Modeling individual Usage Behavior for Business Information System & Information Technology

Doctoral Thesis

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Declaration

I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

I have not submitted this thesis for any other course or degree.

Graz, June 2012 *Sabine Hösch*

Acknowledgement

It has been a bodacious journey from the moment to take the decision for writing a doctoral thesis till writing down the results and finally, holding the hardcover in my hands. On my journey as a doctoral candidate, many lovely people accompanied me. Without their support many things would not have been possible and they made this time so special to me.

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1 Introduction

1.1 Motivation

Information Systems and Information Technology (IST) have become an important success factor for business contexts. Rather than realizing operational benefits like reducing labor or manufacturing costs or increasing productivity tactical and strategic benefits are crucial factors for investing in IST. Improved market share, competitive advantages, growth and success are often based on IST. A low adoption rate and underutilization of IST were identified as reasons for the contradictory relationship between investments in IST and firm performance (Devaraj & Kohli, 2003; Landauer, 1996; Sichel, 1997). Considering that investments in IST will continue to increase this fact is even more important (Westland & Clark, 2000). For an IST to provide benefits to the organization, the system or technology need be used for the business processes. Ensuring optimal use of the IST it is especially important to fully understand usage behavior and factors influencing the individual and organizational adoption. A better understanding of the determinants of the IST usage further improves the management of the IST resources and enhances overall effectiveness. Research in the areas of information system success, acceptance, adoption and usage is one of the most comprehensive topics in information systems, psychology as well as sociology. Hence, in recent decades several models have been developed to describe IST usage behavior under voluntary or mandatory settings. There exist several approaches to examine this problem, e.g. macroeconomic (Banker et al. 1993; Panko, 1991), organization-performance based and focusing the individual level (Davis et al., 1989; Legris et al., 2003; Venkatesh et al., 2003; Venkatesh & Bala, 2008). The models aiming on investigating the individual level mainly relate to technology and task perspectives and try to explain intention or implementation success. Although a number of studies focuses this individual adoption and usage of IST (Gross, 2005; Venkatesh et al., 2003; Venkatesh & Bala, 2008) there is still a lack in understanding the individual usage behavior and the main barriers to successful implementation of IST. For the development of effective interventions and supporting activities it is essential to first understand the individual usage behavior and then the process that leads to continuous usage of IST. Understanding the individual intentions and its determinants will enable the management to precisely intervene. Furthermore, this will allow achieving the desired utilization of systems.

1.2 Research Questions

The primary interest of this thesis is to investigate the individual usage behavior in a work environment and provide a model that explains the individual intention to continuous usage of business information technology and information systems. An often mentioned issue when studying organizational system adoption is first the determinants of individual behavior have to be investigated.

This thesis aims at explaining why individuals feel motivated to use a certain system or reject usage of the system. In order to identify the main key drivers the following research questions are addressed in this doctoral thesis:

1. Is it possible to create a model that explains the individual usage behavior regarding Information System & Information Technology in the work environment?
2. Which known effects of interventions for motivating the individual usage behavior of IST can be explained using the model?

1.3 Structure

The focus of chapter one is to give an introduction to the topic of this thesis. It is supposed to provide a short overview of the orientation of this dissertation. Furthermore chapter one presents an outline of existing approaches and an explanation for the dominance of the question, why individuals use IST in a work environment.

The second chapter introduces the main theory regarding the IST investment process and existing behavior explanation models. The different approaches and their determinants are described and the main critiques are presented. Since the focus of this thesis lies on human individuals using technical systems, the generic approach of socio-technical systems is introduced. As planned and organized changes in an organization require some kind of change management, the basic principles of change management are named and briefly described.

Chapter three deals with materials and methods which were used for modeling and simulation in this thesis. The Behavior Explanation Model is introduced as a causal loop diagram which is provided as a tool by System Dynamics. Vester’s Sensitivity Model and its tools are explained. Concluding the verification and validation process and techniques are presented.

Chapter four includes the extended intention model which is based on the main theories of behavioral intention and presents the IST Behavior Explanation Model. The determinants of the individual usage behavior are described. Feedback to other variables is also introduced. The driving forces and self-correcting effects are identified and explained.

Chapter five gives an overview of the simulation approach and the simulation model. Besides from a characterization of the scenarios used for the simulation, a comprehensive analysis of the simulation results is part of this chapter. Effects of interactions that are known from literature to motivate the individual usage and adoption of ISTs are explained according to their impact on the determinants of usage behavior.

In chapter six case studies are presented to demonstrate the applicability of the model. Three case studies from different industries are described. The individual usage behavior is explained using the IST Behavior Explanation Model.

Chapter seven provides a summary of the previous chapters. It furthermore provides answers to the research questions and a perspective on further research induced by the work in this thesis.

2 Theory

2.1 Information System & Information Technology Investment

Information Systems and Information Technology have become ubiquitous in our everyday life and a crucial success factor for business environments. As such many researchers defined the terms. For the purpose of this work the definition of United Kingdom Academy for Information Systems (UKAIS) is appropriate:

> "Information systems are the means by which organisations and people, utilising information technologies, gather, process, store, use and disseminate information." (UK Academy for Information Systems, 1997)

As the terms Information Technology and Information Systems are many times used interchangeably it is important to define both terms to be able to clearly differentiate between both systems. Ward and Peppard stated the following:

> "IT refers specifically to technology, essentially hardware, software and telecommunication networks. It is thus both tangible (e.g. with servers, PCs, routers and network cables) and intangible (e.g. with software of all types). IT facilitates the acquisition, processing, storing, delivery and sharing of information and other digital content." (Ward & Peppard, 2002)

2.1.1 Information System & Information Technology Investment defined

Described generally an investment means allocating resources for material or immaterial goods to gain a favored outcome in the future. But investments in IST differ from other capital investments due to the existence of a substantial human and organizational interface (Irani et al. 2003; Irani et al., 2005). A very commonly used definition for investments in information technology and information systems is:

> "Any acquisition of computer hardware, network facilities, or pre-developed software, or any 'in-house' systems development project, that is expected to add to or enhance an organisation's information systems capabilities and produce benefits." (Bacon, 1992)

As IST is becoming more and more important to business performance (Milis & Mercken, 2004; Remenyi & Sherwood-Smith, 1999) the acquisition of technology infrastructure and its alignment to business strategy and business processes attracted the attention of decision makers. This involves the need for a better understanding of the investment process as well as the benefits to be retrieved with implementing a specific system.

2.1.2 Information System & Information Technology Investment Process

A dominant part of current research focuses on the evaluation of IST investments rather than on the investment process itself. Based on Gordon and Pinches[1], Czernik and Quint[2], Willcocks and Lester[3], Hogbin and Thomas[4], McKay et al.[5] and Farragher et al.[6] Wang suggested four stages for the IST investment process (Wang, 2007): Analysis and planning, Evaluation of costs and benefits, Selection and implementation and finally Post-implementation evaluation. Some of these four stages might be performed in iteration rather than consecutively to improve effectiveness (Johansen et al., 1995). The investment success not only depends on strictly applying rigorous evaluation techniques, but also on the entire process of investment management (Farragher et al., 1999). These phases encompass several activities (Farragher et al. 1999; Schniederjans et al., 2010) that complete the IST investment process (see Figure 1):

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[1] Gordon, L. and Pinches, G., 1984. Improving Capital Budgeting Systems: A Decision Support System Approach, Addison-Wesley, Reading, Mass.

