im Entstehen	Quartier	Konversion	
ANNA – Eggenbergergürtel/Niesenbergergass	0	3	3	3	3	1	1	zentral	Hbf	fertig	Objekt	Neubau	
Brauquartier (Graz)	1	3	3	3	3	3	1	peripher	Autobahn	Im Entstehen	Quartier	Konversion	■
Green City (Graz)	2	3	0	2	2	0	1	peripher	Autobahn	Im Entstehen	Baufeld	Neubau	
Aspern Seestadt (Wien)	3	3	3	3	3	3	3	peripher	Bahnhof	Im Entstehen	Quartier	Konversion	■
Perfektastraße (Wien)	3	3	3	3	2	0	3	peripher	Autobahn	fertig	Baufeld	?	
Stadtwerk Lehen (Salzburg)	3	3	3	3	3	3	0	zentral	Wasser	fertig	Baufeld	Koversion	■
Hamburg Barmbek Nord Q21	3	3	3	3	3	1	3	zentral	Bahnhof, Wasser, Autobahn	fertig	Quartier	Nachverdichtung	■
Rieselfeld (Freiburg)	3	3	2	3	3	1	2	peripher	Autobahn	fertig	Quartier/Stadtteil	Neubau	
Hunziker Areal (Zürich)	3	3	3	3	3	2	0	innerstädtisch	Autobahn	fertig	Quartier	?	
Erlenmatt Ost (Basel)	0	3	2	3	3	1	0	zentral	Bahnhof, Autobahn	?	Quartier	Konversion?	
Lincoln-Siedlung (Darmstadt)	2	2	1	3	2	0	0	peripher	Autobahn	?	Quartier	Konversion	
Benjamin Franklin Village (Mannheim)	3	3	3	3	3	1	2	peripher	Autobahn	in Planung	Quartier/Stadtteil	Konversion	■
Bahnstadt (Heidelberg)	3	3	3	3	3	2	2	peripher	Bahnhof	fertig	Quartier	Konversion	■
Stadtteil Hubland (Würzburg)	2	3	1	3	2	1	3	peripher	-	in Planung	Quartier/Stadtteil	Konversion	
Domagk Park (München)	2	3	3	3	3	0	0	innerstädtisch	Autobahn	fertig	Quartier	?	
Freiham Nord (München)	3	3	0	2	2	1	0	peripher	Autobahn	in Planung	Quartier/Stadtteil	Koversion	

Fig. 53: *Analysis matrix for the selection of case study districts*

In order to ensure the comparability of the different neighbourhoods, further plausibility criteria are included, such as (1) the location in the city (inner-city, close to the centre, peripheral), (2) the location (motorway, long-distance railway station, airport, port, lake, river, etc.), and (3) the type of development (existing, new, conversion), as well as (4) the progress of development. (See Fig. 53) All selected cases have curtain up measures to promote mobility and the environment, the project type is new district and not an existing one, and finally the good data availability is provided for all six selected districts. Despite of the systemic approach this analysis is an exemplary concept to select suitable case studies but does not extensively cover all spatial dimensions of SC projects. In the second step the two selected quarters are spatially examined on the neighbourhood scale and brought into a direct spatial comparison.

All of the following factors included in the assessment are factors that can and should be influenced and strategically decided by the developers of the neighbourhoods. This assessment shows the spatial qualities in a certain context of a SC and of a conventional quarter. Although the mapping in the context of the two projects indicates conditions which depend on environmental factors, the specific conditions of the project site itself reveal the strategic design decisions. By means of this spatial comparison the ways in which the SC project differs in these six criteria from the conventional project is displayed:

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

• encouragement and encounter (usage mix)

• interface and Infrastructure (collective parking)

• system and synergy (open space system)

• appropriation and atmosphere (pedestrian areas and multi-coding)

• mobility and modality (street connections)

• distance and dimension (path network, grain size).

Finally after the spatial comparison the potential for urban space is described and conceptualized into three spatial principles for urban design.

2 Introduction case studies

The Waagner Biro site is in Graz, the second largest city in Austria and the capital of the province of Styria. Graz currently has about 325.418 inhabitants and the core zone covers an area of 286,88 km². The population density in this core zone is 1,134 E/km^2. Some 87% (2018) of households in Styria have broadband access and 90% of Styrian households have Internet access. By comparison, 89% of households in Austria have Internet access. The motorisation rate in Styria was 593 cars/1000E (2016) and 867,7 cars/1000E (2018). The trend continues to rise. The boiler location of Graz also contributes to the poor air quality. Whereas Zurich has 402.762 (2017) inhabitants living on an area of 153,06 km². The population density is slightly lower comped to Graz with 905 E/km2 (2017). And the motorization rate is with 492 cars/1000E (2016) also slightly lower compared to Graz.

In Austria the Federal Ministry of Transport, Innovation and Technology (Bmvit) established a funding channel, the Climate and Energy Fund[1], which supports the implementation of sustainable energy supply in Austria, to help reduce greenhouse gas emissions and contribute to climate adaptation. SC demonstration projects such as Waagner Biro have been funded by the Fit4set call funding. The project decisions were started in an interdisciplinary consortium shortly before the funding was received. In Graz the SC vision is aimed at two strategic key objectives: (1) to reduce the environmental impact such as energy consumption, waste production or dust emissions in the city and (2) to increase the well-being and quality of life for the citizens. (Stadt Graz 2012, Rainer, Grabner, and

1. Klima- und Energiefonds

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

Konrad 2016) This is why the project suites well for examination of urban qualities such as functional mix, mobility infrastructure, or accessibility to name only a few.

In the former industrial area near Graz Central Station, a new self-sufficient energy district is being created with an integrative planning process. Waagner Biro is located in the vicinity of the Helmut List Cultural Hall and about 2 km northwest of Graz city centre. The main Graz railway station is approx. 800 m distant to the south. The railway line and Graz Central Station are located to the east of the area. The planning area of the urban development master plan covers an area of approx. 127.000 m², or 12,7 ha. Energy technologies for the intelligent "Zero Emissions" city are tested here. The project size is not yet fully developed.

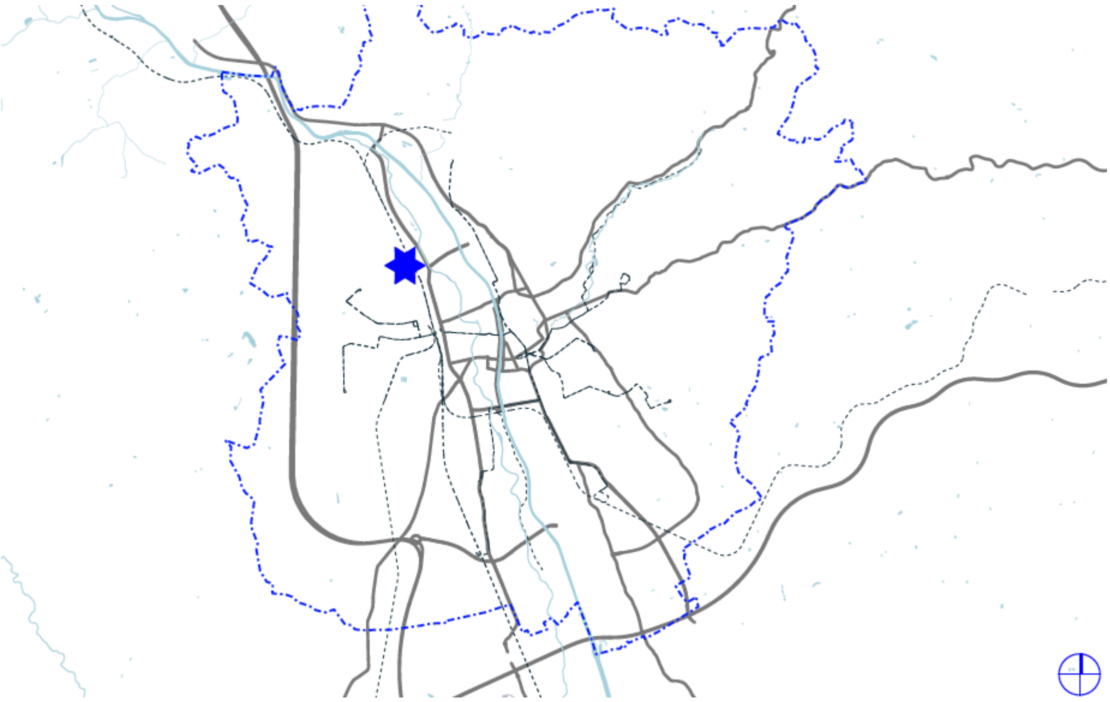


***Fig. 54:** Urban context and location of the Waagner Biro Smart City District in Graz*

While the Hunziker Areal is located 5km from the city centre. The site in Zurich-Leutschenbach is the first project of the building cooperative Mehr als Wohnen. The 4ha site is on the former Hunziker concrete factory territory in the centre of an industrial zone. Similar to the Waagner Biro project the site is bordered by the railway track to the south. The project was stared in 2010 and finished five years later. It now provides offices for 150 citizens and homes for 1.200 people. The vision of the 2000-watt society has been realised here. Energy-efficient buildings, new technologies and few cars support an

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

environmentally friendly lifestyle and save resources. Great importance has also been given to high-quality architecture, quality in construction and sustainability in building maintenance.

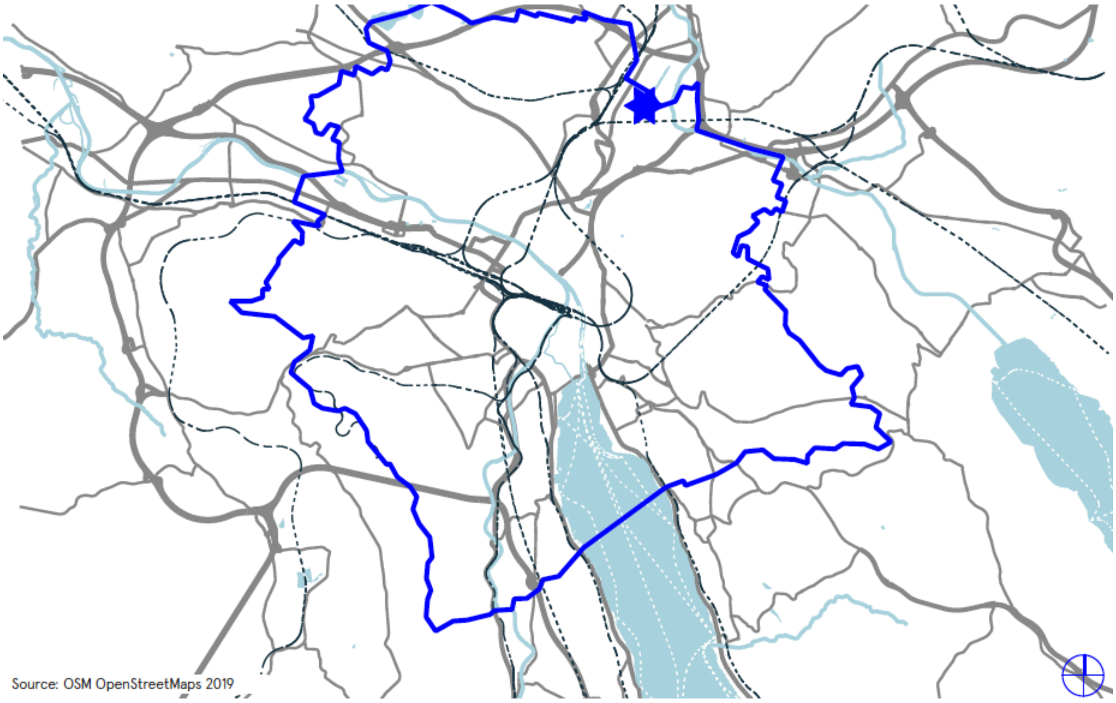


Fig. 55: *Urban context and location of Hunziker Areal in Zurich 2.1 Encouragement and encounter*

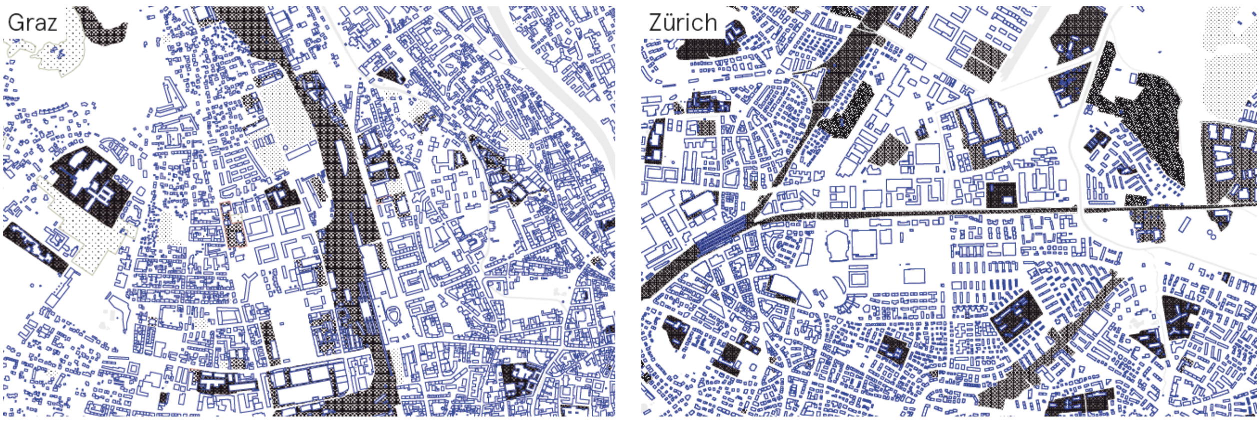


Fig. 56: *Encouragement and encounter – mix of functions*

Accessibility on foot to local suppliers, educational or health facilities for example, promotes active mobility. In the spirit of the city of short distances, the mixed use in the neighbourhood creates pedestrian accessibility for everyday needs. The functional mix of a neighbourhood thus provides information about the walkability value of the development. The Waagner Biro area is one of the last conversion areas along the railway in the

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

Eggenberg district. The surrounding area is largely mono-functionally designated as a residential area. Few educational institutions are located in the immediate vicinity and a school is also planned on the Smart City site to cater for this need. The buildings on the Waagner Biro site are to be large-format and will partly have mixed-uses on their ground floor.

The situation around the Hunziker area is somewhat different. Here, too, educational institutions can be found both in the surrounding and on the site. Many different commercial, service uses and offices are scattered around the area. Object-specific mixed use presents itself as a very small-scale mixed ground floor zone.

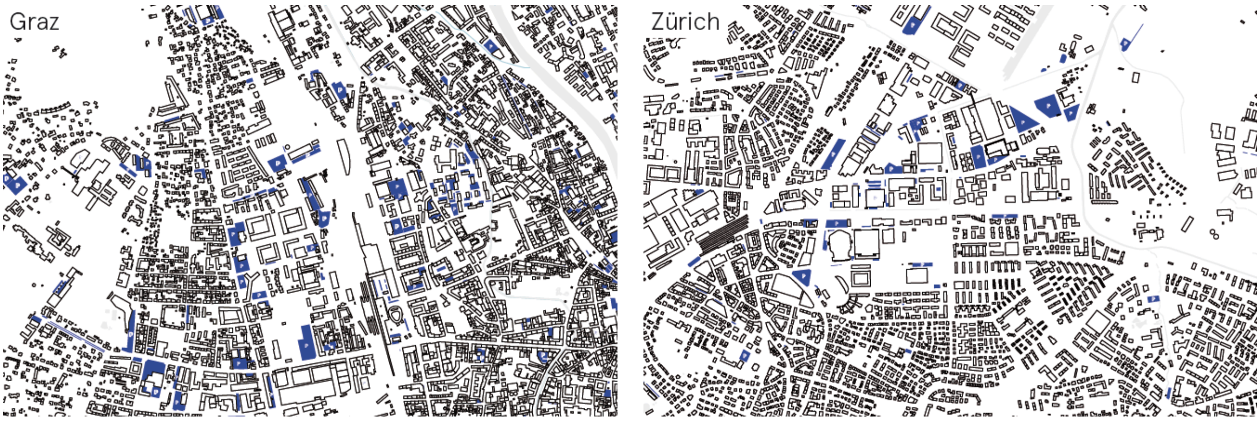


Fig. 57: *Interface and infrastructure – collective parking*

2.2 Interface and infrastructure

The availability of parking spaces is an important key for the choice of mobility. Above ground parking is associated with the sealing of surfaces and reduces the quality of the public space. In Waagner Biro, a rail-bound structure with an above ground collective garage is planned. However, surface parking still exists around the all-purpose events hall Helmut-List-Halle. The aim here is to adapt a car park to different parking requirements over the course of the day and thus use the parking areas as permanently as possible. In the Eggenberg district there are numerous large sealed parking areas. In the Hunziker area, the entire area is free of stationary traffic. A generous underground car park offers parking space for the cars of the residents and visitors. Loading zones for deliveries are provided in the district. These are not, however, for permanent parking use. Only the communal e-car-sharing vehicles park is permanently aboveground, on the road bordering the area.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

2.3 System and synergy

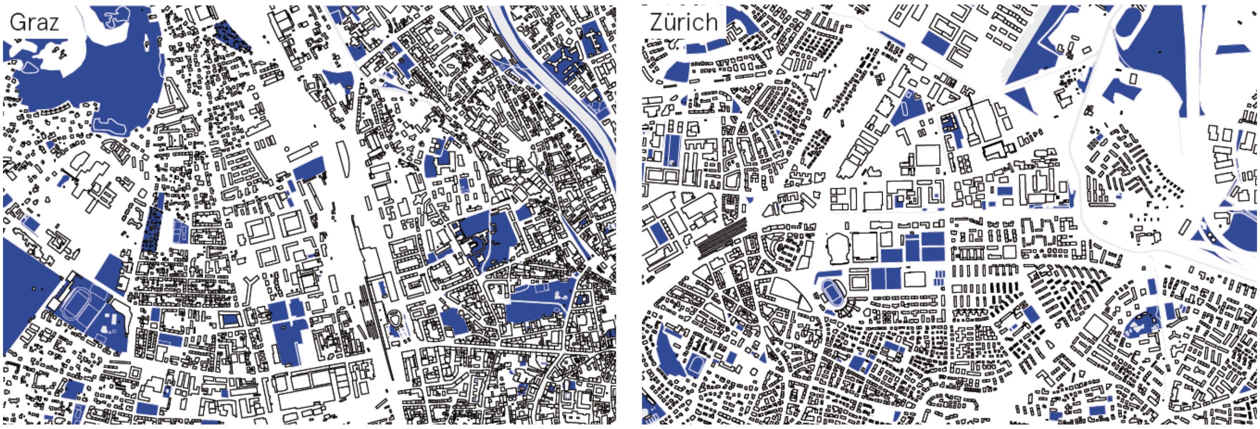


Fig. 58: *System and synergy - open space system*

Green spaces and other public spaces with a high quality of life strengthen social exchange, the sense of belonging to the neighbourhood and thus create identity. In the Waagner Biro area, a spacious public park in an east-west direction is planned, which will also be accessible to the residents of the surrounding area. Greenery along the roads will create green space connections to the north and south.

In the Hunziker area there are several green pocket parks, which extend into the development district in the south and east. A continuous green strip lines the River Leutschenbach a t the western edge. Many pathways with retention strips between the buildings create additional green links to the area. The large school sports facility is in the centre of the area and is freely accessible and offers the residents of the quarter and the wider neighbourhood a diverse green area and small-scale play opportunities. The area is connected to the surroundings by the green strip on the River Leuschenbach in north-south direction and in east-west direction by the green strip on the rails.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

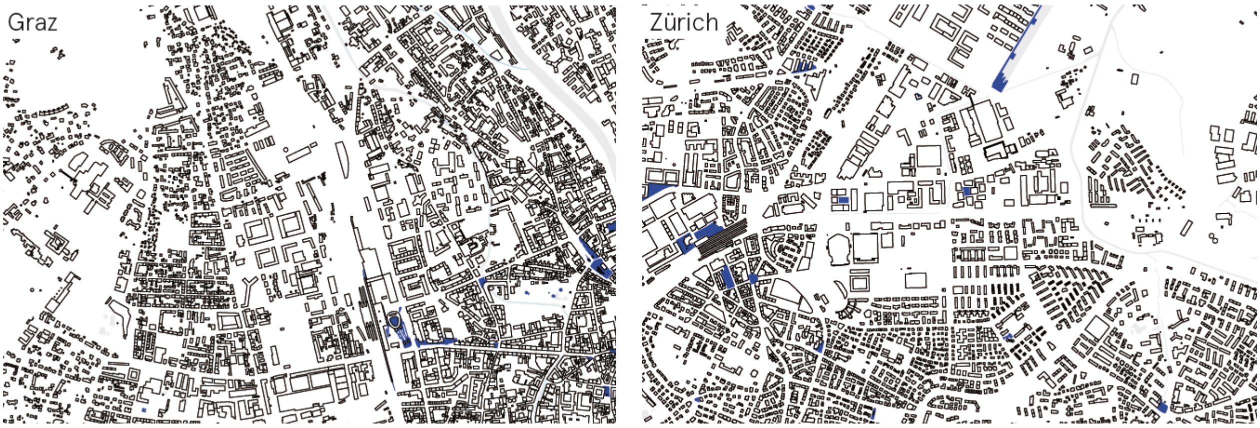


Fig. 59: *Appropriation and atmosphere – pedestrian areas and multi-coding 2.4 Appropriation and atmosphere*

Accessibility to a neighbourhood and thus its networking with the surrounding area is an essential criterion for local mobility. Close-meshed bicycle connections promote health and contribute to the reduction of emissions. Above all, explicitly designated pedestrian areas in the neighbourhoods can significantly increase the quality of life and strengthen the coexistence.

In the Waagner Biro Areal, a street divides the quarter into two. No pedestrian areas are planned, but the street design is intended to create shared space-like areas at two points, on the level of the school and that of the park, in order to reduce driving speeds. Due to the large-format buildings and the noise protection structures along the rails, most of the footpaths run along the roads. A higher-level pedestrian footpath link from west to east is planned with a footbridge crossing the railway. Furthermore, there is no east-west connection.

In the Hunziker area, the location, except for a motorised loop around the neighbourhood square, is designed as a pedestrian area. The neighbourhood square itself is also not passable and can only be used on foot. The small buildings allow a close-meshed network of paths. The cycling quick connection to the rails on Andreasstraße makes the area easily accessible for bicyclists. The areas between the buildings are very diverse and have been adopted and designed by the inhabitants.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

2.5 Mobility and modality

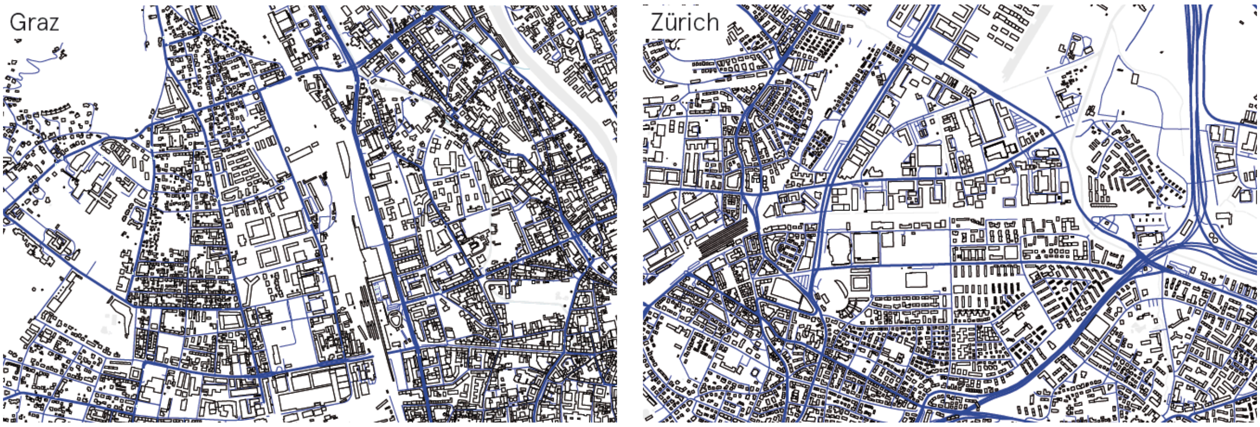


Fig. 60: *Mobility and modality – street connections*

Multimodal hubs ensure a rapid change of means of transport and facilitate the multimodality of everyday journeys. This makes a lasting contribution to the reduction of motorised individual traffic. E-mobility is also sustainable and low in local emissions. The development of a neighbourhood with e-charging stations favours the choice or the switch to electric mobility.

In the Smart City area Waagner Biro a multimodal hub is planned. Here it is possible to change from tram, to bike, to car-sharing, taxi or bus. The proximity to the railway station also means connections are readily available for long-distance travel. In addition to the cultural centre Helmut List Halle, parking spaces are planned for e-car sharing and private e-mobility.

The Hunziker area also has e-car-sharing facilities for residents and visitors. This area, however, does not have a direct connection to the tramway system, but is primarily accessible via the road and the cycle path. The multimodality takes place here between bus, bike, e-car-sharing and private e-mobility.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

2.6 Distance and dimension

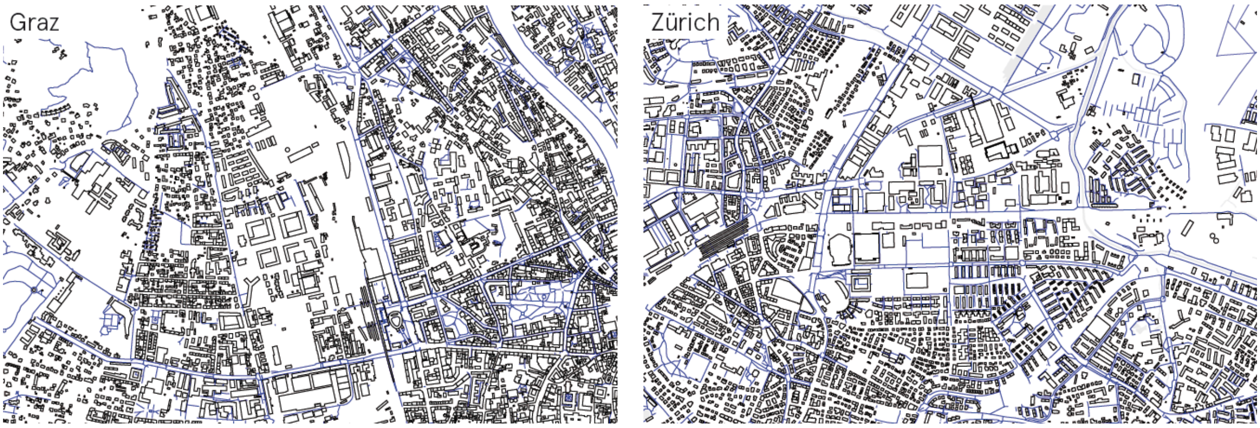


Fig. 61: *Distances and dimension – path network*

Diverse and small-scale path connections in the neighbourhood and in the surrounding neighbourhoods represent a good prerequisite for the extent of walkability. The more enjoyable and varied these connections are, the more incentive is offered to make the paths of daily needs on foot. The relationship between roads and sidewalks, or cycle paths leading into the neighbourhood, also clearly shows the prioritisation for means of transport.

In the Smart City area in Graz the Waagner-Biro-Straße is a fundamental barrier separating the area. It represents the one main connection route into the district, apart from the tram. Scarcely any path links are available here, as the structural granulation is very large and only along the park do paths from the surrounding area lead into the quarter.

In the Hunziker area it has been possible to bridge the railway and to provide an underpass to the neighbourhoods south of the rails and also to create a good pedestrian connection to the surroundings up to the Zürichberg. High-quality and diverse public spaces and paths you are an open invitation for pedestrians to freely cross the quarter. In the north and east of the area there are no road connections. Commercial and recycling companies are located in close proximity.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

2.7 Summary

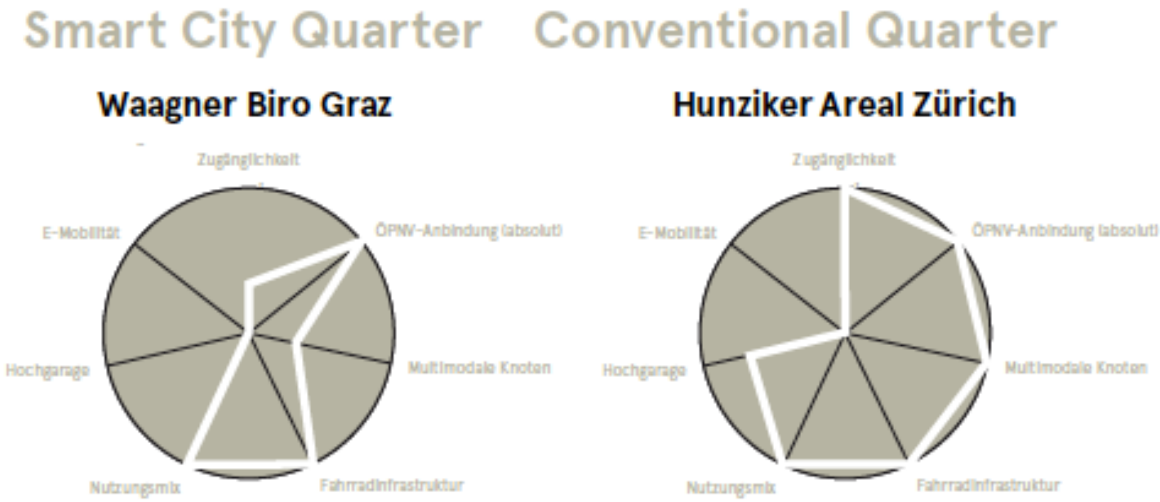


Fig. 62: *Evaluation of case studies*

In summary the comparison of both quarters according to the spatial criteria – encouragement and encounter (usage mix), interface and infrastructure (collective parking), system and synergy (open space system), appropriation and atmosphere (pedestrian areas and multi-coding), mobility and modality (street connections), distance and dimension (path network, grain size) – shows in a comparison that in many of the spatial criteria the non-SC project Hunziker Areal performs significantly better than the SC Waagner Biro neighbourhood.

We can thus conclude from this example that despite its declared goal of improving the quality of life, the production of space in SC neighbourhoods does not perform better. In the following the potentials for urban space are revealed and principles for smart spaces are proposed in order to enable spatial design strategies to contribute to the physical materialisation and implementation of ICTs in urban space.

3 Potentials and principles for urban space

From the spatial comparison three categories for Smart Spaces emerged – multiple spatial overlays and multi-coded surfaces, Time spatial densification of use and seamlessness of surface and openness of use. The three categories for Smart Spaces are described in the following.

3.1 Time spatial densification of use

New technologies enable a time-spatial densification of use. Technologies in the form of applications enable a time-spatial densification of use. The example of couchsurfing or Airbnb summarized under the concept of collaborative consumption or sharing economy, shows the spatial potential of use that can be developed by establishing these applications. What makes these applications spatially effective is that unused and underused spaces in private homes can be put online, mapped on an online map, so they are digitally and physically made visible and accessible via the platform. This results in a spatial densification of use as spaces can be rented and a temporal densification of use as co-habiting space occurs simultaneously. The physical spatial potential is thus increased. In this category, the usage and organization of temporal programming in public space can be spatially condensed. Scarcity of space in public areas can thus be defused while space reserves in both private and public domain areas can be activated.

3.2 Multiple spatial overlays and multi-coded surfaces

Urban technologies enable flexible and multiple spatial overlays. A classic example is the invention of the elevator in 1853. With the introduction of the crash-proof elevator Otis succeeded in enabled living space to be opened up in skyscraper buildings over one hundred meters high. This technology permits a capsule to move vertically and combines the multiple stories and programmes of a building with each other.

This principle can be applied to public space when private vehicles are understood as an infrastructure element roads, sewer pipes or electric cables, with the result that new patterns of thinking and fresh solutions emerge, enabling the creation of new urban spaces. Through this transcoding of the car into a mobility cell, the stationary traffic can be moved underground. This creates a multiple spatial overlay as soon as an area in public space is not exclusively dedicated to parking and other areas are not exclusively understood as green areas, or retention areas. They can be multi-coded with the digitally-based urban technologies of space. In the context of urban space design this could enable the vertical organisation of many multiple programmes that are currently organised horizontally.

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

3.3 Seamlessness of surface and Openness of use

Urban technologies enable the seamlessness of surfaces to be achieved and for establishing a high degree of user-friendliness, bounteousness and appropriation in public spaces. Tidy public spaces increase the appropriation potential for the residents. In Noderhavn, Copenhagen, for example, garbage bins are organized underground. The waste is conveyed by a suction mechanism into the collecting container, which reports its filled level automatically for the bundling and organization of the refuse collection. This urban technology makes it possible to move waste management infrastructures underground and create surface freedom in public spaces. Transferred to urban space developments further "infrastructure cuts" and synergies would be conceivable. Decentralization plays an important role here. Underground decentralized district sewage treatment plants and waste incineration plants ensure short transport routes and create small-scale cycles. The waste heat from the combustion can thus be used directly and locally as heating without significant energy losses. Above-ground vegetation filter systems and retention areas are integrated into the design of the public space.

4 Conclusion and outlook

New technologies are developed by IT service providers and implemented by administrations and private investors. The impact and relevance of these technologies has not yet entered the discipline of urban design or urban planning.

This paper examined the correlation between urban qualities in Smart City physical space and conventional urban districts. The concept of the Smart City has been analysed on the basis of concrete quantitative analyses on the urban scale.

The question how the discipline of urban design can use technological progress to qualify the urban spaces of the future and thus create the best spatial conditions for a high quality of life for citizens is difficult to answer. New ICT developments can help to boost a rethinking of urban design approaches and instruments. The three spatial principles can be suitable for giving a direction to the process but there is no general blueprint solution for the design, which must always be contextual.

Further research needs to be conducted on spatial effects that are able to indicate the potentials of urban technology for the future development of the discipline, if their well-established urban technologies are integrated already in the design process. The question

Radostina RADULOVA-STAHMER
DOI: 10.3217/978-3-85125-668-0-18

then is how urban technologies can help urban design to create qualitative, robust and resilient urban spaces of the future in order to improve the quality of life for citizens.

Urban technologies could be used to benefit spatial planning and urban design and contribute to the qualification of public space. Smart Space Design can help in achieving a strengthening of urban design perception for technological potentials and a holistic understanding of the concept of the SC. However, if we want to live in Smart Cities districts, we first need to design and make them spatially smart.

References

Albino, Vito, Umberto Berardi, and Rosa Maria Dangelico. 2015. "Smart Cities: Definitions, Dimensions, Performance, and Initiatives." Journal of Urban Technology 22 (1):3-21. doi: 10.1080/10630732.2014.942092.

Anthopoulos, Leonidas G. 2017. "The Rise of the Smart City." In Understanding Smart Cities: A Tool for Smart Government or an Industrial Trick?, 5-45. Cham: Springer International Publishing.

Ballas, D. . 2013. "What Makes a Happy City." Cities 32 (1):39-50.

Batty, M., K. W. Axhausen, F. Giannotti, A. Pozdnoukhov, A. Bazzani, M. Wachowicz, G. Ouzounis, and Y. Portugali. 2012. "Smart cities of the future." European Physical Journal-Special Topics 214 (1):481-518. doi: 10.1140/epjst/e2012-01703-3.

Burdett, Ricky; Rode, Philipp. 2012. "Urban Age Conference." The Electric City, London.

C. Harrison, B. Eckman, R. Hamilton, P. Hartswick, J. Kalagnanam, J. Paraszczak, and P. Williams. 2010. "Foundations for Smarter Cities." IBM Journal of Research and Development 54 (4):1-16.

Caragliu, Andrea, and C. Del Bo. 2018. Smart cities: Is it just a fad? Vol. 17.

Caragliu, Andrea, Chiara Del Bo, and Peter Nijkamp. 2011. "Smart cities in Europe." Journal of urban technology 18 (2):65-82.

Comin, Diego A., Mikhail Dmitriev, and Esteban Rossi-Hansberg. 2012. "The Spatial Diffusion of Technology." NBER (Working Paper No. 18534).

Giffinger, Rudolf. 2007a. Smart cities. Ranking of European medium-sized cities. Vienna University of Technology, University of Ljubljana and the OTB Research, Delft University of Technology.

Giffinger, Rudolf et al. 2007b. Smart cities. Ranking of European medium-sized cities. Vienna University of Technology, University of Ljubljana and the OTB Research, Delft University of Technology.

Giffinger, Rudolf; Gudrun, Haindlmaier. 2010. "Smart cities ranking: an effective instrument for the positioning of the cities?" ACE: Architecture, City and Environment = Arquitectura, Ciudad y Entorno 2010, Año IV (núm. 12 Febrero):P. 7-25.

Giffinger, Rudolf; Kramar, Hans; Heindlmaier, Gudrun; Strohmayer, Florian. 2015. "European Smart Cities 4.0 (2015)." http://www.smart-cities.eu/.

Greenfield, Adam. 2006. Everyware : the dawning age of ubiquitous computing. Berkeley, CA: New Riders.

Grentzer, Martin. 1999. Räumlich-strukturelle Auswirkungen von IuK-Technologien in transnationalen Unternehmen. Münster: LIT Verlag.

Hall, Robert E. 2000. The Vision of a Smart City: Brookhaven National Laboratory.

Hollands, Robert G. 2008. "Will the real smart city please stand up?" City 12 (3):303-320. doi: 10.1080/13604810802479126.

Hollands, Robert G. 2015. "Critical interventions into the corporate smart city." Cambridge Journal of Regions, Economy and Society 8 (1):61-77. doi: 10.1093/cjres/rsu011.

Jaekel, Michael. 2015. Smart City wird Realität : Wegweiser für neue Urbanitäten in der Digitalmoderne. Wiesbaden: Springer Vieweg, SpringerFachmedien.

Lazaroiu, George Cristian, and Mariacristina Roscia. 2012. "Definition methodology for the smart cities model." Energy 47 (1):326-332. doi: http://dx.doi.org/10.1016/j.energy.2012.09.028.

Luciano, Edimara; Macadar, Marie Anne; Wiedenhöft, Guilherme. 2014. "IT Governance Enabling Long-Term Eletronic Governance Initiatives." In Electronic Government and Electronic Participation, edited by M. Janssen, Bannister, F., Glassey, O., Scholl, H.J., Tambouris, E., Wimmer, M., Macintosh, A. , 390 - 391. IOS Press.

Mandeville, Thomas. 1983. "The spatial effects of information technology: Some literature." Futures 15 (1):65-72. doi: https://doi.org/10.1016/0016-3287(83)90073-3.

Marsa-Maestre, Ivan, Miguel A. Lopez-Carmona, and Juan R. Velasco. 2008. "A hierarchical, agent-based service oriented architecture for smart environments." Service Oriented Computing and Applications 2 (4):167-185. doi: 10.1007/s11761-008-0030-7.

Marsal-Llacuna, Maria-Lluïsa, and Maria-Beatriz López-Ibáñez. 2014. "Smart urban planning: designing urban land use from urban time use." Journal of urban technology 21 (1):39-56.

Mosannenzadeh, Farnaz, and Daniele Vettorato. 2014. "Defining Smart City. A Conceptual Framework Based on Keyword Analysis." TeMA - Journal of Land Use, Mobility and Environment. doi: 10.6092/1970-9870/2523.

Nijkamp, Peter, and Ilan Salomon. 1989. "Future spatial impacts of telecommunications." Transportation Planning and Technology 13 (4):275-287. doi: 10.1080/03081068908717406.

Ogawa, Hikaru. 2000. "Spatial impact of information technology development." The Annals of Regional Science 34 (4):537-551. doi: 10.1007/s001680000028.

Picon, Antoine. 2015. Smart Cities: A Spatialised Intelligence: Wiley.

Rainer, Ernst, Martin Grabner, and Oliver Konrad. 2016. "Smart City Project Graz." REAL CORP 2016.

DOI: 10.3217/978-3-85125-668-0-18

Roche, Stéphane. 2016. "Geographic information science III - Spatial thinking, interfaces and algorithmic urban places-Toward smart cities." Progress in Human Geography 0 (0):0309132516650352. doi: doi:10.1177/0309132516650352.

Sangeetha G, L. Manjunatha Rao. 2016. "Modelling of E-Governance Framework for Mining Knowledge from Massive Grievance Redressal Data." International Journal of Electrical and Computer Engineering (IJECE) Volume 6 (Nr. 1):pp. 367 - 374. doi: 10.11591/ijece.v6i1.9019.

Sassen, Saskia. 2011. "Urbanizing Technology." Urban Age, London.

Sohn, Jungyul, Tschangho John Kim, and Geoflrey J.D. Hewings. 2002. "Information Technology Impacts on Urban Spatial Structure in the Chicago Region." Geographical Analysis 34 (4).

Stadt Graz, Stadtbaudirektion. 2012. I LIVE GRAZ – smart people create their smart city. In Smart Cities, edited by Blue Globe Report.

Stalder, Konrad Becker; Felix. 2014. "Stadt als Informationsystem." Digitale Wolken und Urbane Räume, Wien, 11.06.2014.

Talvitie, Juha. 2002. "The Influence of Information Technology on Spatial Development." FIG XXII International Congress, Washington, D.C. USA, April 19-26 2002.

Townsend, Anthony M. 2013. Smart cities big data, civic hackers, and the quest for a new utopia. New York: W.W. Norton.

Zawil, Riham 2017. "How does ICT change urban planning, the city, and architecture?".

DOI: 10.3217/978-3-85125-668-0-19

Mapping Activities, Networks and Needs of GE-Practitioners

Sybille REIDL (1), Lisa SCHÖN (1), Ewa KRZAKLEWSKA (2), Marta WARAT (2)
(1) JOANNEUM RESEARCH, Graz, Austria; (2) Jagiellonian University Krakow, Poland

Abstract

The successful implementation of Gender Equality Plans (GEPs)[1] in research organisations remains a difficult challenge. Problems typically stem from a lack of practitioners' respective "know how" but are also related to scattered efforts at inter- and intra-organisational levels. The Horizon 2020 project ACT[2] aims at overcoming these struggles in implementing GEPs by promoting institutional change through the advancement of Communities of Practice (CoPs). For this purpose, ACT in a first step carried out a Community Survey to map actors – practitioners and experts – who are engaged in the advancement of gender equality (GE) objectives at Research Performing (RPOs) and Research Funding Organisations (RFOs) across Europe. The aim of this paper is to give an overview of key results on GE implementation activities based on survey responses, as well as the experienced struggles and needs for improvement. Furthermore, first results of the conducted Social Network Analysis (SNA) are presented, showing some of the most central and well-connected regions but also gaps in the existing network of cooperation regarding GE.

1. In the specific context of research organisations and higher education institutions, the European Commission considers a Gender Equality Plan as a set of actions aiming at: Conducting impact assessment / audits of procedures and practices to identify gender bias; Identifying and implementing innovative strategies to correct any bias; Setting targets and monitoring progress via indicators (European Commission 2012, 13).

2. ACT is short for "Communities of PrACTice for Accelerating Gender Equality and Institutional Change in Research and Innovation across Europe". For more information visit https://www.act-on-gender.eu/project.

Sybille REIDL (1), Lisa SCHÖN (1), Ewa KRZAKLEWSKA (2), Marta WARAT (2)
DOI: 10.3217/978-3-85125-668-0-19

1 Introduction

Advancing gender equality is one of the institutional goals of many research organisations in Europe and beyond. The European Union tackles this issue and the corresponding waste of talent of female scientists by supporting activities directed at institutional change, for instance through funding projects such as ACT. The aim of ACT is to support Research Performing (RPOs) and Research Funding Organisations (RFOs) in their gender equality actions. This aim will be achieved through creating and supporting Communities of Practice (CoPs) – collaborating groups of practitioners, academics and experts – that work towards advancing gender equality at the organisational level and enhancing the integration of a gender dimension in research and teaching.

This paper reflects on some of the main findings of the ACT Community Survey, conducted as a first step in order to address the current status of gender equality in Research Performing and Research Funding Organisations. The following elaborations first provide information on existing policies and activities to promote gender equality at the organisational level as well as the efforts to integrate a gender dimension in research and teaching. This is followed by an analysis of the barriers hindering the implementation processes, and an identification of the internal and external support needed to overcome these barriers. The last section will focus on cooperation patterns and provide some results of the conducted Social Network Analysis (SNA).

2 Methodology and Sample Characteristics

The ACT Community Survey was carried out online between the 27th of November 2018 and the 15th of February 2019. During that time, the survey was repeatedly distributed through various channels but built mostly on the snowball-method, i.e. respondents were asked to forward it to their GE collaboration partners and so on. This way, some regions were reached more than others, depending on the efforts of respondents and the ACT consortium partners. This bias towards countries of the consortium members needs to be taken into account when interpreting the results.

Overall, a sample of 265 survey responses was analysed. Among the responding institutions, 91% are located in the EU28 whereas altogether, surveys were returned from 36 different countries. The majority of survey respondents are female (88%). The survey mainly reached Higher Education Institutions (57%), but also many public research

DOI: 10.3217/978-3-85125-668-0-19

centres and other types of organisations (such as NGOs, RFOs, private research institutions, and scientific/institutional networks) in almost all EU28 countries. Half of the respondents are researchers; one third have a leading position and nearly one third hold a position like Equal Opportunities Officer – the three groups of course overlap. Most of the respondents are directly involved in gender equality issues: they either integrate a gender dimension in research and/or teaching as an individual effort (45%) or hold a position that is directly related to gender equality implementation in the organisation/department (44%). The highest share of respondents conducts or funds research and/or educational activities in the field of Social Sciences (53%) and/or Natural Sciences (51%). However, most respondents' institutions are active in multiple fields, not just one. As most of the respondents are affiliated with universities, every fifth respondent claims that his/her institution conducts or funds research and/or educational activities in all of the listed scientific areas.[1] The interest in ACT turned out to be very high: more than half of the respondents want to become members of a Community of Practice.

One specific characteristic of the survey data is that multiple responses from the same organisation were possible. Altogether, the survey respondents represent 192 distinct organisations. The answer level of the respondent (whole organisation or individual department/institute) had to be selected in the beginning of the survey and was accounted for in the analysis. Hence, one respondent may have answered for the whole organisation (henceforth denoted as "mother-organisation") while another may have answered for a single department.

3 Gender Equality Activities and Needs

Among the respondents of the ACT Community Survey, Gender Equality Plans (GEP) are a frequently applied tool: two thirds plan to have or already have a GEP implemented. In other organisations, a GEP is seen as needed. Interestingly, a higher share of research institutes has a GEP in place compared to Higher Education Institutions – but universities catch up and show a stronger initiative for GEP development (see Fig. 63).

1. Natural Sciences, Engineering and Technology, Medical and Health Sciences, Agricultural and Veterinary Sciences, Social Sciences, and Humanities and the Arts.

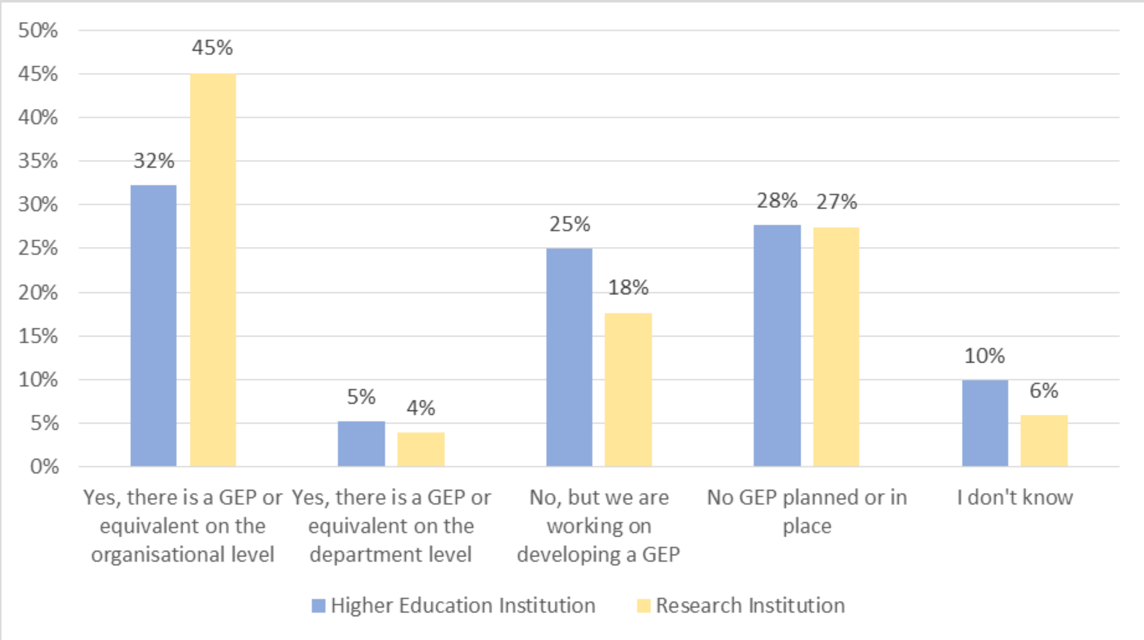


***Fig. 63:** Existence of Gender Equality Plans or equivalent by type of organisation (n = 203).* – Source: ACT Community Mapping Survey (2019) * Excluding other forms of organisations that participated in the study*

The commitment to a GEP is more often reported at the organisational level: 49% of survey participants who represent their entire institution and 28% who represent the departmental level have a GEP in place at the level of organisation. At the same time, only 1% representing the entire institution and 7% representing a single department are aware of such measures at the department level. This illustrates the tendency to implement gender equality measures rather for the whole organisation. Furthermore, it potentially shows a lack of knowledge about gender equality measures implemented at the department level among respondents representing the entire organisation.

The regional differences in the existence of GEPs in research institutions (RPOs and RFOs) are particularly strong: only 10% of respondents from Eastern and South-Eastern European countries report having a GEP in their organisation. In all other regions of Europe, the share lies between 60-74%. Hence, the potential for GEP development in Eastern/South-Eastern Europe is particularly high, according to survey results.

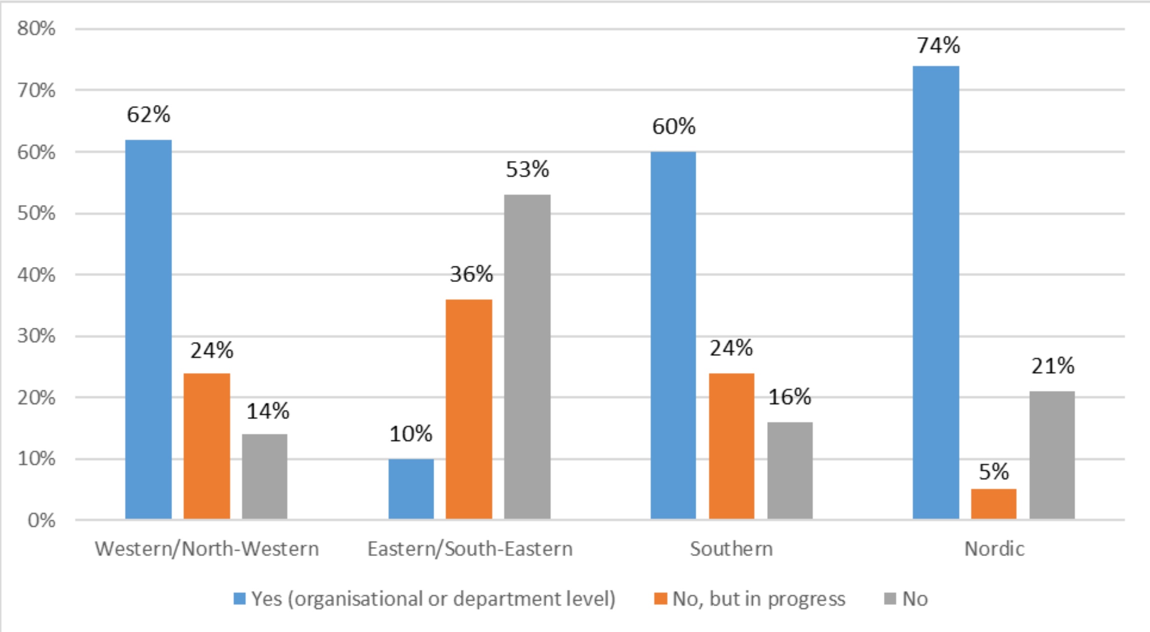


Fig. 64: *GEP Status by European region (n = 265).* – Source: ACT Community Mapping Survey (2019)*
** Single selection, excluding those who replied "I do not know" and non-European countries due to low response*

Gender Equality Plans, as described by respondents from organisations that develop or implement a GEP, cover diverse measures and respond to various aspects of gender inequality. The most frequently implemented measures correspond to activities for identifying gender inequalities and introducing institutional solutions to the problem. Such activities include collecting sex-/gender-disaggregated data, awareness raising measures and setting up a gender equality office or equivalent. These measures are likely to be chosen frequently because they are helpful and needed at the beginning of a structural change process. Yet they are rather "soft measures" that may not lead to sustainable structural change. It is notable, however, that these measures are considered by the respondents to be very effective. Also equal pay measures, even though they are not so commonly implemented, are viewed as effective tools. This suggests that equal pay measures should be considered for inclusion in GEPs.

