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Teaching the Social Construction of Technology: Time to Revise or Time to Forget?

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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

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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.

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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

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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).

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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).

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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,

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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).

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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).

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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).

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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

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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

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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).

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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).

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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.).

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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

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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.

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