[2] Czernik, S. and Quint, W., 1992. Selection of methods, Techniques and Tools for System Analysis and for the Integration of CIM Elements in Existing Manufacturing Organizations, in Production Planning and Control.

[3] Willcocks, L. and Margetts, H., 1994. Risk and Information Systems: Developing the analysis, in Information Management: The evaluation of information systems investments, Chapman & Hall, London.

[4] Hogbin, G. and Thomas, D.V., 1994. Investing in Information Technology: Managing the Decision-Making Process, McGraw-Hill/IBM Series, Europe.

[5] McKay, J., Marshall, P., and Smith, L., 2003. Steps Towards Effective IT Governance: Strategic IT Planning, Evaluation and Benefits Management, 7th Pacific Asia Conference on Information Systems.

[6] Farragher, E., Kleiman, R., and Sahu, A., 1999. Current Capital Investment Practices, in The Engineering Economist (44, 2).

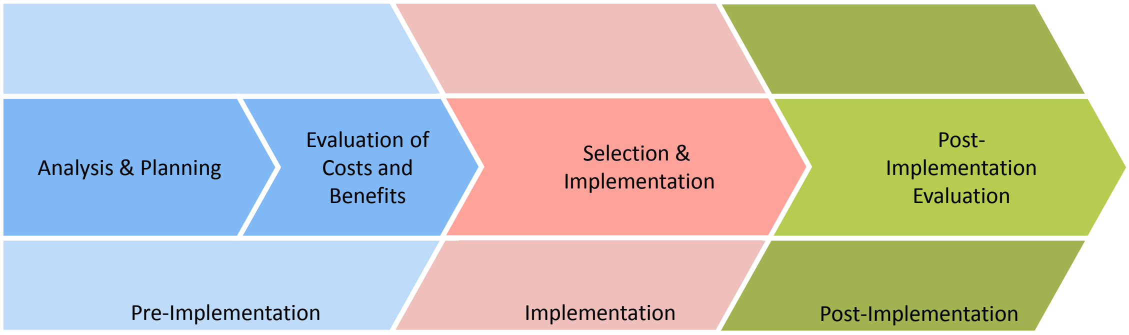

Figure 1: The figure shows the Information System & Information Technology Investment Process, modified from Wang (2007).

Analysis and planning

A detailed strategic analysis should highlight the main reasons for emerging thoughts about IST investment (Farragher et al., 1999). When evaluating an information system it is necessary to understand what the organization is attempting to achieve through the use of the information system and assess the organizational context (Fasheng & Teck, 2000). The company's external environment is analyzed to determine the major threats and opportunities facing the organization. This shall include an analysis of the general environment, like technological factors, political factors, economic factors, physical and social factors (Schniederjans et al., 2010). As such, the following questions shall be answered:

- Technological: Is the speed of change in some IST greater than expected?
- Political: Does the competition use newer IST and is the competition seen as more innovative regarding the adoption of IST?
- Economic: Is the competition spending more on IST?
- Physical: Do we have space and capacity to make IST changes equal to the competition?
- Social: Does the competition have better skilled people than we do?

This internal analysis should also bring up risks that are posed by customer's expectations, suppliers, competitors and regulatory groups. Based on these results the company can determine opportunities for its business. An analysis of the company's internal resources and capacities is done to identify major strengths and weaknesses. Internal and external analyses build the basis for an overall corporate strategic planning and further for the development of a strategic IST plan. (Schniederjans et al., 2010)

Several problems may occur in this stage of the investment process (Hogbin & Thomas, 1994): Planning has low priority because of the firefighting approach to IST investment. There are no clear procedures to link business planning and project appraisal activities and there is a lack of commitment. The main focus in the decision process is on financial data rather than on business need.

Evaluation of costs and benefits

The complexity of the contemporary IST landscape is increasing. As IST become more advanced and interconnected, they often impact multiple business processes in the organization. This in turn increases the complexity of IT investment decisions (Scheepers & Scheepers, 2008). Therefore a rigorous analysis and development of alternative should build the basis for a founded decision. The analysis includes a detailed development and determination of inputs, outputs and business processes of the firm's system (Schniederjans et al., 2010) and the establishment of criteria that will be used to judge the alternatives (Fasheng & Teck, 2000). Alternative solutions are being explored and configurations are examined to find out how well they work together with current and/or future business operations; this step might involve the process of business process reengineering, where current policies, practices and procedures in delivering products to customers are being reviewed and probably revised (Schniederjans et al., 2010). A selection of qualitative and quantitative IT investment methodologies can be utilized to assess financial aspects, potential business value and risks of alternative solutions. According to investment type or intention of investment distinct approaches for investment evaluation can be chosen. In general the appraisal methods can be classified into four different approaches: economic, strategic, analytic and integrated (Drinjak et al., 2011; Earl, 1989; Irani & Love, 2002). Irani and Love (2002) defined the approaches as follows: Economic appraisal techniques are based on the assignment of cash values, but seem to ignore risks, non-financial and intangible impacts. Strategic approaches combine qualitative and quantitative aspects to assess long-term impacts. The analytical approach is structured, but tends to be subjective and even complicated and aims at assessing risks by applying quantitative and qualitative techniques. Integrated approaches can be used to combine subjectivity and structure. These cover financial, qualitative and quantitative aspects.

Considering the type or intention of investment there is a dominant approach to evaluate the investment alternatives:

Investment Type or Intention of Investment	*Evaluation Approach Classification*	*Suggested Evaluation Techniques*
Performance and productivity	Economic	Cost-Benefit Analysis, Internal Rate of Return
Improve management and business process	Integrated	Balanced Scorecard, Scenario Planning
Expansion and growth	Analytic	Value Analysis, Risk Handling
Competitive advantage	Strategic	Critical Success Factors

Table 1: The table shows investment types and evaluation approaches, based on Irani & Love (2002) and Earl (1989).

A more detailed approach regarding the categorization intentions for investment is presented by Hochstrasser (1990), classifying the objectives for IT investments into eight project types:

Infrastructure Projects

Hardware or software systems are installed for subsequent development of front-end systems. Infrastructure systems are one step away from making direct business impact. Hence it is difficult to directly quantify business benefits achieved by implementing a system. Infrastructure projects include installations of networks or servers.

Cost Replacement Projects

Information Systems & Technologies introduced to automate manual activities related to information processing can often be evaluated by cost benefit analysis.

Economy of Scale Projects

Investments in systems introduced to allow a company to handle the increased volume of data are projects implemented for the economy of scale.

Economy of Scope Projects

Economy of scope projects include investments in systems that allow performing an extended range of tasks.

Customer Support Projects

Customer support projects cover investments in Information Systems & Technologies that are introduced to offer better services to customers.

Quality Support Projects

Quality Support Projects include systems that are implemented to increase the quality of the final product.

Information sharing and manipulation projects

Investments in Information Systems & Technologies that offer better information sharing and information manipulation within the company.

New Technology Projects

New technology projects projects include Information Systems & Technologies implemented to exploit strategically the business potential of the new technology – to do things that were not possible before.

Much research has been done on alternative evaluation techniques and frameworks to overcome the difficulties of applying common capital investment evaluation techniques for the judgment of Information Systems & Technologies. With these techniques and frameworks aiming on forecasting the effects on the implemented IST landscapes and business processes a better understanding of effects on firm performance, risks and sustainability should be achieved (Kaplan & Norton, 2007; Irani & Love, 2000; Kanungo, 2004; Kitchenham et al., 2005; Lee, 2004; Milis & Mercken, 2004; Neubauer & Stummer, 2007; Renkema & Berghout, 1997; Sircar et al., 2000; Yusof et al., 2008).