Slightly less popular, but of a more binding character to the institution, are measures aimed at fostering institutional commitment towards tackling inequalities: such measures include a commitment to gender mainstreaming, measures addressing non-discrimination and gender diversity, as well as those combatting sexual harassment. Other measures that have been mentioned frequently by survey respondents address the reconciliation of

DOI: 10.3217/978-3-85125-668-0-19

work and private life, the recruitment and promotion of women and the enhancement of equal representation in decision-making (see Fig. 65). All of these measures were evaluated as rather effective.

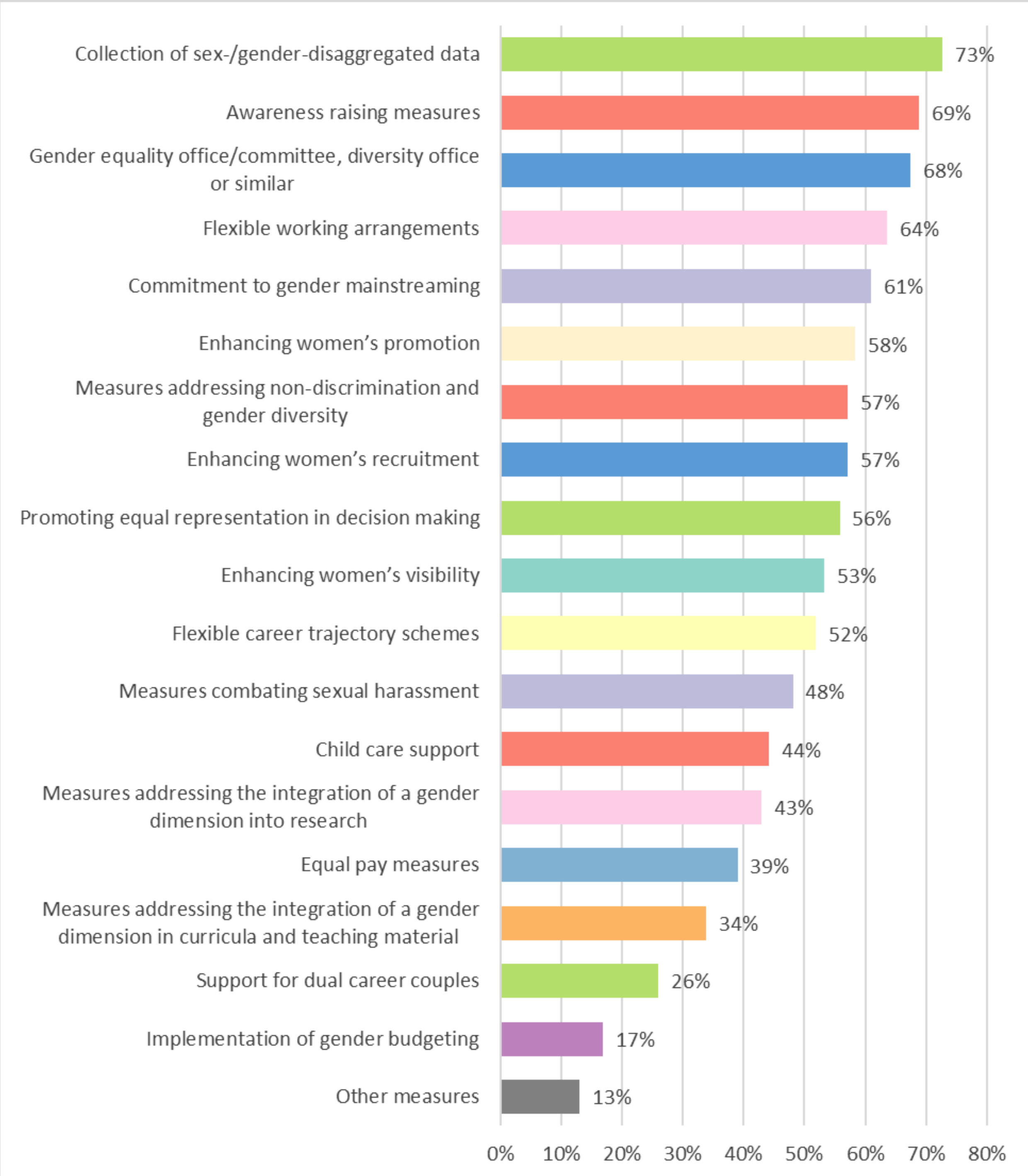


Fig. 65: *Popularity of measures included in Gender Equality Plans or equivalent (n = 77).* – Source: ACT Community Mapping Survey (2019), * Multiple selections possible. N based on number of respondents that selected at least one item*

While many of the respondents include a gender dimension in their research and/or teaching as an individual effort, this is rather not implemented at the institutional level. The most popular activity in this respect is the collection of sex-/gender-disaggregated data within research projects followed by the inclusion of sex/gender issues in teaching curricula as well as in research programmes and policies. However, it is not a common practice to offer a training for research staff on how to integrate a gender dimension in their research and/or teaching practices. Overall, respondents rarely indicate that institutionalised activities oriented towards providing advice on the inclusion of a gender dimension also in evaluation procedures are present in the organisation (see Fig. 66). However, respondents also expect that including a gender dimension in research and/or teaching has a smaller effect on achieving gender equality in the organisation then implementing gender equality measures at the organisational level.

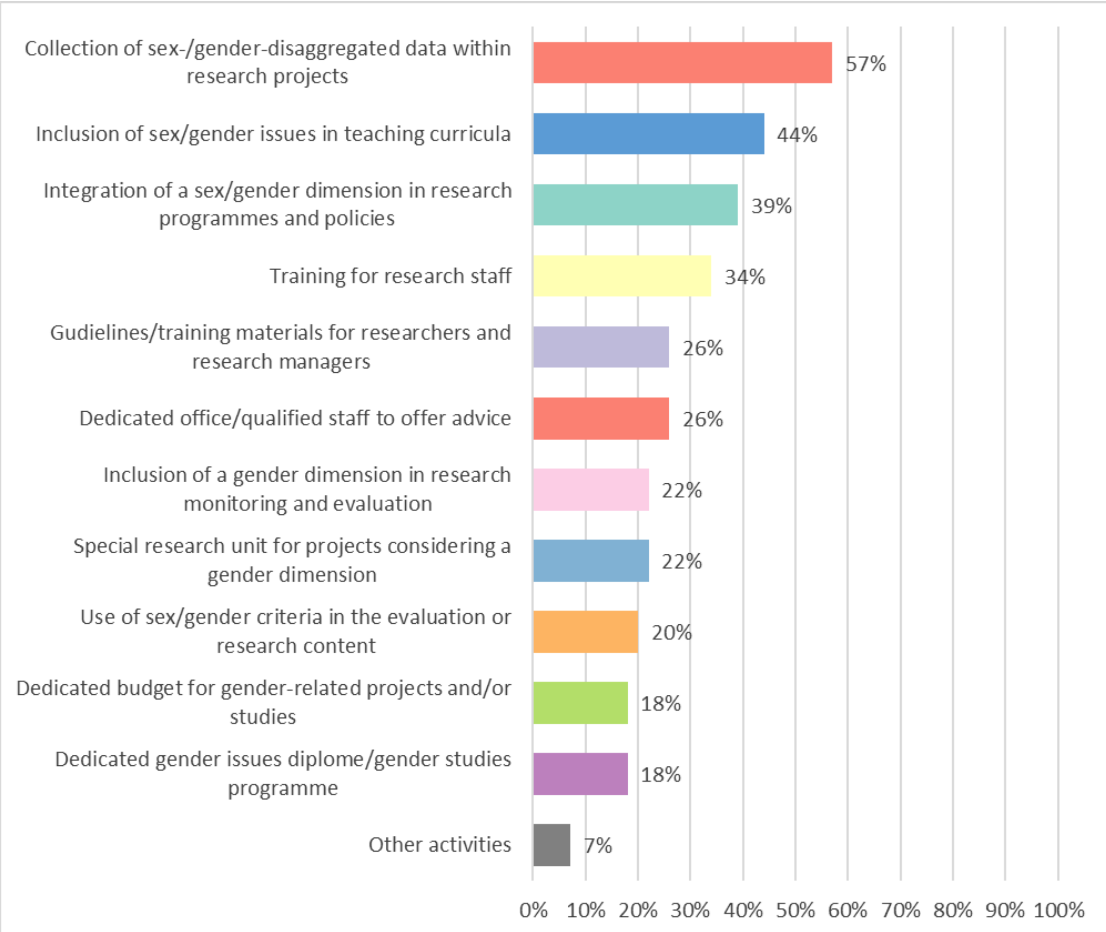


Fig. 66: *Popularity of activities directed at including a gender dimension in research and teaching (n = 165).* – Source: ACT Community Mapping Survey (2019) * Multiple selections possible. N based on number of respondents that selected at least one item*

Sybille REIDL (1), Lisa SCHÖN (1), Ewa KRZAKLEWSKA (2), Marta WARAT (2)
DOI: 10.3217/978-3-85125-668-0-19

Altogether, most respondents see progress in relation to gender equality at their organisations. The share is even higher in organisations that have a GEP in place. Furthermore, a positive change is more often reported by respondents that represent the whole organisation, by those in management positions, Human Resource Managers or those in positions linked to policy implementation such as Diversity or Equal Opportunity Officers. Nevertheless, organisations are also facing barriers when trying to implement gender equality measures: the most often reported ones refer to a lack of personnel, time (65%) or financial (55%) resources. The implementation of gender equality measures is also frequently hindered by the lack of commitment and support from employees/staff members (49%) and management (43%). Finally, a lack of expertise within the organisation/institution (43%) can be an important hindering factor. The survey does show, however, that only few respondents have to deal with active resistance from organisation management or employees/staff members. Hence, it turns out that securing the necessary resources and engaging those who are affected by the solutions are the main challenges, whereas fear of potential opposition may be exaggerated.

Closely connected to the previously mentioned barriers, Fig. 67 shows the internal factors needed in order to improve gender equality in responding organisations. Besides securing the resources, an important strategy should be to broaden the knowledge on gender equality and enhance the support from upper management. Moreover, clear responsibilities within the organisations are necessary. Notable is also that 45% of respondents see the need to participate in gender equality networks/projects or Communities of Practice.

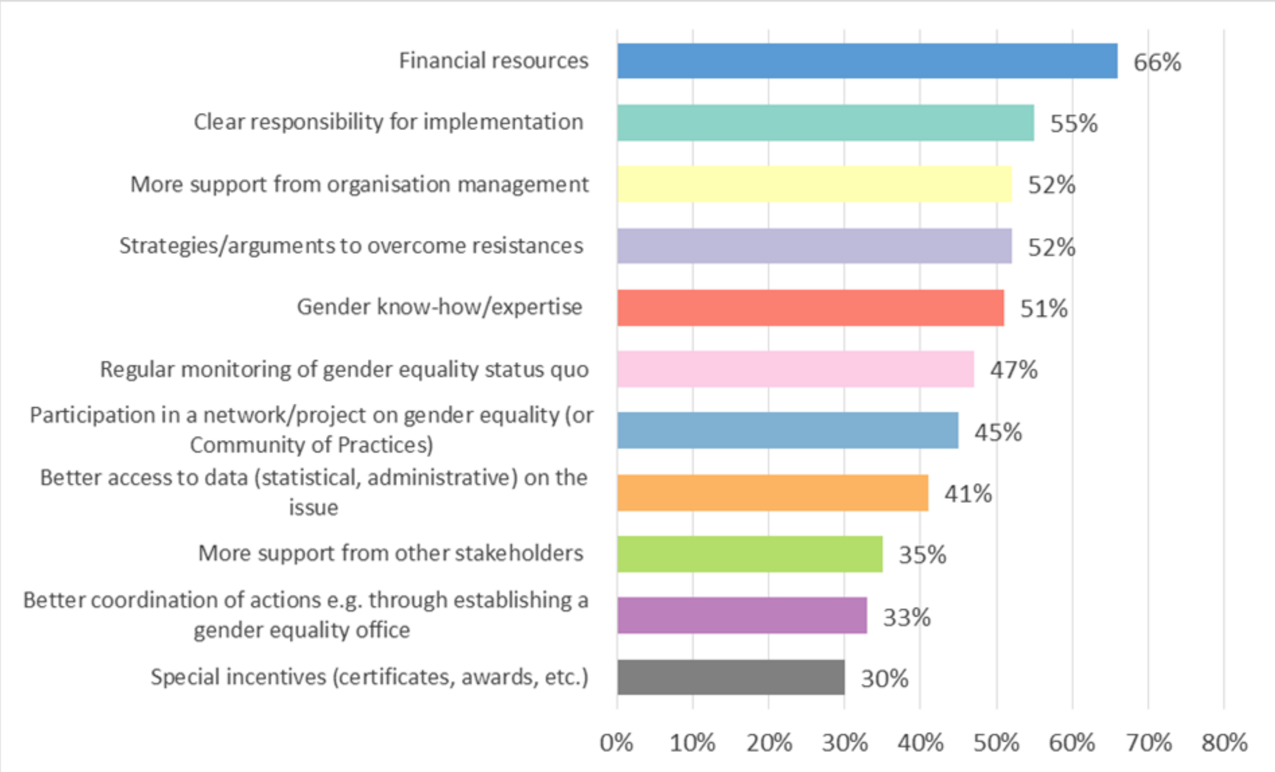


Fig. 67: *Different types of internal factors needed to improve gender equality (n = 204).* – Source: ACT Community Mapping Survey (2019) * Multiple selections possible. N based on number of respondents that selected at least one item*

These internal changes within the institution should be accompanied by external support. The latter refers primarily to international and national grants, as indicated by two thirds of respondents. More than half of the respondents lack external support in the form of trainings, counselling and lectures. Furthermore, 49% of respondents think that an external evaluation of existing GEPs or gender equality measures is needed (see Fig. 68).

Sybille REIDL (1), Lisa SCHÖN (1), Ewa KRZAKLEWSKA (2), Marta WARAT (2)
DOI: 10.3217/978-3-85125-668-0-19

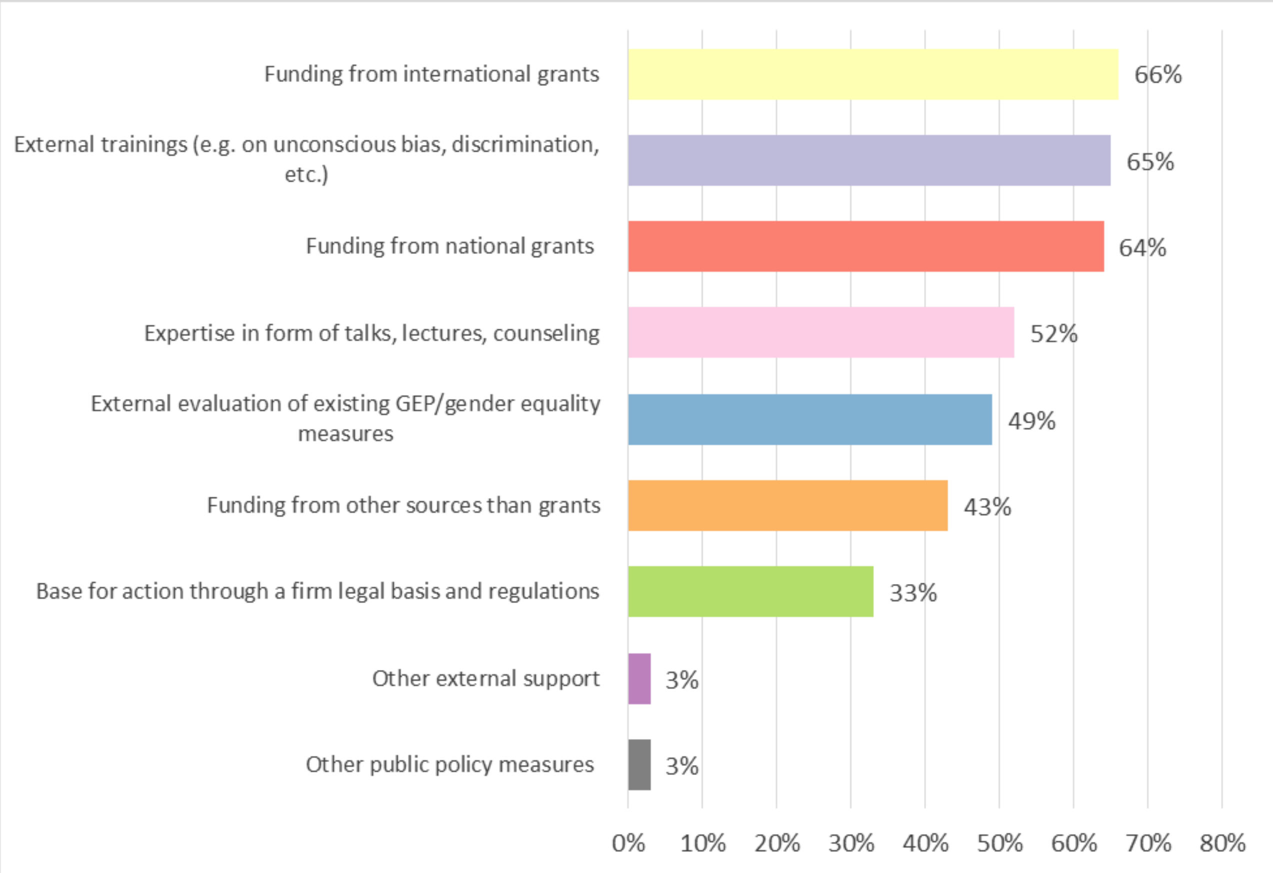


Fig. 68: *Different types of external support needed to improve gender equality (n = 196).* – Source: ACT Community Mapping Survey (2019) * Multiple selections possible. N based on number of respondents that selected at least one item*

4 Gender Equality Networks

Cooperation can be an important resource for promoting gender equality in one's own organisation. Therefore, the ACT survey also aimed at identifying existing cooperation networks for gender equality. In order to do so, the online-survey asked respondents about their main cooperation partners regarding gender equality (max. 5) and their participation in projects for structural change funded by the EU in FP7 and H2020.

In order to analyse cooperation patterns of gender equality practitioners, 222 survey responses could be included in the Social Network Analysis.[1] These respondents represent 175 organisations and named a total of 247 cooperation partners. Some of

1. The SNA was carried out entirely in the software environment of R Studio. R packages used for the SNA include the packages **network**, **sna** (Butts 2008; 2015; 2016) and **igraph** (Csardi and Nepusz 2006). For visualisation mainly **ggplot2** (Wickham 2016) and **igraph** were used.

DOI: 10.3217/978-3-85125-668-0-19

these named partners overlap, and some respondents named each other as partner, leading to clustering within the entire network. Additionally, 60 survey respondents were part of at least one EU-funded structural change project.[1] For each selected project, every consortium member was added as a cooperation partner.

Considering the entire network of all responding organisations and identified connections to other organisations shows the amount of influence of those involved in EU-funded structural change projects. Not only are the projects somehow all connected, but the involved organisations generally seem more actively engaged in GE cooperation activities. In Fig. 69, only small groups of partners can be identified outside of the big cluster that includes all project partners (depicted in green).

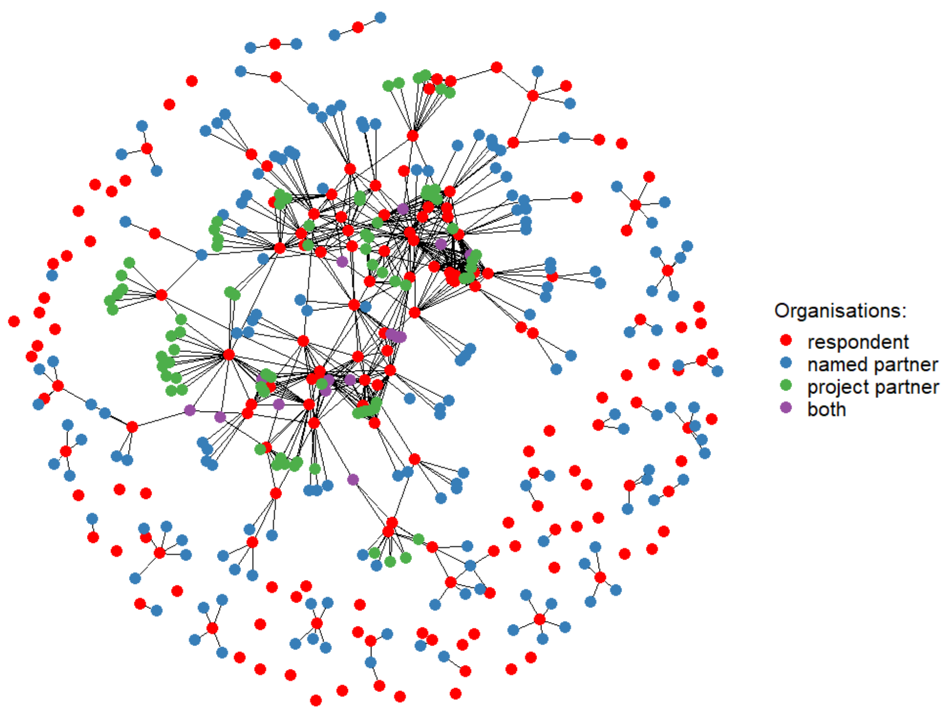


Fig. 69: *The entire network of partners at the organisation level (n = 435). Source: ACT Community Mapping Survey (2019)*

1. The following projects could be selected in the online-survey (in alphabetical order): Baltic Gender, CHANGE, EGERA, EQUAL-IST, FESTA, GARCIA, GEECCO, GENDERTIME, GENERA, GENIS LAB, GENOVATE, INTEGER, LIBRA, PLOTINA, R&I PEERS, SAGE, STAGES, SUPERA, TARGET, and TRIGGER.

Sybille REIDL (1), Lisa SCHÖN (1), Ewa KRZAKLEWSKA (2), Marta WARAT (2)
DOI: 10.3217/978-3-85125-668-0-19

Note that the previous figure looked at the network of partners at the organisational level, i.e. all responses from the same organisation were merged together. In order to take a closer look at selected attributes of the survey respondents, we next focus on the individual (respondent) level. To get a clearer image, we separate the networks into (1) a network of survey respondents and partners named in the survey; and (2) a network of survey respondents and their partners from EU-funded structural change projects.

Fig. 70 shows both networks separately and depicts survey respondents as red nodes[1] and added partners as grey nodes. In order to see which respondents stem from the same organisation in the network visualisations, the "mother-organisation" (depicted as circle) is added as a partner to all responding departments (depicted as triangles). Note that the named partner network (left) is based entirely on survey data, whereas the project partner network (right) is based on respondent selection but with full information on the project consortium members.

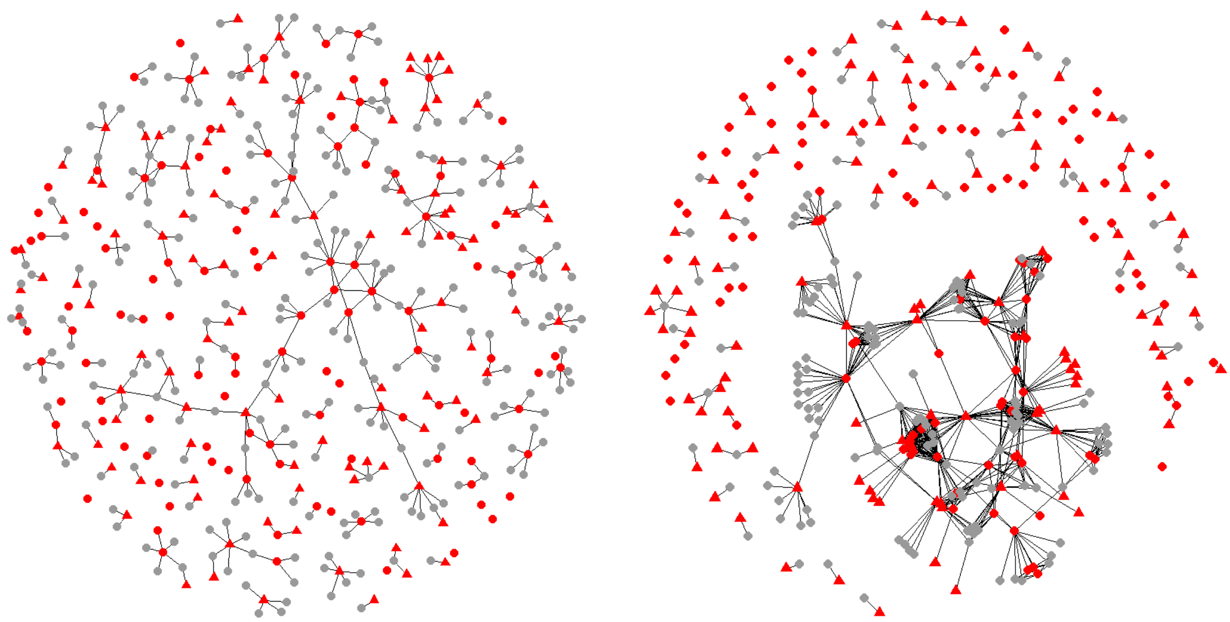


Fig. 70: *Named partners (left) and project partners (right) at the individual level. Source: ACT Community Mapping Survey (2019)*

1. For those unfamiliar with SNA terms, one „node" corresponds to one unit of analysis. In our case, one survey respondent or added partner (i.e. one dot in the figure). A more thorough introduction of general SNA terms and measures can be found in Scott (2000), for SNA in R refer to Luke (2015).

DOI: 10.3217/978-3-85125-668-0-19

Looking at the named partners, a network of 466 nodes (357 distinct organisations) could be analysed. This network covers almost the whole EU28 as well as other European and non-European countries. The highest number of organisations included are located in Spain, the UK, Germany, Austria and Poland. Some South-Eastern and Nordic European countries have scarcely been reached – maybe because there are only a few organisations concerned with the implementation of gender equality, or they have no network connections to the actors depicted. European countries outside the EU28 who are disconnected to the analysed network are Bosnia and Herzegovina, Montenegro, Albania and Macedonia.

In the named partner network, multiple clusters could be identified by looking at connected organisations and social cohesion, i.e. considering the number of connections within subgroups in the network (Luke, 2015, p. 106). Considering the left plot in Fig. 70, it is interesting to see that a rather large share of organisations form one big cluster going through the centre of the plot. This big cluster is held together by five Higher Education Institutions and shows connections of organisations all over Europe. Universities in general play an important role in the survey because they are the biggest group of respondents and they indicated a comparatively high number of cooperation partners. This suggests that this type of organisation is particularly well connected and active in cooperation regarding gender equality. Other (smaller) clusters that were identified are typically more regionally focused than the big central cluster. However, also the small clusters show connections between different organisation types, particularly RPOs and RFOs.

Fig. 71 shows the network of named partners in and around Europe on a geographical map.[1] The size of the points indicates the total number of organisations in the respective city, the thickness of the connecting lines corresponds to the number of connections. Overall, many of the named partners are located in the same country (58%) or even in the same city as the respondents.[2]

1. Additional R packages used for the geographical mapping include **OpenStreetMap** (Fellows, 2016), **tmaptools** (Tennekes, 2018) and **maps** (Minka and Deckmyn, 2018).

2. Note that connections between partners located in the same city are not shown on the map because the points overlap.

DOI: 10.3217/978-3-85125-668-0-19

Fig. 71: *Named partner network in and around Europe (n = 438). – Source: ACT Community Mapping Survey (2019)*

The project partner network, however, is very international. In this network, only 6% of partners are located in the same country as the survey respondent. Furthermore, the country distribution slightly shifts: now also Bosnia and Herzegovina, Estonia, Liechtenstein, Morocco and Ukraine are represented. The network of project partners even stretches out to Morocco, Turkey and Israel (see Fig. 72).

It is interesting to see that the organisations involved in EU-funded structural change projects actually form a big community of organisations, i.e. the consortia are not isolated from each other. This community is held together by some key actors, which participate in multiple projects and – as shown by the cluster analysis – form a group of very well connected actors. Most of the organisations in this cluster are public Higher Education Institutions or publicly funded research institutions, spread out over the EU28 as well as Switzerland and Iceland.

Sybille REIDL (1), Lisa SCHÖN (1), Ewa KRZAKLEWSKA (2), Marta WARAT (2)
DOI: 10.3217/978-3-85125-668-0-19

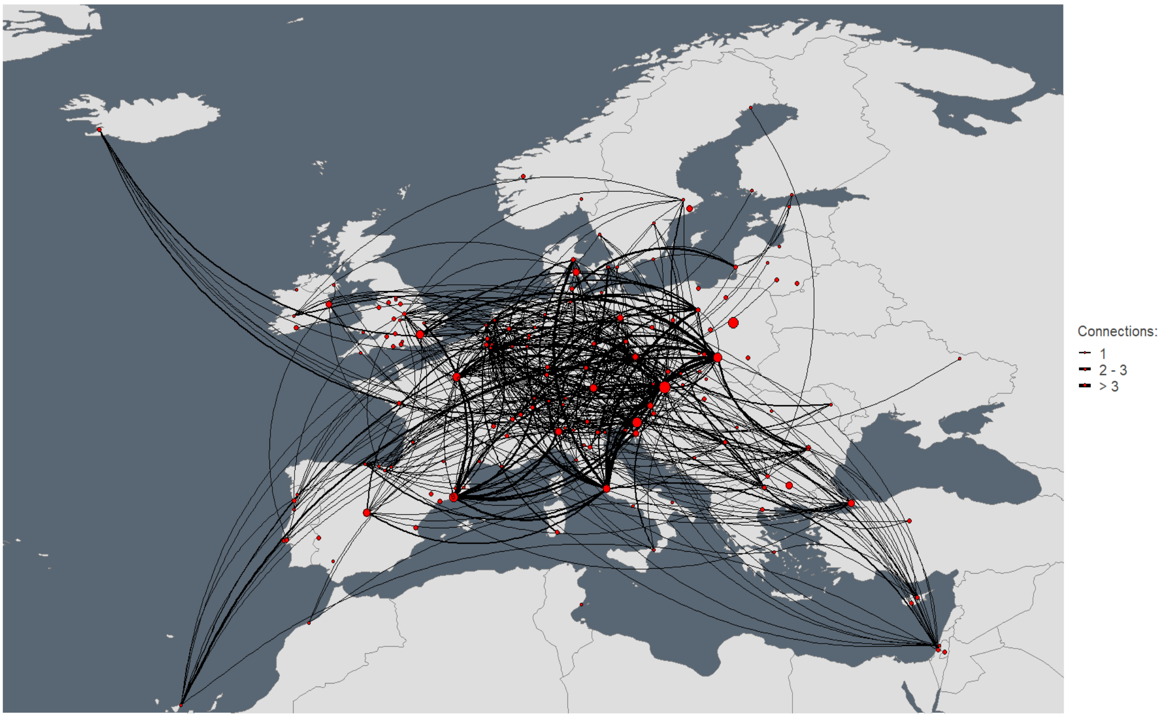


Fig. 72: Project partner network in and around Europe (n = 368). – Source: ACT Community Mapping Survey (2019)

Naturally, these images portray only one part of the existing network connections between European research organisations. The geographical distribution highly depends on the reach of the online-survey and is biased towards a higher representation of countries in which the ACT consortium partners are located. Nonetheless, the analysis shows some of the highly active regions and also identifies gaps that ACT can address. Most importantly, ACT aims at picking up those respondents, which currently do not cooperate regarding gender equality activities but would like to join a Community of Practice.

In this context, it is important to consider not only the number of partners that were actually named in the survey, but how many GE cooperation partners the respondents had in total over the last three years. This takes into account that not all respondents who did in fact cooperate also named some of their partners in the survey, and that only up to five partners could be listed. Fig. 73 therefore shows the network of named partners weighted by the total number of GE cooperation partners in the last three years, as indicated by the survey respondents. All the red nodes are now those, with no GE cooperation partners in the last three years (64 respondents).

DOI: 10.3217/978-3-85125-668-0-19

Half of them are interested in joining one of the ACT CoPs, most of them from Poland, followed by the UK, Spain and Portugal. Yellow and blue nodes are those, with more than 20 GE cooperation partners, i.e. those very active in GE cooperation activities.

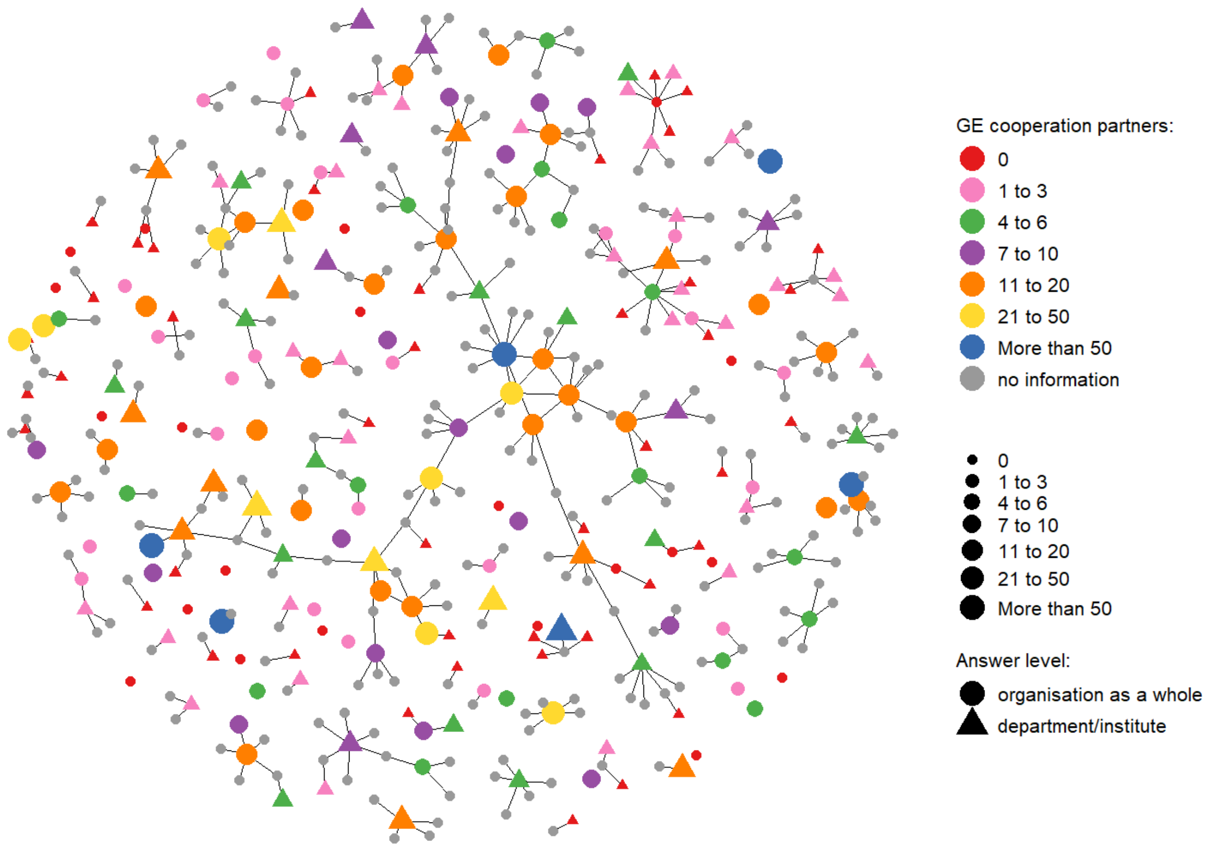


Fig. 73: *Named partner network by total GE cooperation partners in the last 3 years (n = 466). – Source: ACT Community Mapping Survey (2019)*

5 Concluding Remarks

ACT's Community Survey aimed at identifying people who promote gender equality in their research organisation and at gathering knowledge about existing gender equality practices in RPOs and RFOs, their networks of cooperation partners and their support needs. This knowledge will now be used in order to plan effective and successful activities directed at the ACT Communities of Practice (CoPs).

Additionally, the survey aimed at identifying respondents or organisations interested in future collaborations, including the participation in the ACT Communities of Practice. Altogether, 150 respondents from research institutions all over Europe were identified who are interested in participating in the ACT Communities of Practice through this survey. These people will now be contacted by ACT partners in order to invite them to participate in those CoPs that are currently being established. They come from very heterogeneous institutions – and the status of gender equality implementation spans a wide range, as the results of the survey show. ACT will consider this when developing support and forming CoPs. This heterogeneity will be of great benefit to the CoPs because it enables members to learn from each other.

References

Butts, Carter T. (2008): network: a Package for Managing Relational Data in R. In Journal of Statistical Software 24 (2) [online]. Available at: http://www.jstatsoft.org/v24/i02/paper (Accessed: 11.3.2019)

Butts, Carter T. (2015): network: Classes for Relational Data. The Statnet Project. R package version 1.13.0.1 [online]. Available at: http://CRAN.R-project.org/package=network (Accessed: 11.3.2019)

Butts, Carter T. (2016): sna: Tools for Social Network Analysis. R package version 2.4 [online]. Available at: https://CRAN.R-project.org/package=sna (Accessed: 11.3.2019)

Csardi, Gabor, Nepusz, Tamas (2006): The igraph software package for complex network research. In InterJournal. Complex Systems 1695 [online]. Available at: http://igraph.org (Accessed: 11.3.2019)

European Commission (2012): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Reinforced European Research Area Partnership for Excellence and Growth. Brussels. [online]. Available at: https:/ /eige.europa.eu/sites/default/files/era-communication_en_2012.pdf (Accessed: 21.08.2019)

Fellows, Ian (2016): OpenStreetMap: Access to Open Street Map Raster Images. R package version 0.3.3 [online]. Available at: https://CRAN.R-project.org/package=OpenStreetMap (Accessed: 18.4.2019)

Luke, Douglas A. (2015): A User's Guide to Network Analysis in R. Springer International Publishing.

Minka, Thomas P., Deckmyn, Alex (2018): maps: Draw Geographical Maps. R package version 3.3.0 [online]. Available at: https://CRAN.R-project.org/package=maps (Accessed: 18.4.2019)

Scott, John (2000): Social Network Analysis. A Handbook. 2nd Edition, London: SAGE Publications Ltd.

South, Andy (2011): rworldmap: A New R package for Mapping Global Data. In The R Journal 3 (1), pp. 35-43 [online]. Available at: https://cran.r-project.org/web/packages/rworldmap/rworldmap.pdf (Accessed: 18.4.2019)

Tennekes, Martijn (2018): tmaptools: Thematic Map Tools. R package version 2.0-1 [online]. Available at: https://CRAN.R-project.org/package=tmaptools (Accessed: 18.4.2019)

Wickham, Hadley (2016): ggplot2: Elegant Graphics for Data Analysis. New York: Springer-Verlag.

DOI: 10.3217/978-3-85125-668-0-20

Embracing Circularity in Adaptive Reuse – the Grassroots Perspective

M. ROSZCSYNSKA-KURASINSKA, Anna DOMARADZKA, B. ŚLOSARSKI, A. ŻBIKOWSKA

The Robert Zajonc Institute for Social Studies, University of Warsaw, Poland

Abstract

Prolonging the utility of products is the main aim of a circular economy. So far, this concept has been implemented in a growing number of areas, one of which is built heritage. The circular economy argues that, instead of destroying a building to make way for a new one, the owners or managers of the property should care for it systematically by repair and refurbishment. The success of a circular economy depends on the ability of people and communities to change their behaviour and way of thinking. Many initiatives that embody the goals of circularity – like local energy markets based on blockchain technology – stem from local activist groups. This research aims to contribute to a better understanding of the role and capacity of local communities in introducing new ideas of the circular economy in a bottom-up fashion. We define this local potential for the implementation of circular solutions as *grassroots circularity*. In our study we analysed three adaptive reuse projects in the area of built cultural heritage using a social sustainability framework. We discovered that, while all five factors contributing to the social sustainability model are highly relevant in describing and understanding the successful implementation of bottom-up adaptive reuse projects, they require minor modification in order to fit the circular economy model. As a result of our analysis, we can offer insight on how grassroots circularity can be diagnosed and understood. We believe that the concept of grassroots circularity widens the circular economy model to include the neglected bottom-up potential of local communities.

DOI: 10.3217/978-3-85125-668-0-20

1 Introduction

The concept of the circular economy could provide an answer to crucial environmental problems like water, air and soil pollution, resource depletion, and biodiversity loss. The main idea of circularity is built on the notion of the regenerative power of nature, in which nothing is considered waste (Webster, 2017). To the contrary, any by-product of behaviour provides food for something else. Hence, products and their components at all stages of life have a value and can be transformed into something useful (Stindt and Sahamie, 2014; Wells and Seitz, 2005).

Compared to the classical linear economy, in circular economy, the life of the product is deliberated in a much longer perspective. The linear economy focuses on “here and now” and so the origins of materials, as well as the afterlife of products and waste, is not considered important. They remain just inputs and outputs of the production chain. In the circular economy, on the other hand, relationships and feedback loops between materials, waste product, and energy are in the spotlight (Stahel, 2008). A closed cycle of raw materials and energy through multiple phases is assumed and promoted (Bocken et al., 2016). The desired solution is an economic system in which “resource input and waste, emission, and energy leakage are minimized by slowing, closing and narrowing material and energy loops” (Geissdoerfer, Savaget, Bocken, & Hultink, 2017, p. 759).

This closing of loops allows economic logic to be sustainably driven. As Stahel (2016) puts it, the circular economy stresses self-sufficiency over production, so whenever it is possible one should repair what is broken, reuse everything that can be reused, remanufacture what is beyond repair, and recycle what cannot be reused. Prolonging the utility of products is the main aim, which should be achieved by the proper maintenance, repair, reuse, refurbishment, remanufacturing, or recycling of goods. This logic can be applied to any area of production and consumption, including fashion, food, design or built cultural heritage.

The treatment of old buildings is a perfect example. Nowadays, due to the relatively low costs of materials and energy in comparison to labour costs, the preferred solution is to demolish an old structure and erect a new one, instead of refurbishing an often dilapidated building. Such a solution takes into account the cost analysis, but does not reflect on the other aspects – environmental, social and cultural – of potential adaptive reuse. According

DOI: 10.3217/978-3-85125-668-0-20

to Fitch “the adaptive reuse of old buildings is more economic, not only in general terms (e.g., conservation of the energy represented by the built environment, but also in absolute terms (e.g., the relative costs of old and new built space).” (1990, p. 169). The environmental benefits of adaptive reuse only affirm this conviction. Therefore, adaptive reuse can be considered as one of the most effective tools for sustainable urban development (Yung and Chan, 2012).

There are two ways in which adaptive reuse can be introduced into built-heritage investment projects. It can be either a top-down process driven by public or private investors, or a bottom-up grassroots initiative. In the first case, it is often the public investor, with the aim of generating/securing public goods or services that initiates the process. In a similar fashion, the private investor can step in and start the adaptive reuse project in the hope of generating a profit. In the case of bottom-up initiatives, they emerge from local communities that recognize an opportunity or threat that has been overlooked by local authorities or business entities. Domaradzka (2015) argues that local communities are closer to the problems they are dealing with and can be characterized by higher potential for flexibility than formal institutions. Therefore, grassroots initiatives can react faster and more accurately to new challenges, by adopting innovative solutions and ideas, such as the principles of the circular economy. Many initiatives that aim at closing the loops – like repair cafés, food cooperatives, sharing collectives or local energy markets based on blockchain technology – stem from such local activist groups *(Bilewicz and Potkańska, 2013)*.

Despite the importance of grassroots initiatives, they seem to be understudied in the context of the circular economy (Geissdoerfer et al., 2017). This research aims to contribute to a better understanding of the role and capacity of local communities in introducing new ideas of the circular economy in a bottom-up fashion. We suggest defining this local potential for implementing circular solutions as **grassroots circularity**. Through the research results presented here, we can offer insight on how grassroots circularity can be diagnosed, understood and developed.

The paper is structured as follows: in section 2 we briefly compare the circular economy with the sustainable development approach, and then describe the social sustainability framework (Missimer et al., 2017) that we initially employed for the analysis of local adaptive reuse initiatives. Section 3 outlines our research design by presenting the

DOI: 10.3217/978-3-85125-668-0-20

research questions and methods applied. The subsequent section presents the results, based on desk research and case study analyses. We describe three cases of adaptive reuse in which circularity emerged as a bottom-up process, and analyse those local communities through the lens of the social sustainability framework. The paper ends with a discussion on the applicability of social sustainability to study of grassroots circularity. Based on the insights from the analysis, we suggest an expansion of the social sustainability framework and opt for the proper operationalization of the grassroots circularity concept.

The concept of grassroots circularity counterbalances the prevailing top-down mode of thinking in the domain of circularity, in which the responsibilities of companies and governments are mainly discussed. Bringing attention to grassroots circularity underlines the potential of citizens to trigger significant social and environmental change on the local level. Our case studies illustrate how citizens should be considered as actors, not just end-users of circular adaptive reuse interventions.

2 Background

The model of circularity, aiming at redesigning the economic system into one that values the long-term use of goods, fits well into the notion of sustainable development. Sustainable development promotes human activity in which Earth's ecological functions are preserved (ISO 15392, 2008) and the indefinite perpetuation of all life forms are ensured (Ehrenfeld, 2005) while the security, health and well-being of humans are supported (McMichael et al., 2003).

A broad literature review conducted by Geissdoerfer et al. (2017) reveals that there are many similarities between the circular economy and sustainability, such as the recognition of large-scale and long-term commitments motivated by environmental hazards, shared responsibility, a global perspective, cooperation between stakeholders, and integration of non-economic aspects into development (for a complete review see Geissdoerfer et al., 2017). In both paradigms, the socio-technical transition toward circularity can be facilitated and finally achieved with the help of innovations and system design.

However, despite many similarities, the concepts also differ in several dimensions. For example, there is a divergence in understanding of the goals, motivation, as well as the specific responsibilities of different actors. In the sustainability paradigm, the goals are

DOI: 10.3217/978-3-85125-668-0-20

open-ended, diffused and numerous because they reflect the plurality of actors and their diverse interests (Brundtland et al., 1987). The realization of goals requires interaction and cooperation among actors, who first need to align their interests. All actors bear responsibility, and all have to adjust their behaviour in order to reach the goal of sustainability (Bocken et al., 2015). The three main beneficiaries of sustainability interventions are the environment, economy, and society at large (Elkington, 1997). In general, all should be considered and treated with equal attention, but some prioritization is acceptable. For example, when a local specificity requires a particular response in the social domain, placing social needs over environmental ones is acceptable. A well-functioning social system with cooperating actors emerges as a necessary step on the road toward sustainability.

The circular economy depicted by Geissdoerfer et al. (2017) on the other hand, provides an entirely different vision of actors, their motivations and responsibilities. First of all, in the circular economy, there is just one, well-defined objective, i.e., the elimination of “all resource inputs as well as waste and emission leakage from the system” (Geissdoerfer et al., 2017, p. 764). The main actors responsible for reaching this goal are economic actors: largely private business, regulators and specialised NGOs. Society at large is not recognized as an active stakeholder in the process. Society benefits from the implementation of circularity due to improvement of the environment and the condition of the labour market, but does not seem to be listed as an actor who has the power to influence and enforce the transition. In the literature on circularity, the most empowered actors (besides policymakers) are economic actors, whose financial advantages are often prioritized (Webster, 2017).

The marginalization of the role of society in the circular economy might severely impede the implementation of the new economic logic. Communities shouldn’t be seen just as end users, i.e., the beneficiaries of a transition, but rather as active players who can enforce change by pressing companies to adopt new technologies or by introducing change by themselves. In many cases, the adoption of new ideas, products, and solutions starts with local activists who show their neighbours that an alternative form of conduct is possible and actually more profitable in the long term (Brandsen et al., 2016). It may be a food

DOI: 10.3217/978-3-85125-668-0-20

cooperative[1], which closes the loops by minimizing waste and emissions leakage, or a heritage community that contradicts the make-use-dispose approach in cultural heritage investment. By choosing the adaptive reuse of an old building over the construction of a new one, heritage communities aim at reducing construction waste and emission of greenhouse gases (Stahel, 2016) as well as maximizing the complex value of built heritage (Fusco Girard, 2014, 2013).

Local communities can play an essential role in bringing circularity into life, but their potential seems to be understudied. We posit that one of the obstacles is the lack of an established framework for studying **grassroots circularity**.

A similar problem was diagnosed earlier in the sustainability domain (Colantonio et al., 2009). Although many interventions aiming at achieving sustainability have social consequences, the social dimension of sustainability remains vaguely defined and barely examined. Many researchers have called for investigation into which measures should be used to support an effective transition toward sustainability (Johnston et al., 2007, Marsden et al., 2010). Particularly, which solution will work in which conditions, and what makes the social system sustainable? As a response, Missimer, Robèrt, and Broman (2017) proposed a universal framework for studying **social sustainability**. Building on the study of complex adaptive systems, they formed an unique profile of a sustainable social system, one that is able to prosper in a situation of uncertainty and constant change. They list altogether five characteristics of a social system that they consider essential for achieving sustainability: diversity, common meaning, trust, capacity for learning, and capacity for self-organization.

The first aspect of the adaptive capability of social systems is **diversity** (Norberg and Cumming, 2008). This can be understood as diversity of knowledge, skills, opinions, beliefs, and values. Anything that adds to the variety of a community helps to prepare it for the unknown (Folke et al., 2005). Because societies do not know what skills they will need in the future, they should always broaden their spectrum of knowledge and skills. A monolithic society, in the event of external shocks, often lacks the necessary resources allowing for the smooth adaptation to a new situation (Ostrom, 2009). For example, a village in which 90% of inhabitants work in a car factory is not sustainable because the

1. Food cooperatives collaborate with local farmers and promote usage of reusable packaging.

wellbeing its population depends mostly on one company which can decide to relocate. In that case, the lack of diversity of skills may hinder the process of adaptation.

Diversity can be also understood as a latent resource of the community from which it can draw whenever the need emerges. The diversity or heterogeneity of agents is also often mentioned in the context of innovation (Lane, 2016). Heterogeneity, which leads to creative tension and forces people to think out of the box, is believed to facilitate innovation. Confrontation with heterogeneity helps people to understand reality and the plurality of opinions and meanings. The circular economy requires constant innovation; therefore, diversity should also be recognized as an essential aspect of grassroots circularity.

The inner heterogeneity of society interacts with the second aspect of resilient social systems – **common meaning**. Common meaning is the ability of people to make sense of their situation and actions (Cacioppo et al., 2005). It helps them to set goals, rules of conduct, and values that the community collectively agrees on. Meaning making seems to be a primal trait of people who continuously search for answers regarding their past, present, and future (Giddens, 1984). Their goal is not only to understand the world around them, but above all to share that understanding with others (Berger and Luckmann, 1991). Therefore, alignment of understanding is a crucial step in the emergence of common meaning. The greater the heterogeneity of a social system, the harder it may be to agree on common meaning, and thus alternative common meanings may emerge. In the context of a circular economy, the existence of common meaning may enable transition, but only when the shared understanding of a community does not contradict the notion of a system proclaimed by the circular economy. If a local community perceives its environment as an unlimited resource (what can be their common meaning) they might be reluctant to invest extra time and money in recycling, refurbishing or reusing. In such circumstances, the probability of grassroots circularity emerging spontaneously is very low.

An important factor in shaping common meaning is history. The tales that people hear and space they inhabit consolidate a common meaning which can then last for decades or even centuries (Bruner, 1991). Material bearers of common meaning can be buildings, public spaces or landmarks. They evoke past narrations and carry meanings that are passed from generation to generation. Timeless narrations are inscribed into the building's intrinsic value. This does not mean that the meanings do not alter, but once they are

DOI: 10.3217/978-3-85125-668-0-20

rooted in the community they can be difficult to change. It might require extra effort and skills to renegotiate a new understanding of these locations or symbols.

What helps the community to achieve a new understanding of reality is **trust** and a **capacity for learning**, two further aspects of a sustainable social system. Communities differ in their ability to learn; some adjust to the changing environment fast, others need more time to adapt. Societies that have a high capacity for learning are seen as more resilient, because they sense change fairly quickly, gaining extra time for reacting when the change actually occurs (Scheffer et al., 2001). The diversified experience of society members increases their potential for learning. In particular, learning-by-doing is an effective form of skills and knowledge acquisition (Schank et al., 1999). The circular economy requires innovation and experimentation, which can be delivered more easily in a society that is prepared for attaining new skills and knowledge.