Selection and implementation

The purpose of evaluation is to decide whether an investment is able to meet the requirements as identified in the analysis and planning phase of the decision making process (Tallon et al., 2000). The system implementation can be divided into four steps: acquisition and procurement, operational planning, implementation and installation and finally integration into business processes (Schniederjans et al., 2010). There are several strategies to be considered to avoid difficulties due to differences in subsystems, interfaces and platforms in this difficult step (Schniederjans et al., 2010):

> "*Direct conversion* means that an existing system is removed totally and a new system will be installed. This kind of conversion is used, when there are capacity limits or space limits or it is not possible to run both systems simultaneously or even the current system is not working properly. Running an existing system and a new system simultaneously until the new system is fully functional is called a *parallel conversion*. It is used, if the cost of shutting down the existing system is prohibitive. In a *phased conversion* the new system is phased in as modules are systematically brought online – this strategy is used if the current architecture permits gradually updating new modules or the costs of a completely new system are too high. A *pilot conversion* means the new system is fully implemented on pilot basis in one part of the business operation. This kind of strategy is being used, if a system has features that have to be further examined in use or a complete rollout is too risky or expensive."

After system implementation is done the newly created infrastructure is ready to be integrated in the business process through continuous usage of the Information System & Information Technology.

Post-implementation evaluation

The post-implementation evaluation step closes the IT investment process. It covers the check, whether goals and objectives, to be defined in the analysis stage, have been met. This stage includes a comparison of expected and observed costs and benefits. As in the evaluation of costs and benefits stage there is a number of methodologies to be used for the comparison of planned and observed factors. (Schniederjans et al., 2010)

2.1.3 The Process Participants

Planning an investment in Information System & Information Technology an organization will start the investment process that usually involves five core participants each of them with different expectations and objectives: the parent organization, the users, the implementation team, the supporters and the stakeholders (Milis & Mercken, 2004). The *parent organization* is the owner of the project and is represented by the management. The parent organization expects strategic, tactical or operational benefits to be derived by investing in IST. In particular the management is interested in whether the IST is implemented on time, within budget and to specifications (Milis & Mercken, 2004). *Users* feel that the implemented system shall meet their requirements and that they shall be happy with the system (Wateridge, 1997). Users' objective is to work with the best system, while *project managers* focus on short-term criteria set by the sponsor because these will be used to judge them, as usually the actual gains take years to be achieved (Milis & Mercken, 2004). As well as the project managers even the *supporters* like sub-contractors have short-criteria in mind (Turner, 1993). *Stakeholders* usually don't benefit from or influence the investment; they consist of many groups with different goals and objectives and might support or oppose the investment (Love et al., 2005).

2.2 Socio-Technical Systems

A socio-technical system integrates both the social and the technical system into a whole new unit. It forms a new system to be able to reach goals by taking advantage of its new properties. The following definition shall meet the common understanding of a socio-technical system quite well:

> "Socio-technical systems are open and dynamic systems, transforming inputs from the environment to outputs to the environment. A socio-technical system is an organized number of human beings and technologies that are structured in a specific way to achieve a defined result. The production of a defined result is the primary mission." (Udris, 2004)

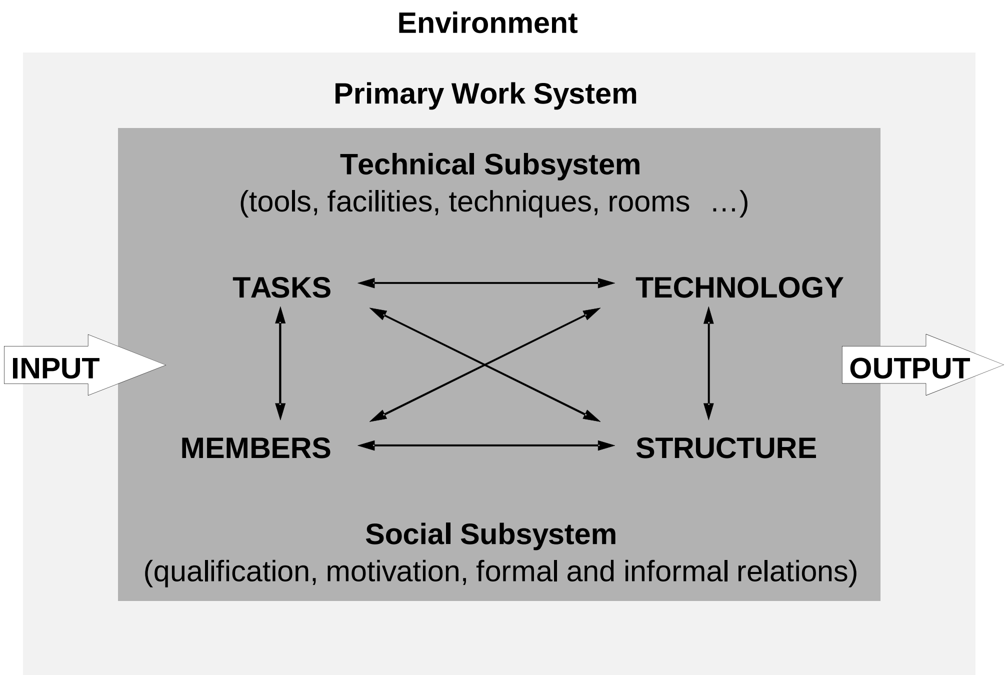

Figure 2: The figure shows the Socio-technical system concept, according to Sydow (1985).

The socio-technical system consists of a technical and a social subsystem working together to achieve the primary mission. The technical subsystem includes tools, facilities, rooms and techniques. The social subsystem is built by the members of the organization, each with individual needs, qualification and skills and values. Furthermore, from establishing formal and informal relations between members of the organization group-specific needs arise. The technical and the social system work together achieve the primary mission that is the main purpose the system is made for (Baitsch et al., 1989). According to this definition there is a second mission, which is to maintain the system, to regulate the input and for coordination (Ulich, 2005) and supporting the achievement of the primary mission.

A socio-technical system (see Figure 2) can be defined as the uppermost level in the hierarchy of requirements and dependence on other systems (see Figure 3). The software system is based on the hardware system and precedes the human-computer interaction (HCI) system. The HCI system serves as the basis for the socio-technical system introducing the social aspects. Each level includes requirements and depends on subjacent levels. The hierarchy is divided, but not limited to the following levels (Grudin, 1990; Kuutti, 1995; Whitworth, 2009):

Hardware System

The requirements for hardware systems are about exchanging energy and they face problems like overheating. The requirements for hardware systems are of physical nature.

Software System

Software Systems are built on hardware systems. It is used to exchange data and code, and face problems like infinite processing loops. This system level includes information requirements to the requirements catalogue. Software and Hardware systems combine the organization’s technology infrastructure.

Human-Computer-Interaction System

Human-Computer-Interaction-Systems (HCI systems) are based on Software-Systems. This level introduces a human being as a user of the computer system. The HCI system level raises user’s personal requirements.

Socio-technical System

The socio-technical system extends the HCI system to a group, organization, community and/or society. In a STS besides the requirements resulting from underlying levels communal requirements have to be satisfied.

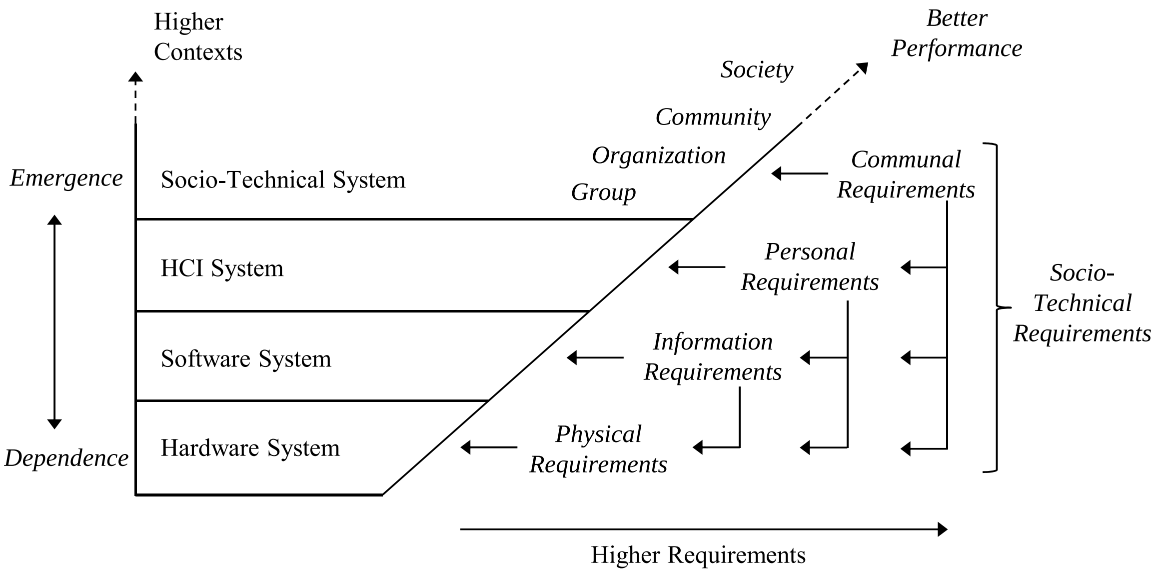

Figure 3: The figure shows the levels of a socio-technical system (Whitworth, 2009).

To clarify the dependence of the levels an example is introduced. A pilot flying a plane is two side-by-side systems, a human and a technical one, each with different needs. In HCI both the human and the technical systems have to work together. The pilot has to understand the controls of the plane and the controls must be understandable by the crew. The socio-technical system is the plane with the crew as one single unit. Treating the social and the technical subsystem as two systems the human system is usually treated secondary. But if social systems include technical ones, the social subsystem contextualizes the system. (Whitworth, 2009) This points out, that socio-technical system research is not about applying sociological principles to technical effects (Coiera, 2007), but rather investigating how social and technical aspects integrate into a higher level of system with emergent properties (Whitworth, 2009). To overcome the limited perspective, Coiera (2007) suggests the process of design itself to be seen as a socio-technical one to allow stop designing for people, and creating socio-technical systems that sustainably design themselves.

Based on the research of Emery[1], Herbst[2], Cherns[3], Pasmore[4], and Pava[5] Molleman and Broekhuis (2001) combined three STS principles:

Sociotechnical Criterion

The sociotechnical criterion deals with the control of variance and states that variances shall be controlled as near to their point of origin as possible (Cherns, 1987). The sociotechnical criterion was incorporated in STS from systems theory, where it was referred to as 'the principle of requisite variety' (Ashby, 1969). According to this principle, to manage environmental demands successfully, an organization should have enough means to transform the input of information, materials and parts into the output that it desires, that is, only variety can beat variety.

Minimal critical Specification

The principle of minimal critical specification refers to the following: define as little as possible how a worker should perform tasks, but provide just enough directives to ensure that he or she is able to perform the task properly while still allowing for the employee's personal contribution (Cherns, 1987; Morgan, 2006). This refers particularly to local autonomy and decentralized control, which will result in enriched jobs and empowered workers.

Joint Optimization Principle

The joint optimization principle deals with the fact that STS endeavors to consider both the social and the technical system simultaneously. The technical system refers to the production structure, the technical equipment and systems from the field of information and communication technology. The social system refers to human resources, job design and the control structure.

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[1] Emery, F.E. (Ed.), 1969. Systems Thinking. Penguin, London. And 1978. The Emergence of a New Paradigm of Work. Centre for Continuing Education, Australian National University, Canberra.

[2] Herbst, P.G., 1974. Socio-Technical Design: Strategies in Multidisciplinary Research. Tavistock Publications, London.

[3] Cherns, A., 1987. Principles of sociotechnical design revisited. Human Relations, 40, p. 153-162.

[4] Pasmore, W., 1995. Social science transformed: the social–technical perspective. Human Relations, 48.

[5] Pava, C., 1986. Redesigning sociotechnical systems design: concepts and methods for the 1990s. The Journal of Applied Behavioral Science, 22, p. 201-221.

The socio-technical systems approach aims at jointly optimizing organization, human resources and usage of technology: *joint optimization* (Pasmore et al.1982; Trist, 1981; Ulich, 2005). A subsequent adjustment of the social subsystem to the technical subsystem frequently leads to suboptimal solutions. Socio-technical systems should be determined by the following characteristics (Ulich, 2005):

Relatively independent Organization Units

Independent organization units and members are responsible for holistic tasks. Due to their independence and the holistic character of the tasks organization units and members are able to balance variations and disruptions at the point of origin. This avoids invasions of variations and disruptions to other organization units. This self-regulation of variations and disruptions even improves the independence of organization units.

Task-coherence within the Organization Unit

Variant tasks within an organization unit shall to be linked together by content to create and maintain the awareness of a common mission. A link in content enables task-related communication and mutual support.

Product and Organization as one Unit

Organizational and process structures need to be aligned to each other, so that work results can be qualitatively and quantitatively assigned to organization units. This aspect is necessary for the creation of holistic tasks and the emergence of a common task orientation.

2.3 Behavior Explanation Models for Success, Acceptance and Usage of Information Technology and Information Systems

Technology has acquired a central role of our lives. It extensively modified the way we work and so our work processes. Technology as part of socio-technical systems is used to achieve a specific result by e.g. reducing task execution time, simplifying processes or supporting organization units or members. Usage of technology brings stakeholders to think about input, output, performance and success of information technology and information systems. A great number of scientists, managers and consultants found a number of success measures to be used for evaluating technologies.

2.3.1 Information System Success Model

A long discussed approach to explain Information System Success is the DeLone and McLean Information System Success Model. Based on the work of Shannon and Weaver[1] and Mason[2] DeLone and McLean (1992) defined the categories of information system success: System Quality, Information Quality, Use, User Satisfaction, Individual Impact, Organizational Impact. After further development and validation of their model by themselves and other researchers in this field they published an updated success model (DeLone & McLean, 2003). This includes the categories Information Quality, System Quality, Service Quality, Intention to Use, Use, User Satisfaction and Net Benefits:

System Quality

System quality measures describe the processing system itself. It measures the technical success, e.g. ease-of-use, functionality, flexibility.

Information Quality

The category of information quality focuses on the quality of the information which the system produces. It includes relevance, informativeness and importance of information.

Service Quality

Due to the pervasion of information technology and information systems information providers and service providers have to face with the huge number of users asking for services and support. The category service quality includes items like reliability, tangibility, responsiveness and assurance of employees and empathy.

Use

Usage of systems is an often proposed measure for the success of information technology and information systems. System use can be measured as frequency of use, time of use, number of accesses, usage pattern, and so forth.

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[1] Shannon,C.E. (1949). Weaver,W. The mathematical theory of communication. University of Illinois Press.