However, the introduction of new solutions and ideas is not the safest path. Changes are often costly and risky, and there is no guarantee that innovation will be accepted and ultimately pay back (Lane and Maxfield, 2005). But the right environment can soften the feeling of uncertainty related to the process of experimentation. An environment in which people feel safe and unthreatened can be beneficial to the introduction of novel ideas. In a social environment, safety can be described by the level of trust between members. When people trust each other, they focus on potentials, not threats, and they do not waste time and effort on verifying others' trustworthiness (Roszczynska-Kurasinska and Kacprzyk, 2013). Instead of securing themselves against potential mistrust, they can concentrate on the elaboration of shared meaning and the development of solutions.

A high level of trust facilitates the open-minded interaction of people and exchange of opinions that can form a base for self-organization. **The capacity for self-organization** is the last aspect of a resilient social system that Missimer et al. (2017) highlighted. In order to react fast and adequately to unpredictable shocks and changes in the environment, communities need to have the potential for self-organization on different levels and of varying scope (Levin, 1998). Top-down, institutionalized interventions often take time, which communities lack in a situation of threat. It is the grassroots communities that know their surrounding and people's abilities best, and therefore have the potential to form an effective response to the challenge.

DOI: 10.3217/978-3-85125-668-0-20

This is what makes the capacity for self-organization the most important aspect of grassroots circularity. Without it, no grassroots initiative can emerge and prosper.

Breaking down the concept of social sustainability into the above dimensions enhances the strategic planning and the introduction of innovations for sustainability. The implementation of circularity involves new technical solutions and new regulations, but mostly it requires the adoption of new ways of thinking; therefore, understanding the conditions under which society can unleash its potential is a critical endeavour.

3 Research design

The paper aims to provide the prototype of a new approach to the circular economy by merging it with the social sustainability concept.

As described in the introduction, the methods employed were mostly case studies, based on qualitative in-depth interviews and a document review. The case studies were conducted as part of the CLIC project, which focused on collecting best practices for the adaptive reuse of cultural heritage[1]. Special attention was paid to the circular aspects of projects and their economic and social sustainability.

The overall research was led by the intention to discover bottom-up mechanisms for conducting successful adaptive reuse projects.

On the empirical level, we started with a wide review of adaptive reuse projects around Poland, based on press articles, internet reports and key word search. When choosing our cases we focused on their diversity in terms of location (urban historic centre, periurban, suburban, rural), type of cultural heritage (building, set of buildings, landscape) and the initiating as well as managing body (association, private company, municipality). We ended up conducting five case studies, three of which were initiated and guided by a local community or grassroots group of activists. These three formed the basis for our analysis in this paper.

1. The research and innovation project “CLIC: Circular models Leveraging Investments in Cultural heritage adaptive reuse”, financed from Horizon 2020, 2017-2020, see also ***www.clicproject.eu***.

DOI: 10.3217/978-3-85125-668-0-20

In each of the locations we conducted a set of in-depth interviews with the following actors of the investment process: 1) project leaders/initiators, 2) site managers, 3) local government representatives, 4) users from the local community. On average we conducted six interviews per case. Each interview was transcribed and analysed using MAXQDA software. We applied codes based on the social sustainability model, adding additional codes on the go.

As mentioned above, the principles for social sustainability were derived from the work of Missimer, Robert and Broman (2017). Our analysis was guided by the following main research questions: What were the roots of the grassroots project's success and sustainability? Can we find all social sustainability aspects (diversity, common meaning, trust, capacity for learning, capacity for self-organization) in the studied cases? Is the social sustainability framework relevant for studying bottom-up circular projects?

During our analysis we discovered that all five factors derived from the social sustainability model are highly relevant in describing and understanding the successful implementation of bottom-up adaptive reuse projects in the cultural heritage field. However, we also discovered that the aspect of diversity is not sufficient to fully describe the underlying dynamic between the local actors. We therefore decided to add a sixth aspect of **openness** to stress the importance of exchange between diverse actors of the process. All of this gave rise to defining the new concept of grassroots circularity, based on our empirical results.

4 Results

The results are presented as follows: firstly, we describe the built heritage and its history and secondly, we analyse the grassroots initiative that led to adaptive reuse using the social sustainability framework.

4.1. Case A – Rural Ecomuseum

Our first case is a rural ecomuseum, which is a network of natural and built sites located over an area of four municipalities. Currently, the ecomuseum network is composed of 38 private actors, such as owners of bed and breakfast establishments, restaurants, local companies, and social actors, predominantly non-governmental organizations. The ecomuseum was launched in 2001 as a joint initiative of one municipality and local

DOI: 10.3217/978-3-85125-668-0-20

activists. In 2003, it obtained European Union funds; however, since then it has been financially maintained by private funding. The revitalization project encompassed various objects connected with the cultural and natural history of the region. The ecomuseum also functions as a networking initiative for local residents – it is a hub for the organization of public events and part-time work opportunities in the region.

In case A, a high-density network of locals has been established, linking private actors working for profit with civic activists. Long-term collaboration has resulted in the creation of a local action group. Our research showed that **trust** was the crucial element in making the collaboration possible. In the beginning, activists, private actors and the municipalities worked together, and their cooperation was characterized by a high level of trust, and an open attitude towards new ideas, proposals and solutions which were realized by establishing links to external actors. In later stages of cooperation, municipalities became less invested in the idea, eventually becoming an obstacle to achieving grassroots circularity in the region. The reasons for this were twofold: first, the project leaders were involved in local elections on the opposition side to the elected mayor, and second, the social support for the ecomuseum decreased when it started to attract large numbers of tourists who contributed to the traffic and parking problems in rural areas. The respondents indicated their current lack of trust as the main reason why the initiative cannot develop further.

However, as reported by the respondents, the core element of the ecomuseum's strategic action is to seek new partners and combine scarce resources for individual events. For example, one interviewee said that local festivals and their cultural offer is produced by grassroots logic, under which networked actors and new partners provide money and material resources (infrastructure, transport) and unique skills (photographic, crafting etc.). A lack of resources for action stimulates **diversity** in the social environment of the ecomuseum. A variety of perspectives – for-profit and non-profit – forces knowledge transfers within the group, but also broadens the local community's **capacity for learning** through workshops developing intangible cultural heritage skills. It would seem that in case A, the grassroots circularity activism is to a certain point stimulated by difficulties posed by the local institutional environment, in this case – the reluctance of local authorities to continue cooperation. In a context of limited opportunities, the most crucial aim is to maintain the initiative itself. In this sense, the specificity of the initiative's grassroots

DOI: 10.3217/978-3-85125-668-0-20

circularity potential is highly visible in two particular dimensions. The first is the **capacity for self-organization**, which is realized by taking care of internal and external relations, as well as building the contingent structures of local activism and entrepreneurship. The collective construction of **common meaning** is also at stake. Actors involved in the initiative are focused on framing rural areas as symbolically significant and having intrinsic value, which could be the basis for place attachment and an important resource for the rural ecomuseum. However, it is not enough to overcome obstacles generated by the lack of trust between local actors.

4.2 Case B – Suburban Residence

The second case is a renovated residence hosting a cultural centre, located in a suburban garden-city. The building was constructed at the beginning of the XX century and its predominant function was to offer leisure and sports activities to local residents. In the 1990's, since there was no public funding to renovate it, the building became largely devastated. When municipal plans for privatization appeared, an organized group of local residents started to actively oppose it, and obtained financial backing for renovation, which made it possible for the residence to remain a public property. As a result, the site became a municipal centre for cultural and educational initiatives as well as a space for non-governmental organizations and civic activism.

At the time of the renovation, one of the local associations of residents played a crucial role in the process of initiating the adaptive reuse. As our respondents told us, the association worked closely with the mayor (who was previously a member), which allowed them to influence the direction of proposed changes in the building and choose activities for the institution that later occupied the space. The **trust** between local actors was strong and enabled them to successfully carry out the process of obtaining funds, despite the short time-frame. Importantly, the **diversity** of the group of active citizens, some of whom were architects, lawyers and historians, allowed the initiative to benefit from their various skills, which contributed to the process of renovation in different areas.

However, over time and due to personnel changes in municipalities, the managers of the residence began to focus on implementing the statutory goals of the municipality in the cultural field of public policy. As a result, the local civic sector lost some of its impact on decision-making and currently acts as a critical reviewer of local policies, which is a

DOI: 10.3217/978-3-85125-668-0-20

symptom of distrust between part of the local community and the authorities. The **common meaning** of the residence as a public place was an important aspect of the fight for its renovation: according to the association, the pre-war owner's will was for the residence to serve local community. It can be argued that this common meaning saved the building from destruction – for local residents the intrinsic and aesthetic value of the residence was very high, inspiring them to fight for what they perceived as part of their shared history and heritage. Moreover, they shared a common understanding that the place belonged to them and they as citizens should never be deprived of it.

Currently the residence is managed by the municipality and has the status of a local cultural centre. Hence, there is no longer a need for **community self-organization**, despite the existing potential for it, which remains dormant. The management of the residence argues that they are still acting as a grassroots initiative, because of their openness toward different actors, such as inhabitants (especially older adults, participating in the Third Age University and theatrical group), non-governmental organizations and the municipal council. For these specific groups, the residence offers space for work, recreation and education. The most significant element of the strategic action of the initiative is the enhancement of the **capacity for learning** in the local community. The place has become an important meeting place for educational activities focused around heritage and cultural issues, thus increasing the learning capabilities of the community as a whole. On the other hand, it has also contributed to higher capacity for learning among local civil society actors, who have created a local heritage community. That is why the residence functions as a hub for knowledge transfer – through Open University classes, by providing space for participation in municipal council meetings, and through the activities of non-governmental organizations.

As we can see, trust, common meaning, diversity and self-organization proved crucial in the process of adapting the building for the benefit of the community, but after some time, most of these aspects began to play a secondary role. The residence is no longer trying to become more circular or sustainable, partly because once it became an institution governed almost entirely by the municipality, it also lost some of its creative and innovative potential. Its program is now well-established, focusing on cultural events such as lectures, workshops, and historical exhibitions, with no new investments in e.g. energy-saving.

DOI: 10.3217/978-3-85125-668-0-20

4.3 Case C – Metropolitan Activist Community

Our third case is a metropolitan community located in a unique settlement of wooden houses. The houses were constructed shortly after the Second World War in the middle of a metropolitan city. Originally the housing estate served a mix of public, educational, and leisure purposes. Since 1967, the houses have been successively demolished in order to clear the ground for a new street or new buildings (like embassies). City and district authorities removed some of the wooden houses, arguing that they were in bad condition and that the area is better suited for other, more prestigious purposes. In 2011, the residents of the wooden houses formed a local association and started to formally and collectively oppose the decisions of policy-makers. In 2015, the local partnership was formalised, allowing local actors and the city representatives to become co-managers of the place. Until today, 27 houses have been preserved – serving as residential units and headquarters of non-governmental organizations, but mainly as creative spaces for urban gardeners, beekeepers, artists, cooperatives and public institutions.

Our analysis shows that from the beginning, the local activists were aware of the importance of self-organization. Their **capacity for self-organization** was fully revealed in 2015, when the members of the local partnership managed to construct a network of horizontally and vertically connected organizations. The main areas of their activity were: education, environment and culture. The subjective sense of agency played an important role due to the fact that initiative was neither the owner nor the manager of the place. The lack of grassroots ownership is perceived as the main limitation of the association's potential. Its mode of coordination is more of an urban social movement than a local community, and access to the group is based on a sense of belonging and a **common understanding** of the positive social role of the wooden houses.

Despite the rather low initial diversity of community (the community was relatively small) it opened up and reached out to other associations and citizens in general. By highlighting the uniqueness of the place, activists have managed to build a common meaning of the area that is shared among wider group of citizens. They have stayed open to other initiatives and actors, which has resulted in the increase of diversity.

Now the place has a wide group of supporters and users, and a diverse socio-cultural offer, which attracts continuous attention. Case C also highlights that in a situation of

DOI: 10.3217/978-3-85125-668-0-20

distrust between local authorities and activists, there is a greater need for self-organization and that diversity can be acquired in the course of initiative's development.

4.4 Analysis of case studies

All three cases represent the potential of grassroots activism to introduce a positive change in the area of circular adaptive reuse. Interestingly, the most important driver of all the studied initiatives was the perceived threat of the community losing a place of a significant cultural or symbolic value. During the process, the threat was transformed into the potential not only to renovate, but also rebuild, recreate or inspire new socio-cultural activities in the previously neglected or underdeveloped sites.

Our analysis was based on rich qualitative data from in-depth interviews, documents and publications concerning the initiative as well as press articles and internet resources. While coding our material we applied the five dimensions of social sustainability as our main codes, developing new ones concerning circularity and sustainability whenever the basic ones were insufficient.

Table 1 summarizes the results of first order analysis, describing the presence and intensity of each factor in the given case. The measure of intensity was derived from a comparison between the cases themselves, as well as with other cases of local initiatives not presented here, but studied by one of the authors (see Domaradzka 2015, 2017, 2018). For example, we could see that the initial diversity of skills and actors involved in the adaptive reuse process was the highest in case B, smaller in case C (especially at the first stage), and lowest in case A, where a group of long-term rural residents coexisted with newcomers from a large city.

In terms of the capacity for learning, we found it high in all the studied locations, which may be key to understanding why the grassroots adaptive reuse was possible to implement. As a complex process of reimagining, redesigning and restructuring, the adaptive reuse projects required a high capacity to learn new skills, transfer knowledge between actors and apply it in practice. During our analysis we discovered several learning loops embedded in the project development and a high intensity of knowledge and skills exchange between the engaged actors.

Different and sometimes competing forms of common meaning were manifested in our three cases. In case B, the location in a garden-city with a long and well maintained history

DOI: 10.3217/978-3-85125-668-0-20

as well as a strong local identity, facilitated the emergence of common meaning around the site (perceived as a symbol of a ‘golden period’ in the history of the town). In case A, the common meaning varied depending on the group – it was slightly different for the well-rooted rural inhabitants and newcomers from the city. However, both groups perceived the cultural heritage as valuable and important (in itself or as means to economic development) which helped the mobilization around the initiative. In case C we could observe competing meaning between the local activist group (who valued the site for its uniqueness and genius loci) and the district authorities (who focused on the economic value of its prestigious location). The initial lack of agreement was overcome due to the strong social support that the initiative gathered and its dynamic development as a cultural services provider.

In analyzing trust we decided to discern in-group and out-group trust to describe its role in a more precise manner. We also defined three groups among which we could measure relations of (dis)trust: leaders of initiatives, citizens (other local residents), and local authority representatives. Based on the interviews conducted with all these three groups we could observe some level of distrust between local leaders and municipal authorities (apart from case B, where initial high trust was later replaced by distrust), while the relations between leaders and local community members were usually based on trust, which helped them to gain support and overcome initial barriers.

	Case A Ecomuseum	**Case B** Suburban Residence	**Case C** Metropolitan Activist Community
Diversity	low (small rural community with urban newcomers)	high (mixed suburban area with high middle class presence)	moderate (small local community, surrounded by several institutions & initiatives)
Capacity for learning	high	high	high
Common meaning	depends on the group – competing meanings	high	moderate – competing meanings
Trust*	L | \LA – low L | \C – moderate C | \LA – high	L | \LA – high L | \C – high C | \LA – moderate	L | \LA – low L | \C – high C | \LA – moderate
Capacity for self-organization	high for leaders; low for local community	high for leaders; moderate for local community	high and contagious – activation of other initiatives

* L – Leaders, C – Citizens, LA - Local authority

Table 5: *Meso level analysis according to social sustainability criteria*

DOI: 10.3217/978-3-85125-668-0-20

During our analysis we discovered that the concept of diversity is not sufficient to explain the circular potential of a grassroots community. Our interviewees recounted how their openness to cooperation, new ideas and other partners' modes of functioning, helped them create local partnerships for the sake of the project. Therefore we propose to widen the concept of grassroots circularity to include **openness** as an important factor supplementing diversity.

In the case of common meaning, we propose developing it to include **compatibility with circularity values** and sensitivity to the intrinsic value of cultural heritage. Finally, we underline the need to discern **in-group** and **out-group relations** when analyzing trust within the grassroots circularity model. As a result, we can propose a model of grassroots circularity evaluation, based on six criteria:

• **diversity** of skills and actors involved

• **openness** to experience and cooperation

• **capacity for learning**

• **common meaning** and compatibility with circularity values

• in-group and out-group **trust**

• **capacity for self-organization**

While during our analysis we focused on the initial and formative stage of the grassroots initiatives, we also evaluated their current state. As a result we can formulate the following reflections:

1) First, the issue of sustained trust is crucial for the long-term successful functioning of the studied sites. In two of our cases, trust was mainly built on interpersonal relations with the local mayor's office, which made them initially strong, but also fragile in the context of long-term political change. In the third case, where the initial distrust was overcome by a formal agreement, the situation remained relatively stable, and inspired the activists to develop different strategies to ensure continuity. In other words, strong ties and in-group trust between a grassroots initiative and decision makers can constitute both an opportunity and a threat. Openness of the initiatives' representatives (e.g. public actors, local association, private investor) to forming partnerships as well as building out-group trust agreements seems to be key in overcoming political change. This finding is especially

DOI: 10.3217/978-3-85125-668-0-20

relevant in the case of Polish society, which exhibits a low level of trust (see e.g. EVS, 2019); however, in a more general sense, it highlights the weaknesses of strong in-group ties, and underlines the potential of loose out-group ties.

2) The capacity for self-organization was high in all the studied cases, usually based on the activists' social skills and cultural capital. While a more diverse community often became engaged at the later stage, the initial group of activists often consisted of middle class professionals, some of them newcomers to the local community. Most of them had a history of earlier social engagement and had the capacity to mobilize their resources and support network to further the idea of adaptive reuse. The newcomer perspective also made them more open to change and innovative ideas, as well as unhindered by previous cooperation experiences.

5. Summary

When introducing circular solutions to built heritage investments, we often struggle to ensure sustainability and a positive social impact. While the notion of intrinsic value helps us understand why some places generate the spontaneous interest and mobilization of local communities, it would be valuable to understand the exact reasons why some circular projects are more successful than others. In this paper we propose widening the concept of circularity to include its grassroots aspect and to underline the potential of local communities to introduce change. The type of change we analysed here concerned adaptive reuse projects in the area of built cultural heritage. However, we assume that the discovered mechanism can also be applied to other areas of intervention, whenever new ideas are introduced and a top-down approach is not sufficient to solve local challenges.

The proposed grassroots circularity model is based on the well-developed concept of social sustainability. We consider the social sustainability concept to be a good starting point for analysing the conditions required to ensure the implementation of new ideas (like circularity) at the community level. The authors of the social sustainability concept point to five main factors without which sustainability cannot be achieved. Based on our case studies we adapted their model to allow for the evaluation of the grassroots circularity dimension.

DOI: 10.3217/978-3-85125-668-0-20

Based on the observation of three cases of adaptive reuse in the field of cultural heritage, we identified six crucial aspects building local potential to introduce changes in values and behaviours necessary for the successful implementation of innovative re-adaptation projects.

We believe that the concept of grassroots circularity allows us to widen the circular economy model to include the neglected bottom-up potential of local communities. In addition, our case analysis shows that each community has different strengths and weaknesses in terms of implementing new projects and sustainable circular solutions.

There always seem to be a driving force that makes it possible to mobilize local resources and relations for the sake of protecting, rescuing, redeveloping or upgrading buildings and landmarks. Following the work of the CLIC project and the intrinsic value concept developed by Fusco Girard et al. (2007) we point out the importance of the spontaneous value-attribution and place attachment present in all cases of grassroots circularity initiatives.

Funding

This work was supported by the European Commission in a framework of the project "CLIC – Circular models Leveraging Investments in Cultural heritage adaptive reuse project" [Grant Agreement number: 776758].

References

Berger, P.L., Luckmann, T., 1991. The social construction of reality: A treatise in the sociology of knowledge. Penguin Uk.

Bilewicz, A., Potkańska, D., 2013. Jak kie\lkuje spo\leczeństwo obywatelskie. Kooperatywy Spoż. W Polsce Jako Przyklad Nieformalnego Ruchu Spolecznego 25–44.

Bocken, N.M., de Pauw, I., Bakker, C., van der Grinten, B., 2016. Product design and business model strategies for a circular economy. J. Ind. Prod. Eng. 33, 308–320.

Bocken, N.M.P., Rana, P., Short, S.W., 2015. Value mapping for sustainable business thinking. J. Ind. Prod. Eng. 32, 67–81.

Brandsen, T., Cattacin, S., Evers, A., Zimmer, A., 2016. Social innovations in the urban context. Springer Open.

DOI: 10.3217/978-3-85125-668-0-20

Brundtland, G., Khalid, M., Agnelli, S., Al-Athel, S., Chidzero, B., Fadika, L., Hauff, V., Lang, I., Shijun, M., de Botero, M.M., 1987. Our common future.

Bruner, J., 1991. The narrative construction of reality. Crit. Inq. 18, 1–21.

Cacioppo, J.T., Hawkley, L.C., Rickett, E.M., Masi, C.M., 2005. Sociality, spirituality, and meaning making: Chicago health, aging, and social relations study. Rev. Gen. Psychol. 9, 143–155.

Colantonio, A., Dixon, T., Ganser, R., Carpenter, J., Ngombe, A., 2009. Measuring Socially Sustainable Urban Regeneration in Europe.

Domaradzka, A. 2015. Changing the rules of the game: Impact of the urban movement on public administration practices. In: Civil society and innovative public administration, Nomos, 188–217.

Domaradzka, A. 2017. Leveling the playfield: Urban movement in the strategic action field of urban policy in Poland. *City Unsilenced*. Routledge, 106–118.

Domaradzka, A. 2018. Urban social movements and the right to the city: An introduction to the special issue on urban mobilization. VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations, 29(4), 607–620.

Ehrenfeld, J.R., 2005. The roots of sustainability. MIT Sloan Manag. Rev. 46, 22–26.

Elkington, J., 1997. Cannibals with forks: the triple bottom line of twenty-first century business. Capstone. Oxford.

EVS, 2019. European Values Study 2017: Integrated Dataset (EVS 2017). GESIS Data Archive, Cologne. ZA7500 Data file Version 2.0.0, doi:10.4232/1.13314

Fitch, J.M., 1990. Historic preservation: curatorial management of the built world. The University Press of Virginia.

Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annu Rev Env. Resour 30, 441–473.

Girard, L. F., Cerreta, M., De Toro, P., & Forte, F. 2007. The human sustainable city: Values, approaches and evaluative tools. In *Sustainable Urban Development Volume 2*, Routledge, 70–98.

Fusco Girard, L., 2014. The role of cultural urban landscape towards a new urban economics: new structural assets for increasing economic productivity through hybrid processes. Hous. Policies Urban Econ. 1, 3–27.

Fusco Girard, L., 2013. Toward a smart sustainable development of port cities/areas: The role of the "Historic Urban Landscape" approach. Sustainability 5, 4329–4348.

Geissdoerfer, M., Savaget, P., Bocken, N.M., Hultink, E.J., 2017. The Circular Economy–A new sustainability paradigm? J. Clean. Prod. 143, 757–768.

Giddens, A., 1984. The constitution of society. Berkeley. CA: University of California Press.

DOI: 10.3217/978-3-85125-668-0-20

ISO 15392, 2008. Sustainability in Building Construction–General Principles. International Organization for Standarization, Geneva.

Johnston, P., Everard, M., Santillo, D., Robèrt, K.-H., 2007. Reclaiming the definition of sustainability. Environ. Sci. Pollut. Res. Int. 14, 60–66.

Lane, D.A., 2016. Innovation cascades: artefacts, organization and attributions. Philos. Trans. R. Soc. B Biol. Sci. 371, 20150194.

Lane, D.A., Maxfield, R.R., 2005. Ontological uncertainty and innovation. J. Evol. Econ. 15, 3–50.

Levin, S.A., 1998. Ecosystems and the biosphere as complex adaptive systems. Ecosystems 1, 431–436.

Marsden, G., Kimble, M., Nellthorp, J., Kelly, C., 2010. Sustainability assessment: the definition deficit. Int. J. Sustain. Transp. 4, 189–211.

McMichael, A.J., Butler, C.D., Folke, C., 2003. New visions for addressing sustainability. Science 302, 1919–1920.

Missimer, M., Robèrt, K.-H., Broman, G., 2017. A strategic approach to social sustainability–Part 1: exploring the social system. J. Clean. Prod. 140, 32–41.

Norberg, J., Cumming, G., 2008. Complexity theory for a sustainable future. Columbia University Press.

Ostrom, E., 2009. Understanding institutional diversity. Princeton university press.

Roszczynska-Kurasinska, M., Kacprzyk, M., 2013. The Dynamics of Trust from the Perspective of a Trust Game, in: Complex Human Dynamics. Springer, pp. 191–207.

Schank, R.C., Berman, T.R., Macpherson, K.A., 1999. Learning by doing. Instr.-Des. Theor. Models New Paradigm Instr. Theory 2, 161–181.

Scheffer, M., Carpenter, S., Foley, J.A., Folke, C., Walker, B., 2001. Catastrophic shifts in ecosystems. Nature 413, 591.

Stahel, W.R., 2016. The circular economy. Nat. News 531, 435.

Stahel, W.R., 2008. The performance economy: business models for the functional service economy, in: Handbook of Performability Engineering. Springer, pp. 127–138.

Stindt, D., Sahamie, R., 2014. Review of research on closed loop supply chain management in the process industry. Flex. Serv. Manuf. J. 26, 268–293.

Webster, K., 2017. The circular economy: A wealth of flows. Ellen MacArthur Foundation Publishing.

Wells, P., Seitz, M., 2005. Business models and closed-loop supply chains: a typology. Supply Chain Manag. Int. J. 10, 249–251.

Yung, E.H., Chan, E.H., 2012. Implementation challenges to the adaptive reuse of heritage buildings: Towards the goals of sustainable, low carbon cities. Habitat Int. 36, 352–361.

Lisa SCHÜTTLER, Dawid KASPROWICZ, G. GRAMELSBERGER
DOI: 10.3217/978-3-85125-668-0-21

Computational Science Studies | A Tool-Based Methodology for Studying Code

Lisa SCHÜTTLER, Dawid KASPROWICZ, G. GRAMELSBERGER
Theory of Science and Technology, RWTH Aachen University, Germany

Abstract

The practice of programming has become a key qualification for scientific research. However, from a STS point of view, general methodologies to access the program code and its semantics are still lacking. We present a new methodological approach called "Computational Science Studies" (CSS). Our main argument is that to get access to the program code on a semantic level, the code has to be considered as a research object. This can be done with software tools that help us to analyse the semantics in the program code. Therefore, we present a software tool, called the Isomorphic Comment Extractor (ICE),[1] to excavate the semantic content by analysing the comments of the code and its data structures. Taking the program code of a geological research project as an example, we argue that the programming practices shape research objects and embody the transition of empirical data into simulations of computational models. Hence, we first introduce the methodology of CSS and then discuss some methodological approaches from the field of Code Studies that have already dealt with computer code as a research object. Then we present the ICE in our geological case study and finally we argue why new software tools in STS are necessary to analyse the impact of computer-driven scientific knowledge.

1. We thank very much Lukas Böhres and Frederic Kerksieck for programming and co-conceptualizing the ICE-Tool.

Lisa SCHÜTTLER, Dawid KASPROWICZ, G. GRAMELSBERGER
DOI: 10.3217/978-3-85125-668-0-21

1 Introduction: Computational Science Studies

In the last twenty years, the research on computer code witnessed an increasing interest from humanities' scholars. With the generally acclaimed importance of algorithms and the impact of computerized models and simulations on scientific expertise, code became an important research object regarding the digitalization of science. This also includes the digitalization of scientific objects in the humanities like manuscripts or fragments, leading to new methods and epistemologies that resulted in the foundation of new disciplines like the Digital Humanities (see for an overview of this process, Jones 2016). However, for sciences like Particle Physics or Climate Sciences, where scientific objects are no longer directly observable, programming turned out to become an essential part of scientific research and study (Gramelsberger 2010 & 2011). Surprisingly, a clear methodology how to approach code as a research object has not been worked out yet. We therefore introduce a new methodological approach called Computational Science Studies (CSS). CSS can be considered as a sub-discipline of Science Studies. It focuses on the computerization of scientific disciplines with an emphasis on the practices of programming. It is thus related to STS as well as to Philosophy of Science and to the Social Studies of Science. Our main argument is that with the growing importance of programming practices, instruments become necessary to examine this hidden level of scientific knowledge production. Since most of the program codes are opaque and written by more than one person, STS scholars without an education in computer science won't have the code literacy needed to understand them. Hence, one goal of CSS is to develop software tools that concede STS scholars and other scientists a semantic access to the code. This can be done either by focusing on the temporal dimensions in coding (e.g. syntactic orders like or by the structure and the content of the comments (semantic level of code). In what follows, we will concentrate on the written comments although we are well aware of the fact that programmers often do not comment at all (Gramelsberger 2010). However, since an external observer barely understands the written lines, it has been our goal to extract and visualize the comments to generate a first overview. Comments can be short annotations to explain something in the code or point to a bug but they can also reveal a deeper issue of the research project. That is why one leading question of the CSS and this article will be: How can we use tools that help us to understand the genealogy of research objects within the code?

Thus, we developed a software tool specialized on the extraction of comments and the visualization of data structures, the so called Isomorphic Comment Extractor (ICE). With this tool, STS scholars are able to trace content and meaning with the help of the comments within a code project. This simple procedure helps to analyse the composition of the code as well as to detect refinements, corrections or the integration of new libraries that would otherwise be ignored in the analysis of scientific knowledge production. We present the ICE in section 4 and exemplify it in our case study from the field of geology in section 5. Using the ICE, we show the diverse functions and semantics of comments and how a navigation through these comments can hint to some critical aspects of 3D-model-building in geology. But before we start with the case study, we have to elaborate further on the field of Code Studies. Since CSS is a methodological approach based on Code Studies, we will first explain the core idea of this approach on Computational Sciences from a Philosophy of Science perspective in section 2. In section 3, we discuss three variations of code studies (ethnographic codes studies, software studies and critical code studies) and compare them with our methodology on computer-driven sciences. In the conclusion, we discuss the results of our case study and point to restrictions and further research questions of our CSS methodology.

2 What are Code Studies?

In a general sense, Code Studies gather together different fields from (mostly) the humanities which explore the role of computer code for economic, social, political and scientific processes, the aesthetics of code as well as the different practices of coding (individual or collaborative coding, e.g., see Strathern 2005). Hence, Code Studies are not systematically coherent, which might be the reason for their lack of a common methodology. Instead, they focus on the practice of computer programming and its significance for the impact of software, which can be described as follows: “Programming languages are the medium of expression in the art of computer programming” (Mitchell 2002, 3). Letting aside the question whether programming computers is an art or a handicraft, programming languages as a medium entail a syntax and certain semantics that are written in the numerous lines of code. Scholars from Code Studies like David M. Berry see in the code the “literary side” of the programming practice that has a “real code” and an “absolute code”. While the first one is fragile and highly contingent, due to the particularity of single solutions, the second one aims at “thinking in terms of both the

DOI: 10.3217/978-3-85125-668-0-21

grammar of code itself, but also trying to capture how programmers think algorithmically, or better, computationally" (Berry 2015, 33). This relation between the "grammar of code" and the ways programmers are thinking through and with their programming languages is essential and we will come back to this later. Another definition of Code Studies highlights the aspect of performativity. Computational processes depend on a logic system with statements such as "*if* something, *then* something else". This turns the code to a two-fold object that describes future events and sets the instructions to execute a specific task (which is mainly the point where algorithms come into play) (Cox and McLean 2013, 41). In other words: The description of the algorithm and prediction of the event are both entangled in the lines of code so that "it [the code, L.S. & D.K.] can be history but intervening in the very process of history" (Cox and McLean 2013, 42). This two-fold logic of doing history and being part of a (research) history makes it hard to distinguish functional practices (to make the history work) from scientific practices in coding (writing the history of the research object).

What is so special for Code Studies is the claim that through code as a medium, the research object is generated and observed at the same time. This does not refer to a constructivist point of view. Moreover, it shows a new temporal regime in which the computational data is controlled by code and processed as scientific data in computational time. Hence, one can argue with the philosopher Sabina Leonelli that we have first to distinguish a time of data maintenance and construction and second a time of the "phenomena under investigation" (Leonelli 2018, 742-743). This distinction is important since it shows how any scientific value – either true/false or valid/non-valid – depends on this new temporality of data embedded in the medium of code. Parting from the idea of Code Studies, the CSS look for ways how to reflect these new temporal data regimes that highly depend on the media in which they are processed - whether this is a computational model of a physical phenomenon or a visualized model of an unknown, anticipated behaviour (e.g. the spread of an infection in a region over a certain time). Tools like the ICE help to understand the dynamics in these relational structures of data between code, database and the visualization on the interface. Of course, to extract comments out of the code is not new and it also might not always lead to new insights. Nevertheless, especially in collaborative coding we can use any programming editor to get an overview about the justifications why some programmer has chosen one kind of algorithm and not the other

DOI: 10.3217/978-3-85125-668-0-21

for a certain problem. Also, we find debugging processes where the computational model did not work or where an important decision has been made so that a documentation of the code modifications is needed.

Thus, taking this into account, Code Studies can be described as a loosely coupled field of disciplines that explore the temporal (syntax) and structural (comments, merging of versions in Version Control Systems[1]) dimensions of coding practices. We argue that these dimensions have become increasingly influential in the production of scientific knowledge. However, in all these cases, the reason why and how these "interventions in the very process of history" have taken place might be difficult to understand for a STS scholar who is neither a part of the scientific group nor one of the programmers. This makes the question of an adequate methodological approach so necessary but at the same time so demanding when it comes to the exploration of the computer code as a research object. Our tool is here just one first step based on the argument that we have to examine the dynamics of programming to know how computational sciences are shaping their research objects. In this emphasis on coding, CSS relates to preceding approaches of Code Studies that we would like to present now to highlight the similarities and differences between them and our methodology.

3 Approaches in the Field of Code Studies

3.1 Ethnographic Code Studies

In the last 15-20 years, several approaches have been developed that try to grasp the technical, ontological but also the ideological dimension of computer code (see for this three-fold problem Chun 2004 & 2011). For our question how computer code could be examined in the context of STS, we looked at three of them. The first, Ethnographic Code Studies (ECS), focuses on the modelling practices in scientific communities. ECS describe

1. "Version control is a system that records changes to a file or set of files over time so that you can recall specific versions later." (Chacon and Straub, 2014, 9) From the developer's perspective, this feature is especially helpful for collaborations, as each collaborator can (simultaneously) work on their own local copy and they update their changes in the shared repository, which then distributes this changes to all the other local copies. From the Code Studies perspective, this presents us with the opportunity to access many projects and their developmental stages without the need for a personal connection to the developing team.

DOI: 10.3217/978-3-85125-668-0-21

the methodological change in the sciences from the experiment to complex models – like in Climate Sciences – that are run via simulations. To do that, it is important to know how the scientific objects have been shaped during the modelling process. For example, the Social Studies of Science scholar Mikaela Sundberg described the development of a meteorological model and its genealogy, going from the field experiments to the modelling process that has taken place in the research group (Sundberg 2009).[1] To have better models means in this case to have a simulation running that produces more precise weather forecasts. This means that data from the field has to be integrated into the theoretical weather models, which means to decide what parameters are most important for the computational model. As Sundberg explains:

"Predictive construction involves the application of existing scientific knowledge to develop new parametrizations. At the weather service, there is a division of labor in this process between researchers and programmers. Researchers transform equations into code or more often make changes directly in the code. But this coding is generally preliminary. Programmers continue where the researchers leave off and develop the code in ways that enable the simulation model to use computer power more efficient but do not change the basic operations that the code executes" (2009, 169).

This cooperation of researchers and programmers for the development of simulation models is the main focus for ECS. On the one hand, this allows – like in the quote – to analyse the transformation of theories and models into the lines of code. On the other hand, Sundberg points out later in the text that it is never the code that becomes important for the scientists but the graphical and numerical outcome of the simulated models. She

1. Computational Models in Climate Sciences are peculiar because they are also widely discussed in the philosophy of science due to their impact on the relation of theory and experiment (Heymann, Gramelsberger and Mahony 2017; Winsberg and Goodwin 2016). These models have two special characteristics: First, the number of parameters (how many parameters, how long is the runtime of the simulation etc.) has to be scaled down to the very necessary factors for the simulation. This necessitates efficient use of the computer resources. The second point is that climate models are based on non-linear equations which cannot be solved analytically but have to be calculated discretely, from one time-point to another, which requires a huge amount of calculation power. Therefore, especially computer models in Climate Sciences are paradigmatic for a new balance between a theoretical claim to be proved and the practice of modelling. As Sundberg explains: "However, there is no algorithm for reading of models from theories. Therefore, theories function as constraints and not as determinants in the process of simulation model construction" (2009, 163).

also calls the code, in reference to Bruno Latour's "immutable mobiles", the "mutable mobile", a dynamic inscription hidden behind the visualized layers but indispensable for the identity of the simulation model and the reproducibility (and therefore mobility) of the scientific predictions (Sundberg 2009, 173 & 175). Hence, what Sundberg lays open are the fragilities of the simulated computational models due to the mutability and modifiability of computer code. But both in the work of the scientists as well as in the journal publications the code is considered as something "secondary" (Sundberg 2009, 172). Thus, it is still one of the open questions in ECR how to trace these changes of the model in the code and to analyse their impact *before* they become a condensed visual result of the simulation. Thus, the switches from researchers to programmers, as described in the quote, might not only have an organizational and technical impact but also a scientific one.[1] To analyse that, one would have to go into the structure of the computer code itself and look for syntactic and semantic indicators.

3.2 Software Studies

A wider perspective on the phenomenon of code has been taken by the interdisciplinary field of Software Studies. Software studies include scholars from media and cultural studies, sociology, computer science, and engineering. Since the 2000s their publications have dealt with the technical impact, the media history and the political power lying behind the everyday use of software (see as early examples Manovich 2001 and Fuller 2003). Thus, for Software Studies, programming languages are a key-element not only to trace the transformations of analog objects into the digital world, but also to take into account the moral and ideological implications that are associated with the use of software (Fuller 2008). In this sense, programming always entails a certain mode of seeing the world, a mode that anticipates its users. As the Software Studies scholar Adrian Mackenzie writes: "Knowledge, truth, speculation and prediction are practically re-configured through programming and coding" (Mackenzie 2013, 329). This view on software as a way of subjectivity became more and more dominant in the last years. The increase of platforms

1. In her ethnographic study about a group of meteorologists, Mikaela Sundberg describes how the code becomes part of a centre collective in the sense that the whoever enters the scientific organization also enters the code until he leaves and loses the access to work with the code (Sundberg 2010, 50). Such strict organizational models around code work are of great importance and they could be combined with tools like the ICE to examine the scientific work done in the code.

DOI: 10.3217/978-3-85125-668-0-21

and online-connected things has led to another emphasis on the code as the element that always mediates but never appears on your bill or your medical health card – something always hidden behind “Coded Assemblages” (Kitchin and Dodge 2011, 7).[1] However, although most of Software Studies approaches emphasize the importance of the code as more than just another technological tool, they rarely go into the code itself to show how (and particularly *when*) the valuing aspects of programming come into play. There are two reasons for that. First, looking into the code of private companies is almost impossible (and they are often the target of critical Software Studies, see for example Rossiter 2016). Second, the code is not treated as a research object but as part of a bigger cultural impact which relates to our everyday usage of software – or, to quote from the title of another of Manovich’s books: “Software Takes Command” (Manovich 2013). Although it is important to emphasize the macrocultural context of software production and distribution, a deeper code analysis is still secondary for most of the contributions to software studies. However, scholars like Adrian Mackenzie have shown how the changing practices of coding (Mackenzie 2017), like the increase of Version Control Systems, libraries, and platforms for coding issues such as Stack Overflow[2], transformed significantly the relation of pure and applied sciences in the age of Machine Learning. Our methodology of CSS tries to develop tools to lay open these connections between changing coding practices and data visualizations, between the performance of the machine and the standardised procedures of knowledge production. Here also, a combination of software studies and the CSS methodology would be an option for the reflection of this double-sided nature of code as written history and writing practice that intervenes in the process of history.

1. Kitchin and Dodge refer especially to the complexification of code through developments like the Internet of Things and other so called smart applications. Moreover, the problem of an opaque computer code is also crucial for the analyses of machine learning as an instrument in science. Adrian Mackenzie even argues for a differentiation between “writing” and “growing” programming languages due to the increase of open source programming, data software packages and further attachments like libraries. Hence, although “machine learning utterly depends on code”, it would be insufficient just to focus on code to explain the use of machine learning in science (Mackenzie 2017, 22-23). Instead, Mackenzie calls for a hybrid methodology connecting code studies, ethnography, diagrammatic reasoning, media archaeology and history of statistics.

2. Stack Overflow is a web-based platform for requests about code writing for private and business programmers. It was developed in 2008 and runs since then under the Creative Common Licence.

DOI: 10.3217/978-3-85125-668-0-21

3.3 Critical Code Studies

The third way of developing a method for the analysis of code has resulted out of the Software Studies movement in 2006 (Montfort et al. 2013, 6), the so called Critical Code Studies (CCS). In the words of one of their founders, the humanities scholar Mark C. Marino, Critical Code Studies "takes for its milieu the code layer of Software Studies […]. Rather than examining source code to the exclusion of these other aspects of technology […], CCS emphasizes the code layer in response to a lack of critical methodologies and vocabulary for exploring code through this cultural lens" (Marino 2014). One way of filling this methodological gap is to explore the "heteronormativity of code" in an experimental way (Blas 2008 after Marino 2014), which has often been done with methods from artistic research. The main goal here is to play with and through the practice of programming and to offer a new look at programming that is not uniquely bound to its functional involvement in software engineering. Thus, code is considered to be an aesthetic object that has also to be explored by artists. Although there has been an increase in the humanities' methods to read code closely, it also became clear that only focusing on code would be too restricted. Hence, Software Studies as well as Critical Code Studies do not represent fields with a certain restricted or fixed methodological approach, but they entangle the analysis of code with interviews, media histories, archive work and artworks (Montfort et al. 2013, 7). This could also be a model for the methodology of CSS since the scientific practices can't be reduced to programming. In contrast, the steps between data gathering, theory and model building, coding and simulation resemble more interwoven cascades than linear work-flows. To show how these dynamics are processed, revised and inscribed again to shape the research object, most analyses lack a new level of reflection. That is why we argue that the CSS methodology depends on software tools that help us to draw the connections between the interventions in the code and the dynamics of computational model-building and its simulations. It is also here where the CSS distincts strongly from the Critical Code Studies and other Software Studies in focusing on scientific processes.

4 What can Computational Science Studies Offer?

These three examples of Code Studies show how important the impact of programming has become – not only for programming software but also for the genealogy of scientific objects. If we take the phrase by Adrian Mackenzie, that "[k]nowledge, truth, speculation

Lisa SCHÜTTLER, Dawid KASPROWICZ, G. GRAMELSBERGER
DOI: 10.3217/978-3-85125-668-0-21

and prediction" are reconfigured through coding, then we have to ask again how to approach code more specifically. What remains problematic in all three examples is that the notion of code has been considered as a neutral tool - in other words, a tool that does not affect the practices of valuing and knowing which influence each other in scientific practice. So first, if we look at code as a research object for STS and Philosophy of Science, we have to make sure how the correlation of valuing and knowing as a scientific practice is expanded through programming. That means also that writing code is influenced by programming languages and the way these languages restrict or expand the scientific ideas that have to be implemented in the code. This can lead to the genealogy of scientific objects but also to tensions between the scientific model and its transformation into code. In-between model building and data visualisation, the practice of programming – and not the ontology of software, as so long claimed by Software Studies – becomes crucial. However, to look more closely at code as an empirical object without being an expert in programming can become difficult. That is why for our approach of CSS, the development of tools to do research in and with the code is fundamental for the study of computerized sciences.

In 2018, we founded the CSS Lab for this purpose where we intend to establish an open science infrastructure for Computational Science Studies in order to facilitate the scientific analysis of code. In the Lab, we are currently developing software tools designed to support STS scholars and other scientists in their case studies on code projects. The tools open up new elements of code analysis by helping to visualize software structures, supporting code genealogies and code comparisons, and allowing for an analysis of the scientific content of software projects (such as scientific models, scientific data analysis algorithms, and measurement procedures). The last of these, in particular, is an entirely new demand resulting from the requirements of conducting Computational Science Studies.

The Isomorphic Comment Extractor (ICE)[1] is the first of our CSS Tools and visualizes comments within the code for the most common programming languages such as Python, C/C++, Fortran, etc. The interface provides a special environment which is easy to use if

1. The ICE can be found on our website: https://www.css-lab.rwth-aachen.de/tools/overview [Accessed 16 September 2019].

DOI: 10.3217/978-3-85125-668-0-21

you are not familiar with software projects (see Fig. 75). It is rooted in the isomorphic basis of all our tools, which represents and depicts the file structure of a software project in isomorphic form. In comments, there may be links to scientific papers on which the code is founded, documentation about ownership and other legal aspects, general hints on how to use the code, explanations about what the code should do, indications of problems that still need to be solved or other aspects related to the genesis of the code. So while not every software project is well documented through comments, it is still a reasonable endeavour to start any analysis by looking for the comments since that is the main location for background information on the code.

5 Case Study: Comments in GemPy's geophysics.py

5.1 The Project GemPy: Modelling of Geological Structures

One main aspect of geological research is "understanding and visualizing how rocks are organized below the Earth surface, both for practical reasons and out of scientific curiosity to understand the world below our feet." (Wellmann and Caumon 2019, 4) In recent years, the visualisation of geological structures is not only done in two-dimensional maps but has been extended to three-dimensional computer models of different types of geological layers. Since real-world measurements are sparse, one important aspect of geological modelling is to combine all existing data points as well as theories of geological events, changes, and concepts into one model.

Various tools, mostly commercial products, exist for the modelling of geological structures. One of them is the software GemPy (de la Varga and Wellmann 2019) which is an open-source project developed in Python by the Chair of Computational Geosciences and Reservoir Engineering at RWTH Aachen University, led by Prof. Florian Wellmann, who kindly allowed us to use their software as a case study for this paper.[1] The output of GemPy are malleable 3D models such as the one you can see in Fig. 74. The different colours represent different types of geological layers.

1. We are looking at GemPy version 1.16, which was released on May 1st, 2019. Since then, the project has been revised and completely redesigned for version 2.0. The version used for this article can be found at *https://github.com/cgre-aachen/gempy/releases/tag/v1.16* [Accessed 16 September 2019].

DOI: 10.3217/978-3-85125-668-0-21

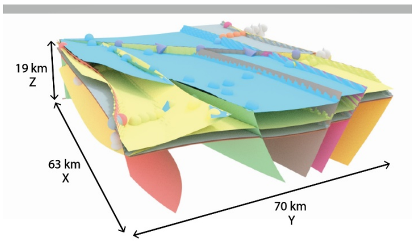


Fig. 74: *Example of a geological model generated with GemPy (de la Varga and Wellmann 2019).*

5.2 Studying Geological Modelling with the ICE

In the following, we will showcase the three main functions of the ICE, followed by an exemplary analysis of one part of GemPy. This analysis exemplifies the relation of model building and comment structure. In order to use the ICE, one needs to have a local copy of the project one is interested in. With GemPy, as with many others of today's software projects, this does not pose a problem, since the code is an open-source project and available for download on GitHub[1]. For starting the analysis, one has then simply to select the local directory of the code.

The main view in the ICE is divided into three parts that represent the main functions (see Fig. 75). The first aspect, which is directly visible after loading a project, is the graphical analysis of the data structure in the upper left corner. The tree structure shows grey boxes representing directories, whereas the coloured squares symbol single code files. The different programming languages are depicted in different colours. In well-maintained software projects, the file structure should give a first overview on the different functionalities of the project because files with similar functions are grouped together in a directory. In object-oriented[2] software projects, each file directly represents one object, i.e. one functionality, which should help even more for identifying the purposes of the different parts of a project. Therefore, a careful look at this structure can be beneficial for understanding the project. With the ICE, this is facilitated by the possibilities to zoom in on the tree and to showcase different branches.

1. GitHub is a host for Git repositories which are part of version control systems.

2. The concept of object-oriented programing "combines data abstraction and inheritance. The central feature is the object [… which] comprises a data structure definition and its defined procedures in a single structure" (Butterfield and Ngondi 2016, 377).

Lisa SCHÜTTLER, Dawid KASPROWICZ, G. GRAMELSBERGER
DOI: 10.3217/978-3-85125-668-0-21

If one of the files in the data structure is selected by a click, the second section in the column on the right side will show all the comments from the selected file. If the project is well maintained, this can provide a good overview on what this file in particular is supposed to do. Especially helpful for this objective are the comments at the beginning of a file, which are usually more of a general nature. They describe the overall purpose of the file as well as general comments with a link to a reference, e.g. a scientific paper. But even if it is not well maintained, it is still possible to infer useful information from the comments: programmers often indicate aspects that do not (yet) work as they should or point out features that are still on the to-do list. If the project is not in a final version, these kinds of comments are vital tools for communication within the team of programmers (they are also fundamental for remembering different aspects if one programmer works alone) and the language used can sometimes be colloquial and/or explicit.

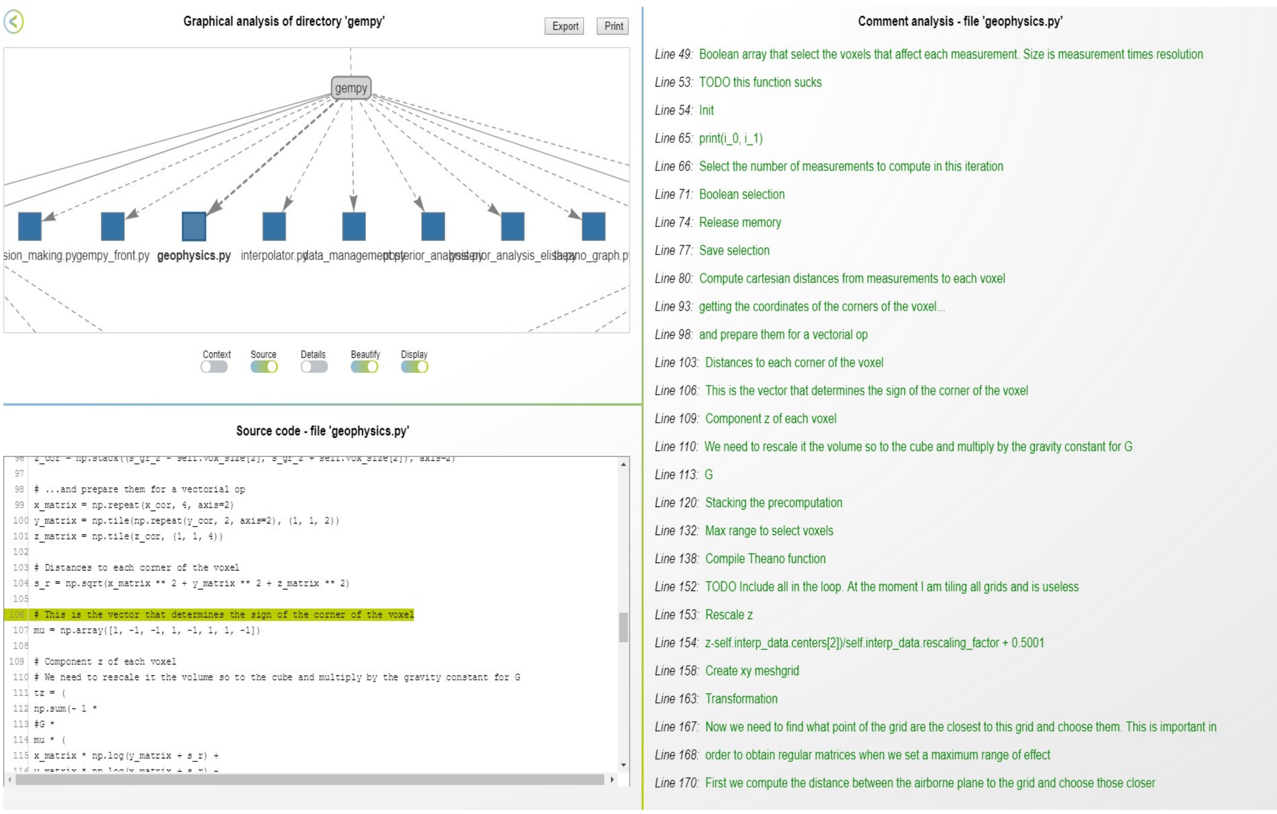


Fig. 75: *Main view in the ICE, exemplified on the GemPy file geophysics.py (authors' illustration).*

The third aspect of the main view in the ICE is the section in the lower left corner. It shows the source code from your selected file. By clicking on one of the comments in the comment analysis section on the right side, one can then add another layer of information: the comment clicked on will be highlighted in the centre of the source code section. This is

DOI: 10.3217/978-3-85125-668-0-21

especially helpful if it is of interest what happens in the direct environment of a comment because comments often introduce the next few steps that will be executed in the code or explain the details of a specific variable. Or, as explained before, they indicate problematic features which can also indicate areas of interest for the STS researcher. It might be also useful in case that there is a paper on the conceptual ideas behind a project and one wants to compare the code with the paper. In this case, it is necessary to see not only the comments but also the specific equations in the code in order to compare them.

When using the ICE with GemPy, one can see a number of Python files (indicated in dark blue) in the project directory and some sub-directories that themselves bear more Python files. This indicates that the files of interest for understanding the geology behind the project are probably in the main directory, since all the names of the sub-directories suggest that they contain auxiliary functions (as they are called “plotting”, “add-ons”, and “utils”).

Looking at the files in the GemPy directory, the file name geophysics.py leaps to the eye, so we choose this file for the starting point of our analysis. The class name “GravityPreprocessing(object)” already hints at a possible functionality of this file, namely the calculation of the influence of gravity on some given object. By reading the comments, we can confirm that the influence of gravity is indeed calculated in this file, since there are comments indicating that a block of code is supposed to do exactly that. We can also infer that this file seems to be responsible for calculating distances and other relational aspects between the measurements and the voxels[1] of an object in the geological model. Since real-world measurements are sparse, the interpolation of those measurements is an important step in the model generation. It simulates the data for the areas in between the geological measurement points. Furthermore, the comments show some aspects that are work-in-progress, as there are comments including “TODO”, one of the main indicators for further work which automatically gets highlighted in many editors used for programming. These work-in-progress comments show a less formal writing style and are not as refined as some of the others. They seem to be meant as reminders for the programming team and not so much as a documentation for outsiders. For example, this difference can be seen in the comparison between line 152 “TODO Include all in the loop. At the moment I am tiling all grids and is useless” and line 106 “This is the vector that determines the sign

1. A voxel is the 3D equivalent of a 2D pixel, i.e. the representation of one value in a grid.

of the corner of the voxel". The first is an example for an informal comment that is not meant for the general public. It seems rashly written and has a slip in grammar. The second one on the other hand is a very descriptive comment on the calculation in the line following it. That is a very common type of comment used for the documentation of a project for people not involved in the programming.

Even though this was just a first glance at a complex project, this analysis of the comments already clarifies many things. The comments reveal the purpose of the file and they bring out (some of) the steps taken to achieve this aim. Furthermore, it is possible to infer the state of development in which the file currently is in. The comments open up a temporal dimension in the code, as they sometimes refer to the point of their creation, sometimes to the future in which a programmer is supposed to work on some aspect, and sometimes to the present of the reader understanding the sequence of the program.

5.3 Benefits from Using the ICE

In contrast to code analysis tools aimed at software programmers which also allow for highlighting of comments, the ICE is easy to navigate and understand even if one is unfamiliar with the peculiarities of programming languages or the structure of software projects. This is especially facilitated by the combination of file structure navigation and the highlighting of comments. The user becomes able to detect hierarchies and connections between the different parts of the project which in comparison to the other forms of Code Studies creates an additional value since it provides a deeper access to the code itself. Even though no contact to the developing team is needed, the researcher can still trace (some) of the interactions through comments (especially with comments that include a "to do"-memo or the authorship of a file). Furthermore, comments can also provide an indication for the intention behind the code (e.g. an explanation which specific problem a certain piece of code is supposed to solve). An analysis of these kinds of comments can make explicit where the programmer has interpreted a scientific idea. In some cases, this can even be extended by showing interconnections between scientific papers, theories, or ideas and their implementations in the code. While the ICE can be used as a stand-alone application as shown here, it is meant to be one of many aspects of a full analysis of a software project. Of course, any analysis that depends on the code as the central textual basis operates under the assumption that the project is well-maintained. Our tools as well as methods from other forms of code studies are envisioned to supplement many different angles from which the analysis of a software project may be fruitful. This also includes established visual forms of knowledge representation like graphs, flow charts, or diagrams. But they all should not supersede an intensive examination of the code by the STS researcher.

6 Discussion

In this paper, we presented a new perspective on Science Studies and Code Studies. We claim that with the increasing impact of computation in science, the practice of programming becomes crucial for the analyses and interpretation of Computational Sciences. Hence, our methodology called Computational Science Studies stresses the point that coding is opaque and mostly written in collaboration. This demands for a new approach that enables STS and other Studies of Science to examine the transformation of empirical objects and scientific models into code. In following positions from Code Studies, we distinguished the syntactical and semantic dimension of programming languages. We emphasized the two-fold logic of coding in doing research history and being part of a research history which is important for the constructive but not constructivist character of computational sciences. To confine our approach more precisely which stems from a philosophy of science perspective, we presented the basic ideas of Ethnographic Code Studies, Software Studies and Critical Codes Studies and compared them with our methodology. We concluded that it is urgent not only to determine the heterogeneous impacts of writing software or the ontology of the code but to develop software tools that concede an access to the functional, organizational and scientific levels of programming. One such tool has been presented in this paper – the Isomorphic Comment Extractor.

In our case study from computational model building in geology, we examined the multiple functions of comments in the practice of programming. Thus, the semantic level of comments embodied functional, organizational and scientific contents around the issue of calculating in-between spaces of geological models. These models are based on measurements of different geological layers, but what they lack are empirical data about the space in-between the measuring points. Consequently, it is this space that has to be simulated and written down in code. Analysing the comments and the data structure with the ICE revealed the points in the project in which the simulated data points were incorporated through the code.

Tools like the ICE offer another point of view to this hidden layer of scientific knowledge production. However, such tools are only one possible way of looking at techniques of knowledge production. Another would be to take the graphs, diagrams or flow-charts into account and to compare their function for the representation and construction of knowledge with the analysis from tools like ICE. Therefore, the ICE is only one possible way to approach the structure of code and it could be complemented with visual tools, leading to what Karin Knorr-Cetina called a “viscourse” (Knorr Cetina 2001, 307), a visualization of knowledge embedded in an ongoing scientific discourse. Hence, the ICE is just a beginning for a tool-based methodology of CSS and not every scientific code offers the quantity and diversity of comments that is adequate to use the ICE as an analytic tool. However, in further research, the comparison of program codes of scientific projects could provide new insights. In particular, a first scheme of semantic code layers with their specific comments would ease the way how to use code as research object in the philosophical and social studies of science.

References

Berry, David M. (2015): The Philosophy of Software. Code and Mediation in the Digital Age. New York.

Butterfield, A. and Ngondi, G. (2016): A Dictionary of Computer Science. 7th ed. Oxford.

Chacon, Scott; Straub, Ben (2014): Pro Git. 2nd ed. Berkeley, CA.

Chun, Wendy H.K. (2004): On Software, or the Persistence of Visual Knowledge. In Grey Room 18 (4), pp. 26-51.

Chun, Wendy H.K. (2011): Programmed Vision. Software and Memory. Cambridge, MA.

Cox, Geoff; McLean, Christopher A. (2013): Speaking Code. Coding as aesthetic and political expression. Cambridge, MA.

de la Varga, M. and Wellmann, F. (2019): cgre-aachen/gempy. [online] https://github.com/cgre-aachen/gempy [Accessed 22 May 2019].

Fuller, Matthew (2003): Behind the Blip. Essays on the Culture of Software. New York.

Fuller, Matthew (2008): Software Studies. A Lexicon. Cambridge, MA.

Gramelsberger, Gabriele (2010): Computerexperimente. Zum Wandel der Wissenschaft im Zeitalter des Computers. Bielefeld.

Gramelsberger, Gabriele (2011): What do numerical models really represent? In Studies in History and Philosophy of Science 42 (2), pp. 296-302. DOI: 10.1016/j.shpsa.2010.11.037

Heymann, Matthias; Gramelsberger, Gabriele; Mahony, Martin (2017): Key Characteristics of Cultures of Prediction. Heymann, Matthias; Gramelsberger, Gabriele; Mahony, Martin (Eds.): Cultures of Prediction in Atmospheric and Climate Science. London, pp. 18-42.

Jones, Steve E. (2016): Emergence of the Digital Humanities (as the Network Is Everything). Gold, Matthew K.; Klein, Lauren F. (Eds.): Debates in the Digital Humanities 2016. Minneapolis and London. [online] https://dhdebates.gc.cuny.edu/read/65be1a40-6473-4d9e-ba75-6380e5a72138/section/09efe573-98e0-4a10-aaa3-e4b222d018fe#ch01 [Accessed 12 September 2019],

Kitchin, Rob; Dodge, Martin (2011): Code/Space. Software Everyday Life. Cambridge, MA.

Knorr-Cetina, Karin (2001): “Viskurse” der Physik: Wie visuelle Darstellungen ein Wissenschaftsgebiet ordnen. Heintz, Bettina; Huber, Jörg (Eds.): Mit dem Auge denken. Strategien der Sichtbarmachung in wissenschaftlichen virtuellen Welten. Wien and New York, pp. 305-320.

Leonelli, Sabina (2018): The Time of Data: Timescales of Data Use in the Life Sciences. In Philosophy of Science 85, pp. 741-754.

Mackenzie, Adrian (2013): Programming Subjects in the Regime of Anticipation: Software Studies and Subjectivity. In Subjectivity 6, pp. 391-405.

Mackenzie, Adrian (2017): Machine Learners. Archaeology of a Data Practice. Cambridge, MA.

Manovich, Lev (2001): The Language of New Media. Cambridge, MA.

Manovich, Lev (2013): Software Takes Command. New York.

Marino, Mark C. (2014): Field Report for Critical Code Studies. In Computational Culture. A Journal for Software Studies. Published 9th November 2014. [online] http://computationalculture.net/field-report-for-critical-code-studies-2014%E2%80%A8/ [Accessed 23 May 2019].

Montfort, Nick et al. (2013): 10 Print CHR$(205.5+RND(1)); : GOTO 10. Cambridge, MA.

Mitchell, John C. (2002): Concepts in Programming Language. Cambridge, MA.

Rossiter, Ned (2016): Software, Infrastructure, Labor: A Media Theory of Logistical Nightmares. New York.

Strathern, Marilyn (2005): Imagined Collectivities and Multiple Authorship. Ghosh, Rishab Aiyer (Ed.): Collaborative Ownership and the Digital Economy. Cambridge, MA, pp. 13-28.

Sundberg, Mikaela (2009): The Everyday World of Simulation Modeling: The Development of Parametrizations in Meteorology. In Science, Technology, & Human Values 34 (2), pp. 162-181.

Sundberg, Mikaela (2010): Organizing Simulation Code Collectives. In Science Studies 23 (1), pp. 37-57.

Wellmann, Jan Florian; Caumon, Guillaume (2019): 3-D Structural geological models: Concepts, methods, and uncertainties. [online] http://publications.rwth-aachen.de/record/754773/files/754773.pdf [Accessed 12 September 2019].

Winsberg, Eric; Goodwin, William M. (2016): The adventure of climate science in the sweet land of idle arguments. In Studies in History and Philosophy of Modern Physics 54, pp. 9-17.

DOI: 10.3217/978-3-85125-668-0-22

Blessings of Open Data and Technology: E-Learning Examples on Land Use Monitoring and E-Mobility

Sujit Kumar SIKDER (1), Hendrik HEROLD (1), G. MEINEL (1), A. LORENZEN-ZABEL (2), R. BiLL (2)

(1) Leibniz Institute of Ecological Urban and Regional Development (IOER), Dresden, Germany

(2) University of Rostock, Chair of Geodesy and Geoinformatics (GG), Rostock, Germany

Abstract

The combination of theoretical knowledge and practice-oriented education are key for future professionals and young scientists. Open data and technologies are providing manifold opportunities within the scope of open science era. This paper aims to present the open e-Learning platform OpenGeoEdu (OGE) that comes with thematic learning module on best practice case studies with real open data. It presents a brief introduction on two best practices case studies: (i) land use monitoring and (ii) e-mobility. The major components of the learning modules are: lecture, test, and practical exercise; besides short teasers and technical tutorials. The multimedia features are: videos, scripts, interactive elements, real data, web-portal and so on. OGE is adopting mostly the open software/tools/frameworks for developing massive open online courses (MOOC) platform, preparing teaching materials and communication purpose. A brief evaluation shows that the OGE properties are addressing the key components and approaches of open science. In fact, everyone can enjoy to learn, participate, contribute and disseminate.

Keywords: Open data, Geo-spatial information, Land use monitoring, E-mobility, E-learning

1 Introduction

The term “Open” is promoting new approaches in science and education today by using the blessing of open digital innovations and collaborative tools, that were never experienced before in order to create/disseminate/maintain new knowledge. For doing so, the vision of open science wants to ensure participation of broader communities for tackling the global challenges together, given that the progress of science are key to innovation, growth and development pathway (Pardo Martínez & Poveda, 2018). The

DOI: 10.3217/978-3-85125-668-0-22

emerging approaches of open science is often mentioned: (i) democratic (ii) pragmatic (iii) infrastructure (iv) public and (v) measurable (Fecher & Friesike, 2013). The key components of open science are: open access, open data and open source (Jomier, 2017). Pisani et al. (2016) suggested to think even beyond such limited open components rather highlighted many other potential basic requirements – e.g. equitable collaboration, supportive infrastructure, investment for future data scientist, shared governance, interpretation and so on.

This paper aims to present the OpenGeoEdu platform (an open e-learning platform for fostering open data for education and science in geospatial domain) that comes with thematic learning module on best practice case studies. It introduces the content of e-learning modules: land use monitoring and e-mobility for promoting innovations of open data as well as technology.

The article is structured as follows: Section two includes a brief discussion on the related key terminologies and concepts. Section three introduces the basis structure/features of OpenGeoEdu platform, lessons learned during two-round online courses and the contribution within the scope of open science approaches. Two best-practice e-Learning modules are presented in section four. Last but not the least, the discussion of the OGE properties and further research scopes are discussed along with conclusion remarks.

2 Key Terms and Concepts

Before introduction to the “OpenGeoEdu” project, this section is briefly presenting and operationalizing to the selected terminologies and concept as below:

2.1 Open Data (OD)

Since late 90’s OD movement has been started to make the way forward, besides the advancement of internet. The Open Data Barometer is systematically measuring the trend and impact of OD with support of World Wide Web (www) foundation in every year at global level. Today, it is widely accepted as one of the important components of open science and promoting informed decision making. According to (Hasegawa & Asano, 2016), “OD means making data with a high level of public interest”. Initially, the data of government agencies were in focus; however, the companies, community agencies, individuals are beginning to make major contributions. For example, in Germany five

DOI: 10.3217/978-3-85125-668-0-22

federal state government authorities are providing of open basic geospatial dataset besides many city authorities. OpenStreetMap is already a known community lead platform at global level. Many interesting OD sources can be found on OpenDataPortal (a comprehensive collection of meta-information on data sources within German-speaking region as part of the OpenGeoEdu platform).

2.2 E-Learning

It refers to electronic media/tools in integration of information and communication technologies that may be used for training and education (Oye, Salleh, & Iahad, 2012). Before e-learning has been known as several other terminologies such as: web-based learning, virtual learning. Gogos (2014) mentioned that the term e-learning has been first-time introduced since 1999. Recently, the e-learning topic got a popular momentum ever, because of individual motivation of online learning. Many e-Learning courses are already launched by the educational institutions, public agencies (UN, FAO, GIZ) and commercial organizations (coursera, udemy, datacamp). As mentioned in El-Ala & Awad (2012), the e-Learning environments are existing in several types: virtual (VLE), personal (PE), mesh-up personal (MUPPLE); the IT systems and infrastructures largely depend on many dynamic and subjective factors. In order to make an efficient learning Chigbu et al. (2015) suggested to formulate specific objective, target, strategies and careful selection of media or tools.

2.3 Open Source Technology and Software (FOSS)

Since 70/80, FOSS is getting attention with the offers of the wider choice and customization options, besides the typical commercial entities. It has made to adopt new computational strategies for many business and organization (Koenig, 2004). A dedicated discussion on popular terminologies in relation to “open source” can be found in OpenXX (Bill, 2019). In the geospatial domain several initiative/projects have been initiated by diverse community – Steiniger and Hunter (2013) published a map of open source GIS software and tools. They suggested a number of guidelines and selection criteria for FOSS for business, research and teaching. According to Bill, Lorenzen-Zabel, and Hinz (2018), there are more than 20 leading e-learning platforms exist; however, four top-scored open-source platforms are ILIAS, Open edX, OpenOLAT und Sakai – as per result of a multi-criteria evaluation.

DOI: 10.3217/978-3-85125-668-0-22

3 OpenGeoEdu: An Open e-Learning Platform for the Geospatial Domain

OGE is not the unique initiative for providing e-learning platforms in the geospatial domain. A good number of offers are available from many international academic and commercial organizations under different business models. In the focus of German speaking region, some well-known e-learning platforms already exist (e.g. GITTA, geoinformation.net, FerGI); however, most of them became outdated due to technical compatibility and lack of active maintenance by integrating technological advancement (Bill et al. 2018). In fact, the ESRI Training/Education (Academy) provides many contents in relation to GIS applications; however, most of them are product-oriented. Like many other open online courses, OGE promises to offer topic specific self-question oriented explorative approaches of e-learning with open data where it ensures the best possible state of art in technical issues, multi-media content, and communication media. The major components in a learning module are: lecture, test, and practical exercise besides short teasers and technical tutorials. The multimedia components include: videos, scripts, interactive elements, a web-portal and so on. The lectures are introducing to the scientific state of art and background on the thematic case study topic. Upon completing the lecture section, the participant should be prepared for working with given exercises that deal with data and basic analytics. Participants are encouraged to pass a short test (max. 20 minutes) for each case study module.

Most of the practical exercises are designed in consideration of space (scale of analysis), time relation, scientific merit and practical relevance to the potential participants; however, there are open options if someone wants to choose a different study scale, study area, dataset and software packages. For doing so, each of the practical exercise prepared in three different format: Basic, Advanced and Click-by-Click (ABC). The Basic version describes the components: general problem, data research, modelling, visualization and interpretation; besides related clarifications, tips and tricks. The Advanced format introduces the tasks and guidelines for experienced learners. Both formats (Basic and Advanced) are independent and flexible to space, time and software requirements. The Click-by-Click version demonstrates an example for beginners with a specific spatial scale, time and software dependency. Every instruction is documented point-by-point with the necessary literature and further clarification; however, it does not include any results rather asked to produce.

DOI: 10.3217/978-3-85125-668-0-22

At this development stage, the project partners come from both educational and applied research institutions. They are: (i) the Chair of Geodesy and Geoinformatics (GG) at the University of Rostock is responsible for project coordination, platform design, implementation, maintenance activities; besides the development of fundamental modules, tutorials and thematic case studies (openXX, open data, e-mobility, noise mapping, GIS, landscape structure measures etc.); (ii) the Federal Office of Cartography and Geodesy (BKG) is contributing for case studies on remote sensing based geovisualisation. (iii) the German Biomass Research Centre (DBFZ) is responsible for the case of biomass potential; (iv) the Leibniz Institute for Ecological Spatial Development (IÖR) contributes to the topic of land use monitoring. Every partner contributes their thematic expert knowledge, services that can support practice oriented career preparation with the blessings of open data and technology.

The OGE is targeting the students that are related to geospatial domain such as geoscience, environmental science, urban planning, regional planning, agricultural and forest sciences; however, this can provide a learning opportunity to any interested individual or professional. OGE offers both tutored learning opportunity by following the timeframe or German University (need to be registered and timely submission) and flexible learning opportunities (do not need to register). A registered participant has the possibility to achieve credit points and certificated upon successfully completion of required tasks (minimum 1 credit points (CP) for 30 hours workload, maximum 6 CP for 180 hours workload). The submitted assignments are evaluated by the qualified teaching staffs rather than anonymous peer/automated evaluation methods. The course participants are encouraged to contribute to the learning platform development (bottom-up approach) through Q&A, forum and open repository (github).

There are three major principals to the development of OGE platform: learning to find open data, learning to use open data and test own learning with practical case studies. Therefore, the course modules are divided into fundamentals and case studies. The fundamental modules are covering the topics of openXX, Open Data and GIS (Fig. 76). The case topic start with an introduction to the topic and practical exercises that cover multiple scales (e.g. local to global). OGE provides an OpenDataPortal that includes most of the potential open data sources in Germany, Austria and Switzerland.

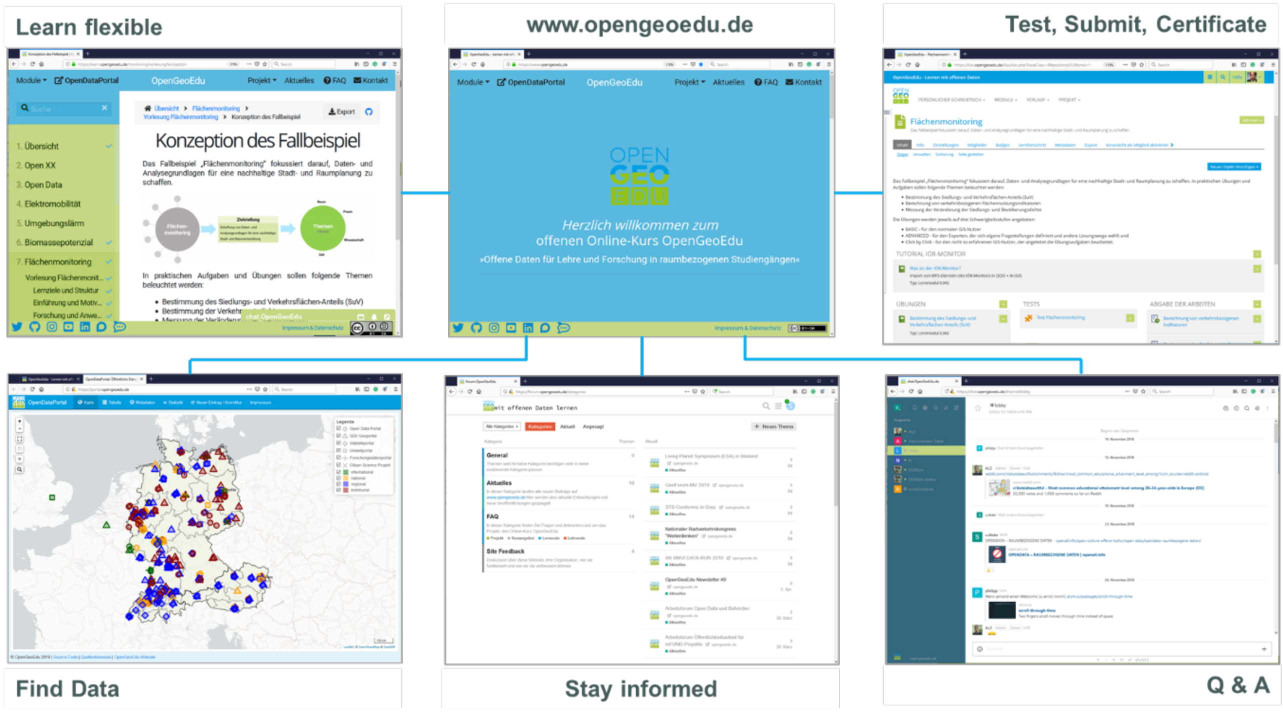


Fig. 76: *Key components of the learning platform. – Source: OpenGeoEdu, 2019.*

OGE aims to adopt the updated state of art in open software/tools/frameworks in the MOOC platform development, preparation of teaching materials and communication. To name some of the used software are: GRAV, ILIAS, GitHub, Rocket chat, R, GDAL, Shiny-server, QGIS, ArcGIS, ArcGIS-Online and so on. The required IT infrastructure is provided and maintained by the University of Rostock at this development stage.

The next section is dedicated to give a brief description of two best practice case study on land use monitoring and e-mobility.

4 Learning Modules – Example

OGE aims to develop an e-Learning platform for fostering the use of open geospatial data with practical case studies (best practice). This section is giving a brief insight about the current state of development by including learning goals, components on lecture materials and practical exercises.

4.1 Land Use Monitoring

The Leibniz Institute for Ecological Urban and Regional Development (IOER) is one of the research and development partners within OpenGeoEdu. The research area of

Sujit Kumar SIKDER (1), Hendrik HEROLD (1), G. MEINEL (1), A. LORENZEN-ZABEL (2), R. BiLL (2)
DOI: 10.3217/978-3-85125-668-0-22

"Monitoring of Settlement and Open Space Development" at IOER is responsible for the case study module on "Land Use Monitoring". Since 2010, IOER is conducting research on this thematic issue and communicate several indicators in a form of open webGIS services called IÖR-Monitor (www.ioer-monitor.de). In general, the learning module should address the integrated topics of land use, existing buildings, green areas, and transport infrastructure.

A short teaser (2-3m video) is the first component of the learning components, which gives a brief introduction to the module. Secondly, a scientific lecture has been delivered to give a comprehensive introduction to the topic in the form of multimedia-video and script. It covers discussion on: key motivation, state of art, related data sources, methods/tools, related services/application and information on further learnings. Fig. 77 presents the basic concept of the learning module.

Fig. 77: *Basic concept of learning module – land use monitoring.*

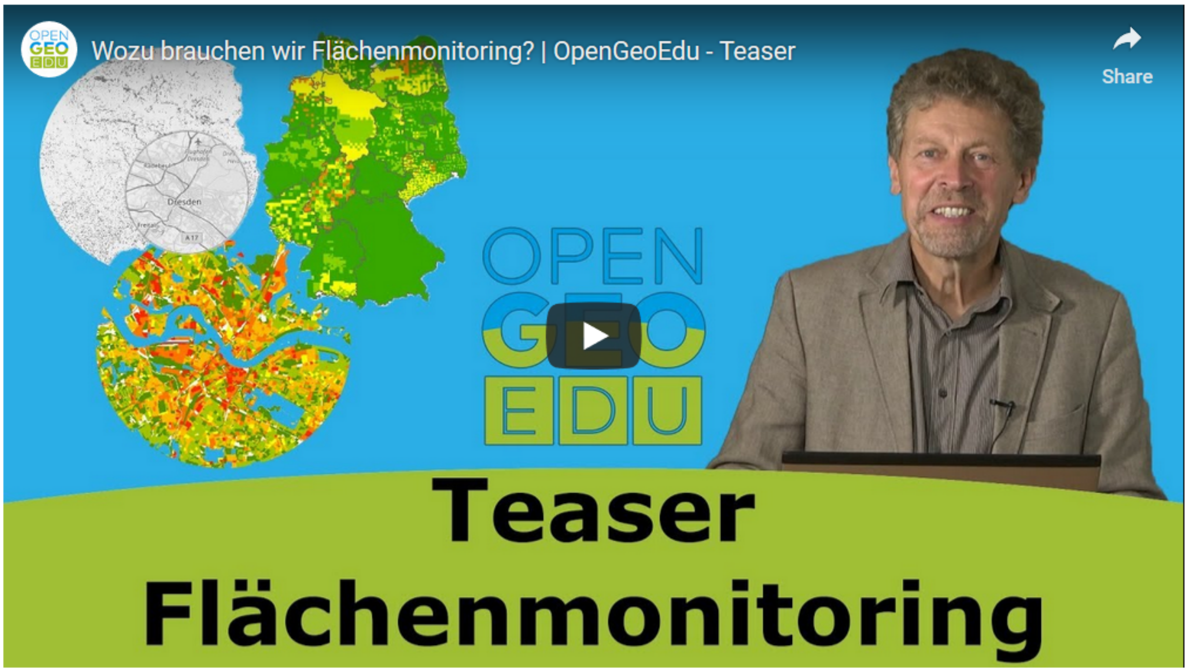
Thirdly, a set of test questions are formulated in relation to the lecture content. Lastly, the practical exercises are offered on thematic topics for beginner to advance level. There are three exercises already available online - such as (i) computation of land use share for settlement and transportation (using WebGIS, QGIS), (ii) estimation of transport-related land use indicators (using OpenStreetMap, QGIS, WebGIS), and (iii) quantification and detection of changes in settlement and population density (using Open-GHSL, ArcGIS-online).

DOI: 10.3217/978-3-85125-668-0-22

4.2 E-Mobility

The Department of Geodesy and Geoinformatics at University of Rostock is offering the case study on e-Mobility. The department has strong focus on research, development and teaching on the domain of geoinformation. The major goal of this learning module is to explore the spatial insight of e-vehicle charging infrastructures.

The lecture gives comprehensive discussion on motivation on this contemporary topic. The policy aspect of e-mobility infrastructure has been discussed along with demand and potential end user context. The case study relevant open data sources has been introduced and at the end further literatures. A pool of test questions are formulated to check the acquired knowledge of the module participants. There are 3 practical exercise on e-Mobility available online that covers multiple geodata, statistical open data and spatial scales: (i) assessment of accessibility to electric vehicle charging stations in the local environment, (ii) analysis of national charging infrastructure with respect to consumer potential of electric vehicles (EVs), (iii) planning a journey in Europe and evaluating this route with regard to the availability of charging stations.



Sujit Kumar SIKDER (1), Hendrik HEROLD (1), G. MEINEL (1), A. LORENZEN-ZABEL (2), R. BiLL (2)
DOI: 10.3217/978-3-85125-668-0-22

Fig. 78: *Short video teasers for introducing a learning module: e-Mobilty (left) and land use monitoring (right). Source: OpenGeoEdu (2019).*

The module component will be updated regularly with multimedia components, practical exercise, new data sources, and important reading materials and so on. Most of the components are openly accessible except the test questions and the delivery of achieved results. The registered course participants can also get some additional intermediated dataset for supporting intensive computational demand (it may help to overcome some limitations of high-speed internet connections, long processing time, simplify workflow for the beginners).

5 Lesson learned (course experiences)

The OGE-MOOCs have already administrated during winter semester 2018/2019 (October to February) and summer semester 2019 (April to September 2019). A total number of 245 registered participants (on ILIAS platform) were actively participating in tutoring, tests and practical exercises (Fig. 79). From the OGE course experience some important lessons have been learned on both general and technical issues.

The didactic preparative has to be intensified in order to ensure more attractive and understandable course contents. These need to be done by including more multimedia interactive content (video, graphics) rather than text. One of the initial obstacles was

DOI: 10.3217/978-3-85125-668-0-22

completing a mandatory user registration process for accessing to the course contents (tests, exercises); however, this has been relaxed since summer semester 2019 by providing all exercise contents completely open for all, besides lecture contents. The registration become an option, only if the participant wants to earn credit points and a certificate. On the other hand, this change may pose some limitation to gather statistics on experience, feedbacks, assessment from course participant for those who are only use the platform without registration. In fact, the online tests still remains one of the obstacles, because a course participant may not pass a test (within three times try) without completing of relevant lecture contents or/and may leave the course by thinking higher level of complexity. In our experiences, the course participants rarely used the provisions of OGE online communication services (chat, consultation hours, and user comments). Therefore, the challenges are often have to deal with active participation of the course participant for improving course content by taking direct user feedbacks. The third course is running for the winter semester 2019/2020 (October to February 2020). The course contents have been revised and new contents were added on thematic exercises.

DOI: 10.3217/978-3-85125-668-0-22

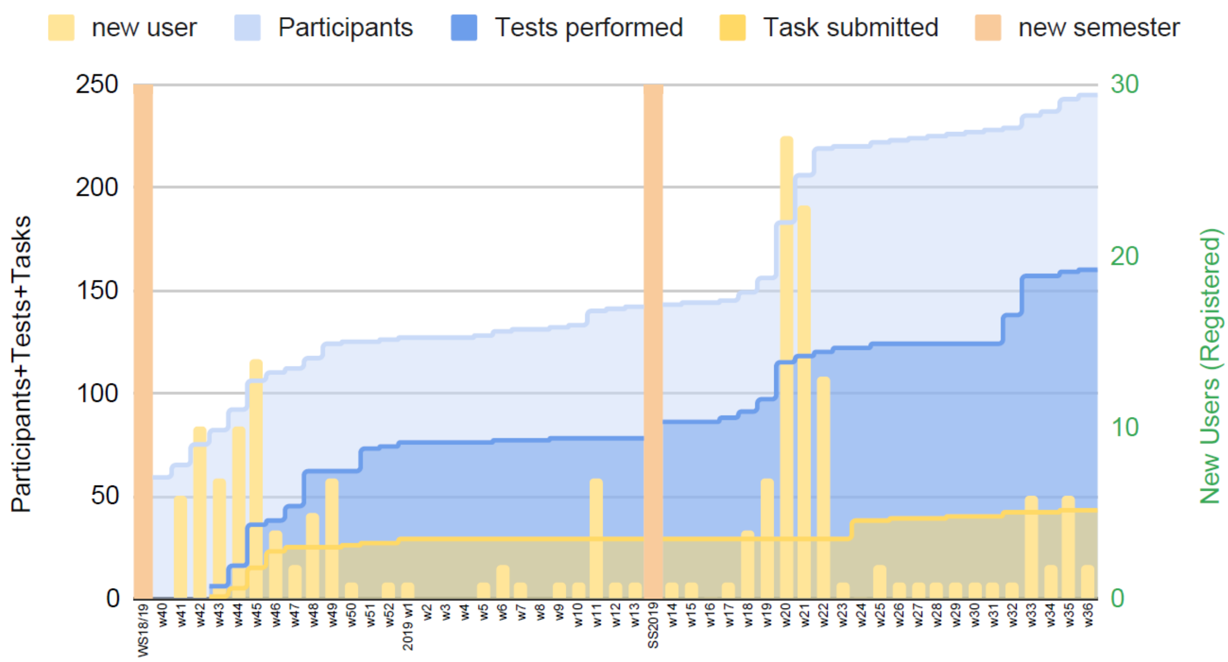


Fig. 79: *Statistics on registered course attendees and completed tasks. – Source: OpenGeoEdu (2019).*

6 Assessment of OGE according to Open Science Principals

OGE is dedicated to offer an open and flexible learning environment that can promote the use of open data. It is committed to address the updated development state of open data and software within the scope of open science. The following table shows an evaluation of OGE properties by following the major components and approaches of open science.

Approach	**Description**	**OpenGeoEdu**
Democratic	Free knowledge	Completely open and free (CC BY-SA 4.0)
Pragmatic	Create together	Intensive collaboration of multiple project partners (educational + applied research; teacher + students)
Infrastructure	Open platform, tools, services	Developing free/open eLearning platform; promote collaboration of teaching professionals
Public	Science for citizen	Targeted participants are spatial science; however everyone welcome to join and contribute. Learning offers cover Basic to Advanced levels
Measurement	Alternative impact of scientific contribution	Contribution and participation to the learning platform will increase visibility and impacts

Fig. 80: OpenGeoEdu in relation to open science approaches. *– Source: Author's Own, assessment by following to the OS approaches mentioned in Fecher and Friesike (2013).*

OGE has mandate to facilitate collaboration, knowledge exchange and make social impacts. Some of them are already covered in the form of direct partnership/contribution and more may happen in indirect form. For instance, there are already some initiatives for e-Learning in Geospatial science in German speaking region. Most of them are suffering due to technical limitations; however, such content can be integrated/re-used within the modernized environment of OpenGeoEdu.

7 Conclusion

This paper presents a new open e-Learning platform OpenGeoEdu that offers topic specific learning modules with best practice case studies on spatial sciences. Two example learning modules have been discussed: land use monitoring and e-mobility. An overview on lesson learned has been reported that are experienced during two round online courses since October 2018. A brief self-assessment shows that the OGE has addressed most of the important components in relation to open science approaches. Within scope of OGE e-Learning offers, the exploration of thematic open data will be promoted rather than the product-related alternative e-learning offers – e.g. ESRI Academy. There are many challenges are remaining in order to reach potential participants and goals of OGE. In the future, the prospective participants need to be approached through different channels and their actively encouraged participate or communicate through the learning platform (e.g. newsletters, events/workshops, creative content related to current world events). This also includes the systematic collection of feedback from course participants and teachers (done so far mainly by questionnaires). The courses are still based on semester durations and will therefore be advertised for students and teachers. The next course will begin on the first of October 2019. In addition, anyone can use the course at any time and complete any part of the course.

The course participants have the opportunity to earn academic credits points (also certificate) upon completing all formal course requirements. However, the acceptance of the credit point by the participant host institution might be necessary to discuss further. The learning contents are available on open public platform (e.g. Github, ILIAS) under open license (CC-BY-SA 4.0). In future, the learning content will be updated regularly with new content, case studies, and data sources. Altogether, OGE may offer an environment for everyone to learn, participate, contribute and disseminate.

References

Bill, R. (2019). OpenGeoEdu Grundlagen – open XX. Retrieved from https://learn.opengeoedu.de/openx

Bill, R., Lorenzen-Zabel, A., & Hinz, M. (2018). Offene Daten für Lehre und Forschung in raumbezogenen Studiengängen – OpenGeoEdu. *gis.Science*(1/2018).

Büttner, B., Kinigadner, J., Ji, C., Wright, B., & Wulfhorst, G. (2018). The TUM accessibility atlas: visualizing spatial and socioeconomic disparities in accessibility to support regional land-use and transport planning. *Networks and Spatial Economics, 18*(2), 385-414.

Chigbu, E. U., et al.(2015). *Land Use Planning for Tenure Security: An E-Learning Tool for Developing Countries.* Paper presented at the World Bank Conference on Land and Poverty.

El-Ala, N. A., & Awad, W. (2012). Cloud computing for solving E-learning problems. *International Journal of Advanced Computer Science and Applications (IJACSA), 3*(12).

Fecher, B., & Friesike, S. (2013). Open Science: One Term, Five Schools of Though. In F. S. Bartling S. (Ed.), *Opening Science*: Springer.

Gogos, R. (2014). eLearning

A brief history of elearning (infographic). Retrieved from https://www.efrontlearning.com/blog/2013/08/a-brief-history-of-elearning-infographic.html

Hasegawa, D., & Asano, Y. (2016). Latest trends and future outlook for open data: Making public-sector data available to the private sector. *Hitachi Review, 85*(1).

Jomier, J. (2017). Open science–towards reproducible research. *Information Services & Use, 37*(3), 361-367.

Koenig, J. (2004). Seven open source business strategies for competitive advantage. *IT Manager's Journal, 14*.

Oye, N., Salleh, M., & Iahad, N. (2012). E-learning methodologies and tools. *International Journal of Advanced Computer Science and Applications (IJACSA), 3*(2).

Pardo Martínez, C., & Poveda, A. (2018). Knowledge and Perceptions of Open Science among Researchers—A Case Study for Colombia. *Information, 9*(11), 292.

Pfenninger, S., Hirth, L., Schlecht, I., Schmid, E., Wiese, F., Brown, T., . . . Wingenbach, C. (2018). Opening the black box of energy modelling: Strategies and lessons learned. *Energy Strategy Reviews, 19*, 63-71. doi:10.1016/j.esr.2017.12.002

Pisani, E., Aaby, P., Breugelmans, J. G., Carr, D., Groves, T., Helinski, M., . . . Marsh, V. (2016). Beyond open data: realising the health benefits of sharing data. *Bmj, 355*, i5295.

Steiniger, S., & Hunter, A. J. (2013). The 2012 free and open source GIS software map–A guide to facilitate research, development, and adoption. *Computers, Environment and Urban Systems, 39*, 136-150.

DOI: 10.3217/978-3-85125-668-0-23

Circular Economy Concepts for Cultural Heritage Adaptive Reuse Implemented Through Smart Specialisations Strategies

Jermina STANOJEV, Christer GUSTAFSSON

Uppsala University, Sweden

Abstract

Although concepts of circular economy are growing, circular economy design processes in the construction sector are as of yet neither advanced nor well-articulated, despite the fact that circular economy models could be applied very well in cultural heritage assets and in the construction sector in regions and cities. Policy and decision makers lack sufficient knowledge on the benefits of cultural heritage assets adaptive reuse, as well as tools for both implementing these actions and articulating them accordingly in policy instruments, such as smart specialisation and others.

A recently developed study at Uppsala University, on mapping European regions (NUTS entities) which recognise cultural heritage and culture as an integral part in their development strategies, offers a comparison of approaches according to economic and scientific domains as well as policy objectives, and shows that only a small percentage of regions consider cultural heritage as an asset for their growth.

The purpose of this paper is to lay a basis for a new, stronger complementarity between cultural heritage adaptive reuse practices and circular economy concepts through smart specialisation strategies and, in particular, specific economic domains, reviewing also approaches of different European regions towards these links within their strategic documents. Preliminary results show that cultural heritage is not adequately recognised as a potential for economic development within the economic domain associated with adaptive reuse and circular economy (mainly construction industry). This research aims to overcome a gap in the qualitative and quantitative data regarding this topic and to clarify how many regions and cities (NUTS entities) are oriented towards including cultural heritage as a part of their circular economy processes.

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

1 Background

Although concepts of circular economy are growing, circular economy design processes in the construction sector are as of yet neither advanced nor well-articulated, despite the fact that circular economy models could be applied very well in cultural heritage assets and in the construction sector in regions and cities. The concept of circular economy is rising in prominence in different sectors, in the academic world, among policy makers and consultants, but also in different fields, particularly those not initially linked with circular economy, i.e. fields beyond waste management, resource efficiency, low-carbon investments, etc. This connection opens up many niches of research for fields and sub-fields that could be linked and conformed with circular economy and be considered as resources for its implementation. We shall consider cultural heritage and its adaptive reuse as one of them. Considering the vast number of cultural heritage sites and building stock in Europe (e.g. only Brussels has between 15.000 and 30.000 unused buildings, 412 UNESCO World Heritage Sites are located in Europe, 143 World Heritage Cities are located in Europe, etc. all of which still represents only a small part of European cultural heritage building stock, mainly unused or not used to their full potential) this sub-field could be considered as one of the pillars of circular economy. There is a large and growing body of literature that investigates adaptive reuse and sustainability of buildings – such as the definitions of adaptive reuse; the interest in adaptive reuse of buildings as an alternative to demolition, for the benefit of the community; analyses of renovation processes in terms of quality of intervention and of investments, as well as of the impact on the environment. Some of them also consider adaptive reuse as a strategy towards conservation of cultural heritage.

However, links between the circular economy and the adaptive reuse of cultural heritage buildings have not been elaborated in recent literature nor incorporated in policy developments, despite the fact that various R frameworks[1] have been in use by academia as well as by practitioners for quite some time (Kirchherr et al., 2017). Complementing different potential policy links to circular economy, the European Circular Economy Action Plan encourages the concept of circular economy to be considered as a broader

1. The latest framework of 9Rs includes refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover.

DOI: 10.3217/978-3-85125-668-0-23

sustainable development strategy, that should also “support Member States and regions to strengthen innovation for the circular economy through smart specialisations” (European Commission, 2015). Therefore, it could be understood that Smart Specialisation strategies should be used as an instrument to identify links between the regional economic priorities, the circular economy and the cultural heritage adaptive reuse.

Recognition of cultural heritage in the European regions’ smart specialization strategies has not been treated in much detail by researchers either. Research on the subject has been mostly restricted to limited comparisons of various regional strategies, but not in an overall review giving a complete picture of the status in the whole of Europe in the context of circular economy.

2 Objectives

The objective of this research is to determine whether European regions consider cultural heritage as a potential component of their circular economy concepts through smart specialisations, providing qualitative and quantitative frameworks based on data available through various sources and platforms.

The research seeks to explore these relations by analysing the literature regarding these concepts, reviewing approaches of different European regions towards circular economy and smart specialisations linked to cultural heritage. The review aims to overcome a gap in the data reviews regarding this topic.

In order to reach this goal, the main questions addressed in this research is: what is the significance and representation of cultural heritage and/or culture through the occurrence of their respective terms in description of circular economy strategies and in smart specialisations strategies?

3 Research Methodology

The analytical framework of the study is built on the combination of qualitative and quantitative approaches used in the data analysis.

The first part of the research addresses, through literature review, the concept of circular economy (CE), circular economy in EU policy development, circular economy in regional policies, including smart specialisations. It involves a review of papers (indexed in Scopus) dedicated to circular economy, the presence of circular economy in the EU Policy

Development and in the EU Regional Policies explaining also the link with smart specialisations.

The second part of the research qualitatively identified and examined national and regional strategies related to the circular economy at the regional level in Europe (First assessment). This part analysed the understanding of circular economy implementation in regard to (non)existing relations with cultural heritage adaptive reuse at the European regional level by search of the following keywords in strategies: “cultural heritage”, “cultural”, “culture”, “creative”, “heritage”, “adaptive reuse”, “historic buildings”.

These first two parts identified contemporary tendencies in circular economy research and policy frameworks as well as limitations regarding its links with regional implementation, smart specialisations and cultural heritage adaptive reuse, both at the theoretical and the applied practical levels.

As the policy review revealed that circular economy should be considered as a broader sustainable development strategy which should also “support Member States and regions to strengthen innovation for the circular economy through smart specialisations” (European Commission, 2015), the third part of the research (Second assessment) quantitatively examines representation of cultural heritage in smart specialisations in European regions, through the Smart Specialisation Platform (S3P) and Eye@RIS3, (a dedicated online tool) within circular economy related economic domains and subdomains associated to adaptive reuse from the understanding of the first assessment.

The quantitative approach offers an explanation of the database and data search conducted from different sources in order to identify how many regions are linking culture and cultural heritage with their circular economy strategies. Smart Specialisations have been used for that identification. A database that offers "regional innovation strategies" (Smart Specialisation platform) has been analysed if strategies in certain economic domains related to adaptive reuse like "construction" included the terms "cultural heritage" or "culture", "cultural", "creative", "heritage", “adaptive reuse”. However, as the term “adaptive reuse” has not been mainstreamed in strategies, respective search has not

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

brought any results. 21 Economic Domains[1] are registered under the Statistical Classification of Economic Activities in the European Community. The research will show only the related ones, meaning, the ones in which "culture" and "cultural heritage" showed up as a priority for at least one region. Furthermore, the focus will be on domains that appeared in circular economy strategies (First assessment) related to adaptive reuse: E – Water supply, sewerage, waste management and remediation activities and F – Construction. Fig. 81 represents research methodology.

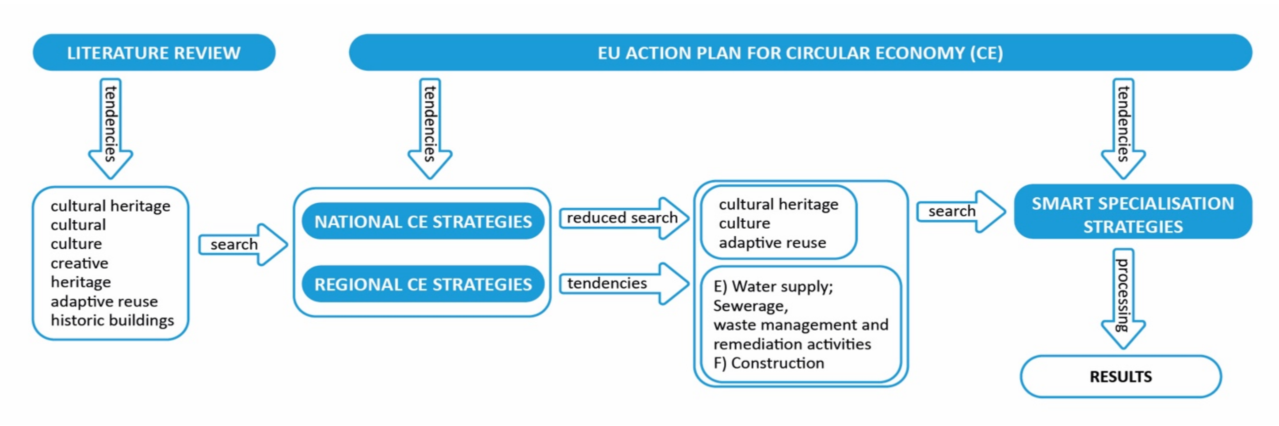


Fig. 81: *Graphical representation of research methodology*

4 Literature review

The concept of circular economy is rising in prominence in various sectors. As for the academic sector, this is indicated by the fast growth of peer-review articles on circular economy (Kirchherr et al., 2017). Also, many studies done by independent expert bodies

1. A- Agriculture, forestry and fishing; B - Mining and quarrying; C-Manufacturing; D-Electricity, gas, steam and air conditioning supply; E-Water supply, sewerage, waste management and remediation activities; F-Construction; G-Wholesale and retail trade; repair of motor vehicles and motorcycles; H-Transportation and storage; I-Accommodation and food service activities; J-Information and communication; K-Financial and insurance activities; L-Real estate activities; M-Professional, scientific and technical activities; N-Administrative and support service activities; O-Public administration and defence, compulsory social security; P-Education; Q-Human health and social work activities; R-Arts, entertainment and recreation; S-Other service activities; T-Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use; U-Activities of extraterritorial organisations and bodies

DOI: 10.3217/978-3-85125-668-0-23

and companies have been made available recently. For example, some of the main consulting firms (Accenture, Deloitte, EY and McKinsey & Company) have published different reports on circular economy in the recent years (Kirchherr et al.; 2017, Gartner, 2016; Hestin et al., 2016; Hannon et al., 2016; Lacy et al., 2015). Furthermore, the concept of circular economy is now considered to be the one of the most interesting (Ellen MacArthur Foundation, 2014) among the prominent concepts which also focus on sustainable development, such as the green economy and the green growth concepts (UNEP, 2011; OECD, 2016).

A considerable amount of literature has been dedicated to the discussion regarding different concepts and definitions of a circular economy (Kirchherr et al.; 2017, Smol et al., 2017; Korhonen et al., 2018; Reike et al., 2018; Prieto-Sandoval et al., 2018). In the previous several years, scholars, but also policymakers and consultants have shown an increased interest in the concept.

A study was conducted on the analysis of 114 circular economy definitions (Kirchherr et al., 2017), giving a comprehensive and systematic investigation of the various definitions of circular economy. The study showed that the concept with so much traction is often used by various stakeholders, and that these can confound the concept since they frequently operate from significantly different standpoints (Gladek, 2017; de Vries and Petersen, 2009). Lieder and Rashid (2016, p.37) point out that “there are various possibilities for defining circular economy”, while Yuan et al. (2008, p.5) claim that “there is no commonly accepted definition of circular economy”.

Despite the attractiveness of the concept, scientists and other professionals have not reached a commonly accepted definition of circular economy (Kirchherr et al., 2017; Yuan et al., 2008). The controversy about scientific evidence on circular economy has been pointed out before, stating that “one interesting difference between circular economy and most of the other schools of sustainable thought is that it has largely emerged from legislation rather than from a group of academics who have split from one field and have started a new one” (Murray A. et al.,2015 p. 373).

The evidence for this is inconclusive, but further exploration is required of existing policy steps regarding circular economy concepts. It has been identified that, since 2014, the EU has actively supported the circular economy concept in several operational stages. The

DOI: 10.3217/978-3-85125-668-0-23

European commitment to the implementation of circular economy is demonstrated in the fact that the concept started to grow into policy making in Europe in 2008, with the Directive 2008/98/EC on waste, and further in the Europe 2020 Strategy for smart, sustainable and inclusive growth for 2014–2020.

The European Parliament in 2014 took further steps for the EU by adopting the communication from the European Commission, "Towards a Circular Economy: a Zero Waste Programme for Europe" (COM 2014, 398) underlining the necessity of involving eco-innovation in order to, inter alia, boost recycling and prevent the loss of valuable materials; create jobs and economic growth; show how new business models can emerge; move us towards zero waste through eco-design and industrial symbiosis; and reduce greenhouse emissions and environmental impacts (Koellner et al. 2007). The European Commission launched in 2015 a set of general and material-specific actions to encourage the EU's transition to a circular economy (COM 2015, 614).

Despite these steps, there was no approach defined to track its progress and screen its implementation. Consequently, it is crucial to foster monitoring frameworks on the levels of the EU, the Member States, the regional and the local levels, in order to be able to track the progress and results of the EU transition toward circular economy (Avdiushchenko, 2018). The European Commission launched a monitoring framework at the end of 2017, with the objective to observe the progress of circular economy implementation at the Member States level. The framework sets out four main monitoring areas: production and consumption, waste management, secondary raw materials, and innovations, containing ten indicators. This suggests that emphasis was mainly placed on resources and material matters at the EU Member States level.