[2] Richard Mason (1948). Measuring information output: A communication systems approach. *Information Management*, 5(1).

Intention to Use

Intention to use is an attitude and in a process sense it precedes the usage of a system and therefore intention is linked to system use.

Net Benefits

This category describes the impacts of the technology on immediate user, work group, -organization, industry, consumer and society.

DeLone & McLean created this model (see Figure 4) to illustrate process links as well as causal links. Information quality, system quality and service quality affect intention to use as well as user satisfaction. Intention to use precedes system use, which leads to user satisfaction in a process sense as well as in a causal sense. User satisfaction in turn affects intention to use and together with system use it affects the net benefits category. Net benefits influence intention to use and user satisfaction. All associations are positive. (DeLone & McLean, 2003)

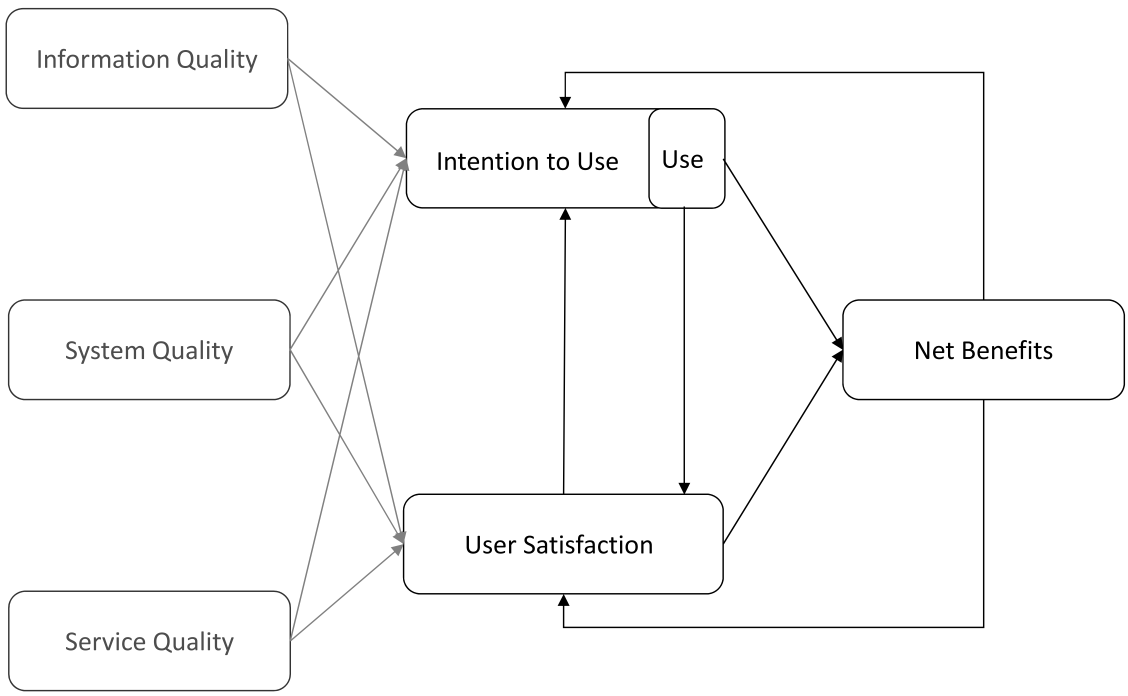


Figure 4: The figure shows the Information System Success Model (DeLone & McLean, 2003).

The IS success model provides an integrated view on how to retrieve net benefits from information systems. Although according to the model any system use and net benefit can be ascribed to information quality, system and service quality – without respect to individual attitudes, experiences and so forth. The model does not differ among different stakeholders and therefore it does not support the understanding of how advantages accrue.

2.3.2 Technology Acceptance Model 3

Based on Venkatesh and Davis'[1] Technology Acceptance Model 2 (TAM2) and the model of the determinants of perceived ease of use[2] Venkatesh and Bala created an integrated model of technology acceptance: TAM3. The Technology Acceptance Model 3 includes the following factors (Venkatesh & Bala, 2008):

Perceived Usefulness

Perceived usefulness is defined as the degree to which a person believes that using a system will enhance the job performance. A system that is perceived to be highly useful is one for which a user believes in the existence of a positive use-performance relationship.

Perceived Ease of Use

Perceived ease of use is defined as the degree to which a person believes that using an IT will be free of effort (Davis et al., 1989) – where ease means the freedom from difficulty or great effort. As effort is a finite personal resource a person has to allocate it to various activities for which he or she is responsible (Radner & Rothschild, 1975).

Behavioral Intention

Intention refers to the degree to which a person has formulated conscious plans to perform some specified future behavior (Warshaw & Davis, 1985).

Venkatesh, V., Davis, F.. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, 46(2), 186-204.

[2] Venkatesh, V. (2000). Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model. *Information Systems Research*, 11(4), 342-365.