However, there are no specific indicators dedicated to it in regional policy in Europe (Smol et al., 2017), although the concept of circular economy has become an accepted and much discussed topic among different stakeholders and sectors.

The generalisability of the policy framework on this issue is challenging and insufficient for observing in other areas that are contributing to the circular economy, such as social innovations, eco-innovations, sharing economy initiatives, the level of greening of the main economic sectors, new business models' implementation, eco-design, and architecture initiatives (Avdiushchenko, 2018) recognised in the leading research on circular economy,

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

which could also be relevant at regional levels (McDowall et al., 2017; Prieto-Sandoval, 2018; Ranta, 2018). As previously mentioned, the European Commission's monitoring frameworks did not offer instruments for following implementation of circular economy concepts and effects at the local and regional level. At the same time, regional policies are one of the main strengths of the European Union development policy. The EU Cohesion Policy for 2014–2020 was dedicated to the circular economy as well, as significant funding was foreseen in the policy's investment framework for circular economy related innovation, resource efficiency, SME competitiveness, low-carbon investments and waste management (Commission of European Communities, 2016). Overall, it can be said that the main focus of the EU Cohesion Policy funds (the European Regional Development Fund, the Cohesion Fund, the European Social Fund, the EU Solidarity Fund, IPA) is greatly in line with the circular economy concepts and principles. Considering the role of regions in the EU policy, as well as the number of funds that are covering circular economy actions, the current study also spotlights the implementation of circular economy at the regional level. Even an EU action plan for the Circular Economy advocates that waste management should not be the only issue tackled within the concept of circular economy, but that it should rather be considered as a broader sustainable development strategy that also should "support Member States and regions to strengthen innovation for the circular economy through smart specialisations" (European Commission, 2015).

Smart specialisation approach is becoming a strategic instrument for identifying regions' opportunities for growth and development. It is a place-based approach and plays an important role in benchmarking regional competitiveness. To have a smart specialisation strategy has been thought of as a key factor in making investment choices. The EU Member States and regions recognised that supporting a limited number of well-identified priorities for knowledge-based investments and/or clusters could promote focusing on competitive assets and realistic growth capabilities, reinforced by a critical mass of action and entrepreneurial resources. An increasing interest in Smart Specialisation can be observed within the reformed Cohesion policy for the period of 2014-2020. Judging by recent developments, (the proposal for the Multiannual Financial Framework (MFF) 2021-2027 regarding the delivery and implementation of cohesion policy beyond 2020), the Smart Specialisation approach shall remain very significant in the Cohesion policy implementation.

DOI: 10.3217/978-3-85125-668-0-23

Complementary to that, in the previous years, researchers have shown an increased interest in understanding emerging bottlenecks of the implementation of smart specialisation (Boschma, 2014; Capello, 2014; Capello, & Kroll, 2016; Kroll, 2015; Kroll, Dornbusch, & Schnabl, 2015; McCann & Ortega-Argilés, 2015). Several studies identified main challenges for smart specialisation-type policy approaches in general. One such challenge is that the diverse structure of governance in European Member States has led to a situation in which mandates for RIS3 processes and strategy implementation were assigned to a widely varying set of spatial levels of governance (Kroll, 2015; McCann, 2015). Another is that several Member States were less than inclined to support and promote new, bottom-up policy approaches, for various, in part quite differently motivated, reasons, while a number of Member States remain used to, and in favour of, the traditional top-to-bottom planning (Capello, & Kroll, 2016). Yet another challenge is that concrete capabilities play a role when it comes to evidence-based policy-making, broad-based consultations and the drafting of innovation strategies. Beyond a robust institutional environment and a general culture of good governance, all administrations need people to drive and execute processes of regional strategy-building successfully (Kroll, 2015). It is worth remembering that Foray's original concept envisages the EDP as something that emerges between relevant actors in particular, the emerging domains and – in well-functioning regional innovation systems – it can and will in principle occur without public intervention (Coffano & Foray, 2014; Foray, 2015).

Smart Specialisation priorities in Europe are further associated with the Economic and Scientific Domains as well as EU Policy Objectives, based on the Eurostat's NACE2 sectorial codes and OECD categories, the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS 2007). In the context of circular economy, these economic domains are: E) Water supply; Sewerage, waste management and remediation activities with subdomains; Water collection, treatment and supply, Sewerage, Waste collection, treatment and disposal activities; materials recovery, Remediation activities and other waste management services; and F) Construction with Subdomains - Construction of buildings, Civil engineering, Specialised construction activities.

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

5 First assessment - National and Regional Circular Economy Strategies

5.1 Data search of National and Regional Circular Economy Strategies

Although a circular economy monitoring tool has been set at the level of the EU, there have been circular economy related actions taking place not only at the EU level, but also at national and regional levels, which is of particular interest for the study. Different European countries and regions have developed their own guidelines and documents related to circular economy and its actions.

At the national level, the EU Member States have developed and adopted different strategic documents regarding circular economy, taking diverse approaches toward its understanding. Several countries developed their circular economy strategic frameworks, roadmaps or national plans[1] (Greece, Italy, Denmark etc.) while some countries integrate circular economy aspects into their national strategies through waste management[2] (Germany, Romania, Slovakia etc.), and Sweden does it through its bio-based economy.

However, regions and cities (NUTS 2 and NUTS 3) have rather identified their circular economy strategies[3] instead of spreading circular economy actions through different plans.

1. National Action Plan on Circular Economy of Greece; Roadmap towards the Circular Economy in Slovenia; Towards a Model of Circular Economy for Italy—Overview and Strategic Framework; Leading the Transition: Circular Economy Action Plan for Portugal; Circular Economy Roadmap of France: 50 Measures for a 100% Circular Economy; A circular economy in the Netherlands by 2050; Danish Circular Economy Strategy; Spain – Circular Spain 2030; Leading the Cycle – Finnish Road Map to a Circular Economy 2016-2025.

2. German Resource Efficiency Programme II: Programme for Sustainable Use and Conservation of Natural Resources; Luxembourg's National Waste and Resources Management Plan.

3. Extremadura 2030: Strategy for green and circular economy; Strategy for the Transition to Circular Economy in the Municipality of Maribor; Strategy of the Government of Catalonia: Promoting Green and Circular Economy in Catalonia; Circular Flanders Kick-off Statement; Making Things Last: A Circular Economy Strategy for Scotland; Northern Irish Region – Circular Economy Strategy; Regional Plan for Circular Economy, Brussels Capital Region; Roubaix's Circular Economy Route Map; Päijät-Häme Roadmap toward a Circular Economy; London's Circular Economy Route Map; Circular Amsterdam, A vision and action agenda for the city and metropolitan area; White Paper on the Circular Economy of Greater Paris.

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

The search was performed by the following keywords in these national, regional and city strategic frameworks, roadmaps or national plans: “cultural heritage”, “cultural”, “culture”, “creative”, “heritage”, “adaptive reuse”, “historic buildings”.

5.2 Results regarding National and Regional Circular Economy Strategies

Although a small number of countries, regions and cities have officially adopted circular economy strategies and roadmaps, it should be taken into consideration that other national and local governments have also started implementing circular economy principles through other actions (a full list of good practices, European Circular Economy Networks and events is available at the European Circular Economy Stakeholder Platform – a joint initiative by the European Commission and the European Economic and Social Committee).

Circular economy became an umbrella assembling strategies, but also practical solutions at different levels regarding economic transformations. However, at regional levels circular economy is also directed at the green and bio-economic sectors, which implies that agriculture and biotechnology are prioritized, as is the case in Germany, Sweden and Portugal. On the other hand, some countries, such as Spain, France and Romania, integrate circular economy principles into their national strategies through waste management. Waste reduction and conversion is an essential part of circular economy; however, it should not be the only possible way to implement the circular model.

A search performed by the keywords “cultural heritage”, “cultural”, “culture”, “creative”, “heritage”, “adaptive reuse”, “historic buildings”, showed the results that “reuse” is the term has been used the most, but mainly in the context of “reuse of building materials”, “material reuse”, “waste reuse”, “reuse by enabling reallocation of materials”. Even Amsterdam city, which manages the Seventeenth-Century Canal Ring Area of Amsterdam inside the Singelgracht designated as the UNESCO World Heritage Site, does not mention the word “cultural heritage” or “adaptive reuse” in context of “historic buildings” in their document “Circular Amsterdam, A vision and action agenda for the city and metropolitan area”.

On the other hand, the “Regional Plan for Circular Economy, Brussels Capital Region” implemented through four sectors (construction, resource and waste, logistics, retail business), in its construction sector clearly recognises “making use of the building stock –

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

urban mining” as one of the main strengths, as well as “occupying empty buildings” and “building conservation”. In Brussels, with between 15.000 and 30.000 buildings standing empty and with increasing numbers of people looking for an affordable place to live or to carry out a wide variety of activities, the local government renovates these buildings and makes them temporarily available for social initiatives, with the idea to bring about a proliferation of urban activities and a laboratory illustrating creative potential which can intermix social, economic and charitable activities, while also accommodating cultural gatherings.

Päijät-Häme region in Finland included circular economy in its regional innovation strategy for smart specialisation, thus defining circular economy as a priority sector for the region, but still not including cultural heritage as a part of its implementation.

No other region mentioned “cultural heritage adaptive reuse” in the context of their circular economy strategies and its understanding mainly remains in domains “Constructions” and “Waste management”.

6 Second assessment - Smart Specialisation Strategies

6.1 Database of the Smart Specialisation Platform (S3P) and Data search with Eye@RIS3 – second level

With the aim to facilitate gathering data and managing strategy development and implementation of RIS, the European Commission has set up the Smart Specialisation Platform (S3P) and dedicated an online tool, Eye@RIS3, where European regions and countries provide their innovation related information. The Eye@RIS3 database represents a summary of country-specific and region-specific documents on smart specialisation strategies in order to prioritise investments, increase productivity, stimulate knowledge-driven growth and seek out potential partners for collaboration.

The database is structured according to the Eurostat nomenclature of the NUTS regions Classification of Territorial Units for Statistics, (NUTS - for the French Nomenclature d'Unités Territoriales Statistiques), created by the European Union for referencing the administrative divisions of countries. Each NUTS entry, country or region consists of priorities as described in their RIS3s, containing a brief description. These description fields range from very short (sentence or two) to extensive ones covering well-explained activities and goals. In addition, where available, detailed RIS3s documentation of smart specialisation can be found. The S3/R&I priorities in Europe are further associated with the Economic and Scientific Domains as well as EU Policy Objectives, based on the Eurostat's NACE2 sectorial codes and OECD categories, the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS 2007) and the so-called “Societal Grand Challenges” identified in Horizon2020, as well as and the headline policies in the Innovation Union Flagship Initiative, respectively.

This research uses data containing 1.394 priorities and 243 NUTS entities in total, covering the EU-28 and their regions, as well as 8 non-EU countries with their 22 non-EU regions, representing a relevant official source of information with sufficient amount of data for data analysis purposes and for objectivity of results.

Although the Eye@RIS3 has been created for non-statistical purposes primarily, this paper uses available information for data analysis to uncover what is the significance and representation of cultural heritage and/or culture through the occurrence of their respective terms in smart specialisations strategies and to what extent they relate to economic domains and subdomains associated to circular economy. A search performed for the term “adaptive reuse” has not brought any results.

With the aim to improve data analytics capabilities, the entire database of the Smart Specialisation Platform has been downloaded and further processed in a spreadsheet. Each list entry of the database consists of: NUTS code, Region/Country Name, Description, Economic Domains, Scientific Domains and Policy Objectives. The search was performed within the description column in the spreadsheet and two different levels of search were used. The first and the most restrictive level used the “cultural heritage” keywords in a refined search. The second level used a mix of keywords “cultural”, “culture”, “creative”, “heritage” and “adaptive reuse” as the database has shown inconsistency in using “cultural heritage” across priorities. After each of the second level keywords search was completed, priorities were combined and duplicates were removed. This implies that only the first level of search shows explicit use of "cultural heritage", while the second level search includes a broader and extended field of "culture" and "cultural heritage". Therefore, two levels of searches produced two lists of priorities, the shorter first level list and the longer second level list (titled “cultural heritage/culture priorities” in Fig. 82-85 below). Furthermore, another relevant analysis for this research was to understand

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

the importance of cultural heritage per country/region (named as “cultural heritage/culture regions” in Fig. 82-85 below). This necessitated the creation of another two lists, grouping priorities into regions, according to the respective region's recognition of the importance of its cultural heritage so that it identifies it as part of its priorities. In total, four lists were created.

6.2 Results regarding Data search with Eye@RIS3

In order to estimate representation, and therefore the importance, of cultural heritage, through the occurrence of their respective terms in description, for other three categories: the economic domain, the scientific domain and policy objectives, different analyses and corresponding metrics were performed in a broader study. However, this paper presents only the results related to the economic domains and subdomains associated to circular economy and adaptive reuse, according to terms identified in the first assessment of the research, which are the Economic Domain E – Water supply; Sewerage, waste management and remediation activities (with subdomains Water collection, treatment and supply, Sewerage, Waste collection, treatment and disposal activities; materials recovery, Remediation activities and other waste management services) and the Economic Domain F – Construction (with Subdomains – Construction of buildings, Civil engineering , Specialised construction activities).

The first set of analyses (still second assessment) examined the impact of cultural heritage, culture and adaptive reuse by means of its presence in the description part of regional priorities under smart specialisations, and by and its direct relation to the Economic Domains selected for the implementation of priorities. This made it possible to quantify the presence and importance of cultural heritage and culture for each of the domains and subdomains through occurrence of their respective terms. Results of the first set of analyses, shown in the Fig. 82 and Fig. 83 contain only the main economic domains items within related priorities (related ones i.e. the ones in which “culture” and/or “cultural heritage” showed up as a priority for at least one region). As expected, this analysis shows a clear linkage between the wider term of culture and cultural heritages and the economic domain R - Arts, entertainment and recreation. A notable difference appeared when using only "cultural heritage" keyword search, where the percentage dropped to around 15%. The other two economic domains: N - Administrative and support service activities and I –

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

Accommodation and food service activities, show notably higher importance of wider search criteria, with percentages around 30%. This could be attributed to the direct connection of these domains with cultural activities that require physical presence and logistics, such as tourism.

However, when using restrictive keywords, the search gives average percentages hardly going above 10%, as is the case in the first three domains mentioned. Average values across domains for "cultural heritage" could perhaps indicate that the term has not been adequately recognised in any other than primary domains. This is especially true for the domain F – Construction, the domain mainly linked to circular economy principles, that has 5% for wider and 2% for restrictive keywords.

Such a low percentage can highlight how cultural heritage is under-evaluated in construction market and not linked to adaptive reuse of cultural heritage in case of Europe under smart specialisations. Another visible aspect across all domains is a highly constant and proportional drop when comparing regions to priorities. This can be a result of much higher number of priorities per region and of priorities in total.

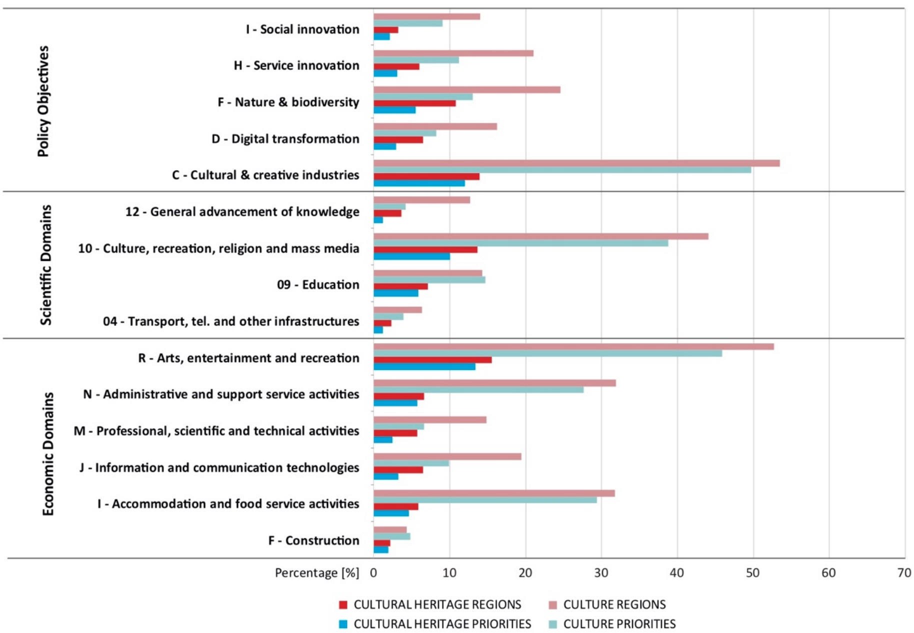


Fig. 82: *Culture and cultural heritage presence in related number of regions and priorities under economic domains of smart specialisations*

Narrowing down from main economic domains to the economic sub-domains mostly related to the circular economy, the same is reflected. The Fig. 83 shows Economic sub-domains of the economic domain F – Construction, with a small peak in F.43 – Specialised construction activities, only for wider keywords, which could imply that "culture" in general is more linked to specialised construction activities than "cultural heritage", a notion that definitely shows underestimation of cultural heritage and its relatively poor perception of importance and inclusion into circular economy sub-domains of smart specialisations, while “adaptive reuse” completely remains excluded.

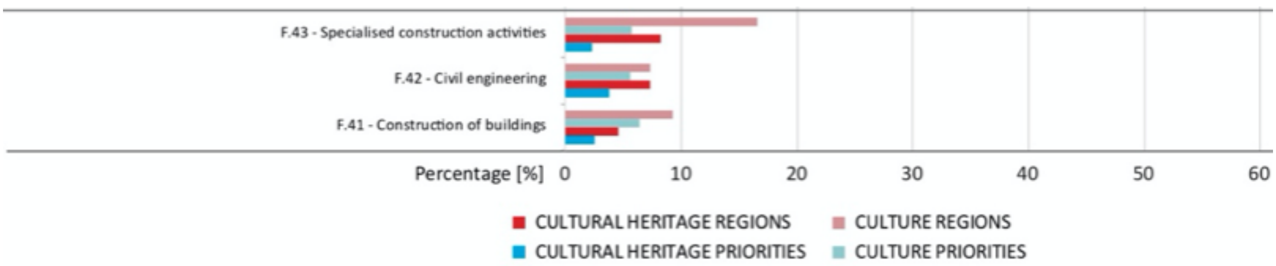


Fig. 83: *Culture and cultural heritage presence in related number of regions and priorities under construction economic sub-domain of smart specialisations*

The second set of analyses to examine the presence and importance of "cultural heritage" and "culture" in overall economic domains through occurrence of their respective terms. Results of those economic domains containing keywords are shown on Fig. 84. The 6 economic domains shown represent 14% of a total of 41 domains/objectives under smart specialisations. The rest of the economic domains are not presented, as their percentages are equal to zero. When counting the number of regions and priorities containing a wider keyword search, we find that "culture" is mentioned in 80 regions and 103 priorities, which represents 33% and 7% of the total respectively. When the search is restricted to only "cultural heritage", the number of regions and priorities falls to 24 and 26 respectively. Their percentages also fall to 10% and 2% of the total number of regions and priorities respectively. Since this time the comparison is conducted on the total number of domains and the total number of regions and priorities, and not just those associated with the cultural heritage, a significant drop in percentages is recognisable. Exceptions are, like in the analysis 1, in the economic domain R - Arts, entertainment and recreation. However, this peak is applicable only for wider search keywords and when taking into account regional distribution.

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

Nevertheless, the importance and the overall distribution of percentage is in the range from 5% to 15% for "culture" and from 3% to 9% for "cultural heritage" on the regional level, while again the Construction sector may neglect cultural heritage adaptive reuse and evaluate it at barely a few per cents.

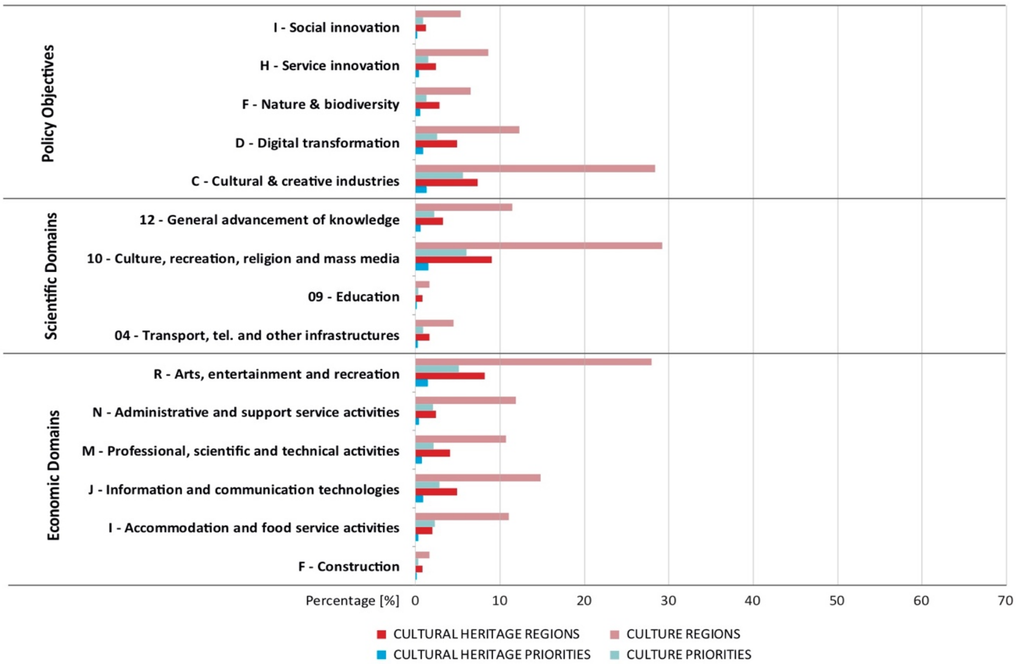


Fig. 84: Culture and cultural heritage presence in total number of regions and priorities under economic domains of smart specialisations

Three relevant circular economy related economic sub-domains, out of 82 in total, are presented in Fig. 85. It is worth mentioning that there is a lack of differentiation between F.43 Specialised construction activities and F.41 Construction of buildings, while some difference in favour of the first could have been expected.

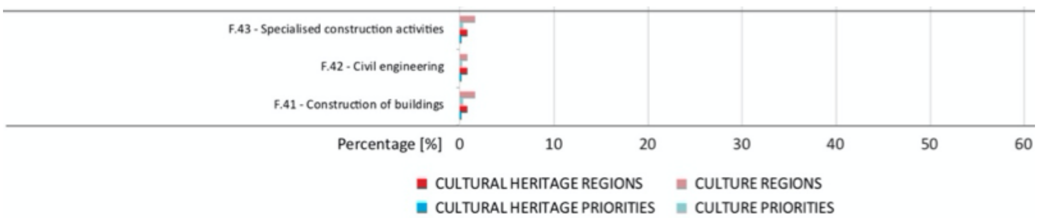


Fig. 85: Culture and cultural heritage presence in total number of regions and priorities under construction economic sub-domain of smart specialisations

DOI: 10.3217/978-3-85125-668-0-23

The findings related to the economic domain E – Water supply; Sewerage, waste management and remediation activities have not been elaborated in more detail, as their percentages was equal to zero.

7 Conclusions and future work

Returning to the questions posed at the beginning of this research, it is now possible to state that only a very small number of regions include cultural heritage adaptive reuse through smart specialisation in their regional circular economy strategies. Findings from both the qualitative and the quantitative analysis, through first and second assessment, suggest the following: some NUTS entities have included circular economy in their regional innovation strategies for smart specialisation, thus defining circular economy as a priority sector for the region, but still not including cultural heritage adaptive reuse as a part of its implementation. The second major finding is that the economic sub-domain related to circular economy, Construction, has integrated cultural heritage under smart specialisation strategies in a very small number of regions. Another of the more significant findings to emerge from this study is that cultural heritage is not adequately recognised as a potential for economic development under the economic domain associated with adaptive reuse and circular economy. Adaptive reuse in relation to cultural heritage, as a term, has not been mainstreamed in circular economy strategies, neither in smart specialisation strategies.

Nevertheless, the study offers the answer to the questions addressed showing that the significance and representation of cultural heritage and/or culture through the occurrence of their respective terms in description of circular economy strategies and in smart specialisations strategies is very low. This data, with accurate percentages shall offer a starting point for further improvements at both, academic research and policy improvements.

Overall, these results indicate that, although creative and cultural sector forms are an important growth factor in many cities and regions, integration of these aspects in circular economy domains remains a challenge that national and supranational governments will have to address in the future. Regions need to recognize and take into account the complexity of interconnections between the traditional cultural assets, such as cultural heritage adaptive reuse, on the one hand, and the improvement of circular economy, on the other.

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

This study could be characterized as an addition to discussions on forming a proposal of the areas and pillars to be subjects of analysis in tracking the implementation of circular economy. Previous studies (Ranta et al., 2017) highlighted that norms and cultural aspects play an important role in shaping the transition towards more sustainable choices and the adoption of circular economy principles.

The current research also poses a question on the social and cultural aspects of technical issues and of the technology aspects of circular economy. Although many “R frameworks” in academia as well as in regional strategic documents could have incorporated terms such as “cultural heritage buildings”, “historical buildings”, they simply fail to do that (even in cases when they indirectly refer to them). Therefore, in addition to the fundamental challenges concerning these matters, the technical issues and the technological aspects of the circular economy, efforts need to be made in awareness raising regarding the social and cultural aspects, which is considered as yet another little explored area.

References

Avdiushchenko, A., 2018. Toward a Circular Economy Regional Monitoring Framework for European Regions: Conceptual Approach. *Sustainability*, *10*(12), p.4398.

Blomsma, F., Brennan, G., 2017. The emergence of circular economy: a new framing around prolonging resource productivity. J. Ind. Ecol. 21 (3), 603–614.

Boschma, R., 2014. Constructing regional advantage and smart specialisation: Comparison of two European policy concepts. *Scienze Regionali*.

Capello, R. and Kroll, H., 2016. From theory to practice in smart specialization strategy: emerging limits and possible future trajectories. *European Planning Studies*, *24*(8), pp.1393-1406.

Capello, R., 2014. Smart Specialisation Strategy and the EU Policy Reform. *SR SCIENZE REGIONALI*, *13*(1), pp.4-14.

Coffano, M. and Foray, D., 2014. The centrality of entrepreneurial discovery in building and implementing a smart specialisation strategy. *Scienze Regionali*.

Cooke, P. and De Propris, L., 2011. A policy agenda for EU smart growth: the role of creative and cultural industries. *Policy Studies*, *32*(4), pp.365-375.

Cooke, P.N. and Lazzeretti, L. eds., 2008. *Creative cities, cultural clusters and local economic development*. Edward Elgar Publishing.

Council of the European Union, 2017. Council conclusions on Synergies and Simplification for Cohesion Policy post-2020, doc. 14263/17, p. 6.

Council of the European Union, 2017. Delivery and implementation of cohesion policy after 2020: Council adopts conclusions Doc. 11426/17 + ADD 1

De Vries, B.J. and Petersen, A.C., 2009. Conceptualizing sustainable development: An assessment methodology connecting values, knowledge, worldviews and scenarios. *Ecological Economics*, *68*(4), pp.1006-1019.

Ellen MacArthur Foundation, 2017. Priority Research Agenda. Available at. https://www.ellenmacarthurfoundation.org/assets/downloads/higher-education/EMF_ Priority-Research-Agenda-copy.pdf.

European Commission, 2012. Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3)

European Commission, 2015. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions Closing the Loop - an EU Action Plan for The Circular Economy

European Commission, 2017. Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth (Doc. 11426/17 + ADD 1)

European Commission, 2018. Multiannual Financial Framework (MFF) 2021-2027

Foray, D., 2014. *Smart specialisation: Opportunities and challenges for regional innovation policy*. Routledge.

Foray, D., 2016. On the policy space of smart specialization strategies. *European Planning Studies*, *24*(8), pp.1428-1437.

Gladek, E., 2017. The Seven Pillars of the Circular Economy. Available at. http://www. metabolic.nl/the-seven-pillars-of-the-circular-economy/.

Kipping, M. and Clark, T. eds., 2012. *The Oxford handbook of management consulting*. Oxford University Press.

Kirchherr, J., Reike, D. and Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, pp.221-232.

Kroll, H., 2015. Efforts to implement smart specialization in practice—leading unlike horses to the water. *European Planning Studies*, *23*(10), pp.2079-2098.

Lieder, M. and Rashid, A., 2016. Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *Journal of cleaner production*, *115*, pp.36-51.

McCann, P. and Ortega-Argilés, R., 2015. Smart specialization, regional growth and applications to European Union cohesion policy. *Regional Studies*, *49*(8), pp.1291-1302

McCann, P., 2015. *The regional and urban policy of the European Union: Cohesion, results-orientation and smart specialisation*. Edward Elgar Publishing

Murray, A., Skene, K. and Haynes, K., 2017. The circular economy: An interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics*, *140*(3), pp.369-380.

OECD, 2016. Farm Management Practices to Foster Green Growth. Available at. http:// www.oecd.org/publications/farm-management-practices-to-foster-green-growth- 9789264238657-en.htm.

Sauvé, S., Bernard, S. and Sloan, P., 2016. Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. *Environmental Development*, *17*, pp.48-56.

Smol, M., Kulczycka, J. and Avdiushchenko, A., 2017. Circular economy indicators in relation to eco-innovation in European regions. *Clean Technologies and Environmental Policy*, *19*(3), pp.669-678

Sörvik, J. and Kleibrink, A., 2015. Mapping innovation priorities and specialisation patterns in Europe. *European Commission: Brussels, Belgium*.

UNEP, U., 2011. Towards a green economy: Pathways to sustainable development and poverty eradication. *Nairobi, Kenya: UNEP*. Available at. http://web.unep.org/greeneconomy/sites/unep.org.greeneconomy/files/field/image/green_economyreport_final_dec2011.pdf

Abbreviations

RIS3 – Research and Innovation Strategies for Smart Specialisations (is a process, at the end of which regional/national strategies should identify activities, in which an investment of resources is likely to stimulate knowledge-driven growth);

Eye@RIS3 – an online database, intended as a tool to help strategy development. The purpose of the database is to give an overview of regions' priorities in order to enable others to position themselves, to find their unique niches and to seek out potential partners for collaboration. By updating the online database with regional/national priorities regions/countries gain visibility and have an opportunity to be recognised by potential counterparts looking for collaboration on a certain topic. The online tool also allows making comparisons of RIS3 and R&I specialisations across Europe for a better understanding of how other regions and countries are developing their strategies and innovation priorities and possibly identify competitive niches. Regions are requested to introduce/update input in the database, which will produce a realistic map of the process of RIS3 development.

NUTS – for the French “Nomenclature d'Unités Territoriales Statistiques”

ERDF – European Regional and Development Funds

The S3/R&I priorities in Europe are defined in the tool through the following three categories:

1) "Economic Domains" categories are based on the Eurostat's NACE2 sectoral codes and OECD categories;

2) "Scientific Domains" categories are based on the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS 2007);

3) "EU Policy Objectives" category is composed of ten EU-wide policy areas - each with a set of various sub-categories – corresponding to the so called 'Societal Grand Challenges' identified in Horizon2020 and the headline policies in the Innovation Union Flagship Initiative, including Creative and Cultural Industries, KETs, Social Innovation and the Digital Agenda.

The three categories aim to provide an overview of the R&I activities, in which combined investments of the

Jermina STANOJEV, Christer GUSTAFSSON
DOI: 10.3217/978-3-85125-668-0-23

EU, national, regional public and private resources are likely to stimulate knowledge-driven growth. The tool also combines and aligns the identified regional/national economic and R&I capabilities with the EU wide policy objectives.

Acknowledgments

This research was funded under the framework of Horizon 2020 research project CLIC: Circular models Leveraging Investments in Cultural heritage adaptive reuse. This project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement No 776758.

DOI: 10.3217/978-3-85125-668-0-24

E-Mobility Through RRI to Achieve Social Sustainability: A Case Study of Women Commuters of Delhi, India

Swati KUMARI, Rajbeer SINGH

Centre for Studies in Science Policy, Jawaharlal Nehru University, New Delhi, India

Abstract

Due to various external and internal factors, the Public Transport System (PTS) is at the cusp of transition in Indian cities. In the current socio-technical landscape, the big question is how this transition should be guided towards social sustainability. For this purpose, the innovation process starting from the ideation level should have certain identified desirable values at its core. How to embed these values in the innovation process is the main focus of this research work. This research paper has been divided into four parts. Part one is focused on introducing the research problem in the contextual background of the policy, economy, technology, and cultural aspects to pave the way for the field study. Part two has discussed in detail Responsible Research and Innovation (RRI) as a theoretical framework along with rationale for selecting this framework and need of further developing this framework to suit the need of the different social, cultural and economic contexts. Part three has discussed the field study which is done in the city of Delhi (India). Primary data has been collected through in-depth face to face interviews with women commuters of the PTS in Delhi. Part four has brought forward the insights from the field study and policy suggestions which can make adoption of E-Mobility more socially sustainable along with providing a pathway for a smooth transition from the current environmentally unsustainable fossil fuel-based technology used in the PTS.

1 Introduction

Delhi is one of the world's most populated cities with large and complex Public Transport System (PTS). The PTS in Delhi is an amalgam of road transport including buses, auto-rickshaws, small vehicles, etc., along with rail network and ever-expanding metro train connectivity network. Still, road PTS plays a significant role in the mobility of people including the last mile connectivity which is very critical for the unrestrained mobility in the congested city like Delhi. Within road PTS, new trends are emerging to fulfill the need of commuters as well as to address environmental concerns(De et al., 2017; Harding, 2017;

DOI: 10.3217/978-3-85125-668-0-24

Harding and Kandlikar, 2017). The new emerging transport systems in Delhi have witnessed a series of challenges for commuters, residents, policymakers, the environment, and investors (Aggarwal and Jain, 2016; Lucas et al., 2016; Paget-Seekins, 2015; Rizvi and Sclar, 2014). Some of the issues are related to the social and legal aspects of human life. One such issue is women's 'safety'. In December 2012, gruesome sexual assault (popularly known as the Nirbhaya-Kand) on a woman, in a bus, created a wave of protests across the nation. This public demand created pressure for many safety steps by the government. Yet, the perception studies shows that there is no improvement in the woman's perception of the road PTS in Delhi (Bharucha and Khatri, 2018; Gopal and Shin, 2019; Govinda, 2019; Madan and Nalla, 2016; Nieder et al., 2019; Zietz and Das, 2018) which indicates the gap between the ‘policy at paper’ and ‘policy in operation’.

There are other associated culturally complex issues. For example, it was found in Indian cities that women are more dependent on public transport than men (Verma, 2015; Verma et al., 2016). Due to prevalent patriarchy guided societal norms, the first right to a private vehicle is often going to the male members in the family. Further, the intermediate public transport such as auto-rickshaws becomes very important for the mobility of the women in cities (Mahadevia and Advani, 2016). Despite women's more dependence on public transport, Delhi has performed very poorly on women's safety in PTS. For instance, in the report in 2014, Delhi ranked 4th unsafe city in PTS for women (Foundation, n.d.). As such, poor mobility planning can lead to a situation where it hampers women’s full and free access to employment, social support networks, health facilities, recreational and sports facilities (Hamilton and Jenkins, 2000; Natarajan, 2016). Similarly, the media reports, along with personal experiences of women, act as a demotivation for using public transport. For example, it was found that instances of the so-called 'eve-teasing' hamper the young girl's access to educational institutions by using public transportation (Dhillon and Bakaya, 2014; Natarajan, 2016). Such instances have far-reaching consequences. As it has been found that harassment in the PTS has resulted into the emergence of the phenomena of the 'private student' in the peripheral areas of the city, which is only for the social sciences, as result denying the young girl students opportunities in education and career in sciences[1]. In the present situation the concern for the 'safety' get priority over the need for mobility (Fernando and Porter, 2002; Mahadevia and Advani, 2016; Srinivasan and Rogers, 2005). Therefore, a responsive, gender-sensitive PTS is critical for women empowerment in the cities.

The other dimension is sustainable urban development which is also a part of the identified Sustainable Development Goals (SDGs), which India supposed to achieve by 2030. Inclusive, safe and environmentally sustainable, the public transport system is an indispensable part of 'sustainable urbanization' and stated as one of the objectives of the national program on the Smart Cities (Cervero, 2016) as well. In the past decade, Delhi has faced severe air pollution, of which vehicular pollution has been identified as a major contributing factor (Bhalla et al., 2019; Bhanarkar et al., 2018; Tiwari et al., 2018). There are two dimensions to this problem, one is related to an increasing number of private vehicles. The other associated factor is that current PTS failed to cater to the rising demand for mobility. In this context, the government has envisaged adopting e-mobility by 2030 for the public road transport system. Though the mission was launched in 2013, it has accelerated after the government's FAME scheme in 2015-16. Further, in the light of achieving the SDGs by 2030, the mission is expected to garner the thrust in 2020 (Delhi, 2015). This mission of adoption of e-mobility by 2030 would demand a better understanding and embedding of women's safety as part of the new public transport system (Hopkins and Higham, 2016). There is a need to look into future transport demands and patterns and the meaning of travel for better mobility planning. Making

1. ‘Private student’ is a unique phenomenon specific to the Indian education system. In the educational institutions including schools (offering education in the 10th and 10+2) and collages for graduation, have the category of the 'private student' for student enrollment. Students registered under this category are exempted from attending the regular classes held at the respective educational institution. This provision has been provided keeping an eye on the socio-economic realities of the society. For instance, girls who are also burdened with domestic work are not able to attend the classes, as a result, they are denied an educational degree altogether. Such students can study at home and can appear directly for the exams. However, the provision of private students is only for social sciences subjects. Under the Indian education system, a science subject students must attend the classes on 'laboratory experiments' regularly. Lack of 'safe mobility' options from home to education institution is found to be one major reason behind girl students opting for the 'private student' category. Lack of safe mobility is also a reason behind that ninety percent of the enrolled private students in Delhi are women. This fact also translates into the poor presence of women students in the discipline of science.

public transport safe and accessible would enable women to commute regularly to educational institutes, workplaces, and communities without the fear of being socially, psychologically or physically exploited. Thus, a public transport system with embedded women's safety would enhance the functionality, productivity, participation, confidentiality of women as part of society and economy.

The 'safety aspect' has also impact on the number of commuters choosing the bus PTS. It has been found that despite the rising city population the ridership in the public buses has gone down in the past decade (Suman et al., 2017, 2016). This brought us to the fact that current PTS does not address the needs and issues of the women commuters. Gender studies often talk about the 'denial of agency to the women' (Mosedale, 2005; Rahman and Rao, 2004) as both cause and effect of the poor development among women. Exclusionary PTS, by restricting the mobility of the women, is an important factor in denying the agency to women which have adverse cumulative effects on various dimensions of life. Some studies talk about 'transport poverty' and its social consequences (Cervero, 2016; Lucas et al., 2016). Yet, women face various issues in accessing public transportation freely, which leads to the exclusion of women from social and economic spheres by limiting their participation opportunities. Such, gendered exclusion is fundamentally antithetical to the goal of sustainable urbanization (Mills, 2015; Reeves, 2014; Williams, 2017). Though the term ‘sustainability’ embraces three equally important aspects of environmental, economic and social, yet the social aspect has not been developed much particularly in the developing countries especially in the urban context (Axelsson et al., 2013; Larsen and Jensen, 2019; Mehan and Soflaei, 2017; Missimer, 2015). Despite this, certain parameters are agreed upon as an inseparable part of social sustainability. Social inclusion, the fulfillment of basic needs such as employment, equity and future orientation are some of them (Mani et al., 2016; Mehan and Soflaei, 2017). Therefore, the future e-mobility PTS in India must include the women-centric values to be socially sustainable. There are various studies located in the Indian cities which have focused on the economic and environmental aspect of the e-mobility, but the social aspect has been neglected on which this research paper is focused.

'Women's safety' as a part of public safety and as well as part of inclusive mobility opportunities have emerged as significant issues for public transportation planning and policy during the last decade in India. The major identified issue is a lack of common

Swati KUMARI, Rajbeer SINGH
DOI: 10.3217/978-3-85125-668-0-24

understanding of the concept of women’s ‘safety in public transport’. This is a wicked problem, as even the problem itself is not clear (Buchanan, 2010, 1992). For instance, the problems faced by women in PTS, against which the concept of safety of women could be constructed are not identified from the first-person perspective. This issue becomes more complex with a new emerging transportation system by transitions from old public transport systems. The new technology and innovations are bringing more challenges to the concept and issues of women's safety. However, as of now, there is no existing consensus on the concept of 'Women's Safety' in PTS. The women's safety in the workplace, house, educational institutes, and public transport systems would vary significantly. Moreover, the concept of 'Women's Safety' would also vary from Women and Men's perspectives. The understanding of women's safety would be different when we consider experiences of different age group females (school-going girls, College going girls, Working Girls below the age of 20 years, working women, etc.) and public. Similarly, the 'safety' also varies with time. For example, the concerns regarding safety are different during day and night time. It means the different meanings of women's safety would lead to different futures of women's safety. There is a challenging task of reconciling these different futures of women's safety into concrete concepts.

Therefore, this research has explored the contested concept of 'women's safety' in public transport systems by the inclusion of women's perspectives and experiences as commuters in the PTS. At the same time, it is important to keep in sight the experiences of other stakeholders as well. The other issue is about the non-inclusion of empathetic understanding and women's experience about Women's Safety as 'value' in public transport systems from policy designing to deployment level. As the sociologist, Talcott Parsons noted that "values exert pressure on the empirical reality, thus, intangible values effectively mold the tangible manifest action"(Parsons, 1978, p. 98) Values play a most important part in guiding the behavior, actions, and perceptions. This lack of empathetic understanding about women safety as 'value' among the designers, innovators, planners, and policymakers deprives the PTS of becoming adaptive to the needs of women for their safety. Another serious issue is the lack of enough evidence, research results, non-participation of women in innovation and technology adoption as well as less representation to women among relevant policymakers. Therefore, there is a need for including the women's experience and women's safety as 'value' in the whole process of adoption of the new transport system. Though the science, technology and innovation policy (2013) has emphasized the inclusion of gender and social aspect for the deployment of innovations and technology to ensure social sustainability (Axelsson et al., 2013; Missimer, 2015). But, the ways and mechanisms that how to include the aspect of social sustainability as part of public transport systems are not identified or understood. further, there is not enough understanding regarding, how innovation policy would have to enable the effect on women's safety in public transport systems. There is a need to take care of such issues at the policy design and planning level.

2. Theoretical Framework: Responsible Innovations

A suitable theoretical framework is critical for the successful completion of the research. The process of the selection of the theoretical framework is very important in itself. After literature review gaps are identified based upon which research problem is formulated, but it is the theoretical framework that offers the guidance for achievement of the research objectives in a systematic manner. Since the research problem is centering around the technological evolution in PTS in the form of e-mobility, 'Innovation Studies' frameworks offered an opportunity to study the changes. Within Innovation Studies, various frameworks were analyzed for suitability. The Systems Perspective including Sectoral Innovation were carefully considered (Bergek et al., 2015, 2008; Breschi and Malerba, 1997; Carlsson et al., 2002). One of the key limitations among these frameworks was the lack of the focus on the innovation 'process' itself, which is central to the core 'idea of embedding the women's safety as a value' to future e-mobility PTS. At the same time, this work is dealing with the 'wicked problem' where the clarity over the problem itself would require the inputs from the field (Head, 2018; Termeer et al., 2019). For instance, threat and the potential threat to the future of women safety in e-mobility PTS is not identified from the women's perspective, without which any conception of women's safety largely remains superficial. However, the responsible innovation framework, especially amended to suit the needs of developing countries (Setiawan and Singh, 2015), has provided a way forward to address such 'action-oriented research'.

In the developing countries, the primary objective of the innovations is largely constituting the eradication of poverty and underdevelopment. As a result, a theoretical framework with features responsive to such needs of society is needed. Therefore in the context of the

Swati KUMARI, Rajbeer SINGH
DOI: 10.3217/978-3-85125-668-0-24

developing countries, a Responsible Innovation framework essentially includes key dimensions such as Anticipation, Reflexivity, Deliberation, Responsiveness, and Participation (Singh and Kroesen, 2012). These five dimensions enable the sustainability analysis of the new technologies. Here it must be noted that sustainability to be effective and practical includes social, economic and environmental sustainability (Koops, n.d.).

The responsible innovation (Armstrong et al., 2012; Blaskó et al., 2014; Burget et al., 2017; de Jong et al., 2015; Macnaghten et al., 2014; Muniesa and Lacoste, 2012; Owen et al., 2013a, 2013b, 2012; Ravesteijn et al., 2014; Setiawan and Singh, 2015; Singh and Kroesen, 2012; Van den Hoven, 2013; Von Schomberg, 2013; Zahinos et al., 2013) and design thinking (Chou, 2018; Plattner et al., 2012; Stickdorn et al., 2011; Warnecke, 2016) framework is capable of offering ground level evidences for meaningful policy on the desired future scenario. For this research work, responsible innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (Von Schomberg, 2007). A collective commitment of care for the future through responsive stewardship of science and innovation in the present (Owen, Stilgoe, Macnaghten, Gorman, Fisher, and Guston 2013) is essential. Being caring or ensuring care for certain values (such as women's safety) for social, economic and environmental sustainability by engaging in anticipation, reflexivity, deliberation, responsiveness and participation for bringing up any change in the existing public transport systems to bring them in specific market or use in specific society (Indian)(Setiawan and Singh, 2015; Singh and Kroesen, 2012) is the framework for this study. The responsible innovation framework focuses on the Certain Values, which include Universal and Culture-Specific Values, along with five dimensions. The Value of 'Women's Safety' has both aspects – Universal and Culture-specific meanings. Due to this variability in the socio-cultural public perception of women's safety, the threats and issues also vary. The responsible innovation framework through its interactive transparent process help in navigating through these socio-cultural varieties by engaging in i) Anticipation- an act of forwarding looking, plausibility or foresight and helps in decisions about usage and adoption, funding, regulation, and policy issues. ii) Reflexivity Creating and shaping innovations at different stages. iii) Deliberation- exploring and carefully considering various aspects and discussions. iv) Participation- involvement of stakeholders in the innovation

Swati KUMARI, Rajbeer SINGH
DOI: 10.3217/978-3-85125-668-0-24

process. v) Responsiveness- the reaction and response of the process towards different needs, views, issues, and values. Anticipation emphasizes the 'foresight' for different aspects of the innovation including the possible impacts. Such foresight shall help in the innovation process, adaptation, and diffusion of innovations. Such an exercise is also important for minimizing the risk associated with the implementation of new technologies, as a result providing higher ethical credibility to the new technologies (Hoven, 2014). The dimension of reflexivity correlates with the empathetic understanding of the cause and effects. Here for a broader perspective 'influences' are also taken into account (Owen et al., 2012). All these dimensions of responsible innovation framework provided the suitable analytical framework to make innovation process inclusive and providing inputs from the field level for effective, inclusive, evidence-based policy on e-mobility based public transportation system in Delhi and India. The framework also constitutes goals of sustainability (Voegtlin and Scherer, 2017) for the innovation process which includes Social sustainability, Environmental sustainability as well as Economic Sustainability. This paper, as discussed earlier is focusing on Social sustainability (Fisher, 2017; Missimer, 2015) as its main objective without compromising on economic and environmental sustainability.

3. Field Study

For collecting the primary data field study was conducted in the 'Munirka' area of South Delhi. There are multiple reasons for the selection of this particular site. The infamous 2012 rape and murder of a woman, happened in the vicinity of this area only. Poor public transport infrastructure and the facility were identified as one of the causal factors by an expert committee on the incident (Atluri, 2016). Another important factor is that this area, though part of South Delhi, forms the periphery of transport route connecting to the neighboring, fast-expanding city of Gurugram (part of Haryana state) therefore, witnesses the interstate routine mobility. It is also important to note that the economic profile of the women commuters (who are using the public buses) is mostly lower income levels and most of them engage in the service sectors. Munirka got connected by metro only in 2019, despite having a university, schools and other public institutions adjacent to it. Therefore, road transport has always been an important mode of transportation here. Another factor that made Munirka an interesting site is related to the 'legal-cultural' aspect. Officially, Munirka is still identified as 'village', despite its location in the city. At the cultural front, as well, many rural areas like features are quite visible. It offered the unique cultural context of a village embedded in an urban center, which is a unique feature specific to Delhi. All these factors made Munirka an interesting site for conducting a field study.

In-depth face to face interviews was conducted on various bus stops of the Munirka. Building rapport is very important for conducting interviews among women commuters, therefore, the nature of collected data is qualitative. Since 'time' is a very crucial parameter in women's safety, these bus stops were visited at four different times as 7:00 AM, 11:00 AM, 3:00 PM, and 7:00 PM, on five working days of the week. Inputs were also taken from the workshop conducted with the school going girls and one focus group discussion. The participants were selected based on the parameters of 'age' and 'income level'. The participating women commuters are classified in the age brackets as, below the age of 18 years, 18-40 years, 40-60 years and 60 years and above. The collected data was analyzed for providing the technological and policy inputs for technology developers and policymakers. From the collected data, a definition of women's safety also derived. Conceptualized definition very important for embedding the value of women's safety in future e-mobility from the ideation level of innovation itself. As experiences from the implementation of metro rail project (Kumar et al., 2017; Pradhan, 2018) shows, that after adoption and mainstreaming it is very difficult to alter the values, which is very much in line with what Schumpeter has said about the ‘social inertia’ towards change (Schumpeter and Backhaus, 2003).

4. Reflections from the Field

Firstly, it is important to bring forward that, for women safety, the term 'mobility' is not limited to the vehicles only rather, it also encompasses the areas of a bus stop, pick up and drop points of smaller vehicles such as e-rickshaws, etc. Further, it is also to be noted that battery-operated e-rickshaws have already become very popular over short distance trips, in future the private cars, public buses and e-scoters are also going to be part of the e-mobility. There are specific technological features if embedded in e-mobility PTS, would enhance women's safety along with creating gender-sensitive values.

Based on the conducted interviews and focus group discussion we propose the following definition of women safety in road PTS, “*A reliable, predictable and comfortable road PTS, in which women commuters of all age group are, physically, psychologically &*

environmentally safe, feel welcomed and treated equally without undue financial burden”. Here the term 'reliable' is closely associated with 'trust', but it is a reliable and predictable system that leads to the trust-building among commuters. The term 'psychological safety' encompasses the 'feelings & internal experiences' which ultimately lead to the building of the 'perception' among the commuters. Therefore, along with the percentage of women commuters based on overall commuters' load, trust and perception are identified as important criteria to measure the efficacy of future e-mobility PTS on gender sensitivity scale. The captive women commuters (who have the comparatively higher financial capacity to pay for rides) emphasize on having more 'comfort' in road PTS. For example, it was brought forward that no additional passengers should be taken beyond stipulated capacity during peak hours. Most of the women respondents agreed that they experience more harassment in the overcrowded buses. 'Overcrowding' is also found to be one of the leading factors behind the near absence of women commuters above the age of 60 years, particularly during peak hours. The majority of the respondents were aware of the environmental benefits of e-vehicles. The introduction of 'e-rickshaws' has enhanced their mobility and due to its design added more comfort, more frequency made the trips less time consuming (Mahadevia et al., 2018; Mohanty and Kotak, 2017). Further, it was also found that, due to smaller size, no standing capacity and direct contact with the driver women feel more cared for and welcomed at the e-rickshaws. However, only a few women were found to be aware of the problem of e-waste to be generated by the disposal of the batteries. These batteries have harmful chemicals and can lead to public health hazards of which women are particularly vulnerable (Heacock et al., 2015; Trottier et al., 2018). Therefore, the policy on e-waste management will have a direct impact on the environmental sustainability of e-mobility.

On the technology front, the availability of the 'real-time information' was rated of highest significance by most of the respondents. Such information was desired not only on stations but also within the vehicle. Some kind of 'color code' was also suggested for those commuters who are illiterate. In the focus group discussion 'staring by the male fellow commuters' emerged as one of the most complicated forms of harassment which is difficult to prove and punish legally, but make women uncomfortable and at a time make them feel 'threatened'. It is suggested that the audio-visual system displaying the offenses should be installed in the e-vehicles so that it can educate and make aware of the commuters about

DOI: 10.3217/978-3-85125-668-0-24

such instances. Similarly, most of the women also favored the installing of the CCTV cameras within the vehicles. It must be noted that women commuters under the pressure of unsafe PTS, found to be supporting strong surveillance despite a threat to their privacy. Other demands on the technology fronts were the installation of the 'stop button' which is specially activated during night time so that women can get down near their place and have to walk less distance in the darker areas. Further, the installation of 'audio communication set' to talk with the driver directly which will help in immediate reporting to the driver. Post-2012, if women commuter report to a driver of 'sexual harassment', in such a situation, the driver is bound to take the bus to the nearest police station. Respondents with smartphones are found to be aware of the government's 'Himmat' app, through which mobile police vans can be contacted in case of harassment. But economically less privileged women commuters are found to be not aware of this app, for them it is suggested that such applications installed in the vehicles only can be tracked through GPS.