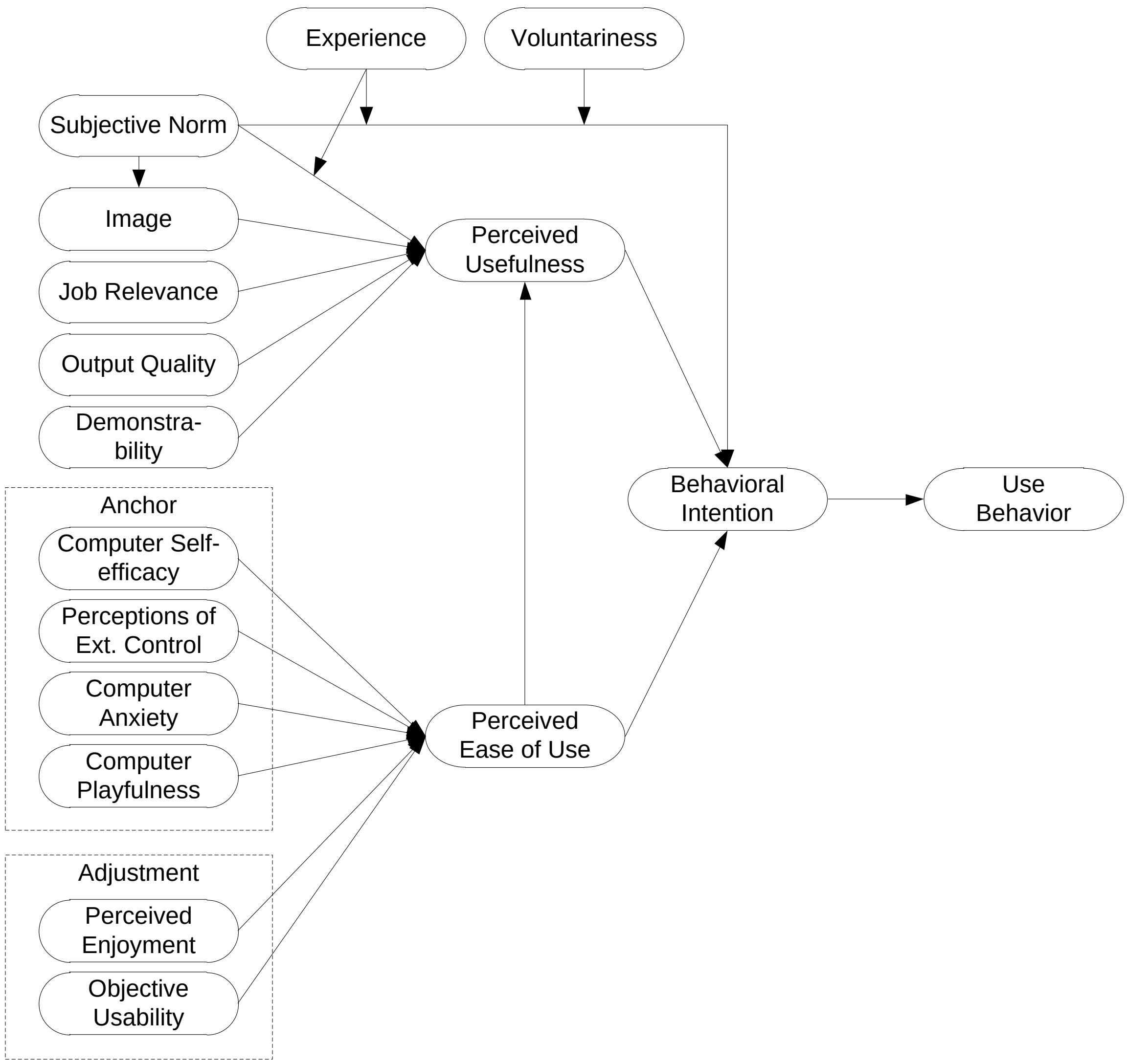


Figure 5: The figure shows the Technology Acceptance Model 3 with anchors and adjustments (Venkatesh & Bala, 2008).

Use Behavior

Use behavior is the factor that is intended to be explained by the determinants and represents the actual usage of a system.

Subjective Norm

Subjective norm refers to the perception that most people who are important to the user think he should or should not use the system (Fishbein & Ajzen, 1975; Venkatesh & Davis, 2000).

Image

Image represents user's individual perceptions about the enhancement of user's status in its social system by using the innovation (Moore & Benbasat, 1991).

Job Relevance

The individual's beliefs that the target system is applicable to the user's job is defined as job relevance (Venkatesh & Davis, 2000).

Output Quality

Output quality is defined as the degree to which an individual believes that user's job tasks can be well performed by the system (Venkatesh & Davis, 2000).

Result Demonstrability

Result demonstrability is defined as the degree to which an individual believes that the results of using a system are tangible, observable and communicable (Moore & Benbasat, 1991).

TAM3 is based on an anchoring and adjustment framework. When there is a lack of specific knowledge about a system individuals rely on general beliefs about computers and computer usage. Later on, when user's direct experience with the system enables an updated judgment of perceived ease of use the user still relies on the initial anchoring criteria and adjusts its perception to adjustment criteria. The user is expected to anchor and adjust its perception to the following factors:

Computer Playfulness

Webster & Martocchio (1992) defined computer playfulness as the degree of cognitive spontaneity in microcomputer interactions. Computer playfulness encompasses five dimensions: cognitive spontaneity, social spontaneity, physical spontaneity, manifest joy and sense of humor (Barnett, 1990, 1991; Lieberman, 1977; Webster & Martocchio, 1992).

Computer Self-efficacy

Computer self-efficacy refers to an individual's beliefs that the user has the ability to perform a specific task using the computer (Compeau & Higgins, 1995a, 1995b).

Perception of external Control

The degree to which an individual perceives that there are organizational and technical resources to support the use of the system is defined as user's perception of external control (Venkatesh et al., 2003).

Computer Anxiety

The extent of user's apprehensiveness, or even fear, when situations occur that offer the possibility of using computers is defined as computer anxiety (Venkatesh & Davis, 2000).

Perceived Enjoyment

Perceived enjoyment is defined as the extent to which using a specific system is perceived to be enjoyable, aside from any performance consequences resulting from system use. (Venkatesh & Davis, 2000)

Objective Usability

In contrast to user's perceptions objective usability refers to a comparison of systems based on the actual level of effort required to completing a specific task (Venkatesh & Davis, 2000).

The Technology Acceptance Model (TAM, see Figure 5) is one of the most discussed models regarding system usage. Although TAM3 is a very popular model for explaining and predicting system use and there has been done a lot of research based on TAM, there are still some limitations regarding the applicability for practice. Bagozzi (2007) stated that user's intention might be affected by evaluation and reflection – therefore it might be not practicable for predicting and explaining system use. Furthermore, the model does not include experience resulting from prior system use and therefore is not suitable for predicting and analyzing continuous usage behavior.

2.3.3 Theory of Planned Behavior

In the 1970ties there was a great focus on research to study attitudes and behavior. Fishbein and Ajzen (1975) developed the Theory of Reasoned Action to predict volitional behavior. Later on Ajzen extended the theory to be able to predict mandatory environmental settings: the Theory of Planned Behavior. The Theory of Planned Behavior (see Figure 6) is based on the idea that behavioral achievement depends both on motivation and ability and explains intention induced behavior based on the following factors (Ajzen, 1991):

Behavioral Attitude

Attitude toward the behavior refers to the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question.

Subjective Norms

The second determinant of intention is the social factor Subjective Norm. It refers to the perceived social pressure to perform or not to perform a behavior in question.

Perceived behavioral Control

Perceived behavioral control represents the third determinant of intention and its definition is based on Bandura's understanding of self-efficacy (Bandura, 1982; 1978). It refers to an individual's confidence in its ability to perform a behavior (Ajzen, 1991).

Intention

An individual's intention captures the motivational factors influencing a specific behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior. As a general rule, the stronger the intention to engage in a behavior, the more likely should be its performance. The presented determinants behavioral attitude, subjective norm and perceived behavioral control together form the individual's intention to perform a given behavior. The stronger the intention to perform a behavior, the more likely is the behavior. (Ajzen, 1991)

Behavior

The performance of a behavior is a joint function of intentions and perceived behavioral control. To be able to make precise predictions, the context of intention and perceptions of control has to be the same as the context for the behavior in question. That means, assessing the intention to use an IT system *A* can only be valid for predicting usage of the IT system *A*, but not IT systems in general.

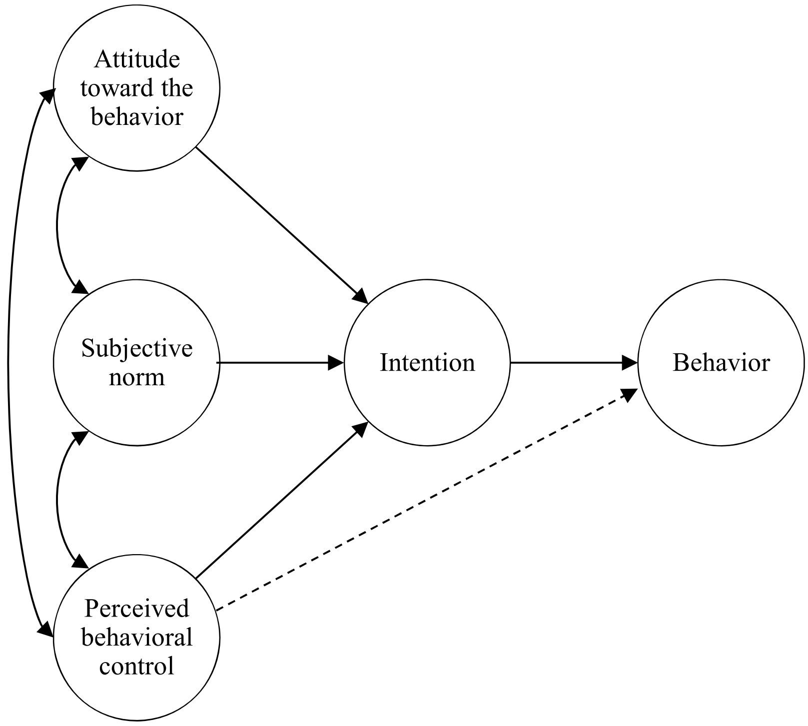


Figure 6: The figure shows the Theory of Planned Behavior explaining intention induced behavior (Ajzen, 1991).