On the policy front, most respondents supported the inclusion of women drivers and assistants in the road PTS. It must be noted that in the present road PTS there are not even one present women drivers. In the future e-mobility PTS, there is an opportunity to have the design of the vehicle which is more appealing to women. Further, the government policy on the recruitment of drivers should also be more gender-neutral. Further, more women representation is required in the committees responsible for formulating the transport policies. Providing incentives to the technology developers in the field of e-mobility would also act as motivation for embedding gender-sensitive values in the upcoming technologies.

This research work is highly relevant to these practical questions at the interface between the application of new technology through innovation and societal interaction and influences. As 'technological fixation' alone is no answer to the deeper social issues rooted in the particularities of the cultural contexts. Therefore, there is a need for timely research with both theoretical and empirical studies to address these gaps, which this research proposing to undertake systematically.

The research in this direction has the further scope in the direction of developing a matrix system of women safety from women's perspective with identifiable and measurable parameters. Such a quantitative matrix can be based on the qualitative data such as collected by this work. Further, there is a need for continuous operation of the feedback loop until the mainstreaming of e-mobility to ensure the true participation and reflexivity in the entire innovation process.

References

Aggarwal, P., Jain, S., 2016. Energy demand and CO2 emissions from urban on-road transport in Delhi: current and future projections under various policy measures. J. Clean. Prod. 128, 48–61.

Armstrong, M., Cornut, G., Delacôte, S., Lenglet, M., Millo, Y., Muniesa, F., Pointier, A., Tadjeddine, Y., 2012. Towards a practical approach to responsible innovation in finance: New Product Committees revisited. J. Financ. Regul. Compliance 20, 147–168.

Atluri, T., 2016. Bus/Bas/बस: The 2012 Delhi Gang Rape Case, City Space, and Public Transportation, in Space, Planning and Everyday Contestations in Delhi. Springer, pp. 219–233.

Axelsson, R., Angelstam, P., Degerman, E., Teitelbaum, S., Andersson, K., Elbakidze, M., Drotz, M.K., 2013. Social and Cultural Sustainability: Criteria, Indicators, Verifier Variables for Measurement and Maps for Visualization to Support Planning. AMBIO 42, 215–228. https://doi.org/10.1007/s13280-012-0376-0

Bergek, A., Hekkert, M., Jacobsson, S., Markard, J., Sandén, B., Truffer, B., 2015. Technological innovation systems in contexts: Conceptualizing contextual structures and interaction dynamics. Environ. Innov. Soc. Transit. 16, 51–64.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Res. Policy 37, 407–429.

Bhalla, N., O'Boyle, J., Haun, D., 2019. Who Is Responsible for Delhi Air Pollution? Indian Newspapers' Framing of Causes and Solutions. Int. J. Commun. 13, 24.

Bhanarkar, A.D., Purohit, P., Rafaj, P., Amann, M., Bertok, I., Cofala, J., Rao, P.S., Vardhan, B.H., Kiesewetter, G., Sander, R., 2018. Managing future air quality in megacities: Co-benefit assessment for Delhi. Atmos. Environ. 186, 158–177.

Bharucha, J., Khatri, R., 2018. The sexual street harassment battle: perceptions of women in urban India. J. Adult Prot. 20, 101–109.

Blaskó, B., Lukovics, M., Buzás, N., 2014. Good practices in responsible innovation.

Breschi, S., Malerba, F., 1997. Sectoral innovation systems: technological regimes, Schumpeterian dynamics, and spatial boundaries. Syst. Innov. Technol. Inst. Organ. 130–156.

Buchanan, R., 2010. Wicked Problems in Design Thinking. Kepes.

Buchanan, R., 1992. Wicked problems in design thinking. Des. Issues 8, 5–21.

Burget, M., Bardone, E., Pedaste, M., 2017. Definitions and conceptual dimensions of responsible research and innovation: A literature review. Sci. Eng. Ethics 23, 1–19.

Carlsson, B., Jacobsson, S., Holmén, M., Rickne, A., 2002. Innovation systems: analytical and methodological issues. Res. Policy 31, 233–245.

Cervero, R., 2016. Public transport and sustainable urbanism: global lessons, in: Transit Oriented Development. Routledge, pp. 43–56.

Chou, D.C., 2018. Applying design thinking method to social entrepreneurship project. Comput. Stand. Interfaces 55, 73–79.

de Jong, M., Kupper, F., Roelofsen, A., Broerse, J., 2015. Exploring responsible innovation as a guiding concept: The case of neuroimaging in justice and security, in: Responsible Innovation 2. Springer, pp. 57–84.

De, M., Sikarwar, S., Kumar, V., 2017. Intelligent systems to enhance last mile connectivity for upcoming smart cities in India. J. Adv. Res. Constr. Urban Archit. 2.

Delhi, S.I.-N., 2015. Fame-India Scheme—Putting E-Mobility on Road. Auto Tech Rev. 4, 22–27.

Dhillon, M., Bakaya, S., 2014. Street harassment: A qualitative study of the experiences of young women in Delhi. Sage Open 4, 2158244014543786.

Fernando, P., Porter, G., 2002. Balancing the load: women, gender and transport. Zed Books.

Fisher, E., 2017. Responsible innovation in a post-truth moment. Taylor & Francis.

Foundation, T.R., n.d. Most dangerous transport systems for women [WWW Document]. URL http://news.trust.org//spotlight/most-dangerous-transport-systems-for-women/ (accessed 5.4.18).

Gopal, K., Shin, E.J., 2019. The impacts of rail transit on the lives and travel experiences of women in the developing world: Evidence from the Delhi Metro. Cities 88, 66–75.

Govinda, R., 2019. From the taxi drivers' rear-view mirror: masculinity, marginality and sexual violence in India's capital city, Delhi. Gend. Place Cult. 1–17.

Hamilton, K., Jenkins, L., 2000. A Gender Audit for Public Transport: A New Policy Tool in the Tackling of Social Exclusion. Urban Stud. 37, 1793–1800. https://doi.org/10.1080/00420980020080411

Harding, S., 2017. Regulating the last mile: paratransit in Delhi (PhD Thesis). University of British Columbia.

Harding, S., Kandlikar, M., 2017. Explaining the rapid emergence of battery-rickshaws in New Delhi: Supply-demand, regulation and political mobilisation. World Dev. Perspect. 7, 22–27.

Heacock, M., Kelly, C.B., Asante, K.A., Birnbaum, L.S., Bergman, \AAke Lennart, Bruné, M.-N., Buka, I., Carpenter, D.O., Chen, A., Huo, X., 2015. E-waste and harm to vulnerable populations: a growing global problem. Environ. Health Perspect. 124, 550–555.

Head, B.W., 2018. Forty years of wicked problems literature: forging closer links to policy studies. Policy Soc. 1–18.

Hopkins, D., Higham, J., 2016. Low Carbon Mobility Transitions. Goodfellow Publishers Ltd.

Hoven, V. den J., 2014. Responsible innovation 1: the ethical governance of new and emerging technologies. Springer, New York.

Swati KUMARI, Rajbeer SINGH
DOI: 10.3217/978-3-85125-668-0-24

Koops, B.-J. (Ed.), n.d. Responsible Innovation 2: concepts, approaches, and applications.

Kumar, P., Arora, A., Singhal, S., 2017. Public Transit User Captivity in Delhi: A Case Study of Metro Rail and Bus Users in Nehru Place Business District. Transp. Dev. Econ. 3, 22.

Larsen, N.B., Jensen, L.B., 2019. Current work on social sustainability in the built environment, in: IOP Conference Series: Earth and Environmental Science. IOP Publishing, p. 012063.

Lucas, K., Mattioli, G., Verlinghieri, E., Guzman, A., 2016. Transport poverty and its adverse social consequences, in: Proceedings of the Institution of Civil Engineers-Transport. Thomas Telford (ICE Publishing), pp. 353–365.

Macnaghten, P., Owen, R., Stilgoe, J., Wynne, B., Azevedo, A., De Campos, A., Chilvers, J., Dagnino, R., Di Giulio, G., Frow, E., 2014. Responsible innovation across borders: tensions, paradoxes and possibilities. J. Responsible Innov. 1, 191–199.

Madan, M., Nalla, M.K., 2016. Sexual harassment in public spaces: Examining gender differences in perceived seriousness and victimization. Int. Crim. Justice Rev. 26, 80–97.

Mahadevia, D., Advani, D., 2016. Gender differentials in travel pattern–The case of a mid-sized city, Rajkot, India. Transp. Res. Part Transp. Environ. 44, 292–302.

Mahadevia, D., Bhatia, N., Abhilaasha, N., Patel, S., 2018. Improving Women's Safety on Sabarmati Riverfront.

Mani, V., Agrawal, R., Sharma, V., 2016. Flexibility in Social Sustainability: Evidence from Indian Manufacturing Industries, in: Flexible Work Organizations. Springer, pp. 71–88.

Mehan, A., Soflaei, F., 2017. Social sustainability in urban context: Concepts, definitions, and principles. CRC.

Mills, E., 2015. 'Leave No One Behind': Gender, Sexuality and the Sustainable Development Goals. IDS.

Missimer, M., 2015. Social sustainability within the framework for strategic sustainable development (PhD Thesis). Blekinge Tekniska Högskola.

Mohanty, P., Kotak, Y., 2017. Electric vehicles: Status and roadmap for India, in: Electric Vehicles: Prospects and Challenges. Elsevier, pp. 387–414.

Mosedale, S., 2005. Assessing women's empowerment: towards a conceptual framework. J. Int. Dev. 17, 243–257.

Muniesa, F., Lacoste, A., 2012. Responsible innovation in finance: a culture of testing, public deliberation and shared knowledge. Debating Innov. 2, 33–38.

Natarajan, M., 2016. Rapid assessment of "eve teasing"(sexual harassment) of young women during the commute to college In India. Crime Sci. 5, 6.

Nieder, C., Muck, C., Kärtner, J., 2019. Sexual violence against women in India: daily life and coping strategies of young women in Delhi. Violence Women 1077801218824056.

Owen, R., Bessant, J., Heintz, M., 2013a. Responsible innovation: Managing the responsible emergence of science and innovation in society. John Wiley & Sons.

Owen, R., Macnaghten, P., Stilgoe, J., 2012. Responsible research and innovation: From science in society to science for society, with society. Sci. Public Policy 39, 751–760. https://doi.org/10.1093/scipol/scs093

Owen, R., Stilgoe, J., Macnaghten, P., Gorman, M., Fisher, E., Guston, D., 2013b. A framework for responsible innovation. Responsible Innov. Manag. Responsible Emergence Sci. Innov. Soc. 31, 27–50.

Paget-Seekins, L., 2015. Bus rapid transit as a neoliberal contradiction. J. Transp. Geogr. 48, 115–120.

Parsons, T., 1978. Action theory and the human condition. Free Pr.

Plattner, H., Meinel, C., Leifer, L., 2012. Design thinking research. Springer.

Pradhan, S.K., 2018. Gender Issues in Project Design: A Case of Metro Rail in India. J. Resour. Energy Dev. 15, 13–23.

Rahman, L., Rao, V., 2004. The determinants of gender equity in India: examining Dyson and Moore's thesis with new data. Popul. Dev. Rev. 30, 239–268.

Ravesteijn, W., He, J., Chen, C., 2014. Responsible innovation and stakeholder management in infrastructures: The Nansha Port Railway Project. Ocean Coast. Manag. 100, 1–9.

Reeves, D., 2014. Putting women and gender in the frame–A consideration of gender in the Global Report on Human Settlement Planning Sustainable Cities 2009. Habitat Int. 43, 293–298.

Rizvi, A., Sclar, E., 2014. Implementing bus rapid transit: A tale of two Indian cities. Res. Transp. Econ. 48, 194–204.

Schumpeter, J., Backhaus, U., 2003. The theory of economic development, in: Joseph Alois Schumpeter. Springer, pp. 61–116.

Setiawan, A.D., Singh, R., 2015. Responsible innovation in practice: the adoption of solar PV in telecom towers in Indonesia, in: Responsible Innovation 2. Springer, pp. 225–243.

Singh, R., Kroesen, O., 2012. Understanding responsible innovation from developing countries perspectives, in: The 2nd Conference on Responsible Innovation 2012.

Srinivasan, S., Rogers, P., 2005. Travel behavior of low-income residents: studying two contrasting locations in the city of Chennai, India. J. Transp. Geogr. 13, 265–274.

Stickdorn, M., Schneider, J., Andrews, K., Lawrence, A., 2011. This is service design thinking: Basics, tools, cases. Wiley Hoboken, NJ.

Suman, H.K., Bolia, N.B., Tiwari, G., 2017. Comparing public bus transport service attributes in Delhi and Mumbai: Policy implications for improving bus services in Delhi. Transp. Policy 56, 63–74.

Suman, H.K., Bolia, N.B., Tiwari, G., 2016. Analysis of the factors influencing the use of public buses in Delhi. J. Urban Plan. Dev. 142, 04016003.

Termeer, C.J., Dewulf, A., Biesbroek, R., 2019. A critical assessment of the wicked problem concept: relevance and usefulness for policy science and practice. Policy Soc. 1–13.

Tiwari, S., Thomas, A., Rao, P., Chate, D.M., Soni, V.K., Singh, S., Ghude, S.D., Singh, D., Hopke, P.K., 2018. Pollution concentrations in Delhi India during winter 2015–16: A case study of an odd-even vehicle strategy. Atmospheric Pollut. Res. 9, 1137–1145.

Trottier, B., Heacock, M., Suk, W., 2018. An Overview of the Sources and Hazards of E-Waste Exposure on Human Health, in: ISEE Conference Abstracts.

Van den Hoven, J., 2013. Value sensitive design and responsible innovation. Responsible Innov. Manag. Responsible Emergence Sci. Innov. Soc. 75–83.

Verma, M., 2015. Growing car ownership and dependence in India and its policy implications. Case Stud. Transp. Policy 3, 304–310.

Verma, M., Manoj, M., Verma, A., 2016. Analysis of the influences of attitudinal factors on car ownership decisions among urban young adults in a developing country like India. Transp. Res. Part F Traffic Psychol. Behav. 42, 90–103.

Voegtlin, C., Scherer, A.G., 2017. Responsible innovation and the innovation of responsibility: Governing sustainable development in a globalized world. J. Bus. Ethics 143, 227–243.

Von Schomberg, R., 2013. A vision of responsible innovation.

Von Schomberg, R., 2007. From the ethics of technology towards an ethics of knowledge policy & knowledge assessment.

Warnecke, T., 2016. Capabilities, human development, and design thinking: a framework for gender-sensitive entrepreneurship programs. Rev. Soc. Econ. 74, 420–430.

Williams, K., 2017. Spatial planning, urban form and sustainable transport. Routledge.

Zahinos, A., Singh, R., González-Benítez, M., 2013. Moving toward responsible innovation approach in the automative industry: the SEAT case. Conference responsible innovation, The Hague, The Netherlands.

Zietz, S., Das, M., 2018. ‘Nobody teases good girls’: A qualitative study on perceptions of sexual harassment among young men in a slum of Mumbai. Glob. Public Health 13, 1229–1240.

Anita THALER
DOI: 10.3217/978-3-85125-668-0-25

What Could Possibly Go Wrong? About Evaluating Technology Education Projects

Anita THALER

Interdisciplinary Research Centre for Technology, Work and Culture, Graz, Austria

Abstract

This paper discusses impact and process evaluation methodologies for the field of science and technology education with the aim to not only produce measurable outcomes, but also valuing the whole learning process. Therefore, the "Kids4Wearables" project will be presented as an empirical example, in which methods of pedagogical ethnography and further quantitative as well as qualitative instruments have been used, to evaluate this science and technology education project, and assess the interest in technology and gained competences of the 129 participating 6 to 15 year old pupils. While the quantitative instruments served the purpose of measuring the impact of the education project, pedagogical ethnography, drawings, focus group discussions and interviews have been used as additional qualitative evaluation methods. Along the example of this case study, methodological challenges and practical solutions will be presented.

1 Introduction

The theoretical background of this paper is rooted in science, technology and society studies (STS) and critical education theory. According to STS, technology is seen as a social construction, in which "certain intentions and regime interests" (Bammè 2007, p. 26) are inscribed. Therefore, technology influences people not only in their relations to nature, but moreover technology influences human bodies and their minds. As technologies pervade our everyday lives – Oskar Negt talks about a „world constituted by technology" (Negt 1999, p. 228), Nina Degele says that „technology plays a constitutional role for society" (Degele 2002, p. 162) – gaining technological competence or literacy becomes more and more important. And this is where critical educational theory comes into play.

Beside a 'general education' (in German: *Allgemeinbildung*) which is defined by Wolfgang Klafki as "[…] historical mediated awareness of main problems of the present time and the future – as far as they are foreseeable; an understanding of common participation in view of those problems and the willingness to take part in their accomplishment." (1993, p. 56;

Anita THALER
DOI: 10.3217/978-3-85125-668-0-25

translation by the author) critical theory in education defines key problems, which consequently lead to certain educational demands. For instance Klafki (2005) postulated a ‘critical technological literacy’ (in German: *kritische technologische Grundbildung*), which emphasizes a level of reflection in addition to the level of use, in order to assess possible consequences of technological applications.

Negt pointed out that technological competences are “[…] in fact, not only technological qualifications in the sense of skills, but moreover knowledge about societal effects of technologies; I think that to understand those complex effects extending into societal micro-structures is a specific competence which through expansion of knowledge and training of skills leads to the perception of technology as a societal project.” (Negt 1998, p. 35, translation by the author).

These roots of an emancipatory science and technology education theory have led to the development of the ‘vehicle approach’ (based on Thaler & Zorn 2010, further developed by Thaler & Hofstätter 2012), which aims at a “technology education for everybody” (Dahmen-Adkins & Thaler 2019). By not only connecting to the learner’s living environment (Schelhowe 2006), but moreover by using kids’ interests and expertise as a vehicle (e.g. music, TV series, fashion), technology and science education is connected to a meaningful and motivational learning experience for diverse students of all genders (see Hofstätter & Thaler 2019 for more details about the practical realisation of the vehicle approach).

2 The case study

The empirical case study and methodological experiences in this paper stem from the transdisciplinary education research project “Kids4Wearables[1]” (K4W), which aimed at increasing interest in technology as well as science and technology literacy of 6 to 15 year old pupils in five Austrian primary and secondary schools.

1. Kids4Wearables (2017-2019) was a research project funded by the Austrian research funding agency FFG. The coordinator is Birgit Hofstätter from the Internationale Akademie Traunkirchen, the consortium comprised five comprehensive schools in the Salzkammergut region, two science and technology departments from Kepler University Linz, an artist specialised in fashion, and the textile company Lenzing AG. IFZ (Anita Thaler & Michaela Jahrbacher) had the task of doing the evaluation of the project.

Anita THALER
DOI: 10.3217/978-3-85125-668-0-25

	Pupils	Female	Male
Total	129	60	69
With migration background	31	15	16

Table 6: *Participating pupils of the Kids4Wearables project*

The group of the 129 participating pupils (in the school year 2018/2019) comprised 46.5 % females and 53.5 % males[1], 24 % of all participating children have migration background (see table 1). However female pupils as well as children with migration background have been quite differently distributed from school to school (see Table 6).

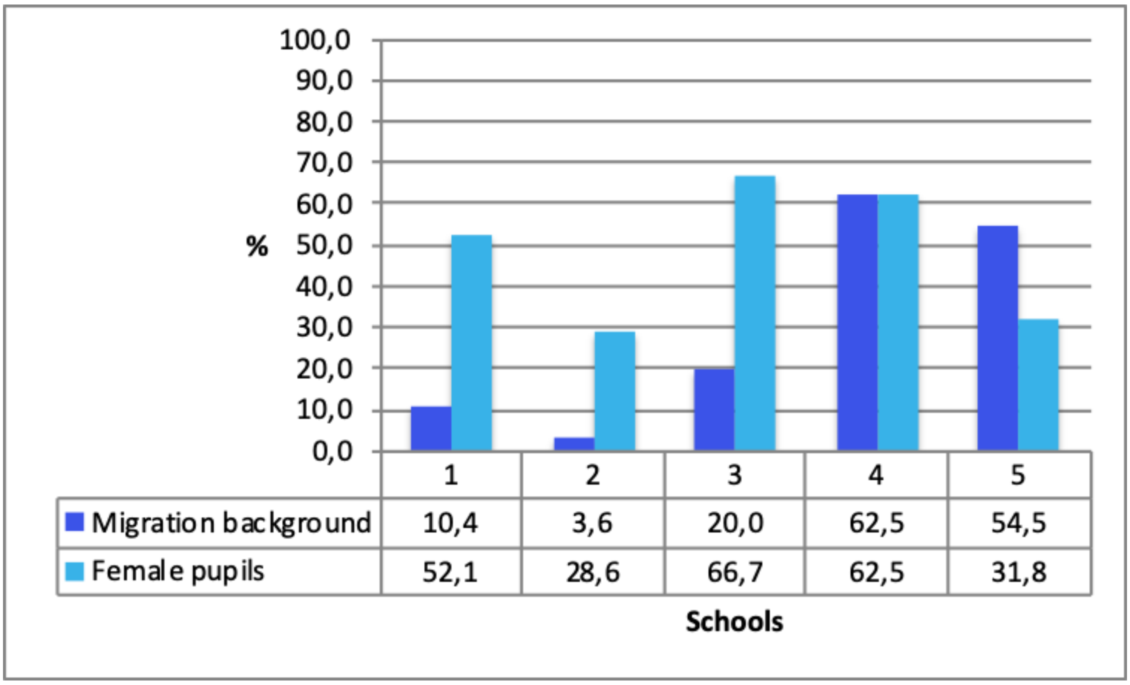


Fig. 86: *Distribution of gender and migration background of children participating in K4W*

All five schools are located in the rural area of Upper Austria. While the first two schools in Fig. 86 (school 1 and 2) are schools using ‘alternative’ pedagogical concepts, partly based on Montessori pedagogics, where pupils have more degrees of freedom in class und could choose to participate in K4W activities or opt out. The other schools (3, 4, 5 in graph 1) are

1. We offered also gender diverse categories for our data collection, but theye have not been used.

Anita THALER
DOI: 10.3217/978-3-85125-668-0-25

‘traditionally’ organised comprehensive schools, where whole school classes took part in K4W, therefore the gender composition of these ‘natural groups’ was not influenced by K4W. The second and fifth school offer lower secondary education (“*Neue Mittelschule*”), the first school is a private (by parents organised) school offering primary and lower secondary education.

3 The methodological challenges and solutions

Research funding organisations understandably ask for proof that the (tax payer’s) money spent on research projects was successfully invested. Therefore evaluation is more and more integrated as an accompanying element in research projects.

In this paper’s case study K4W, the participating kids’ ‘interest in technology’ before and after the project was the main impact category.

While this might sound very simple, the task actually presented itself with several difficulties. It is one thing to assess interest in technology qualitatively (with interviews, drawings etc.), but a different enterprise to measure interest in technology quantitatively, to make it comparable between groups (like schools, school types, age groups, gender etc.), and between two different points of time. The biggest challenge was to find a quantitative technology-interest-instrument, which would work equally for six- as for fifteen-year olds. In other words, the challenge was to design a simply usable instrument, which can be understood and handled by kids with no or limited writing and reading competencies.

Therefore, two *Visual Analogue Scales* (VAS) have been developed for this project. VAS can be applied as alternative questionnaire formats for children. As VAS are based on the cognitive ability to bring items into relative order, it is discussed in paediatrics and children’s psychology whether young school children are able to answer VAS properly. Some studies suggest that VAS can be used only for seven- years olds and older children, others say VAS are not applicable for children under five years (Shields et al. 2003). As those studies refer to pre-school and kindergarten children, we used VAS for the quantitative part of our impact evaluation for our group of 6-year old school children.

The first VAS used in K4W assessed the individual interest in technology before and after the K4W project, posing the question of how interested the participants are in technology. This VAS contains a single line limited by “not at all” at the very left and “very much” at the very right of the line. The scale has been verbally explained to the children and they indicated their interest in technology with a cross on the line, the more on the right side, the higher the interest. This VAS can be evaluated by measuring the position of the respective crosses (in mm) and compare the outcomes by potential relevant categories like gender, age, schools, etc.

The second VAS measures the groups' satisfaction with K4W workshops led by external persons and consisted of five emoticons visualising very high, high, medium, low and very low satisfaction.

However, a qualitative instrument has been added to the VAS for measuring interest in technology: an adaption of the Draw a Scientist Test (DAST by Chambers 1983) respectively the Draw and Engineer Test (DAET by Thompson & Cunningham 2004). Both tests have been developed to visualise the images children have in their minds of scientists and respectively engineers.

One challenge hereby lay in the German language and the gendered word "engineer". If we would use the German word for "engineer" it would be either the female or male version ("*Ingenieurin*", "*Ingenieur*") and if we want to test also the genderedness of children's images of engineering, we cannot bring attention to gender in our test formulation. Hence, we asked all K4W children to "Draw a person, who works in engineering" – although the precise question in German ("*Zeichne eine Person, die in der Technik arbeitet*") refers to "technology" ("*Technik*") as a broader field as engineering ("*Ingenieurswesen*", which is not a commonly used term). In return, we received drawings comprising computers and generally information and communication technologies compared to the DAET.

The aim of using children's drawings is to have qualitative data about the potentially changed images of technology after K4W, which hopefully will enrich and potentially further explain the results of the quantitative data of the VAS.

When we asked the children before their very first K4W workshop to fill in the VAS "interest in technology" and to draw "a person working in technology", and after their first workshop the VAS "workshop satisfaction", all children participated actively, despite age, gender or school type. More than 1.5 years later, after the last K4W event (a "research festival", where more than 300 children and youths from various schools of the region, teachers, companies and researchers took part), all participating children were asked to fill

Anita THALER
DOI: 10.3217/978-3-85125-668-0-25

in the evaluation tools a second and last time. They filled in the VAS “interest in technology” and drew “a person working in technology”. However, there have been problems with this before-and-after measurement.

Due to the length of K4W with several different external persons coming to the schools, different ways of organising the K4W workshops from school to school (e.g. integrated in physics and crafts classes; regular additional project classes in the afternoon; condensed project activities in a shorter time period) some participating pupils had difficulties to comprehend the full range of the project. This had the consequence that some children – from the groups who could choose to participate (and opt out of all or some K4W activities) – could not remember taking part in (some or other) project activities, and therefore refused to participate in the after-measurement (although we recognized some of those children from K4W workshops). The principle of voluntariness in some participating schools additionally led to changing numbers of participating pupils in K4W, which additionally complicated the before-and-after measurement.

Therefore the VAS “interest in technology” delivers now three results:

1. A measurement of all pupils filling out the VAS before K4W,

2. a measurement of all pupils filling out the VAS after K4W

3. a difference between measurements before and after K4W for those pupils who filled out both VAS[1].

Only the last outcome is relevant for measuring the impact, but the other two measurements can be used as stand alone assessments to compare groups of children (e.g. age, gender, school type).

The second approach used to evaluate the process of K4W is pedagogical ethnography (Zinnecker 2000), which comprises participatory observation, interviews, analyses of documents and learning materials, and reflection workshops. With these ethnographical methods, teaching and learning can be accompanied in their making and doing. Results from pedagogical ethnography are not limited to verbally and consciously accessible

1. As the VAS „interest in technology“ and the drawings (of persons working in technology) have been combined on two sides of one page of paper, indicating school, age and first name of the pupil, the drawings, and hence the VAS of the two time points can be related.

Anita THALER
DOI: 10.3217/978-3-85125-668-0-25

information, nor are they censored by social desirability or ‘political correctness’. In this sense the process evaluation follows the one of the core motives of action research in schools, which “lies in the will to improve the quality of teaching and learning as well as the conditions under which teachers and students work in schools.“ (Altrichter et al. 1993, p. 4). In the case of K4W, the action research comprised not only the evaluation but moreover the whole project, with its teacher education modules, testing of newly acquired technology related teaching units, and bilateral and group reflection meetings. Additionally the process evaluation stimulated individual reflections through interviews with teachers, and regular sent out milestone reports about the current phase of the project[1].

Additionally to the methodological challenges of developing instruments, which could measure the impact of K4W for 6 to 15 year old kids and youths with ‘before-after-measurements’, two other facts proved to be difficult for the pedagogical ethnography and the evaluation in general. Firstly, the education project consisted of various different sub-groups (e.g. primary and secondary schools; groups with less than 5% vs. more than 60% pupils with migrant background), which are learning/working with different teaching methods (e.g. alternative schooling based on Montessori principles vs. ‘traditional’ schooling). Secondly, not only the evaluation team worked four train hours apart from the education project, but also the schools were on different locations, hence school visits had to be planned well beforehand, and were very time-consuming and were therefor limited.

To enrich the results from the VAS “interest in technology”, an assessment of the pupils’ gained competencies during K4W has been added to the impact evaluation. This assessment was filled out from the main teachers involved in all 5 participating schools, during interviews after the end of all K4W workshops and school activities (in June 2019). These teacher interviews have been conducted as expert interviews (Bogner et al. 2005), as the position of the transdisciplinary project K4W was to include the teachers as partners and experts, and they certainly spent most of the time of K4W activities with their pupils. The expert interviews comprised the aforementioned assessment of the learned (technological) competencies of each participating group and a retrospective analysis of

1. The project and its evaluation has been divided in different phases: the first with the aim to produce customized didactical concepts for each school and group, the second about inquiry based learning, the third highlighting the kids’ inventing and developing, the fourth about transferring the knowledge within and beyond the participating schools, and the fifth to evaluate the impact of the project.

Anita THALER
DOI: 10.3217/978-3-85125-668-0-25

the didactical concept used for K4W in the respective school. Furthermore, four focus group discussions with 36 pupils have been conducted (in June 2019) to evaluate the groups' perceptions and attitudes (Lamnek 1998) towards specific K4W activities as well as get further validation and examples for the kids' interest in technology.

4 Conclusion

This paper introduced the framework as well as instruments for the process and impact evaluation of science and technology education. The case study of Kids4Wearables, an Austrian transdisciplinary technology education project with five schools, and various experts from textile industry, art, pervasive computing, physics and pedagogy served as an example to visualize potential challenges and the respective solutions in this very project.

It could be shown that although impact evaluation is often connected to quantitative methods, it is not limited to it (like using a visual analogue scale to measure interest in technology), and could benefit by using additional qualitative methods (like drawings, focus groups and interviews).

On the other hand, although the presented methodology of pedagogical ethnography for the evaluation of an educational process has a lot of advantages (for instance in terms of accessibility of non-verbal information), too many different locations and groups can make a regular and accompanying participation of the evaluation team very hard.

In the case of K4W the evaluation team decided to implement additional expert interviews with the main involved teachers to validate observation results as well as assess the participating kids' competencies (in addition to the interest in technology, which was the focus of the funding agency). Finally, more than a quarter of all participating pupils have been invited to focus group discussions to hear their opinion of the K4W activities and visualize their interest in technology with examples, which are otherwise missing in quantitative research.

In this sense the discussed case study showed several methodological difficulties and fixes, however the decision to complement quantitative data and research instruments with an ethnographical approach and interviews and focus groups with the participating children and teachers have surely contributed to the quality of the research.

Anita THALER
DOI: 10.3217/978-3-85125-668-0-25

References

Altrichter, Herbert; Posch, Peter & Somekh, Bridget (1993): Teachers investigate their work. An introduction to the methods of action research. London, New York: Routledge.

Bammè, Arno (2007): Die Neuordnung des Sozialen durch Technologie. Marburg: Metropolis.

Bogner, Alexander; Littig, Beate & Menz, Wolfgang (Eds.) (2005):Das Experteninterview. Theorie, Methode, Anwendung. Wiesbaden: VS Verlag für Sozialwissenschaften

Chambers, David Wade (1983): Stereotypic images of the scientist: The draw-a-scientist test. Sci. Ed., 67: 255-265.

Degele, Nina (2002): Einführung in die Techniksoziologie. München: Wilhelm Fink Verlag.

Dahmen-Adkins, Jennifer & Thaler, Anita (2019): Technologische Kompetenz für alle? Interdisziplinäre Technikdidaktik mit emanzipatorischem Bildungsziel. In: Alexander Franz Koch, Stefan Kruse & Peter Labudde (Eds.): Zur Bedeutung der Technischen Bildung in Fächerverbünden: Multiperspektivische und interdisziplinäre Beiträge aus Europa. Wiesbaden: Springer, S. 15-27.

Hofstätter, Birgit & Thaler, Anita (2019, in publication): Gelebte Utopie – Mit Transdisziplinarität zu einer Technikbildung für alle? In: „Blätter für Technikgeschichte, Band 81 / 2019 Gender & Technik".

Klafki, Wolfgang (2005): Allgemeinbildung in der Grundschule und der Bildungsauftrag des Sachunterrichts. www.widerstreit-sachunterricht.de, 4, 2005. In: http://www2.hu-berlin.de/wsu/ebeneII/arch/klafki/klafki.pdf [13.6.2019]

Lamnek, Siegfried (1998): Gruppendiskussion. Theorie und Praxis. Weinheim: Beltz.

Negt, Oskar (1998): Lernen in einer Welt gesellschaftlicher Umbrüche. In: Heinrich Dieckmann & Bernd Schachtsiek (Eds.): Lernkonzepte im Wandel. Die Zukunft der Bildung. Stuttgart: Klett-Cotta, 21-44.

Negt, Oskar (1999): Kindheit und Schule in einer Welt der Umbrüche. Göttingen: Steidl Verlag.

Schelhowe, Heidi (2006): Medienpädagogik und Informatik: Zur Notwendigkeit einer Neubestimmung der Rolle digitaler Medien in Bildungsprozessen. In. MedienPädagogik. Online-Zeitschrift für Theorie und Praxis der Medienbildung, 1-21. In: http://www.medienpaed.com/05-2/schelhowe05-2.pdf [12.06.2019]

Shields, B. J. & Palermo, Tonya & Powers, J. D. & Grewe, S. D. & Smith, G. A. (2003): Predictors of a child's ability to use visual analogue scale. Child: Care, Health and Development. 29. 281-90.

Thaler, Anita & Hofstätter, Birgit (2012): Geschlechtergerechte Technikdidaktik. In: Kampshoff, Marita & Wiepcke, Claudia (Eds..): Handbuch Geschlechterforschung und Fachdidaktik. Wiesbaden: VS-Verlag. S. 287-297.

Thaler, Anita & Zorn, Isabel (2010): Issues of doing gender and doing technology – Music as an innovative theme for technology education. In: European Journal of Engineering Education, 35 (4), S. 445-454.

Thompson, Meredith & Cunningham, Christine. (2004): Draw an Engineer Test (DAET): Development of a Tool to Investigate Students' Ideas about Engineers and Engineering. ASEE Annual Conference Proceedings.

Zinnecker, Jürgen (2000): Pädadogische Ethnographie. In: Zeitschrift für Erziehungswissenschaft, 3, 81-99.

DOI: 10.3217/978-3-85125-668-0-26

Back to the Future? Why TA May Become More Relevant – Again

Helge TORGERSEN, Alexander BOGNER

Institute of Technology Assessment, Austrian Academy of Sciences Vienna, Austria

Abstract

Technology Assessment (TA) has sometimes been criticised for adhering to an outdated and technicistic view on the relationship between science, technology and society, which may even convey the impression that it has fallen out of time. Has it?

Following different conceptualisations of rationality, inclusiveness and neutrality (as foundational myths of TA) through three historical phases ever since the implementation of TA, this article traces different roles of TA in the respective contexts. Against this background, TA's relevance for solving problems related to science, technology and society in today's world of the "post-factual" is assessed and some requirements for TA's remaining relevant in the future are sketched out. It turns out that actively addressing normative questions may be key in maintaining relevance when knowledge claims are being challenged; two alternative ways to do so are sketched out.

The article concludes that TA does not need to appear having fallen out of time provided it takes on the normative challenge.

Keywords: Technology assessment, rationality, inclusiveness, neutrality, normativity

Helge TORGERSEN, Alexander BOGNER
DOI: 10.3217/978-3-85125-668-0-26

1 Introduction

Technology development and implementation may have consequences other than those intended. This simple insight became a politically relevant issue in the USA around 1970. Over the following decades, Technology Assessment (TA) gained a substantial but hard to define role in the political and public deliberations about the governance of technoscientific endeavours in the Western world. TA aimed at a practical advisory function to politics in the role as an 'honest broker' (Pielke 2007), informed by both social scientific approaches as well as the natural sciences and engineering. Although the mother of all parliamentary TA, the US Congress' Office of Technology Assessment had to close after two decades (as well as some European offices), a considerable number of other institutions stepped in and keep doing TA to this day – either connected to the national parliaments, to scientific academies or as independent entities.[1]

At about the same time, from the 1970s on, the relation between science, technology and society had become a prominent subject of interdisciplinary social scientific research. Under the name of Science and Technology Studies (STS), this resulted in a new understanding beyond the dominant simplistic stage model emerging from concepts such as Vannevar Bush's famous "endless frontier" (Bush 1945). Among many other findings, the insights that technology is socially constructed (Pinch and Bijker 1984), that separating nature and culture is precarious (Latour 1993), that scientific facts are established by researchers and that uncertainty entails conflicts (Nowotny and Gibbons 2001) became mainstream – all relevant findings for TA. While TA had met scepticism mostly from engineering and market-oriented politics, criticism from the social sciences focussed on shortcomings in the conceptual understanding of the very subject of TA.

To this day, critics have not fallen silent. For example, van Lente et al. (2017) have found fault with TA as being normatively blind and following an alleged but impossible neutrality as well as an old-fashioned notion of technology as a thing separate from society. This hinders TA from adequately coping with today's problems from conceptual reasons. As an

1. Examples include the German TAB, the French OPECST, the Dutch Rathenau Instituut, the British POST, TASwiss, the Austrian ITA, the Danish DBT, the Norwegian NBT, the Catalan FCRI or STOA at the European Parliament (see PACITA, http://www.pacitaproject.eu/).

Helge TORGERSEN, Alexander BOGNER
DOI: 10.3217/978-3-85125-668-0-26

alternative, they advocated Responsible Research and Innovation (RRI) for assessing and mediating the societal consequences of technology in a more inclusive way. Furthermore, a constructivist background would prevent technological determinism and do away with the claim for an impossible neutrality. In their reply (Nentwich 2017), TA practitioners rejected this view, emphasising that neutrality can be upheld and that indeed, TA sees technology as belonging to society. Van Lente's criticism, accordingly, was due to a restricted perception of the many and diverse forms TA had developed ever since the OTA had been set up in 1972. In fact, TA had amalgamated much of the respective zeitgeist, adopting new methods, institutional settings and different agendas. While the reply pointed at a somewhat distorted image of TA among critical scholars, some of their criticism cannot be so easily dismissed. TA is afflicted with a couple of problems, for example:

• In contrast to a genuinely social scientific approach, which looks upon technology from outside and has its own concepts and perspectives, TA as an inter-disciplinary field depended also on the expertise of natural scientists and engineers and therefore has had to reconcile concepts of the social, the natural and engineering sciences. Yet, especially during the implementation phase at national parliaments, scientists and engineers often criticised TA for prioritizing abstract societal concerns over, in their perspective, more topical issues like security or product convenience. In their view, TA appeared as a hindrance to industrial development, slowing down the speed of innovation (Haberland 2016).

• TA often emphasized that technological innovation may be a contribution to economic growth but that it is neither a panacea nor an end in itself. This attitude changed somewhat when environmental activists promoting sustainability argued for rapid innovation, for example to produce renewable energy or to introduce more adequate forms of mobility (e.g. Manifesto 2015). In such cases, TA tends to be less critical of innovation. So why did TA consider innovation desirable in some contexts and ambivalent in others? Without a clear normative framework, such a discrimination appeared inconsistent.

• Furthermore, the quest for the "best available knowledge" initially put that of scientific experts centre stage, which attracted criticism early on (Wynne 1975). This preoccupation became even more suspect when situated and lay knowledge, to be retrieved through participatory procedures organised by TA, gained in importance. Consequently, it was by no means clear which form of knowledge would be "better" in the sense of more suitable to

Helge TORGERSEN, Alexander BOGNER
DOI: 10.3217/978-3-85125-668-0-26

solve societally relevant problems. Yet with participatory activities two practical problems arose: firstly, how to activate situated knowledge without inoculating lay people with the experts' explanations, and secondly, whom to include, especially if participants were difficult to find or reluctant to engage (Bogner 2012).

The lack of binding standards, the oscillation between normative tenets and neutrality, an inconsistent use of different forms of knowledge and tricky issues around participation may have contributed to the image of TA of having fallen out of time. Many scholars seem to have their doubts whether there is a future for TA as it builds on seemingly old-fashioned ideas.

Has TA indeed fallen out of time? Is it a concept of the past, when technology development was considered to be separate from society? Should it be replaced by RRI or another approach informed by social constructivism? Or does it still have its merits and should occupy a place in technology governance? Is its way of processing knowledge, its effort to stay neutral, its aim at being inclusive and its sober yet often lacklustre form of policy advice still topical?

The article tries to shed some light on this question. Since many of TA's problems relate to rationality, inclusiveness and neutrality, these three foundational concepts, if not to say myths, of TA (Torgersen 2019) will be briefly addressed as they have acquired different meanings over time. To emphasise TA's diversity, and to provide a background for lessons to draw and inspirations to derive, three historical phases of TA development will then be looked at to identify main differences in a variety of parameters.

After discussing some more recent problems of TA, its relation to normativity will be discussed before sketching out its potential future role with reference to the above foundational myths in the conclusion.

2 Foundational Myths

When in the late 1960s, TA was established at the US Congress as a political instrument to empower the legislative vis-à-vis the executive branch, the basic ideas included neutrality, rationality and inclusiveness (Grunwald 2018); properties that were quite rare in (or even at odds with) the political life at Congress.

As a kind of unique selling proposition, they became essential for TA, but in practice they were difficult to reconcile with the political reality. Without claiming comprehensiveness, these foundational myths of TA may briefly be sketched out as follows (Torgersen 2019):

Rationality refers to the way factual knowledge is applied. Rather than relying on hearsay, TA is committed to use, in an unbiased way, the best available knowledge, often understood to be scientific evidence. Yet in some cases, other forms such as situated and lay knowledge derived from trustworthy sources may be equally or more relevant. Where evidence is shaky or unavailable, such as with new and emerging technologies, convincing arguments e.g. derived from analogies and supported by empirical findings may be applied. If issues are contested, different bodies of knowledge linked to opposing interests may compete against each other. Therefore, the input, the way the information is processed and the results must be kept entirely transparent.

Inclusiveness manifests in considering all relevant sources of information, not favouring a particular interpretation or stake. Apart from scientific evidence, situated or lay knowledge should be considered. All relevant stakeholders should be heard; if not, the exclusion needs to be argued. Results must be openly disseminated so that experts, stakeholders, politicians and members of the public can understand them.

Neutrality means that TA must not take a stand but remain distant to all parties, interests and worldviews. This implies an open-ended investigation of an issue and a non-biased choice of information, way of deliberation and drawing of conclusions as well as results that are comprehensive and relevant. Options proposed should be feasible, oriented at the public good rather than at particular interests and described in a neutral way.

These concepts aka foundational myths are interrelated in many ways. For example, the body of knowledge taken to be relevant influences the form of rationality the assessment process will follow. Who to include determines to some degree what knowledge is available. And whether or not to include a particular stakeholder depends on the respective understanding of neutrality. In other words, these concepts (or myths) mutually influence each other while they together shape the form and understanding of the TA process.

Helge TORGERSEN, Alexander BOGNER
DOI: 10.3217/978-3-85125-668-0-26

In the phase of implementation at various parliaments, neutrality, rationality and inclusiveness were prerequisites for success. Over time, procedural and substantial neutrality served to defend TA against the allegation of partisanship. Remarkably, majority factions at parliaments often tried to prevent TA because they suspected that the opposition would benefit more (Petermann/Grunwald 2005). TA used to be a foreign object in the daily political business, bringing in and promoting forms of knowledge, expertise and solutions more suited for solving controversies by factual arguing than by partisan bargaining (Bogner 2010).

Over time, other institutions and actors in society became important addressees as well, which changed the role of TA and in part, its rationale. With the benefit of hindsight, several phases can be identified, each with a different perspective, respectively, on the relation between science, technology and society (Bogner/Torgersen 2019). They emerged, flourished and partly lost their salience again without disappearing for good. Their following description may appear rough or even a bit exaggerated, but this is necessary to spot the differences in understanding and conceptualising major issues across the different phases. In reality, things were less clear-cut and more ambivalent, but assuming three phases can be discerned, let us see what can be learned.

3 Tasks and rationales of TA

3.1 Expert orientation for multiplying options (from 1970)

Initially, the task of TA at the US Congress was to provide more and better options for decisions on technological issues. So far, pertaining political decisions had mostly been taken by the Government on the basis of information from selected experts and/or lobbyists. Now, “better knowledge” backed by scientific expertise that included all relevant positions should also enable the legislative branch to develop a better understanding of the issue at stake without having to rely on information prejudiced by partisan interests or Government’s intentions. It was hoped that more options would emerge beyond those that powerful political actors would suggest to Congress. This hope was rooted in the confidence that analysis-based planning on the basis of objective knowledge would promote the common good (Bimber 1996). In today’s terms, policy development should become more evidence-based without determining the outcome in someone’s favour. From a normative point of view, this program followed mostly US Democratic (in Europe:

Helge TORGERSEN, Alexander BOGNER
DOI: 10.3217/978-3-85125-668-0-26

social democratic) thinking that was influential in many political institutions during the 1970s, the age of systems analysis and rational planning. In this spirit, Emilio Daddario, one of the founders of the OTA, referred to TA as a method of analysis that systematically appraises the nature, significance, status, and merit of a technological program (Braun 1984).

At that time, the pace of technology development not only appeared as a huge source of benefits but also as a potential socio-political problem. In the long run, it was feared, technology would determine society while securing economic progress and material well-being. Accordingly, technology would impose a single option to every choice: the technological one (proposed by industry and government), and so democracy would suffer. According to Ellul's de-humanized "technological society" (Ellul 1964), public life would be determined by rationality, efficiency and control. The remedy proposed by the OTA was better-founded scientific expertise from more varied sources, as well as a re-alignment of technology development at the interests of the common good rather than that of particular (industry) stakeholders.

TA saw one of its main tasks in advising political actors on decisions over big and costly technological projects. A famous example was the SST project to develop a supersonic civil airplane in the US, or the Sänger project to construct a space shuttle in Germany. Both were eventually abandoned because there was no acceptable return on investment economically, scientifically or in terms of common good benefits. In retrospect, this was well-founded (Petermann/Grunwald 2005).

Regarding the three foundational myths, rationality in this phase can be understood as following the best available scientific knowledge to arrive at robust decisions. Inclusiveness refers to taking on board different scientific disciplines as well as the interests of all relevant institutional stakeholders. Neutrality meant not taking sides with partisan interests but to promote solutions in the interest of the common good.

3.2 Participation to extend inclusiveness (from 1985)

During the late 1970s and 1980s, certain technological developments gained an image as a hazard not only to democracy but to sheer physical existence. Deep controversies over nuclear arms were subsequently extended to technological risks from atomic energy and, later, from biotechnology. While stakeholders promoted the technologies and their

DOI: 10.3217/978-3-85125-668-0-26

applications and the state was interested in economic growth through innovation, civil society organisations protested against the deployment of a number of contested technologies. Controversies often ended up in violent protests. As a side effect, the perspectives of "those affected" became acknowledged as those of legitimate stakeholders. Initially, the affected consisted of the neighbours of a plant to be erected; later, virtually everybody was included as the technologies were said to pose risks to society at large. Hearing non-experts turned the focus from top-down planning to more distributed decision-making and triggered the development of participative methods; new forms of TA made available new forms of knowledge and delivered alternative values for novel options. Elaborate procedures generated alternatives to the official experts' discourses that were intended to make decisions more socially robust (Nowotny et al. 2001). From this perspective, TA understood itself as a hinge, or translator, between science, stakeholders, politics and the public.

The disagreement of experts from various disciplines mostly over risks exacerbated conflicts and fired up criticism of science. Achieving the one best solution with the best available knowledge according to the dominant expert appeared unrealistic because a counter expert would immediately question the epistemic foundation of such a solution. While Paul Feyerabend (1978) depicted western rationalism as "ratio-fascism", an extreme constructivist relativism would consider lay expertise as equivalent to the results of scientific inquiry. Science and technology appeared as irresponsibly and undemocratically inflicting risks to society at large for the material interests of the powerful few. Calls for a more democratic technology development contributed to the preference for governance over top-down ruling, and for assigning the responsibility for decisions to be made to multiple stakeholders.

One of the main occupations of TA under these conditions was to assess risks and to determine whether they would be acceptable. In practice, this often translated into checking the conditions under which the respective technology would find acceptance. In some cases, such as with genetically modified food products, this seemed never to be the case as environmental or health risks were always claimed even if they could not be scientifically demonstrated. Multiple TA exercises established divergent interpretations of risk that were rooted in different scientific disciplines, interests, world-views or cultures (Levidow/Carr 2010).

DOI: 10.3217/978-3-85125-668-0-26

The focus on constructivism suggested that there were different forms of rationality, and TA was not in the position to decide which form was more relevant. Inclusiveness meant taking on board all voices, irrespective which ideological stance they represented, what kind of argument they put forward or which form of knowledge they were derived from. Consequently, neutrality was understood as mainly procedural, making sure that all voices would be heard at equal level, with TA in the role of an organiser or moderator of the process.

3.3 Pragmatically promoting innovation (from 2000)

Two major developments brought a preliminary end to the traditional form of open technology conflicts that had been dominant so far: firstly, events such as the assault of 9/11 captured the imagination of politics, the media and the public, shifting the attention to topics other than new technologies. Secondly, the term technology became almost synonymous with computers and in particular with the internet and social media as parts of everyday life. Technology, hence, no longer had the image of a menace but turned into a playful and useful tool enhancing productivity and self-fulfilment (Torgersen/Schmidt 2013). Under similar auspices, the term “converging technologies” transgressed the boundaries of information technologies and described the growing together of various sectors to one all-encompassing technological idea that would inevitably govern our lives in the future, it appeared.

Yet public opposition was still a concern in the minds of technologists, at least when it came to biotechnology or related endeavours (Torgersen/Hampel 2012). Whether a new development would be acceptable should therefore be determined early-on by comprehensively assessing, in a pragmatic way, the ethical, legal and societal implications (ELSI).[1] This program and the term were coined under the debate on the Human Genome Program when it emerged that the consequences for the acceptance of the developments to emerge might be far-reaching when not properly addressed (Cook-Deegan 1994). In contrast, for information technology, the Silicon Valley business and innovation model served as an irresistible blueprint for a successful economy, conveying a libertarian individualist ideology that considered technology as the solution to every problem including

1. in the US; in Europe, “issues/implications” had been replaced by “aspects” (ELSA)

DOI: 10.3217/978-3-85125-668-0-26

boredom and individual death. Transhumanism, space exploration, but also geoengineering fired up the phantasies of technologists aka entrepreneurs. Risks were something for the faint-hearted while technological gadgets occupied a growing share of reality. This model eventually led to framing synthetic biology accordingly (Torgersen/ Schmidt 2013).

At the same time, coming to terms with menacing societal challenges demanded the rapid introduction of appropriate technologies. Innovation again appeared without alternative, provided it pursued the right aims: to secure privacy through IT design, to keep the Internet accessible for all, and last but not least, to produce renewable energy or devise emission-free public transport. Scientific advice to politics should ensure that technology is “useful, usable and used”, for example in disaster risk reduction and sustainable development (Aitsi-Selmi et al. 2016).

Such a “correct” technology would have another advantage: it would open up promising business fields because the respective processes and products would be in demand. With the right incentives, they would find a market, reconciling industry’s need for economic viable innovations with the demands from environmentally and socially conscious citizens for more sustainability (von Schomberg 2011).

Responsible Research and Innovation (RRI) was to apply both expert knowledge, as well as the wisdom of the crowd, as useful resources to identify areas where a normative consensus over the aims of new technology could be reached. Targeted research on areas of general concern should deliver new value-generating processes and products addressing pressing problems, like antibiotic resistance or climate change. RRI appeared as a historical compromise between forces oriented at industrial innovation and at sustainability. Criticism of technology might still exist in the form of individual NIMBY protests but no longer as a political ideology.

Many TA projects revolved around issues of sustainability (e.g. the implications of renewable energy production, e.g. Grünwald 2009) or the protection of individual rights (such as privacy in IT, e.g. Friedewald et al. 2017). They often addressed a mission – a clearly defined aim – and sought appropriate ways to reach them by adequate means without causing too many unwanted side effects (Mazzuccato 2017). The label of technoscience indicated that application orientation already guided the early phases in the

DOI: 10.3217/978-3-85125-668-0-26

development cycle, so “upstream” participation was considered necessary (Guston/ Sarewitz 2002) to effectively influence technology development. Being future-oriented, TA had to deal with visions (Grin/Grunwald 2000) or even adopt a “hermeneutic” approach (Grunwald 2014).

To find a place within all these requirements, TA took on a predominantly instrumental perspective, often following pre-determined missions. Rather than questioning the missions’ aims, instrumental rationality guided the choice of the best options towards fulfilling the respective mission’s aim, and inclusiveness developed into an epistemic tool to collect situated knowledge, views, interests and options to inform this choice. Neutrality referred to selecting the way how to pursue the mission to the best result (or solutions eliciting little opposition) with least possible input.

3.4 Tasks and Rationales: a Summary

Table 1 summarizes the forms TA adopted in different phases (Bogner/Torgersen 2019). In the left column, the five upper rows show broader societal context characteristics during the phases influencing the respective form of TA. The items in the five lower rows refer directly to TA, the bottom three are the foundational myths. N.B.: The different roles of TA under particular phases emerged gradually through shifts in focus rather than disruptions. Although this summary is necessarily coarse it becomes obvious that TA is, and for a long time has been, a multi-facetted endeavour almost impossible to address as a homogenous entity. Over time, it has become ever more diverse, developing new tasks and skills without giving up previous preoccupations. Around 2010, TA had acquired the status of an umbrella term indicating a manifold assortment of different approaches and practices. What they had in common was an orientation towards novel technologies, broader socio-technological issues and societal problems where technology plays a role, either in evoking them or in potentially mitigating them. From an epistemic point of view, TA remained trans-disciplinary: rather than investigating concepts and practices from an outside perspective (like sociology or STS do), the aim was to include insights from various natural and social sciences as well as situated and lay knowledge. This went along with an integrative approach towards balancing the diverse interests involved in the development and deployment of new or substantially altered technologies.

Rather than sticking to assessing the consequences of deploying a ready-made technology, as the name suggests, TA saw itself as a player in shaping technologies in a way that would benefit society as a whole while minimising the inevitable downsides. To obtain this, ever more emphasis was placed on public debate, partly as a response to the allegation of being lopsided in favour of scientific insights and consequently, world-views. While this may have been justified sometimes, the accompanying allegation of being more open to certain political and economic interests is not very plausible. Rather, TA always seemed to feel obliged, although seldomly addressing it in an open way, to a somewhat old-fashioned conceptualisation of the public good as a moral compass guiding its choice of topics and its daily practice.

	phase 1 (from 1960)	phase 2 (from 1980)	phase 3 (from 2000)
zeitgeist	faith in planning progress	scepticism on progress	pragmatism
paradigmatic society	technological society (Ellul)	risk society (Beck)	network society (Castells)
image of technology	dominant, jeopardising democratic decisions	threat to existence	problem solver, gadget
governance	top-down	bottom-up	network negotiation
status of science	authority	voice among others	competitive advancement
role of TA	increasing the number of options	widening the range of those included	improving innovation
rationale	return on investment	acceptance	mission fulfilment
rationality	scientific	pluralistic	instrumental
inclusiveness	relevant stakeholders	all voices	potential influencers
neutrality	equidistance to partisan interests	epistemic indifference	instrumental plurality

Table 7: *Perspectives of TA in different phases (Bogner/Torgersen 2019, adapted)*

DOI: 10.3217/978-3-85125-668-0-26

4 Back to the future of TA?

4.1 Contemporary problems

Today, many problems have become extremely pressing, like climate change, microplastic pollution, loss of biodiversity, antibiotic resistance etc. More than ever, TA is called to support the societal transformation towards more social, ecological and economic sustainability in a mission-oriented way. Expertise through TA from the sciences, from stakeholders and from citizens on social and technological innovation is highly welcome, provided the relevant actors, especially from the political sector, consider it trustworthy, relevant and significant. Therefore, options and recommendations have to be knowledge-based, balanced, comprehensible and transparent. There is a consensus in western-style liberal democracies that the only way to meet these requirements is through a “rational” debate, highlighting more or less accepted “facts”.

However, there are indications that things have changed over the second decennium, so rather, one should say that a consensus was reached. Scholars have bemoaned that our liberal democratic societies are at risk of deteriorating as implicit social and behavioural rules erode (Levitsky/Ziblatt 2018). Accordingly, the accepted habit of using factual arguments and acknowledging opposing positions have given way to hate speech, minority-bashing and blunt lies. Trumpeting against a so-called elite being detached from the views and interests of ordinary people goes hand in hand with scepticism against any specialised expertise (Nichols 2017). In such an anti-rational environment, accordingly, it has become increasingly difficult to cling to sober facts, no matter what their factuality is built on.

This diagnosis is not unfounded. For example, scientific dissent over man-made climate change has been disavowed as a lack of facts, and experts claiming the existence of facts have been accused of being corrupt and pursuing elite interests only. The scientists’ consensus over substantive indications but not yet fully conclusive evidence yet (Oreskes 2004) did not manage to sway those in doubt; rather, it confirmed those already convinced, deepening the split in society.

If there was a justified allegation against TA of not having identified a new technology’s unintended side effects it must have been its epic failure to foresee the multiplication of the ranting at the pub’s bar to the filter bubbles of social media. Originally, the possibility to

Helge TORGERSEN, Alexander BOGNER
DOI: 10.3217/978-3-85125-668-0-26

freely upload any opinion was praised as a contribution to a lively democracy. In effect, it promoted the erosion of the public space. The pattern of “belief trumping evidence” fuelled technology conflicts that were said to have waned, with issues from climate change to vaccination, the refusal of the latter having developed into a global threat simply for social reasons (Larson/Schulz 2019).

TA and similar exercises are caught between the demand for transforming society along the lines of better knowledge and an increasingly anti-rationalist critique of experts that denies the mere basis for such an endeavour. Apart from splitting society over the conflict issues of the day, this division allows for an increasingly authoritarian politics to focus on power and mission control. TA might shy away from considering such a form of policy-making to be a proper addressee for its advice.

The obvious question is what an appropriate strategy could be for TA. Should it meet the critics half-way in an attempt at staying neutral? After all, the TA philosophy would demand to deal with the relevant dissenting views in a serious way in order to develop a consensual position. But what does relevant and serious mean here? Which dissenting view can be considered as being grounded in a relevant form of knowledge so that it can be taken seriously? What about pathetically staged arguments built on fake news, intended to raise emotions in social media – should they be included? Would transparency regarding sources and methods and a comprehensive reference to dissenting minority views be the solution, as the TA cooking book would suggest? Or would it be futile to rely on rational arguments anyway, because the critics’ business model is built on exactly the opposite?

4.2 Rationality, inclusiveness and neutrality in a post-factual world

The expert oriented, the participatory and the pragmatic phase emerged from a particular societal setting in the relation of science, technology and society, entailing different conceptualisations of rationality, inclusiveness and neutrality, respectively. The legitimacy of TA has always been predicated on it being a rational endeavour. It also related to the demand of being inclusive, which played out in the form of neutrality. Today, there is a new and different societal situation, with new technologies and new challenges, in particular a problematic public space, which may demand a new interpretation of the three foundational myths rather than giving them up altogether. However, simply rejuvenating the past and digging out old solutions does not seem appropriate. This said, past experiences may nevertheless serve as inspirations.

To be rational, TA needs the best available knowledge for example on climate change. In many cases, such knowledge still comes from science. Bruno Latour (in an interview, de Vrieze 2017, p. 159) recently claimed that “we will have to regain some of the authority of science” when it comes to combatting climate change denial. However, this was not an argument in favour of “strategic essentialism” presenting science as indisputable from strategic reasons only. Rather, the solution should be the same as in STS: “You need to present science as science in action.” (ibid.) This may be interpreted as critically describing how scientists arrive at a conclusion and which theories and experimental practices guide them. Such a description may be considered more accurate, relevant and therefore convincing than mere gut feeling or general arguments about scientists being corrupt because they are part of the elite. It may even claim to be more neutral.

Hence, one may adopt, from the expert-oriented first phase of TA, a certain prerogative of scientific findings – provided they can be argued not only in disciplinary terms but on a more general level, referring to how science works. This does not away with the significance of situated or lay knowledge as emphasised in the participatory second phase, but its relevance must be critically argued in an analogous way, for example by describing the situation of the respective speaker in relation to the issue at stake. The mere ennoblement of an argument by the ignorance of a lay person should not be enough for its eligibility. Finally, knowledge must be good for something, it must provide a relevant insight that enables action (as in Aitsi-Selmi et al. 2016). Here, inspiration may be found in the third, the pragmatic phase.

The relation between inclusiveness and neutrality is trickier. On the one hand, Grunwald (2018) had argued that the demand for inclusiveness requires neutrality, because otherwise some views might get neglected, curtailing the knowledge base. Rationality, on the other hand, does not allow keeping equidistance to all positions because taking on board views aiming at discrediting (not only scientific but also situated) expertise and replacing it with mere belief would make a consolidated neutral stance of TA non-rational. As a result, it would erode its legitimacy. Neutrality and rationality in a strict sense as prerequisites for TA’s role as an “honest broker” (Pielke 2007) thus seem to exclude each other under some conditions. But is this the only possible role TA can adopt? Traditionally,

DOI: 10.3217/978-3-85125-668-0-26

the honest broker is the ideal role that has been assigned to TA. These days, however, scholars like Pierre Delvenne consider it necessary that TA adopts the role of an "issue advocate" actively promoting rationality, neutrality and inclusiveness against an increasingly irrational, lopsided and divisive political climate that jeopardises the very elements of a liberal democracy (Delvenne/Parrotte 2019).

4.3 Normativity and neutrality in TA

The main bone of contention here seems to be the relation of TA to normativity. In the first phase, TA derived its normative orientation – apart from its basic predication on rational decision-making in the interest of the common good – from the relevant experts' and stakeholders' views; in the second phase, it took those of "the affected" on board as well while staying as neutral as possible itself. Today, this neutrality grounded in a sociology-inspired, procedural approach collecting and integrating norms as found in society no longer seems fully adequate. In post-factual times, sticking to a totally detached position would undermine the very basis on which TA operates. Somehow, TA has to re-discover its normative basis.

Recently, Armin Grunwald and Pierre Delvenne proposed two different options, respectively, to deal with the tension between neutrality and normativity (Grunwald/ Delvenne 2019). According to Armin Grunwald, TA should emphasise its epistemic basis in scientific rationality and, at the same time, uphold neutrality to guarantee inclusiveness (see also Grunwald 2018). This does not preclude that TA openly refers to a normative basis, namely to the very general values of enlightenment, including personal autonomy and human rights, as well as to the tenets of a liberal democracy such as the division of powers and personal freedom of speech. It may also refer to the values enshrined in the concept of sustainability, to societal equity, the pursuit of the common good or even to a socially sustainable technology development. René von Schomberg referred to a similar corpus of general norms and treaties when describing the normative basis of RRI (von Schomberg 2011). On the level of the respective technical and societal questions at stake, however, TA would be obliged to uphold an operational neutrality regarding stakeholder interests, the hierarchy of aims or the way they are pursued etc. This partition would enable TA to keep its self-assigned role as an honest broker in policy advice, which conveys political credibility and influence while not falling into the trap of eroding its own basis.

DOI: 10.3217/978-3-85125-668-0-26

In contrast, Delvenne (ibid.) recommended that TA should adopt a more pronounced (or even political) stance in the sense of an actor who deliberately pursues concrete yet democratically legitimised aims (such as sustainability goals, social equality, forms of justice or the common good) that lie behind certain proclaimed missions (Delvenne/Parotte 2019). TA would have to declare its normative stance with respect to those aims very transparently and, in every case, to hierarchically deduce operating instructions from this general normative positioning for all its actions, including detailed questions and the choice of options it would have to promote. This could even entail giving up the role of an honest broker and adopting that of an issue advocate, recommending certain solutions rather than others. It could also imply getting into conflict with stakeholders that do not agree with the positions TA defends.

There is something to be said for and against each alternative, and it is difficult to speak out for one as a general recommendation for TA. Rather, both roles, that as an issue advocate or as an honest broker, may be adopted depending on the context, provided TA indicates openly, as a prerequisite for its credibility, in which role it acts in a particular setting. TA would need to adopt a program of reflexive normativity (Kollek 2019), constantly reflecting on the normative foundations that guide its actions in every stage of an assessment. This should become a daily practice by default rather than an effort carried out only on special occasions.

Conclusion

Has TA really fallen out of time? Certainly not. The demand for an institution that analyses, as far as possible and applying multiple bodies of knowledge, various options for socio-technological ways to proceed in a neutral and rational way, that organises and stimulates the public debate on them and provides, at best, sober policy advice for decisions to be made seems still topical. One may claim that such an institution is even more necessary in an era where the public space is eroding, where anti-rational assaults jeopardize effective policy-making and where it becomes increasingly difficult to sort out conspiracy theories from critical positions, fake news from unexpected facts and staged claims from well-founded arguments. Within the realm of technology governance, few institutions may be in a better position.

DOI: 10.3217/978-3-85125-668-0-26

However, to do so successfully TA needs to better adapt to this function. It must learn from experiences without aiming at bringing back the past days of glory. The TA of the future will have to be inclusive, i.e. take on board expertise from multiple scientific disciplines and views, from public involvement and from a variety of stakeholders. In addition, it will have to lay open the form of neutrality it follows as well as the normative tenets it holds, which everybody is free to agree with or not and therefore to criticise TA – and TA will have to tolerate and take up criticism. How exactly such a regime would look like is unclear yet, but some points with regard to neutrality, rationality and inclusiveness might render TA more viable in the future.

Regarding neutrality, TA might secure its institutional basis so to keep major actors at arm's length, which means establishing good relationship e.g. to industry, NGOs, the executive branch or various political forces at different levels. Yet TA should not risk falling into an institutional or financial dependency. This is more difficult than it appears since TA is increasingly dependent on doing project work paid by institutions that have self-interests such as the European Commission, e.g. in mission-oriented research programs. In other words, reducing the dependency of TA on third party funding will be essential but difficult.

Regarding rationality, TA should remain, on the one hand, science-based, i.e. relying on scientific insights but keep in mind that they are only temporarily valid. On the other hand, it should also consider non-scientific forms of knowledge, because they are essential in balancing hidden interests inherent in the scientists' data interpretations. Yet all forms of knowledge must be subject to the same level of scrutiny and double-check, irrespective of their origin, whether they fit a particular view or contribute to reaching an aim proclaimed in a mission. TA should be committed to state what the case is, and not what it should be, unless clearly argued.

However, this is not enough. TA, as all trans-disciplinary fields, needs to develop its own concepts and approaches rather than bouncing between the detached approach of the social sciences (viewing technology from outside) and the risk of being engulfed by the standards of the natural sciences (coming from within technology). This requires more emphasis on, and reception of, theoretical work.

Regarding inclusiveness, certain views and interests suggest themselves; the same goes for particular scientific disciplines. Yet they cannot claim to depict the entire reality, so searching for alternative views is necessary but tedious. When it comes to popular views on scientific issues, they often command a certain credibility and should not be entirely dismissed. However, conspiracy theories need to be separated from relevant critical stances. The only possible way to do so is through a rational analysis, the criteria of which need to be made fully transparent.

Such a TA may fulfil a role that is needed in a post-factual society stricken by news whose trustworthiness deteriorates by the hour. TA may become one of the few trusted sources for what remains to be called truth, even if it is not to the taste of those in power – provided the institutional setting allows TA to pursue its task.

References

Aitisi-Selmi, A.; Blanchard, K.; Murray, V. (2016): Ensuring science is usable, useful and used in global disaster risk reduction and sustainable development: a view through the Sendai framework lens. Palgrave Communications 2:16016. DOI: 10/1057/palcomms.2016.16.

Bimber, B. (1996): The Politics of Expertise in Congress. The rise and Fall of the Office of Technology Assessment. New York: State University of New York Press.

Bogner, A. (2010): Let´s disagree! Talking Ethics in Technology Controversies. In Science, Technology & Innovation Studies 6 (2), pp. 183-201.

Bogner, A. (2012): The Paradox of Participation Experiments. In Science, Technology & Human Values 37 (5), pp. 506-527.

Bogner, A.; Torgersen, H. (2019): Die Transformation der TA im Zuge der TA von Transformationen. In: Ralf Lindner et al. (Eds.), Gesellschaftliche Transformationen: Gegenstand oder Aufgabe der TA? Berlin: Edition Sigma/Nomos (in print).

Braun, E. (1984): Wayward technology. London: Pinter.

Bush, V. (1945): Science The Endless Frontier. A Report to the President. Washington: United States Government Printing Office.

Cook-Deegan, R. (1994): The gene wars: science, politics and the human genome. New York/London: Norton.

de Vrieze, J. (2017): Bruno Latour, a veteran of the ‘science wars,’ has a new mission. In SCIENCE oct.10, http://www.sciencemag.org/news/2017/10/latour-qa (accessed 18.04.2018).

Delvenne, P.; Parotte, C. (2019): Breaking the Myth of Neutrality: Technology Assessment Has Politics, Technology Assessment as Politics. In Technological Forecasting and Social Change 139, pp. 64-72.

Ellul, J. (1964): The Technological Society. New York: Vintage Books.

Feyerabend, P. (1978): Science in a Free Society. Ann Arbor: University of Michigan Press.

Friedewald, M.; Cas, J., Bellanova, R.; Burgess, J.; Peissl, W. (2017): Surveillance, Privacy and Security: Citizens' Perspectives. London: Routledge.

Grin, J., Grunwald, A. (eds.) (2000): Vision Assessment: Shaping Technology in 21st Century Society. Towards a Repertoire for Technology Assessment. Heidelberg: Springer.

Grunwald, A. (2014): The hermeneutic side of responsible research and innovation. In Journal of Responsible Innovation 1 (3), pp. 274-291.

Grunwald, A. (2018): Technology assessment in practice and theory. Abingdon, New York: Routledge.

Grunwald, A. (2019): Balancing engagement and neutrality in TA. Interview (with Pierre Delvenne). In TATuP 28 (1), pp. 71-74.

Grünwald, R. (2009): Greenhouse gas - bury it into oblivion. Options and risks of CO2 capture and storage. TAB Technology Assessment Studies Series 2. Norderstedt: BoD – Books on Demand.

Guston, D.; Sarewitz, D. (2002): Real-time Technology Assessment. In Technology in Society 24, pp. 93-109.

Haberland, M. (2016): Technology Arrestment oder Innovationsmanagement? Technikfolgenabschätzung und Industrie in Deutschland in den Jahren 1970 bis 2000. Dissertation, TU Berlin.

Kollek, R. (2019): Implizite Wertbezüge in der Technikfolgenabschätzung. Plädoyer für eine Praxis der reflexiven Normativität. In TATuP 28 (1), pp. 15-20.

Latour, B. (1993): We have never been modern. Cambridge MA: Harvard University Press.

Levidow, L.; Carr, S. (2010): GM food on trial: testing European democracy. New York: Routledge.

Larson, H. J.; Schulz, W. S. (2019): Reverse global vaccine dissent. In Science 364 (6436), p.105.

Levitsky, St.; Ziblatt, D. (2018): How Democracies Die. New York: Crown/Penguin Random.

Manifesto - The Breakthrough Institute (ed.) (2015): An Ecomodernist Manifesto (www.eco-modernism.org)

Mazzucato M. (2017): Mission-Oriented Innovation Policy: challenges and opportunities. IIPP Working Paper 2017-1.

Nentwich, M. (2017): A short response to van Lente, Swierstra and Joly's essay 'Responsible innovation as a critique of technology assessment'. In Journal of Responsible Innovation 4 (2), pp. 262-267.

Nichols, T. (2017): The Death of Expertise. The Campaign Against Established Knowledge and Why it Matters. Oxford: Oxford University Press.

Nowotny, H.; Scott, P.; Gibbons, M. (2001): Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty. Cambridge, Boston, Oxford: Polity.

Oreskes, N. (2004): The Scientific Consensus on Climate Change. In: Science 306 (5702), p. 1686.

Petermann, T.; Grunwald, A. (2005): Technikfolgen-Abschätzung für den Deutschen Bundestag. Das TAB -

Erfahrungen und Perspektiven wissenschaftlicher Politikberatung. Berlin: Edition Sigma.

Pielke, R. A. Jr. (2007): The honest broker. Making sense of science in policy and politics, Cambridge, UK: Cambridge University Press.

Pinch, T. J.; Bijker, W.E. (1984): The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. In: Social Studies of Science 14, pp. 399-441.

Torgersen, H. (2019): Three myths of neutrality in TA. How different forms of TA imply different understandings of neutrality. In Technology Forecasting & Social Change. DOI: 10.1016/j.techfore.2018.06.025.

Torgersen, H.; Hampel, J. (2012): Calling Controversy. Assessing synthetic biology's conflict potential. In Public Understanding of Science 21, pp. 134-148.

Torgersen, H.; Schmidt, M. (2013): Frames and comparators: How might a debate on Synthetic Biology evolve? In Futures 48, pp. 44-54.

van Lente, H.; Swierstra, T.; Joly, P.-B. (2017): Responsible innovation as a critique of technology assessment. In Journal of Responsible Innovation 4 (2), pp. 254-261.

von Schomberg, R. (2011): Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields. European Commission Services. https://philarchive.org/archive/VONTRR (accessed 18.04.2018).

Wynne, B. (1975): The rhetoric of consensus politics: a critical review of technology assessment. Research policy 4 (2), pp. 108-158.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

Evolution of Biotechnology in India: (Re-) Emergent Form of Governance

Abhinav TYAGI

Department of Humanities and Social Sciences, Indian Institute of Technology Bombay, India

Abstract

Scientists often introduce metaphors and entities, carve out spaces and bring forth new technologies that either disrupt or exist outside the realms of existing structures of governance and statecraft. Knowledge production has a complicated relationship with social context, material condition and political mandate and vice versa. This paper enquires into the process of evolution of the biotechnological programme with the emergence of newer forms of governing structures and hierarchies in India. The paper engages with the archival records of forty years (from the mid-40s to mid-80s) related to the governance of biotechnology in the country. The paper observes the process of metaphor construction around biotechnological research, during three different phases of biotechnological interventions. These metaphors as technoscientific trope create the conditions for bureaucratic interactions, set agendas for the scientific programmes and national/international collaborations. By engaging with the textual nature of these interactions, the paper attempts to articulate the process of formalisation of the structure of governance for biotechnology in India. The paper utilises the theoretical framework of assemblage to articulate the evolving forms of biopolitics during various biotechnological epochs in the country.

Keywords: Biopolitics, History of biotechnology, Metaphors and Science, Governance

1 Introduction

This paper examines the process of historical evolution of the forms and structures of governance for biological entities with the emergence of the ‘biotechnology’ programme in India. By engaging with the materiality of archival documents from the mid-40s to mid-80s, the paper explores how the metaphor of ‘biotechnology’ was constructed. These records utilise biotechnology as a techno-scientific trope for creating meaning and urgencies for the interaction between various actors such as scientists and bureaucrats from national and international governing bodies. By engaging with the textual nature of these

DOI: 10.3217/978-3-85125-668-0-27

interactions, the metaphor of ‘biotechnology’ became central to set the tone of bureaucratic interactions, formulating a narrative of futuristic growth, setting the agenda for development and forging ties with international agencies. The entangled interaction between various social actors and material objects are mediated through metaphors, co-created agency, structures and the forms of politics and governance. These scientific advancements were entangled with socio-political norms and hierarchies. It facilitated the production of a new socio-political order and got (re)produced by the new social order and so on.

The production of knowledge would be fused with a material embodiment, social aggregations and organisational structure. The paper attempts to rearticulate the process of knowledge production in relationship with the policy mandate during three different epochs. It further enquiries into the process through which the evolution of the specific trajectory of biological research shaped the newer forms of governance or vice versa. The biotechnological research introduced the biopolitical gaze in the policy mandate. With the evolution of biotechnological research, the body in different forms became the site for state intervention and manifestation of power. Through sophisticated biotechnological tools and techniques, bodies were nominalised, stratified and regularised by the state. Through these three phases, the paper has attempted to understand the (re)emergence of biopolitical forms with the evolution of biotechnological advancements.

The entanglement between biotechnological advancements and the emergence of new forms of governance cannot be articulated by the traditional sociological or political sciences framework. The paper utilises the theoretical framework of assemblage to articulate the (re)emergence of newer forms of governance meshed with the biotechnological innovations. It does provide a vantage point to understand the complex historical interactions between social actors and material objects. It creates a lucid and over-encompassing space for the interactions between human and non-human agents. These interactions lead to the emergence of biopolitical forms, with the evolution of biotechnological tools and techniques.

The paper has relied on the theoretical framework of assemblage for the articulation of biopolitics and its relationship with biotechnological programmes during different phases. The framework has facilitated the theorisation of power relationships developed through

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

diverse, ever-evolving, non-deterministic interactions taking place within the assemblage. The dynamics of these interactions within the assemblage were created by urgencies, crisis, solution, and power dynamics within its connectives (Rabinow, 2000). It has further assisted in developing an articulation about the ever-shifting power relationship, as a response to the dynamics of the assemblage. The dynamics of these interactions has further shaped the trajectory of the discipline in the country.

The paper is divided into four sections, focusing on three different phases of policy mandate related to the governance of biological entities. The second section of the paper focuses on the role of science and technology during the post-World War reconstruction phase of the colonial era. In 1943, A.V. Hill, a Nobel laureate and biological secretary of Royal Society, London, was invited by the British government ruling the Indian subcontinent. Prof. Hill was invited to provide consultancy on the status of science and technology in the country. For the section, the paper has relied on the archival records of the visit, reports and recommendations by A.V. Hill published by the Royal Society. It further explored the secondary material available on Hill’s report on the status of science in the country (Hill, 1945, 1946). Hill’s report was one of the first reports evaluating the status of science and technology in India. It further prescribed policy initiatives concerning reconstruction and future development of the country. Hill’s recommendations were significantly responsible for the inception of biopolitics as a tool of governance in the country. Hill’s recommendation argued for drawing the focus on body politics as a tool for reconstruction and governance.

For the third section, the paper focuses on the policy initiatives in the post-Independence era. It attempts to explore the linkages between the policy directives and the scientific discourse of that time. It enquiries into the role of emerging scientific tools and techniques, in shaping the biopolitical form of governance in India. During this phase, the mandate for science policy was set by the Department of Science and Technology (henceforth DST), a regulatory body for the governance of science and technology in the country. This section builds its understanding through keynote addresses by the Prime Minister, National Committee on Science and Technology and plenary sessions at Indian Science Congress that did provide reflections about the priorities set by the government for the biotechnological research, scientists and experts involved in biotechnological research and

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

allied technologies. The phase had significance for ‘scaling-up’ the ontology of biotechnological programmes in the country.

The fourth section of the paper focuses on the inception of the Department of Biotechnology (henceforth DBT), a dedicated centralised governing body for the sector of biotechnology. As a material, the section has utilised the Report of the Working Group, constituted by the Planning Commission for the eighth five-year plan[1] (Report of the Working Group, 1989). It was a classified report. The report discusses the priorities set for the sector of biotechnology for the first five years. The formation of DBT was one of the significant landmarks in formalising a biopolitical institution in the country. The country got a centralised, dedicated department that set the mandate, regulated and controlled the biotechnological research initiatives.

2 Reconstruction Phase: Colonial Era, ‘Quadrilateral Dilemma’ and the Inception of Biopolitics

This paper intends to explore the forms of biopolitical initiatives in India with the evolutionary trajectories of biotechnological research in the country. The dynamics between humans and microbes has changed significantly after the discovery of microbial culture by Louis Pasteur and the discovery of enzymes from cell-free extract of yeast by Eduard Buchner (Demain, 2000; Ben-Menahem, 2009, pp. 2005-2008). Subsequent experiments explicated that these tiny little organisms were mediating various aspects of our day-to-day lives. From the fermentation of food and beverages to the production of life-threatening toxic chemicals, these organisms were found to be influencing our day-to-day processes of life. By the early twentieth century, occupations such as wine preparation, having involvement of microbes, got a makeover in their operational settings and found linkages with laboratories. India was not untouched with the transformations taking place in the west. Many Indian scientists were travelling to England for their higher

1. In India, national economic planning is done for every five years. It proposes an economic plan for the next five years, and after every five years, these plans are assessed by the Planning Commission of India.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

education, with a desire to replicate the success which they witnessed in the West in the Indian context (Parthasarathi, 1992; Burma, 2011).

Globally biochemistry was the precursor to modern biology and biotechnology. In general, biochemistry as a discipline tends to enquire into the chemical processes within life forms. Indian scientists trained in western institutions began to explore their spaces within the new biochemical paradigm. In the 1930s, a few of the prominent names who pioneered biochemical education and research in India were Biresh Chandra Guha from Calcutta University, V.K. Giri from Indian Institute of Science (henceforth IISc), Bangalore and M. Damodaran at Madras University (Ramasarma, 2007). Though Biresh Chandra Guha was considered as the father of biochemistry in India, yet his contemporaries were matching his steps in biochemical research on vitamins, nutrients, and so on (Chatterjee, 2004). As these individuals pioneered the field of biochemistry in India, most of these individuals were associated with the 'first in India' tag for their research in the discipline (Ramasarma, 2007); (Chatterjee, 2004). Hence, the initial phase of biochemistry was dedicated to the few interested individuals attempting to extend their expertise and research skills, which they honed during their education and training in the West.

Though these were fragmented efforts in the area of biochemistry, yet these individual efforts were labouring to replicate the western success in India. New institutions of biochemistry in the form of new departments/centres/chairs started getting recognition within the university premises. Institutes such as IISc, Calcutta University, and Madras University started courses in biochemistry. Still, the fragmented efforts had to rely on the dedication and drive of individual scientists to achieve the desired success in biochemistry. Except for a few committees, there was no coordinated effort from the government to regulate and support biochemical research in the country. Biochemical research, at that time, was lying at the periphery of the scientific discourse in the country (Burma, 2011). This scenario drastically changed after the arrival of Prof. A. V. Hill's report.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

2.1 Quadrilateral Dilemma: Throwing the Spotlight on the Biological Crisis

During the early phase of the twentieth century, science was heavily linked with economic prosperity and political strength of the country. Scientific researchers were oriented to create new economic opportunities and resolve the bottlenecks in the existing arrangement. Hence, the role of scientists, scientific institutions, and policymakers started to become crucial in shaping the future trajectory of the country. One of the significant moves was the arrival of the biological secretary of the Royal Society, London and a Nobel laureate, A. V. Hill in India. Hill was invited in 1943 by the colonial government to provide consultancy on the status of science and technology in the country (Hill, 1945; Anon., 1946). The pressure was mounting on the colonial government from India for the post-World War reconstruction of the country. The context of the invitation to A.V. Hill had an undertone of post-World War reconstruction of a colony.

The Royal Society published a note saying 'At the request of the Government of India (GOI), the council of the Society give permission for the biological secretary, Professor A.V.Hill to go to India and advise the government there on scientific matters (Visit to India by the Biological Secretary Notes & Records 4, 1946).' In 1943, Hill was deputed in India for five months. During his visit, Hill met most of the prominent Indian scientists working in diverse scientific areas of research in the country. Hill pointed out four critical areas of immediate concern from the government. These four critical areas were population, nutrition, health and agriculture. He coined a new term to address these four critical areas collectively as a 'Quadrilateral Dilemma' (Kumar, 2008). The term Hill coined as 'Quadrilateral Dilemma,' created much stir in the policy circles. To find the solution for the perceived crisis, Hill recommended overhauling in the existing structure of governance for science and technology programmes in the country. He further argued for policy measures to bring biological beings and biological research to the centre of the scientific discourse.

The report further asked for a balance between market initiatives and state control. He argued for government support for scientific and technological research (Visvanathan, 1985). The state should balance between government support and government control over scientific research. Hill emphasised on the need for a centralised institution for planning and regulation. Hill's recommendation led to the formation of the Department of Planning and Development (henceforth DPD), a centralised body which provided

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

comprehensive planning, guidance and support to scientific research programmes. It led to the formation of six boards under the flagship of the department. These six autonomous research boards had their research focus on medicine, agriculture, natural resources, engineering industry and war (Visvanathan, 1985).

A. V. Hill's report was one of the significant moments in science policy, which emphasised the importance of biological research during the reconstruction phase. It created urgency around various aspects of life forms, nutrition, health, population, etc (Sinha, 2009). The biological crisis was given priority over the physical, chemical and infrastructure challenges in the country. Hill's report played the pivotal role in reorganising the fragmented research efforts by individual scientists researching in the areas of nutrition, biochemistry and health. Subsequently, life forms were brought under the microscope within the confinements of the laboratory. The Centre for Agriculture and Biosciences International (CABI) acknowledges the impact of Hill's report and describes it as a valuable report for the history of biology and agriculture in the country. It asserted that the people interested in understanding the history of plant breeding in India would always have a keen interest in Hill's report (Das, 2018).

2.2 Inception of Biopolitical Programmes: Indian Scenario

Many eminent historians of science have emphasised the impact of Hill's report on the governance of scientific institutions. Shiva Visvanathan and Deepak Kumar have extensively dealt with the consequences of Hill's recommendations. They further emphasised on the centralisation of the governance structure as one of the effects of the report (Kumar, 2008; Visvanathan, 1985). None of these works has elaborated on the biopolitical aspect of Hill's report. Hill has argued in his report that India should re-organise its policy framework to deal with the 'Quadrilateral Dilemma' (Kumar D., 2001). As Kumar argued, 'according to the Prof. A.V. Hill 'the fundamental problems of India were not really physical, chemical or technological, but a complex of biological ones referring to population, health, nutrition and agriculture all acting and reacting with another' (Kumar D., 2000).

The other significant shift was 'scientification' of the Indian policy discourse. During the first half of the twentieth century, 'Science' was considered to provide solutions for the

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

abysmal socio-economic conditions in the country. Scientists were incorporated into prominent government positions to articulate solutions for the socio-economic crisis in the country. In 1944, B.C. Guha, a biochemical scientist, was appointed as technical advisor to the Food Department in GOI. He played a pivotal role in launching a nationwide nutritional survey in 1935. Till 1935, there was very little quantitative information about the nutritional status of the population. A central committee titled as the ‘Indian Nutritional Committee’ was formed and Guha was appointed as the convener and secretary of the committee. Under his leadership, a nutritional survey was conducted at different locations of the country (Sen, 2005). Simultaneously, the Indian Research Fund Association (now ICMR) also launched a ‘Nutritional Advisor Committee’ which was later recognised as ‘National Nutritional Advisory Committee’ (Patwardhan, 1947). Eventually, in 1944, two regional research units for nutritional research were established, one at Bombay (now Mumbai) and another one at Dacca (now Dhaka). These surveys were one of the first biopolitical interventions in which bodies were nominalised and stratified on the national scale.

The dominant discourse around nutritional research argued for the increment in the calorie content of an average Indian diet. A group of biochemists, including Guha, argued otherwise and staunchly stood for the nutritional balance in the average Indian food plate. As a technical advisor, Guha envisaged establishing a food technological research institute in the country. In 1950, The Council of Scientific and Industrial Research (CSIR) with assistance from the maharaja of Mysore established the Central Food Technological Research Institute (CFTRI) in Mysore. B.C. Guha was inducted in the executive council of the institute (Chatterjee, 2004). Apart from institutional development, the Nutritional Research Laboratory (NRL), Coonoor and All India Institute of Hygiene and Public Health (AIIHPH), Calcutta were providing training and short-term courses at their facilities from the early 1940s (Patwardhan, 1947). These efforts had emphasised the significance and urgency to take up biological research seriously in the country before Hill’s arrival. Hill’s report functioned as a stimulus, which streamlines the fragmented efforts under the flagship of DPD.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

2.3 Summary

Hill's report marked the urgency around the areas such as health, food and nutrition and brought the spotlight on the researchers, scientists, and practitioners working in the above-highlighted areas. These experts from different disciplines brought their practices, tools, methods and funding opportunities to form an interdisciplinary space. There was churning within the space to devise possible solutions for the 'Quadrilateral Dilemma (Kumar, 2008).' The interdisciplinary space was formed by an assemblage of experts from diverse fields such as physiologists, nutritionists, agriculturists, biochemists and bureaucrats. All of them had oriented themselves to the pursuit of solutions for the biological crisis mentioned in Hill's report (Visvanathan, 1985). The metaphor of 'Quadrilateral Dilemma' oriented the science-policy framework for the next four decades. The interdisciplinary space created an assemblage facilitating all kinds of subject and object interactions. These interactions were non-deterministic and minor. The trajectory of the discipline was determined by the location of actors and their interactions within the assemblage.

With the emergence of novel techniques of biochemistry, with higher predictive success, biochemistry dominated the assemblage of interdisciplinary space that was looking for solutions. Various institutes started introducing new departments, centres, chairs and courses in biochemistry. The rise of biochemistry as a discipline paved the way for the (re)production of a new socio-political aggregation. Hill's recommendation catalysed the emergence of new social aggregation. The focus on biological research brought the focus on the body as a site for intervention and governance. In this sense, the interdisciplinary space of biochemistry formed an assemblage of smooth connectives. As American anthropologist Paul Robinow argues, an assemblage would emerge out of a much smaller decision, a decision that was not sure of their conditions, not wholly determined. The new social aggregation catalysed existing actors, things, and institutions into a new mode of existence in the new assemblages (Rabinow, 2000). The new social structure and hierarchies in subsequent times created conditions for the emergence of newer (biopolitical) forms of governance.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

3. Department of Science and Technology: 'Scale-Up' Era and the Steering Committees

3.1 Scale-Up

In the post-Independence scenario, the legacy of Hill's recommendation is reflected in the structures of governance in succeeding years. Due to the impact of Hill's emphasis, centralised planning, control and power became the hallmark of Indian science policy in the post-Independence era. Those six boards formed under the flagship of DPD were transformed into formal governing bodies in the form of councils and departments. The Indian Council for Medical Research (henceforth ICMR), and Indian Council for Agricultural Research (henceforth ICAR) were providing centralised funding and control for the agricultural and health care research in the country (Visvanathan, 1985).

This philosophy of central planning and funding laid the ground for a large scale revolution in the field of agriculture and food security. During the decades of the 50s and the 60s, the country witnessed extreme government interventions in the areas of agriculture, food and nutrition. These interventions cumulated into large scale programmes in the field of agriculture and dairy production as 'Green Revolution'[1] and 'White Revolution'[2]. One of the primary focuses of these programmes was to gain knowledge about the hybrid variety of seeds, development of chemical fertilisers and register best practices for the selected crops in the country (Chakravarti, 1973). In the wake of extensive centralised planning and control, local practices were neglected and excluded from the whole process.

This negligence of local practices and local knowledge emerged as one of the most substantial criticisms of these two large scale government programmes (Singh, 2004). These programmes were case study examples of the Foucauldian relationship between 'knowledge' and 'power'. All critical decisions from crop choices, seed procurement,

1. Worldwide, the Green Revolution was aimed to increase agricultural yields. In the 1960s, India for the first time introduced hybrid seeds, coupled with improved systems of irrigation, and the introduction of chemical fertilisers to increase the yield of average Indian farmers.

2. The National Dairy Development Board launched a project to overhaul the dairy production in the country in the 1970s. Within a few years of the project, India went from being a milk deficient nation to become a milk surplus nation in the world.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

agricultural practices, and cultivation processes had central control and regulation by the state or by its allied institutions. Despite the criticism, the large scale initiatives in the area of food and agriculture such as 'Green Revolution' and 'White Revolution' partially resolved the food and nutritional crisis in the country.

Apart from centralisation, these large-scale revolutions in the field of agriculture changed the cropping pattern in the country. The High Yielding Variety-Seeds Programme (HYVP) had its focus on a bunch of crops. In the long run, very few crops such as wheat, rice and jowar (sorghum), showed a steep growth under the programme (Dhanagare, 1987). It pushed millets (regional crops) outside the food plate of the average Indian consumers (Singh, 2004; Chakravarti, 1973). Another government programme that affected the production and consumption of an average Indian household was the Public Distribution System. Through PDS, the government procured specific crops from the farmers and distributed them to the masses through fair price shops (Mooij, 1994). The scheme providing food security was conceived under the Essential Commodity Act 1955 (India, 1955). The government procures a few food items, like wheat, rice, edible oil and sugar, in a large quantity for distribution. PDS further marginalised the regional crops with its procurement policy.

The scaling up interventions in the field of agriculture opened up space for chemical engineers to intervene and set up food processing units, sugar mills and edible oil refineries in various parts of the country. The knowledge and expertise gained in the areas of biochemistry and biochemical engineering provided an external push to pursue research in the areas of food processing and fermentation technology. These developments introduced chemical engineers to food-based industries and evolved Biochemical Engineering as a separate engineering discipline. The introduction of Chemical Engineering brought the research focus to the 'scaling-up' of biochemical practices.

In India, engineering education under Biochemical Engineering was part of the final year elective or specialisation in the discipline of Chemical Engineering from 1952-63. Till 1963, there was no separate bachelor's programme in Biochemical Engineering. Three significant institutes and universities, namely Jadavpur University, Kolkata, Harcourt Butler Technical Institute (now HBTU), Kanpur and University Department of Chemical

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

Technology (now ICT), Mumbai offered a full-fledged bachelors degree in technology in food and fermentation technology/biochemical engineering from 1963-1965 (T. K. Ghose, 1979); Department of Food Engineering and Technology, ICT, (Mumbai, 2019). All three institutes and universities have the legacy of providing engineering education from the colonial era. At the same time, the University Grants Commission (UGC) Committee on Biochemistry was formed under the leadership of B.C. Guha in 1959. The UGC Committee aimed to promote biochemical education and research in the university space. It was the untimely death of Prof. Guha in 1962 that hindered the pace of the process.

Technological creativity and institutional support in the areas of life sciences have ushered in new possibilities. Now, the manipulation of the life forms was not limited to searching for solutions for the 'Quadrilateral Dilemma' or nutritional crisis. It has instead created solutions in new avenues of life. These new movements in biochemical technologies were strengthened by the newly introduced molecular techniques in biology. The manipulation of life forms was linked with national progress and economic growth. Now, the life forms were trained to 'scale-up' to extract more significant economic benefits. These programmes have 'scaled-up' the ontology of the biological programmes.

3.2 The Steering Committees and Bureaucracy

This section emphasises the role of bureaucracy and governance during the 70s and early 80s. These were the years when most of the funds for research came from the GOI. Private participation in research was almost abysmal. Hence, the government had significant stakes in decision making. Therefore, the role of bureaucrats became very significant in shaping the trajectory of the discipline. There was no dedicated institutional mechanism in the government to respond to the developmental aspirations of biotechnology research in the country. Biotechnological programmes were supported and regulated through 'steering committees'. There were steering committees under the DST, a centralised governing body commissioned in 1973 for laying policy measures, execution and controlling scientific programmes in the country. Some of these committees were either issue-based or interest-based bodies such as 'steering committee' on the '*Fuels from Biomass'* programme (IIT, 1980). In the wake of such structural constraints, the interest of the government, the interest of a particular bureaucrat and his approach towards a particular issue became an important factor in decision making (T. K. Ghose, 1979).

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

One of the significant reflections about the government's expectations from scientists can be drawn from the keynote address by the then Prime Minister Mrs Indira Gandhi at the 63rd Indian Science Congress held at Vishakhapatnam in 1976. The congress was headed by Dr. M.S. Swaminathan, one of the architects of the HYVP programme in the Green Revolution. It was for the first time since its inception that the Indian Science Congress adopted a focal theme relevant to the national interest. Rural development was the focal theme for the 63rd congress. Mrs. Gandhi, the keynote speaker, in her inaugural address emphasised on the significance of the rural turn in scientific policy discourse (Titus, 1976; Agarwal, 1976). The Green Revolution and government-directed interventions introduced energy-intensive agricultural technologies and practices in rural India. It was the call for the scientific community to explore the possibilities of decentralised energy resources for rural India. A few non-conventional energy themes, solar energy, wind energy and bioconversion echoed in the plenary sessions. In 1977, N.M. Swani from the Indian Institute of Technology Delhi (henceforth IIT Delhi) submitted a proposal to set up a centre for advanced studies in 'energy'. The centre was proposed to function under the leadership of M.S. Sodha, a renowned physicist and energy expert (Swani, 1977).

Almost after one year, P. N. Haksar, Chairman of the National Committee on Science and Technology in the Planning Commission of India, echoed similar views in front of an international audience. In 1977, P. N. Haksar, having a keen interest in renewable energy resources, addressed an international gathering convened to discuss the production of non-conventional energy sources through bioconversion. Renewable energy resources were considered a solution to the energy crisis during that time. During his keynote address at the conference on renewable energy in IIT Delhi, Haksar asserted that scientists should have social and economic awareness. Haksar asserted that, in the absence of social and economic awareness, a technological solution for social change had the potential to create new social problems. During the conference, Haksar cautioned the scientists to be grounded and avoid over-enthusiasm around any potentially lucrative breakthrough (Ghose T., Biochemical Engineering and Bioconversion, 1978). Haksar did try to point out the limitations of the relationship between bureaucracy and scientists, 'It is heart-breaking to make our political culture sensitive to the needs of our very talented scientist and technologist. It is frustrating to make our scientist and technologist sensitive

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

to the problem of interaction between science and society in the specific and concrete context of India as they are (Ghose T., 1978).'

There were two significant reflections drawn from the address of then Prime Minister, Mrs. Indira Gandhi, P. N. Haksar and the plenary session at Indian Science Congress. First, there was an energy deficit in rural India post-Green Revolution experiences. It highlighted the significance of non-conventional energy resources as a decentralised recourse for energy. The second significant reflections drawn from P. N. Haksar's address was about the importance of 'scale-up' and 'replicability.' He considers replicability of biotechnological research to a 'pilot-scale' plant as the benchmark of success. A pilot-scale plant has the potential to replicate the results of a research project beyond the laboratory premises to the field area. It has the potential to penetrate the findings of a biotechnological programme into the remotest location of the country.

Renewable resources created through biochemical treatment generated much buzz in the policy circles and scientific communities. Renewable energy was observed as a decentralised energy resource and a potential solution to the energy crisis in the country. The Biochemical Engineering practices have brought a new set of tools, techniques and research experts to manipulate and organise the biological entities in large scale bioreactors. T. K. Ghose was one of the prominent names who had made a significant contribution to the flourishing biochemical engineering in the country. He played the pivotal role in establishing biochemical engineering as a separate engineering discipline at Jadavpur University, Calcutta, and HBTI, Kanpur in 1963-65. Within two years, Prof. Ghose moved out from HBTI and joined the Swiss Federal Institute of Technology (now ETH), Zurich for higher studies. After returning from SFIT, he joined the Department Of Chemical Engineering at IIT Delhi in 1968. He used his research experience and training to initiate research projects in the area of bioconversion of cellulosic materials at IIT Delhi. In 1974, he played an instrumental role in stitching collaboration between SFIT, Zurich and Biochemical Engineering Research Centre (BERC) at IIT Delhi. This collaboration between the two institutions was able to provide BERC technological assistance and access to the international research community working in the areas of non-conventional energy resources (Ghose, 1978).

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

3.3 Summary

As the research focus, BERC picked a few themes of non-conventional energy resources. Hydrogen fuel cell, Synthetic Natural Gas (SNG) and bio-fuels by bioconversion of the cellulosic substances, were some aspects of primary research focus at the centre. Within five years, BERC was able to place itself on the global map as a non-conventional energy research centre. The centre commissioned a pilot-scale plant for the production of 500 litres of biofuels every 24 hours (IIT, 1980). It was one of the first experiences in India in the production of second-generation biofuels. The steering committee on the *'fuel from biomass'* appointed the centre as one of the chief executors of the programme. These developments put research centres such as BERC on the global map of Biochemical Engineering. The centre was given the further responsibility to provide technical consultation for setting up a pilot-scale plant for biofuels at other universities and institutions (IIT, 1980). The centre was able to engage with the metaphor of 'scale-up' and 'replicability' coined by the government. Through assistance from Chemical Engineering tools, the state was able to spread the biotechnological programme to the remotest locations in the country. The penetration and replication of such a biotechnological programme strengthened the central control and power over the state subjects.

In the process, chemical engineers, who were situated on the periphery of the biotechnological assemblage, got the central position to steer the discourse of the energy crisis in the country. They had the immense experience of 'scaling-up' and commissioning a pilot-scale plant for a variety of chemical processes. Breaking disciplinary boundaries, they brought the tools and techniques of chemical engineering to the discipline of biology. They brought large scale bioreactors at the centre of the assemblage of the biochemical epoch. At least in that time, engineers sidelined the biochemists, which were focused on finding the breakthroughs within the laboratory settings. The large scale bioreactors and pilot-scale plants became the hallmark of that era. The introduction of engineering techniques 'scaled-up' the ontology of the biotechnology programme.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

4. The Inception of the DBT: Reorganising Knowledge and Power

Since the mid-seventies, institutions supported by DST were taking up research related to biotechnology in the form of biochemistry, biochemical engineering and molecular biology. All these biotechnological initiatives have influenced the trajectory of biotechnology in India. Before the inception of DBT, DST was the focal point for the governance and regulation of biotechnological programmes. The model of governance within DST was in the form of high-level committees and steering committees. These committees were formed by the group of bureaucrats, experts and scientists working with a specific research problem.

By the mid-seventies, the interest in recombinant DNA technology and the advancements in biochemical engineering had substantially increased the importance of biotechnology in the country. In 1982, the National Biotechnological Board (henceforth NBTB) was set up within the DST to integrate and regulate research work in the fields of biotechnology (Ghose, 2000). DST had provided secretarial service to NBTB within its premises. Within a period of six months, two significant events, the International Genetic Congress in December 1983 and International Biotechnology Conference in April 1984, were held in Delhi, India. Both events critically influenced the trajectory of biotechnology in the country and emphasised the presence of India at the global biotechnological scenario. The enthusiastic reception and the excitement around the idea of biotechnology had significantly increased the volume of biotechnological research. There was a need to have an independent body for the governance and regulation that could anchor as a focal point to integrate the biotechnological projects. To govern, regulate, and fund the biotechnological initiative, the government established a separate department of DBT in India.

In 1986, the DBT, with a committed policy mandate, had regularised and formalised biotechnology education and research across the country. In that sense, the arrival of DBT reorganised the power centres of biochemical epochs and further concentrated them within itself in an institutional manner (Ramachandran, 1991). Therefore, it was a step forward in the direction of the institutionalisation of biotechnological research. It was expected that the DBT would emerge as a governing body with focused research initiatives in the area of biotechnology. The DBT had adopted vaccination and

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

immunisation as a National Technological Mission (NTM). For the execution of the mission, it identified two significant initiatives. First, it urgently wanted to strengthen the existing infrastructure and create some new infrastructure. Second, it took up the mandate to create a human resource base for biotechnology research (Anon., 1989).

4.1 Developing Human Resources and Infrastructure

DBT has started sponsoring teaching programmes for the postgraduate and doctoral students in biotechnology in 17 selected universities/ institutions across the country. A national level entrance test was designed for the selection of the students to fill up the seats in these universities. All the selected students were offered a scholarship in the form of a monthly stipend. Within five years, due to the high demand for the course, the number jumped up to 25 universities (Anon., 1989); (Ghose, 2000).

Within four years, NBTB identified the need to upgrade the infrastructural facility for the mission. It was identified that a few existing infrastructure facilities required upgradation and some new infrastructure facilities had to be set up. DBT had the policy directive to promote research related to immunology and vaccination. It proposed to commission a few dedicated institutions with the mandate for participation in the National Technological Mission. The DBT conceptualised three new institutes as premium institutions focusing on advanced level research. These three institutes were the National Institute of Immunology (henceforth NII), New Delhi, the National Facility for Animal Tissue and Cell Culture (Henceforth NFATCC), Pune and the Institute of Microbial Technology (henceforth IMTECH), Chandigarh. DBT directly controlled these three autonomous institutions (Anon., 1989).