For simpler presentations of the model Fishbein and Ajzen refrained from showing any feedback effects of the specified behavior on the determinants. Therefore the model is appropriate for behavior prediction at an initial state rather than for predicting continuous usage behavior that results from subjective evaluation based on the outcomes of past behavior. An individual's behavior results from its emotions and cognitive perceptions. The Theory of Planned Behavior deals well with cognitive perceptions, but regarding emotions the model excludes especially negative feelings like fears. In particular in non-volitional settings, where individual behavior might result from supervisor's instructions, non-performing the behavior might lead to fears e.g. of losing a job. The Theory of Planned Behavior and other reasoned action models are often criticized to be too rational and not to take sufficient account of affective and cognitive processes as the Theory of Planned Behavior focuses the controlled aspects of the human decision making process. (Ajzen, 2011) Neglecting affect and emotions in the theory is one of the most frequently mentioned aspects (Conner & Armitage, 1998; Rapaport & Orbell, 2000; Richard et al., 1998; Wolff et al., 2011; Ajzen, 2011).

2.4 Change Management

2.4.1 Change Management defined

Talking about implementing new IST change management is always an issue. According to Kotter (2011) change management

> "… is a set of processes and a set of tools and a set of mechanisms that are designed to make sure that when you do try to make some changes, *A*, it doesn't get out of control, and *B*, the number of problems associated with it – you know, rebellion among the ranks, bleeding of cash that you can't afford – doesn't happen. So it is a way of making a big change and keeping it, in a sense, under control."

Anderson and Ackerman Anderson (2010) categorized organizational change into three types: developmental, transitional and transformational change (see Figure 7).

> *Developmental Change*
>
> Developmental change represents the improvement of an existing skill, method, performance standard, or condition that for some reason does not measure up to current or future needs. Metaphorically, developmental changes are improvements "within the box" of what is already known or practiced. Such improvements are often logical adjustments to current operations. They are motivated by the goal to do "better than" or do "more of" what is currently done. The key focus is to strengthen or correct what already exists in the organization, thus ensuring improved performance, continuity, and greater satisfaction. The new state content is a prescribed enhancement of the old state, rather than a radical or experimental solution requiring profound change. The impact on people is relatively mild, usually calling for developing new knowledge or skills.
>
> *Transitional Change*
>
> Transitional change begins when leaders recognize that a problem exists or that an opportunity is not being pursued – and that something in the existing operation needs to change or be created to better serve current and/or future demands. Once executives, change leaders, or employee teams have assessed the needs and opportunities at hand, they design a more desirable future state to satisfy their distinct requirements. As can be seen from Figure 7, to achieve this new state, the organization must dismantle and emotionally let go of the old way of operating and move through a transition while the new state is being put into

place. Examples of transitional change include reorganizations, simple mergers or consolidations, installation and integration of new technology that does not require major changes in mindset or behavior, and creation of new products, services, systems processes that replace old ones.

Transformational Change

Transformation is the radical shift from one state of being to another, so significant that it requires a shift of culture, behavior, and mindset to implement successfully and sustain over time. In other words, transformation demands a shift in human awareness that completely alters the way the organization and its people see the world, their customers, their work, and themselves. In addition, the new state that results from the transformation, from a content perspective, is largely uncertain at the beginning of the change process and emerges as a product of the change effort itself.

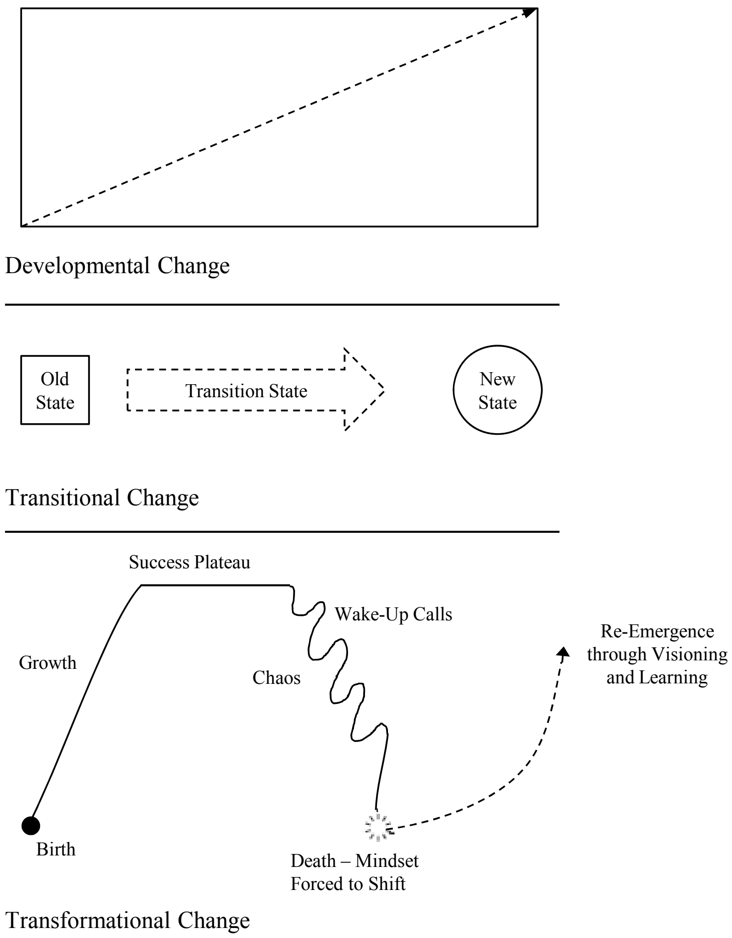


Figure 7: The figure shows the three types of organization change, according to Anderson & Ackerman Anderson (2010).

2.4.2 Principles of Change Management

Jones et al. (2004) mentioned four characteristics to recognize a long-term structural transformation: scale (the change affects all or most of the organization), magnitude (it involves significant alterations of the status quo), duration (it lasts for months, if not years), and strategic importance. Jones et al. (2004) developed a systematic framework for the transformational change:

Address the "human side" systematically	Any significant transformation causes the development of new skills and capabilities, and employees will be uncertain and resistant. Dealing with these issues on a reactive, case-by-case basis puts speed, morale, and results at risk. A formal approach for managing change – beginning with the leadership team and then engaging key stakeholders and leaders – should be developed early, and adapted often as change moves through the organization. This demands as much data collection and analysis, planning, and implementation discipline as does a redesign of strategy, systems, or processes.
Start at the top	Change unsettles people at all levels of an organization. Therefore all eyes will turn to the leadership team for strength, support, and direction. The leaders themselves must embrace the new approaches first, both to challenge and to motivate the rest of the organization. They have to model the desired behaviors.
Involve every layer	As transformation programs progress from defining strategy and setting targets to design and implementation, they affect different levels of the organization. Change efforts must include plans for identifying leaders through-out the company and pushing responsibility for design and implementation, they affect different levels of the organization. Change efforts must include plans for identifying leaders throughout the company and pushing responsibility for design and implementation down, so that the change "cascades" through the organization. At each layer of the organization, the leaders who are identified and trained must be aligned to the company's vision, equipped to execute their specific mission, and motivated to make change happen.