DBT took up vaccination and the production of vaccines as an immediate priority. Supporting DBT, the GOI launched a universal immunisation programme in 1985, having a focus on vaccine-preventable diseases. The mission came to promote and undertake R&D activities for vaccination. DBT set the goal to achieve 85% coverage of children and 100% coverage of pregnant women by 1995. Having experience in the storage and distribution system, the Ministry of Health and Family Welfare (MoHFW) joined DBT for the joint implementing of the mission. DBT was given the responsibility for the research and development of new and improved vaccines (Ramachandran, 1991). DBT decided to

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

collaborate with the Institut Merieux, Lyon, France to set up a Joint Sector Unit (JSU) as Indian Vaccines Corporation Limited (IVCL) in Gurgaon, Haryana. Another Public Sector Unit (PSU), the Bharat Immunological and Biological Corporation Limited (BIBCL) was set up in collaboration with the technical consultancy and cooperation of the Institute of Poliomyelitis and Viral Encephalitis (IPVE), Moscow, Russia (then USSR) (Anon., 1989).

4.2 Immunological Research and Vaccination Programme

NII was one of the premium institutions that DBT decided to set up with the given mandate to participate in the National Technological Mission on vaccination and immunisation. NII has its roots in immunological research. A working group at the Immunological Centre in the Department of Biochemistry at the All India Institute of Medical Sciences (AIIMS), World Health Organisation (WHO) and Indian Council of Medical Research (ICMR) came together to set up the National Institute of Immunology in New Delhi (Raghupathy, 1991). One of the aims of setting up NII was to boost the healthcare initiatives proposed by the DBT in the eighth five-year plan. Within five years after its inception, NII developed 14 laboratories with 45 scientists and approximately 45 PhD students, technical and administrative staff (Raghupathy, 1991).

The government has identified population growth as one of the significant challenges for the future growth and development of the country. NII designed projects for the development of safe reversible long-acting and low-cost fertility controlling vaccines. NII had the mandate to develop excellent methods of controlling fertility in both humans and animals (Ramachandran, 1991). Generally, vaccines were developed to generate immunity against foreign antigens. The birth control vaccine proposed to counteract the hormones or proteins which were critically responsible for fertility (Talwar, 1987).

The aim of the vaccination programme was not only limited to the production of a contraceptive vaccine but to develop a new immunological approach that could be extended to develop immunity against internal disorders such as diabetes, rheumatoid arthritis, and so on. The institute was striving to device an injectable technique that would render the semen free of sperms without affecting libido and the production of male sex hormones. The vaccine was named as ‘Tulsar’ and was marketed by Karnataka Antibiotic and Pharmaceuticals Limited (KAPLTD), Bangalore (Raghupathy, 1991). It was claimed

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

that the drug had received new drug authorisation from the Drug Controller of India (DCI), (Raghupathy, 1991).

4.3 Summary

By pointing out at the various historical epochs of biotechnological research, the paper has tried to demonstrate the very complicated relationship between biotechnological advancements and the (re)emerging structure of governance of that time. Biotechnology has always been an assemblage of an interdisciplinary space that has experts, researchers, research focus, tools and techniques from different disciplinary locations. Every historical epoch of biotechnology was oriented around a particular form of experts, research skills, tools and techniques. There was the domination of a disciplinary orientation within biotechnology, but biotechnology was never reduced to a particular disciplinary approach dominating the interdisciplinary space. The dynamics and interactions among various inter-disciplinary locations have steered the course of biotechnology in India.

The governance of biological entities had a very complicated relationship with biotechnological research and projects. The biotechnological tools and techniques were evolved, responding to the ‘metaphor’ and ‘urgencies’ constructed by the government in every historical period. They were the outcome of a complex yet small and non-deterministic subject-and-object interactions. The new biotechnological tools create conditions for the construction of new ‘metaphors’ for the subsequent biopolitical regimes and set new challenges for the experts, scientists and bureaucrats. Biotechnology, as an interdisciplinary space, reorganised itself around the new ‘metaphor’ or vice versa. It is a complex process through which biotechnology facilitated the (re)production of new biopolitical regimes.

The inception of biopolitical regimes aimed to have greater control and power over the state subjects through intervening in and manipulating the biological aspects of their lives. The coinage of the term ‘Quadrilateral Dilemma’ highlighted the unfathomable aspect of the biological processes. Hill’s recommendation called for attention towards the puzzling and obscure health, nutritional, and agriculture situation during that period. It became the priority for the government to look for the mechanisms to provide greater control over the

Abinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

biological crisis. It further oriented its policies and promoted research that can provide access to the dietary choices, consumption patterns and nutritional status of the people. Large scale surveys in the form of nutritional surveys generated quantitative data about the food habits, nutritional data and health situation in various parts of the country. Biology became the site for the (re)production of ‘power’ and ‘control’ over the masses. Biologists and biochemists engaged in developing more sophisticated tools and techniques that gave rise to the bio-political regimes.

During subsequent phases, the government established more significant control over the biological processes with the evolution of new biochemical and biotechnological programmes. These tools constantly reinvented themselves and opened up new avenues of lives for the (re)production of ‘power’ and ‘control.’ In the post-Independence phase, large scale revolutions were partially able to overcome the nutritional crisis by ensuring food security. Food security, as a biopolitical intervention, controlled the dietary habits and consumption pattern of the people. The evolution of biotechnological tools has facilitated the biopolitical regimes to strengthen their control and power by intervening in the personal spheres of their lives.

The inception of DBT was marked by control and power over biotechnological initiatives. Biotechnology was the new metaphor that reorganised biochemical, molecular biology, genetics and biochemical engineering projects around itself. There was a tectonic shift in the structure of governance of biological entities after the inception of DBT. The previous regimes consisted of councils, boards and steering committees. In the era of DBT, this balance was gone. DBT had control over all kinds of biotechnological programmes in the country, encompassing education, infrastructure and the content of the research projects.

The content of biotechnological projects supported by DBT did reflect the concentration of power. Biotechnology was not limited to the exploitation of the microbes, improving the nutritional content of the crop, developing high-nutritional varieties and breeding the animals. DBT-driven projects had the intention to impregnate deeper into the personal spheres of state subjects. Government through DBT and its projects has a clear intention to discipline the personal choices, such as the subjects’ sexual behaviour, choices of health care and choices of offspring. The National Technological Mission in the form of the universal vaccination project and immuno-contraceptive projects left little room for the

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

state subjects to avoid the programmes. With the evolution of sophisticated biological tools and technologies, the government re-adjusted itself and initiated programmes that intended to provide control over the public and private lives of the state subjects.

5 Conclusion

The trajectory of biopolitics in the country had a complicated relationship with the evolution of biotechnological institutions in the country. The evolution of sophisticated techniques and knowledge about the biological entities facilitated the development of the biopolitical institutions in the country. New biopolitical institutions and technologies facilitated greater control over the biological aspects of the state subjects. Through various biological epochs, this paper has demonstrated the complicated relationship between 'knowledge' and 'power'. Scientists and experts in every phase introduced novel entities that existed outside the governance regimes of that time.

Biotechnology was an assemblage of smooth connectives formed by experts, tools, techniques and biopolitical priorities. This was an assemblage that reoriented itself based on the complex interaction between biological knowledge and policy directives. The historical evolution of bio-political institutions was closely linked with the development of novel biotechnological techniques and tools. The biopolitics of every biotechnological epoch engaged with the scientific methods and techniques that could provide greater centralised control. Most of the biotechnological programmes were organised around the metaphor coined by the biopolitical institutions of that time. The metaphors created urgencies and set the priorities for subsequent biotechnological research.

During the reconstruction phase, biochemists existed at the periphery. Hill's recommendations had significantly changed the location of the biochemist in the discourse. Biochemists reorganised the biotechnological discourse around the metaphor of 'Quadrilateral Dilemma' or biological crisis. It was the historic moment in science policy, which emphasised a research focus on the biological aspect of the state subjects. It should be marked as a biopolitical turn in the Indian science policy.

In the post-Independence phase, chemical engineers were not part of the biotechnological discourse. They were brought to the centre of the discourse as they could respond to the metaphor of 'scale-up' and 'replicability.' The discourse of biotechnology evolved as an

DOI: 10.3217/978-3-85125-668-0-27

interdisciplinary space guided by the biopolitical directives. Biopolitical institutions create urgencies and set the tone for the discourses in biotechnology. During every phase, the interaction between scientists, experts, and bureaucrats was guided by certain ‘metaphors’. These metaphors were constructed by the government accounting the ‘priorities’, ‘urgencies’, ‘solutions’, and ‘crisis’ during that time.

The novel molecular biological techniques and evolution of recombinant DNA techniques offered greater predictive success in biotechnological research. These techniques were able to provide a concentration of power for the biopolitical regimes. The newer of biopolitical regimes promoted the biotechnological projects that would offer greater central control and concentration of power. The manipulation of the microbes, developing transgenic varieties of animals/crops and universal vaccination programme proposed greater control over biological processes of living entities. The projects promoted by DBT had the objective to impregnate deeper into the biological processes of the state subjects. The sophisticated biotechnological techniques affected the public and personal lives of the people. Eventually, the lifestyle choices, health care choices and choice of the number of progeny became the site for state intervention. The evolution of biotechnological research in India facilitated the emergence of biopolitical regimes that could penetrate deeper into the biological processes of the life forms.

References

Agarwal, A., 1976. Science takes a rural turn. *India Today*, 31 Jan, pp. 11-13.

Anon., 1946. *Visit to India by the biological secretary notes & records 4 ,* London: The Royal Society.

Anon., 1989. *Report of the working group,* New Delhi: Department of Biotechnology, Government of India.

Ben-Menahem, A., 2009. *Historical encyclopedia of natural and mathematical sciences.* s.l.:Springer Science & Business Media.

Burma, D. P. a. C. M. ed., 2011. *From Physiology and Chemistry to Biochemistry.* Pearson Education India.

Chakravarti, A. K., 1973. Green revolution in India. *Annals of the Association of American Geographers,* Volume 3, pp. 319-330.

Chatterjee, I. B. a. B. D. P., 2004. Bires Chandra Guha: Father of modern Biochemistry in India. *Current Science,* 87(6), pp. 823-830.

Das, A. M., 2018. AV Hill and shaping of modern science in India. *Journal of Scientometric Research,* Volume 1, pp. 60-70.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

Demain, A. L. a. A. F., 2000. The natural functions of secondary metabolites. In: *History of Modern Biotechnology.* Berlin Heidelberg: Springer, pp. 1-39.

Ghose, T., 1978. *Biochemical Engineering and bioconversion.* New Delhi: Biochemical Engineering Research Centre,IIT Delhi.

Ghose, T. K. a. V. S. B., 2000. Development of Biotechnology in India. In: *History of Modern Biotechnology I.* Berlin Heidelberg: Springer, pp. 87-124.

Hill, A. V., 1945. *A report to the Government of India on scientific research in India,* London: The Royal Society.

IIT, D., 1980. *A decade of education and research in Biochemical Engineering,* New Delhi: The Indian Institute of Technology Delhi.

Kumar, D., 2000. Reconstructing India: Disunity in the science and technology for development discourse, 1900-1947. *Osiris,* Volume 15, pp. 241-257.

Kumar, D., 2001. Science and society in colonial India: Exploring an agenda. *Science, Technology and Society,* 6(2), pp. 375-395.

Kumar, D., 2008. Colonialism and science in India. In: *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures.* s.l.:Springer Science & Business Media, pp. 622-625.

Parthasarathi, A. &. S. B., 1992. Science in India: The first ten years. *Economic and Political Weekly,* pp. 1852-1858.

Patwardhan, V. N., 1947. The nutrition research laboratories, Indian Research Fund Association, Coonoor, South India. *Current Science,* 16(2), pp. 47-49.

Rabinow, P., 2000. Epochs, presents, events. In: M. A. Y. a. A. C. Lock, ed. *Living and working with the new medical technologies: Intersections of inquiry.* Cambridge: Cambridge University Press, pp. 31-48.

Raghupathy, R. a. H. S. E., 1991. Basic and biomedical product-oriented research: The National Institute of Immunology. *Current science,* 60(9), pp. 528-533.

Raghupathy, R. a. S. E. H., 1991. Basic and biomedical product-oriented research: The National Institute of Immunology. *Current science,* 60(9), pp. 528-533.

Ramachandran, S., 1991. Government funding and support: The Department of Biotechnology. *Current Science,* 60(9/10), pp. 518-536.

Ramasarma, T., 2007. A view of the history of Biochemistry in India. *Current Science,* 92(8), pp. 1169-1172.

Sen, S., 2005. Dawn of nutrition research In India:Preindependence era. *Indian Journal of History of Science,* Volume 40, pp. 81-106.

Singh, J. a. R. S. S., 2004. Factors in declining crop diversification: Case study of Punjab. *Economic and Political Weekly,* pp. 5607-5610.

Abhinav TYAGI
DOI: 10.3217/978-3-85125-668-0-27

Sinha, J. N., 2009. *British scientific opinion and india's development: A case study of AV Hill.* s.l., *Proceedings of the Indian History Congress,* pp. 404-412.

Swani, N. M., 1977. *Proposed Centre for Advanced Studies in 'Energy',* New Delhi: Indian Institute of Technology Delhi.

T.K.Ghose, 1979. *Twenty years of Biochemical Engineering education and research in India,* New Delhi: IIT Delhi and Jadhavpur University.

Talwar, G. P. a. A. G., 1987. Recent developments in immunocontraception. *American Journal of Obstetrics and Gynecology,* 157(4), pp. 1075-1078.

Titus, W., 1976. We should ensure that every citizen has a place in our developmental framework: Dr. M.S. Swaminathan. *India Today*, 30 Jan, pp. 08-10.

Visvanathan, S., 1985. *Organizing for science.* Oxford: Oxford University Press.

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

Teaching the Social Construction of Technology: Time to Revise or Time to Forget?

Bernhard WIESER
Graz University of Technology, Austria

Abstract

A wealth of classical texts has been produced in the field of Science and Technology Studies (STS). This literature plays an important role in teaching. Apart from being used to educate new generations of academicians, teaching is also a way in which members of a scientific community engage with the theoretical foundations of their field. While acknowledging the value of the STS heritage, a range of issues has arisen due to the nature of the classical texts. Many of these texts were written in the 1980s and include claims that may be viewed in a different light today. Those teaching the classical STS literature not only need to take early reviews into account but also recent findings that are relevant to the issues at stake. In this paper, I discuss Pinch and Bijker's "Social Construction of Technology" (SCOT) and point out weaknesses in this highly regarded work. The findings of contemporary cycle research challenge the empirical foundation upon which Pinch and Bijker developed the conceptual claims of SCOT. Against this backdrop, the goal of writing this paper was to encourage a critical reading of Pinch and Bijker's classical work and propose a way in which the "Social Construction of Technology" can be taught in an informed way.

Keywords: teaching STS, core literature, review, SCOT

1 Introduction

What are the core ideas expressed in Science and Technology Studies (STS)? What concepts are essential for our scientific community, and which papers and books capture the theoretical foundation of our field? These questions arise when STS scholars attempt to define their own field. Researchers are prompted to do so when colleagues from other fields request one or when negotiating with funding bodies and reviewers. Those who identify themselves as STS community members need to be able to describe the

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

conceptual backbone of Science and Technology Studies clearly to potential future members, especially in teaching contexts. Graduates of STS programmes are eventually expected to be familiar with the core ideas of STS.

In any scientific community, a core set of literature has an important function as it constitutes the unique field (cf. Kuhn 1962). This theoretical basis serves as a common ground, allowing scholarly exchange and supporting mutual understanding. Even when exploring new terrain, the existing literature is important as it is used to explain how knowledge in the field will be expanded, revised, or complemented. A theoretical canon may be used at times as a gatekeeper and keep new ideas from being appreciated by members of a scientific community (cf. Kuhn 1962). Nevertheless, although it is important to keep an open mind, it is equally important to maintain a body of core conceptual ideas to facilitate mutual exchange. Without this, members of a scientific community would face a continual struggle to understand each other, especially when trying to expand the existing body of knowledge in the field. Considering the useful function of a core set of theoretical concepts, it is clearly helpful to compile a list of essential literature that every STS graduate should know. Several prominent resources provide such a list, such as Martin et al. (2012) and the curriculum of the European Studies of Society, Science and Technology (ESST), a network of 14 European STS masters programmes (http://esst.eu/core-literature/; last access 1.7.2019). However, the question of *how* we use classical STS texts in teaching contexts remains open. Whatever we consider as an essential text, our choice requires us to gather and provide additional information to facilitate critical learning. In this paper, I refer to the classical work by Pinch and Bijker (1984), and later versions of it, (Bijker et al. 1987, Bijker 1995; Bijker et al. 2012) as examples.

I will demonstrate the need to encourage students to gain a deeper understanding of the topic that is addressed in the text we choose to use while teaching. If this is not done, STS teaching will suffer significant shortcomings. To be completely clear, it is a fallacious deception to assume that Pinch and Bijker convey an accurate history of the cycle. It is our task as teachers to point the *factual errors* in this classical text out to our students and discuss whether Pinch and Bijker drew correct *conceptual conclusions* when using what has turned out to be an unsound empirical foundation. To encourage others to teach the classical STS literature in this informed way, I will specify the factual errors in Pinch and Bijker's paper and challenge some of their central theoretical claims. To that end, I will refer to several prominent reviews that I consider instructive for this purpose.

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

2 Dealing with factual mistakes

It is important to get the facts right. If the data collected in a study are not accurate, it is unlikely that the addressed audience will appreciate the presented argument. A famous example in the STS literature relies upon weak evidence. When Langdon Winner asked "Do Artefacts have Politics" (Winner 1980), he argued that technological artefacts such as bridges could in fact pursue discriminatory agendas of social separation and exclusion. The bridges across the Long Island parkways, Winner argued, were built to accommodate vehicles with only a certain height, thus making it impossible for public transit buses (used mainly by poor persons) to pass under them. Today, we recognize the flaws in Winner's argumentation. The bridges did not prevent public transportation from overcoming the alleged obstacle. Bernward Joerges clearly demonstrated this point in his paper (Joerges 1999). Still, we can ask whether the entire argument was flawed or if Winner made some kind of point. This question was explored by Woolgar and Cooper (1999) in a third paper that acknowledged the week empirical basis of Winner's argument and Joerges's justified criticism of that. However, Woolgar and Cooper argued that, despite its apparent shortcomings, Winner's paper should not be dismissed altogether. This is because artefacts are "ambivalent": Their identities are never entirely clear and neither are the effects they cause. Those who found Winner's paper useful did not exclusively judge it on grounds of the validity of its empirical examples; they appreciated the concerns it raised about power, social exclusion and discrimination. This suggests that we should keep examining the argument, rather than solely the validity of the chosen example, to demonstrate an analytical point (e.g. that artefacts can indeed entail political agendas).

A similar, although not fully explicated story, concerns another STS classic which also uses a flawed empirical foundation to support its analytical conclusions. Pinch and Bijker (1984) chose to ground their conceptual approach – which became broadly known as Social Construction of Technology (SCOT) – in the history of the bicycle. Later, Bijker created a new version of the bicycle paper he wrote together with Pinch in 1984, adding more detail. In his book published in 1995, Bijker tells a more detailed story about the development of the bicycle. Bijker calls his own writing 'an impressionistic sketch of early bicycle history' (ibid. 1995: 20).

In my analysis, I will refer to all versions, the original 1984 paper (its reprinted versions of 1987 and 2012) and the more detailed 1995 book chapter. The main reason that all texts are used is that Bijker's 1995 version is easier to comprehend and, therefore, more

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

suitable for teaching purposes. However, the publications mentioned overlap considerably. Many aspects I address in this paper concern all versions, whereas some apply to only one of these texts.

Criticizing a 35-year-old text may seem unfair or even pointless. In 1984, Pinch and Bijker used sources of information that were available to them at the time. How should they have known that historians would refute the story that Leonardo da Vinci[1] was the inventor of an archetypical bicycle just a few years later (cf. Lessing 1998)? How should Pinch and Bijker have been aware that Louis Baudry de Saunier (1891) generated numerous fake myths about French ingenuity, including dubious priority claims for the cranks on the front wheel of the velocipede (Hadland and Lessing 2014: 50)? Bijker (1995) guessed that the story about a machine that had been allegedly built by André Guilmet and Mayer & Cie. in 1869 was not quite right, but, nonetheless, he decided to include it in his historical account (ibid.: 29). Of course, we have access to more information today than Pinch and Bijker had access to in 1984 when they published the first version of their famous paper. Historical research has advanced and has revealed many flaws in earlier accounts. It is not difficult to list all the factual errors in Pinch and Bijker's work and correct something that can be viewed in a new light today. The real problem is that these corrections are not being done.

In 2012, MIT press reprinted *The Social Construction of Technological Systems* edited by Bijker, Hughes and Pinch (1987), which introduced Pinch and Bijker's 1984 paper to a large audience. At the time, the book and its contributions were clearly regarded as classical STS texts that justified the printing of a voluminous anniversary edition. It is, however, surprising that nobody considered mentioning the fact that, in the meantime, the inaccuracy of its account of the history of the bicycle had been exposed (Clayton 2002). Neither the book editors nor the MIT press staff considered it necessary to include a note on how the text should be read in light of contemporary research. If *The Social Construction of Technological Systems* (Bijker et al. 1987, 2012) deserves to continue to be treated as a classical book that is suitable for teaching purposes, a comment on the factual errors inherent in the original issue is desirable.

The MIT editor and the book editors proudly mentioned on more than one occasion that the book would be broadly used as a teaching resource, commented on how popular the

1. 'In retrospect, it seems as though all the technical elements needed to modify the first bicycle (a "running machine") into the safety bicycle had been available since the time of Leonardo da Vinci' (Bijker 1995, p. 19).

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

book had become and stated that it ‘achieved a somewhat iconic status’ (xiii). ‘It is regularly cited and used in research and teaching; it is one of the best-selling edited collections ever published by the MIT Press; it was included in the list of thirty most influential titles ever published by the Press …’ (xiii). The book editors explained why they decided to keep the chapters[1] and the original introduction unchanged. To acknowledge criticism and explain the changes in approaches taken since 1987 edition of the book, the editors decided to add a new preface and preceding foreword by Deborah G. Douglas of MIT (Preface to the Anniversary Edition, p. xi). The editors of the anniversary edition explicitly address Langdon Winner’s criticism of ‘the lack of a general ethical stance on technology within the new social studies of technology’ (xxi). However, neither the empirical flaws in the argument nor the critics who pointed these out are mentioned.

This is an issue with far-reaching implications. The presentation of an inaccurate account of subject matter – in this case, the history of the bicycle – runs the risk of evoking ridicule. Bicycle historians do not take Pinch and Bijker’s account seriously (Clayton 2002: 355). If it is not ignored entirely, Pinch and Bijker’s work is considered outdated since it draws on popular bicycle histories, and particularly John Woodforde’s *Story of The Bicycle* (1970). Still, we teach it to students of engineering, sociology, economics, innovation studies and many other fields. What can we offer to researchers in other disciplines when we claim Pinch and Bijker’s work (i.e. the social construction of technology) as one of the conceptual cornerstones of STS? I believe that the MIT press staff need to ponder their stance on this issue should they consider publishing another edition of *The Social Construction of Technological Systems* (Bijker et al. 1987) or *Of Bicycles, Bakelite and Bulbs* (Bijker 1995).

However, the MIT press is not the only publishing house that has treated a classical text like an archaeological find that needs to be conserved in its original state.[2] The prestigious, German publishing house Suhrkamp has also recently decided to publish a collection of classical STS texts (Bauer et al. 2017). It is instructive to observe what the editors of this

1. The Introduction to part I: “Common Themes in Sociological and Historical Studies of Technology” was kept in its original form. In other words, no hint of the claim that no controversy was to be found regarding Pinch and Bijker’s bicycle case study was included (not in The Engineer, the main source). Accordingly, no closure can take place for a debate that did not happen (see Introduction: 6-7).

2. Deborah G. Douglas of MIT (curator of science and technology at the MIT Museum) even claims explicitly that the book had “become an artefact” (ibid. ix).

DOI: 10.3217/978-3-85125-668-0-28

collection considered an STS classic, and it is hardly surprising that Pinch and Bijker's 1984 paper was included. The collection is ambitious and carefully presented. In order to present the background of the original text to the reader, explaining its reception and relevance for contemporary research, an introductory chapter complements each selected STS classic. My article does not allow for the space necessary for a review of the entire book. I, therefore, will limit my comments to Jörg Potthast (2017) who wrote the introduction to Pinch and Bijker's 1984 text.

Potthast apparently has no interest in bicycles. Instead, he chose to write about motorcars (Potthast 2017). For this reason, he implicitly proposes that the analysis of historical developments in the automotive industry is applicable to other contexts, such as bicycle manufacturing. Not only does this proposition presuppose a form of epistemological universalism, which is highly questionable in relation to a constructivist approach, but it also demonstrates a complete ignorance of the subject matter under investigation. Here, it becomes most apparent that my criticism does not primarily address Pinch and Bijker, but addresses the way in which the STS community deals with its classics. The German introduction to Pinch and Bijker's classical STS text lacks background knowledge on the discussed subject matter and, therefore, inevitably perpetuates the empirical mistakes present in Pinch and Bijker's account of the bicycle history. We are only in the position to identify empirical flaws in classical texts and consequentially determine whether the conceptual claims that are made can be substantiated if we are familiar with contemporary research findings.

Two problems become apparent when reading all versions of Pinch and Bijker's bicycle account. Both Macmillan's and Guilmet's bicycle histories are uncertain sources of evidence and are now considered false. Bijker uses these machines to contrast conventional linear models of innovation, relying on his evolutionary understanding of sociotechnical change. Macmillan's bicycle was predated as an invention of 1839 by a relative of his, Thomas McCall. Evidence confirms its existence in 1869, although the earlier models are not documented (Clayton 2016: 25). The reasons why this aspect matters are subsequently explained. The false account of Thomas McCall suggests that Macmillan should be given credit for having designed a bicycle with some type of drivetrain before the pedals were attached to the front wheel in France during the 1860s. Macmillan's efforts pre-empted Lawson's attempt to create the safety bicycle as well. The predating of the Macmillan bicycle compromises Bijker's criticism of the linear model of innovation; the machine did not exist until 30 years later (Pinch & Bijker 1984: 412, 413,

DOI: 10.3217/978-3-85125-668-0-28

Pinch & Bijker 1987: 29, 31; Pinch & Bijker 2012: 23, 25; Bijker 1995: 8, 9). However, when explaining the shift from the high wheeler to the safety bicycle, Bijker does not refer to the Macmillan bicycle, but instead focuses on John Boyd Dunlop's pneumatic tyres.

Guilmet's bicycle (aka the "Guilmet-Meyer Bicycle") is an uncertain piece of historical evidence, too. It was discovered and first displayed in the Paris Retrospect Exhibition of 1906 (Clayton 2016: 65). Hadland and Lessing, however, challenge whether it truly existed in 1870, since it has a welded frame, a production technology that was not known in France until 1892 (Hadland and Lessing 2014: 76; also Dodge [1996] 2011: 94). Regardless of the dating issue, Guilmet's bicycle and Lawson's "Bicyclette" are very much alike. Bijker's diagrams of sociotechnical change suggest, however, that they are associated with different design ideas of the bicycle. The Guilmet bicycle would serve as an alternative to the Boneshaker, whereas the Lawson "Bicyclette" serves as an alternative to the high wheeler. This is irritating since both bicycles look remarkably similar. Again, Bijker uses Guilmet's bicycle to criticise the linear model of innovation (Pinch & Bijker 1984: 412, 413, Pinch & Bijker 1987: 29, 31; Pinch & Bijker 2012: 23, 25; Bijker 1995: 8, 9). Most likely, the Guilmet bicycle is a fake[1] that was invented later and that creates unnecessary speculation as to why it has not short-circuited the evolution of the bicycle, 'leaving out the high wheeler altogether' (Clayton 2016: 67; see also Bijker 1995: 29).

Bijker decided to add more bicycle history to his 1995 book. Although the book is wonderful to read, and Bijker explains the SCOT framework in detail, the added bicycle history contains a number of factual mistakes, which are listed below. Nevertheless, I prefer the 1995 version of the bicycle study because of the clarity with which SCOT is described. I consider it easier to comprehend and, therefore, more suitable for teaching purposes.

1. Hadland and Lessing (2014) as well as Dodge ([1996] 2011) suggest that the Guilmet bicycle represents an artefact that was built to suggest a false priority claim for a design that became known only later in the form of the Lawson Biciclette in 1879. If it had truly existed in 1869, the Guilmet would predate even the earliest high wheeler, such as the iconic 1870 Ariel by James Starley and William Hillman (cf. Dodge ([1996] 2011).

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

List of factual errors

- Leonardo da Vinci bicycle, 1492;[1] (Lessing 1998); (Bijker 1995; 20, 21)
- Le Comte de Sivrac and the celerifere, 1791 (Seray, 1976); (Bijker 1995: 20, 21, 22)
- Kirkpatrick Macmillan bicycles, c. 1839[2] (Dodds 1999; Clayton 2016: 25); (Bijker 1995: 25, 26; see also Pinch & Bijker 1984, 1987, 2012)
- André Guilmet, c. 1869 (Hadland & Lessing 2014: 76); (Bijker 1995: 29; see also Pinch & Bijker 1984, 1987, 2012)
- Philipp Moritz Fischer velocipede, c. 1852/3 (Lessing, 1991); (Bijker 1995: 26)
- Michaux crank invention 1861, (Hadland & Lessing, 2014: 35-63); (Bijker 1995: 26)
- Michaux production, 200 per day (Clayton, 2016: 34; Hadland & Lessing, 2014: 53); (Bijker 1995: 28)

Except for the Macmillan and the Guilmet bicycles, none of these debunked claims are cited in the version Pinch and Bijker had published in a book entitled *Social Construction of Technological Systems* (2012: 11-44). In this text, however, as in all expositions of SCOT by Pinch and Bijker, one major empirical problem arises. It concerns the pneumatic tyre, which I will now address.

3 Conceptual problems

Over the years, I have shared my worries about Pinch and Bijker's paper with colleagues in the field. They often admit that there may be certain issues with the historical facts, but consider them to be merely minor details. What really counts – so they argue – are the conceptual aspects of SCOT. Sometimes colleagues tell me that they would not be interested in the bicycle. They explain that they use the paper for teaching purposes, because it provides such a nice example of socio-technical change. Many people who have read about the social construction of the safety bicycle regard it as a given that the pneumatic tyre resolved the controversy over bicycle design. The shift from the high

1. The myth of the Leonardo da Vinci bicycle resulted from a sketch discovered in a collection of his drawings. The story was debunked as a forgery by Lessing (1998).

2. Lessing agrees with the attempted forgery, but claims it was dated as of 1838 (cf. Lessing in Dodge 1996: 9).

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

wheeler to the safety bicycle took place – so they think – because the pneumatic tyre proved to be faster on the racetrack (cf. Bijker 1995: 81-85). Bijker claims: 'The pneumatic tire made the scales tip in favour of the safety bicycle' (ibid.: 88). Yet, what if this was not the case?

Here, we face a common problem that was tellingly expressed by Steven Gould, who pointed out that '…facts achieve an almost immortal status once they pass from primary documentation to textbooks. Nobody ever goes back to study the fragility of the original document' (Clayton 2002: 354). So let us have a look at the original document. As early as 1887, it had become clear that the future of the cycle would belong to the safety bicycle (c.f. *The Engineer* 18. Feb 1887: 134). During the following years, the observed shift became steadily more apparent (cf. *The Engineer*, 22. Feb 1889: 157). In 1890, there was no doubt about the trend. The reporters at *The Stanley Exhibition of Cycles* – the most important bicycle exhibition at the time – stated: 'Owing to the ever-increasing popularity of the rear-driving safety bicycle, it would be safe to put down at least 85 per cent of the exhibits to this type of cycle' (*The Engineer*, 7. Feb 1890: 107). In his detailed account, Bijker provides data on the uptake of the pneumatic tyre bicycle in Britain. Referring to the Encyclopaedia Britannica, he notes that the market share of pneumatic tires was as low as 1.2% in 1890, but grew to 89.5% by 1894. Taken together, this information clearly demonstrates that the shift to the pneumatic tyre bicycle FOLLOWED the shift to the safety bicycle; it did not precede, let alone CAUSE it.

In fact, Nick Clayton made exactly this point in his review of Pinch and Bijker's work. He argued that the shift from the high wheeler to the safety bicycle had already taken place BEFORE the pneumatic tyre bicycle became accepted in the bicycle world (Clayton 2002: 358).[1] This is not only an empirical objection to some minor details; it undermines Pinch and Bijker's conceptual claim about the social construction of the safety bicycle as a whole. Pinch and Bijker responded to Clayton's criticism, but they did not address his point regarding the pneumatic tyre bicycle (Bijker and Pinch 2002). Clayton's comment was

1. Clayton leaves no doubt: "No modern bicycle historian holds this view. Solid-tired, rear-driven safeties were introduced in 1885 and quickly dominated the market. The ordinary was dying before the pneumatic tire was ever launched." (ibid. 358). Clayton goes on to quote from a contemporary source by Harry Griffin, who notes that some manufacturers only had one order in fifty for an ordinary in 1888. "Thus, before pneumatic tires appeared, rear-driven safeties had effectively replaced the ordinary and the high bicycle was doomed even if pneumatic tires had taken another decade to arrive." (Clayton 2002: 358).

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

harsh and written in an aggressive style. Clayton's ideas about historiography, his disapproval of constructivist perspectives and his (numerous) misrepresentations of Pinch and Bijker's work especially did not win him many favours. For these reasons, it was easy to reject his comments. Unfortunately, his justified objections were not echoed by STS scholars.

This episode shows how boundaries are drawn within academic disciplines, how members of a scientific community choose who is qualified to engage in scholarly debates and whom they designate as unqualified outsiders (Gieryn 1999). As in many other scientific communities, STS scholars do not easily accept contributions from scholars working in other disciplines. At least on this occasion, the criticism voiced by a historian of technology had virtually no effect on the reception of the social construction of the safety bicycle and the historical account upon which this construction rests.

The use of historical data for STS case studies raises wider epistemological questions about how evidence is constructed and how we determine whether it is correct. In their famous study, Pinch and Bijker relied heavily on existing historical research and worked with these accounts. I do not object to this method, since STS researcher can indeed benefit from accessing research findings from other disciplines, such as historiography. The main issue is that Pinch and Bijker's sources have become outdated, and especially John Woodforde's *Story of The Bicycle* (1970). Hence, if STS scholars decide to refer to historical bicycle research, we need to appreciate how the knowledge in this field has advanced since the 1970s. This is recommended even if we "merely" teach the social construction of technology and explain to our students what Pinch and Bijker concluded from the development of cycle design.

To a certain extent, relying on sources from other academic disciplines implies accepting their scientific authority over the consulted truth claims. Of course, it is possible to challenge the knowledge that is referenced in other scientific disciplines. However, if we chose to use such literature to support our arguments (and this is what Pinch and Bijker did), we may appreciate what each respective scientific community regards as their state of the art.

Scientific knowledge claims are debated, challenged, agreed upon, revised and, after some time, disputed again. Within the field of STS, scholars have a long tradition in conducting research on the social dynamics of such discursive negotiations that occur inside academia (e.g. Collins 1981b, 1983, 1985) and involve a broader set of societal

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

actors (e.g. Irwin and Wynne 1996). Just because the production of scientific knowledge is a social undertaking does not mean that it is arbitrary. Certain knowledge claims are more credible than others precisely because they are associated with specific social practices (Jasanoff 2003, 2005).

4 Rosen and STS reception

Pinch and Bijker's work is widely recognised by and has received many accolades from STS peers. However, STS peers have also voiced some criticism. Early comments addressed the lack of social and political dimensions in the work. Steward Russell (1986) criticised SCOT for not taking into account the power relations between different social actors, their abilities to shape technological developments and their meanings. Along the same lines, Langdon Winner (1993: 440-442) disapproved of an analysis that, in his view, did not reveal who benefited from the stabilisation of meanings associated with technology. Such an analysis, he argued, would only serve the interests of the powerful. He concluded by making a general attack on the morality of social constructivism: 'Unlike the inquiries of previous generations of critical social thinkers, social constructivism provides no solid, systematic standpoint or core of moral concerns for which to criticise or oppose any particular patterns of technical development' (Winner 1993: 374).

Winner's concern were related to 'the ways in which technologies transform personal experiences and social relations' (Winner 1993: 369). His criticism addressed the research agenda and the "narrowness of this perspective" (ibid.: 368). He observed 'an almost total disregard for the social consequences of technical choice' (ibid.: 368). Instead, he saw the perspective shift to what causes technological change and the dynamics of technological innovation. Winner considered that the interpretative flexibility related to contemporary manifestations of social constructivism was not far from what positivists call "value neutrality". He noted: 'Interpretative flexibility soon becomes moral and political indifference' (ibid.: 374). Still, Winner was also appreciative of SCOT, of "its conceptual rigor, its concern for specifics, its attempt to provide empirical models of technological change that better reveal the actual course of events" (ibid.: 367-368). Like many other commentators, Winner had no personal knowledge about the history of the bicycle and, therefore, was not in the position to identify errors; he took the accuracy of the presented empirical material for granted.

Another reviewer, Stewart Russell, was especially critical of the relativist approach used by SCOT and insisted that a more political stance be taken. To do so, he suggested a taking

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

Marxist approach, which would be more suitable for ‘not only explaining technological development, but also demonstrating possibilities of changing its course to suit different objectives’. (Russell 1986: 343). Russell insisted on the significance of the production process and suggested applying labour process theory for its analysis instead of SCOT.

Both Russell and Winner criticised the fact that the study of the changes in the design of bicycles did not explicitly include an investigation of the links between these changes and the wider social context. In fact, this had been a declared goal of SCOT as the third stage of their research agenda. With reference to Harry Collins’s (1981) *Empirical Programme of Relativism* (EPOR), which inspired Pinch and Bijker, they noted in 1987: ‘A *third stage*, which has not yet even been carried through in any study of contemporary science, is to relate such “closure mechanisms” to the wider socio-cultural milieu’ (Pinch & Bijker 1987:27). With regard to their own study, Pinch and Bijker did not have much to offer either (ibid. 1987: 46). In 2012, they principally had the option to mention Rosen’s (2002; see below) work (at least in the “Preface to the Anniversary Edition”), but they decided not to do so. Bijker is much more open regarding the critical points raised to his 1995 book. Although he did not specifically mention to whom he was responding, he declared an ambition to gain a better account of social and ethical concern and political actionability (Bijker 1995: 17).

For the most part, the critical remarks made by the STS peers concerned what Pinch and Bijker did not do and suggestions to add what was missing. It is remarkable how few STS peers commented on aspects related to the empirical bicycle case study. It is hard to say if this was due to their lack of knowledge or lack of interest in the subject matter. The fact remains that little were said about bicycles and the empirical robustness of the presented case study.

There is, however, one prominent exception. In 2002, Paul Rosen published a book on the British bicycle industry in which he focused on bicycle production and cultural change. Rosen used an approach grounded in SCOT, but in an advanced form and according to his own ideas (Rosen 2002: 14, 20). His main objective was to represent technology within a broader context of social and cultural change that he conceptualised as “sociotechnical frames”.[1] He argues that there are not enough social considerations in SCOT (Rosen

1. Rosen explains: „A sociotechnical frame is, in fact, something quite different qualitatively from Bijker’s framework.“ (Rosen 2002: 22).

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

2002: 17-18; see also Rosen 1993; Grint and Woolgar 1997). Furthermore, Rosen criticises the fact that the role of users in shaping technologies was treated as secondary to the roles of designers and engineers (Rosen 2002:18). Finally, Bijker's notion of technological frames was too narrowly applied in relation to discrete artefacts, falling short of addressing the sociotechnical changes in production, its machinery, organisation, management and economy.

Rosen focuses on two periods of the 20th century and does not write about the same time period that Pinch and Bijker described in their work. His goal was to apply a revised version of SCOT to a new research question; he, therefore, adapted Pinch and Bijker's approach to study the British bicycle industry in the 20th century. More so than Bijker, Rosen is interested in change rather than stabilisation (Rosen 2002: 24) and considered the investigated time periods to be times of transition. The first is "the transition from the sociotechnical frame of the factory bicycle to one of the mass bicycle", and the second is 'the transition from the latter to a frame of the globally flexible bicycle' (Rosen 2002: 26).[1] Still, Rosen does not discuss the shift from the high wheeler to the safety bicycle in relation to the social and cultural developments of the time.

5 Discussion: how to teach SCOT

This paper reveals a number of factual and conceptual shortcomings in Pinch and Bijker's classical study on the social construction of the safety bicycle. The point of concern is that this text is, nevertheless, taught to students in STS study programmes as well as to students in other fields, such as engineering, sociology, economics and innovation studies, since it is regarded as a cornerstone of STS. Against the backdrop of the apparent shortcomings of Pinch and Bijker's paper, we face two alternatives: dismissal or revision.

Langdon Winner's paper "Do Artifacts have Politics" (1982) has been dismissed by STS peers as it was found to inaccurately describe Robert Moses's design of the bridges over the Long Island parkways leading to Jones Beach. Bernward Joerges showed that despite

1. Rosen also says that he wants to contribute to „promoting a participatory politics of bicycle technology" (Rosen 2002:26) and to deliberate change. Why is this so? SCOT is not a theory, and Rosen's revised version is not one either. On page 4, Rosen states: "In drawing such links among technology, society, and culture I hope to throw some new light onto processes of technological change, especially the possibilities for directing change in ways that make the control and the accessibility of technology more egalitarian for producers and consumers, for designers and users, and for employers and employees." (ibid.: 4).

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

Winner's claim, Moses's bridges are in fact not overly low and therefore do not prevent public transit busses from passing beneath (cf. Joerges 1999). But, in dismissing Winner's paper, have we thrown the baby out with the bathwater? Have we stopped asking relevant questions about power, inequality and exclusion in relation to socio-technical configurations? Again, we need to ask what we think students need to learn when we invite them to read the classical STS literature. Hence, what do we believe students can learn from a historical case study on the design shift from the high wheeler to the safety bicycle?

Some textbook authors (e.g. Schulz-Schaeffer 2000; Bammé 2009; Sismondo 2010; Bauer et al. 2017) have argued that Pinch and Bijker's work is so important because they encourage readers to reject simplistic ideas of technological determinism and demonstrate that the design of artefacts does not follow an inherent, merely technical logic (c.f. Bijker and Law 1992: 3; Rosen 2002:13).[1] Instead, technology can be much better understood in relation to the problem it has been developed to solve (Bijker 1995: 50). The crucial point is that the definition of the problem is the result of deliberations amongst members of social groups, including engineers, producers, investors, reporters, users and non-users. According to SCOT, innovation is not a linear sequence of events (on a path that leads to an apparent one-best-way), but rather an evolutionary process involving a variety of different solutions that each respond to the specific needs of social actors. If this is what we think, and if Pinch and Bijker's work offers suitable material to convey this thought to students, one question still remains: How do we do precisely this, when we know that much of Pinch and Bijker's historical account of the bicycle is incorrect. Many academic fields have developed a way to use classical works in informative and critical ways (c.f. Stinchcombe 1982). With this paper, I hope to contribute to such a critical culture. In the following section, I briefly outline a syllabus that summarizes one possible way to teach the social construction of technology in an informative and critical way.

1. Many STS researchers share a particular political goal: They are committed to demonstrating the possibility that alternative technologies can be used to reach alternative goals, and the process of technological development can be opened up to sections of society that have previously been denied access to it (c.f. Russell : 333 and Rosen 2002). Russell, in particular, objects to the fact that Pinch and Bijker's relativist approach is inadequate analytically and politically unacceptable (cf. ibid.).

Syllabus

Step 1: Becoming familiar with the original text.
Reading: Bijker 1995.
Main task: Familiarize yourself with the text. Identify central claims of the text.

Step 2: Historical review
Reading: Clayton 2016, Hadland & Lessing 2014, Dodge 1996
Main task: Find historical errors in Bijker's text.

Step 3: The EPOR connection
Reading: Collins 1981a; Collins 1981b; Collins 1983; Collins 1985
Main task: Identify the main conceptual analogies between EPOR and SCOT

Step 4: STS reviews and reception
Reading: Russell 1986; Winner 1993; Sismondo 2010
Main task: Discuss the reviews by STS peers

Step 5: Socio-technical frames
Reading: Rosen 2002
Main task: Review Rosen's criticism and grasp how he advanced the SCOT analytical framework

Step 6: Conclusion and open questions
Main task: Encourage students to reflect on the learning process and encourage them to identify open questions

6 Conclusion

Scientific inquiry is an open and ongoing process. STS researchers were and still are desirous of demonstrating this point. One important element of university teaching is to familiarise students with the temporary nature of knowledge. Exposing knowledge claims to critical debate and allowing the revision and sometimes even dismissal of accepted propositions lie at the heart of STS. This critical attitude doubtlessly also applies to the STS classics (Bloor [1976] 1992).

Those teaching advanced subjects or even conducting STS research in its own right need to investigate how the uncovered empirical flaws influence SCOT's theoretical positions. This ultimately raises the question of whether the essential arguments of SCOT can be derived in any case or if contemporary knowledge endangers SCOT as a whole. In this

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

paper, I did not discuss the explanatory power of “interpretative flexibility”, “closure and stabilization”, “irreversibility” and “dominant design”. The scrutiny of these central conceptual claims of SCOT will be made at another time, as such an analysis requires more space than this paper can afford. I conclude, however, that the empirical basis Pinch and Bijker used as a basis for their conceptual notions is deficient. Those reading Pinch and Bijker’s work for the first time, however, and especially those unfamiliar with the subject, cannot recognize that the authors do not convey an accurate cycle history, and therein lies the danger.

However, my goal was not to refute SCOT altogether, but to facilitate an informed reading of Pinch and Bijker’s classical work. *The Social Construction of Technology* is an excellent classical text, when read in its proper historical context, and it has much to offer for anyone who has developed an interest in understanding socio-technical change. It also provides readers with a great opportunity to develop a critical attitude in general toward classical reference texts and towards STS classics, in particular. Other disciplines value the contributions of classical literature as well. Sociologists and philosophers consider it important to have read the masterpieces in their field and have developed a culture of critical readership. I hope that this paper has encouraged teachers to continue to use Pinch and Bijker’s work on *The Social Construction of Technology* as a classical piece of STS literature in an informed and critical way.

References

Bammé, Arno (2009): Science and Technology Studies. Ein Überblick. Marburg: Metropolis-Verlag.

Baudry de Saunier, Louis (1891): Histoire générale de la vélocipédie. Paris: Paul Ollendorff.

Bauer, Susanne; Heinemann, Torsten; Lemke, Thomas (Eds.) (2017): Science and technology studies. Klassische Positionen und aktuelle Perspektiven. Suhrkamp Verlag. Erste Auflage, Originalausgabe. Berlin: Suhrkamp (Suhrkamp Taschenbuch Wissenschaft, 2193).

Bijker, Wiebe E. (1995): Of Bicycles, Bakelites, and Bulbs. Toward a Theory of Sociotechnical Change. Cambridge, London: MIT Press.

Bijker, Wiebe E.; Hughes, Thomas P.; Pinch, Trevor (Eds.) (1987): The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology. Cambridge, London: MIT Press.

Bijker, Wiebe E.; Hughes, Thomas P.; Pinch, Trevor (Eds.) (2012): The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology. Cambridge, London: MIT Press.

Bijker, Wiebe E.; Law, John (Eds.) (1992): Shaping technology/building society. Studies in sociotechnical change. Cambridge, Mass.: MIT Press (Inside technology).

Bijker, Wiebe E.; Pinch, T. J. (2002): SCOT Answers, Other Questions: A Reply to Nick Clayton. In *Technology and Culture* 43 (2), pp. 361–369. DOI: 10.1353/tech.2002.0050.

Bloor, David ([1976] 1992): Knowledge and Social Imagery. 2nd ed. Chicago: Chicago University Press.

Clayton, Nick (2002): SCOT: Does It Answer? In *Technology and Culture* 43 (2), pp. 351–360. DOI: 10.1353/tech.2002.0054.

Clayton, Nick (2016): The birth of the bycycle. Stroud: Amberley Publishing.

Collins, H. M. (1981a): Introduction: Stages in the Empirical Programme of Relativism. In *Social Studies of Science* 11 (1), pp. 3–10.

Collins, H. M. (1981b): Son of Seven Sexes: The Social Destruction of a Physical Phenomenon. In *Social Studies of Science* 11 (1), pp. 33–62.

Collins, Harry (1985): Changing order. Replication and induction in scientific practice. London: Sage Publ.

Collins, Harry M. (1983): The Sociology of Scientific Knowledge. Studies of Contemporary Science. In *Annual Review of Sociology* 9, pp. 265–285.

Dodge, Pryor ([1996] 2011): Faszination Fahrrad. Geschichte – Technik – Entwicklung. Bielefeld: Delius Klasing.

Gieryn, Thomas (1999): Cultural Boundaries of Science. Credibility on the line. Chicago & London: The University of Chicago Press.

Grint, Keith; Woolgar, Steve (1997): The machine at work. Technology, work and organization. Cambridge: Polity Press.

Hadland, Tony; Lessing, Hans-Ehrhard (2014): Bicycle design. An illustrated history. Cambridge, Massachusetts: The MIT Press.

Irwin, Alan; Wynne, Brian (Eds.) (1996): Misunderstanding Science? The Public Reconstruction of Science and Technology. Cambridge: Cambridge University Press.

Jasanoff, Sheila (2003): Technologies of Humility. Citizen Participation in Governing Science. In *Minerva* 41 (3), pp. 223–244.

Jasanoff, Sheila (2005): Designs on Nature. Science and Democracy in Europe and the United States. Princeton and Oxford: Princeton University Press.

Joerges, Bernward (1999): Do Politics Have Artifacts? In *Social Studies of Science* 29 (2), pp. 411–431.

Kuhn, Thomas S. (1962): Historical Structure of Scientific Discovery. In *Science* 136 (3518), pp. 760–764. DOI: 10.1126/science.136.3518.760.

Martin, Ben R.; Nightingale, Paul; Yegros-Yegros, Alfredo (2012): Science and technology studies. Exploring the knowledge base. In *Research Policy* 41 (7), pp. 1182–1204. DOI: 10.1016/j.respol.2012.03.010.

Bernhard WIESER
DOI: 10.3217/978-3-85125-668-0-28

Potthast, Jörg (2017): Einführung. In Susanne Bauer, Torsten Heinemann, Thomas Lemke (Eds.): Science and technology studies. Klassische Positionen und aktuelle Perspektiven. Erste Auflage, Originalausgabe. Berlin: Suhrkamp (Suhrkamp Taschenbuch Wissenschaft, 2193), 99-122.

Rosen, Paul (1993): The Social Construction of Mountain Bikes: Technology and Postmodernity in the Cycle Industry. In *Social Studies of Science* 23 (3), pp. 479–513. DOI: 10.1177/030631279302300300З.

Rosen, Paul (2002): Framing Production. Technology, Culture, and Change in the British Bicycle Industry. Cambridge, London: MIT Press.

Russell, Stewart (1986): The Social Construction of Artefacts. A Response to Pinch and Bijker. In *Soc Stud Sci* 16 (2), pp. 331–346.

Schulz-Schaeffer, Ingo (2000): Sozialtheorie der Technik. Frankfurt am Main: Campus.

Sismondo, Sergio (2010): An introduction to science and technology studies. 2. ed. Chichester: Wiley-Blackwell. Available online at http://lib.myilibrary.com?id=320473.

Stinchcombe, Arthur L. (1982): Should Sociologists Forget Their Mothers and Fathers. In *The American Sociologist* 17 (1), pp. 2–11. Available online at http://www.jstor.org/stable/27702490.

Winner, Langdon (1980): Do Artifacts Have Politics? In *Daedalus* 109 (1), pp. 121–136.

Winner, Langdon (1993): Upon Opening the Black Box and Finding It Empty. Social Constructivism and the Philosophy of Technology. In *Science, Technology, & Human Values* 18 (3), pp. 362–378. DOI: 10.1177/016224399301800306.

Woodforde, John (1970): The story of the bicycle. London: Routledge Kegan Paul.

Woolgar, Steve; Cooper, Geoff (1999): Do Artefacts have Ambivalince? Moses' Bridges, Winner's Bridges and other Urban Legends in S&TS. In *Social Studies of Science* 29 (3), pp. 433–449.

The Engineer: *The Engineer, The Stanley Exhibition of Cycles. Vol. 63,* 18. Feb 1887: 134-135; *The Engineer*, *The Stanley Exhibition of Cycles.* Vol. 67, 22. Feb 1889: 157-158; *The Engineer*: *The Stanley Exhibition of Cycles, 1890*. Vol. 69, 7. Feb 1890: 107-108