Make the formal case	Individuals are inherently rational and will question to what extent change is needed, whether the company is headed in the right direction, and whether they want to commit personally to making change happen. The articulation of a formal case for change and the creation of a written vision statement are invaluable opportunities to create or compel leadership-team alignment. There are three steps to the development of the case: Confront reality and articulate a convincing need for change. Demonstrate faith that the company has a viable future and the leadership to get there. Provide a road map to guide behavior and decision making. Leaders have to customize the message for their internal audiences.
Create ownership	Leaders of large change programs must overperform during the transformation and be the zealots creating a critical mass among the work force in favor of change. This requires more than passive agreement that the direction of change is acceptable. It demands ownership by leaders willing to accept responsibility for making change happen in all of the areas they influence or control. Ownership is often best created by involving people in identifying problems and developing solutions.
Communicate the Message	Too often, change leaders make the mistake of believing that others understand the issues, feel the need to change, and see the new direction as clearly as they do. The best change programs reinforce core messages through regular, timely advice that is both inspirational and practicable. Communications flow in from the bottom and out from the top, and are targeted to provide employees the right information at the right time and to solicit their input and feedback. This will often require overcommunication through multiple, redundant channels.

Assess the cultural landscape	Successful change programs pick up speed and intensity as they cascade down, making it critically important that leaders understand and account for culture and behaviors at each level of the organization. Companies often make the mistake of assessing culture either too late or not at all. Cultural diagnostics can identify the core values, beliefs, behaviors and perceptions that must be taken into account for successful change to occur.
Address culture explicitly	Having understood the culture, it should be addressed as another area in the change program. Leaders should be explicit about the culture and underlying behaviors that will best support the new way of doing business, and find opportunities to model these behaviors. This requires developing a baseline, defining an explicit end-state or desired culture, and devising detailed plans to make the transition.
Prepare for the unexpected	Planned changes never happen as planned. People react in unexpected ways; areas of anticipated resistance fall away; and the external environment shifts. Effectively managing change requires continual reassessment of its impact and the organization's willingness and ability to adopt the next wave of transformation.
Speak to the individual	Change is both an institutional and a personal issue. Individuals will have to know how their work will change, what is expected of them during and after the change program. People will react to what they see and hear, and need to be involved in the change process.

Table 2: The table shows the framework for transformational change (Jones et al., 2004).

3 Materials & Methods

3.1 System Dynamics

In order to talk about modeling systems and their behavior the general term system is being introduced. From its greek definition one can learn that a system is a “whole compounded of several parts or members” in a composition (Liddell & Scott, 1958). Later Senge defined systems to be

> “…a perceived whole whose elements hand together because they continually affect each other over time and operate toward a common purpose.” (Senge, 1994)

These definitions identify the two major components the system consists of: elements and effects. Furthermore, where humans are part of a system, the perspective has to be objective. From the systems perspective, the human actor as part of the feedback process, is not standing apart from it – this represents a profound shift in awareness. Thinking about systems, it is an axiom, that every influence is both cause and effect. (Senge, 1994) System Dynamics is a major approach that is introduced in this chapter, to model the interaction between system elements and the effect on each other system.

3.1.1 History

System Dynamics (SD) was developed in the 1950s at the Massachusetts Institute of Technology (MIT) by Jay W. Forrester. From his engineering background he was interested in how systems work. In his work with General Electrics Forrester wanted to explain the employment instabilities and started some simulation using a pencil and a page in a notebook. These hand simulations were the beginning of System Dynamics. Based on these hand simulations Forrester and a couple of students developed the first formal computer model stage. In 1961 Forrester published the first book in the field of System Dynamics ‘Industrial Dynamics’. The first application areas were related to corporate and managerial problems until Forrester cooperated with John Collins and published ‘Urban Dynamics’. This book was the first work on non-managerial application of System Dynamics. From a trip to Europe Forrester was infected by the idea of modeling socioeconomic systems. That was the beginning of using System Dynamics for many different fields, e.g. economics, public policy, physics, biology, social systems and biology. (Forrester, 1995)

3.1.2 Approach

Trying to understand a problem forces the investigation of how it occurred. An often used approach for problem solving is the event-oriented world-view (Sterman, 2000). Figure 8 shows this very common way to try to solve problems. The comparison of our goals with the current situation defines the problem. We assess several actions and implement the one that seems to work, aiming to achieve a better result and to correct the problem. The result of the actions defines the new situation we are facing in the future. This new situation will lead to a redefinition of the problem and influences the decisions of tomorrow. For example, an organization that did not achieve the sales goals for the last period cuts the prices to stimulate the demand and increase the market share. Indeed, the desired sales might be reached, but competitors will react and cut prices too. The sales would decrease. Yesterday's solution becomes today's problem. For this kind of problem the event-orient view of the world is not sufficient. This kind of thinking does not consider feedback from other systems, side effects or delays. As a system alters the state of other systems reactions will occur and even side effects may arise. The feedback view is useful to better understand this kind of problems. The results of our actions define the situation we face in the future. The new situation alters our assessment of the problem and the decisions we take tomorrow. Our decisions alter the environment and lead to new decisions of others according to their goals (see Figure 9). (Sterman, 2000)

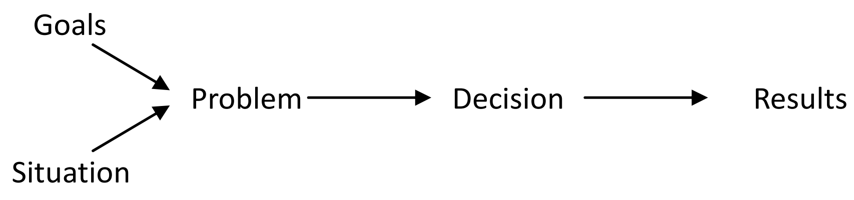


Figure 8: The figure shows the event-oriented view of the world (Sterman, 2000).

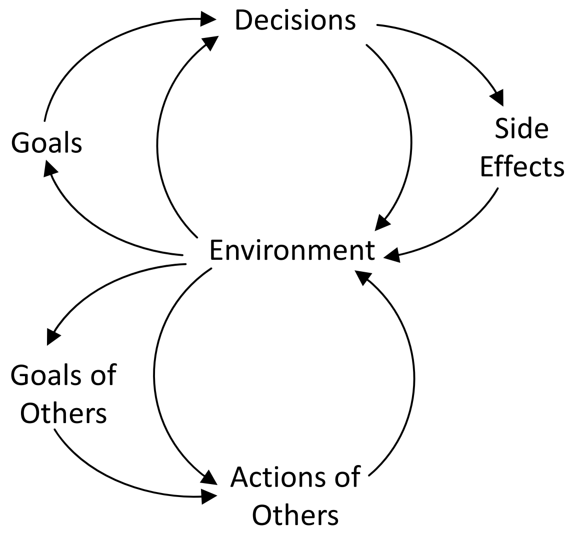


Figure 9: The figure shows the feedback view (Sterman, 2000).

System Dynamics (SD) is an approach that offers powerful tools to model feedback systems. It was defined by Forrester as

> "… an approach that should help in important top-management problems. The solutions to small problems yield small rewards. Very often the most important problems are but little more difficult to handle than the unimportant. Many predetermine mediocre results by setting initial goals too low. The attitude must be one of enterprise design. The expectation should be for major improvement. The attitude that the goal is to explain behavior; which is fairly common in academic circles, is not sufficient. The goal should be to find management policies and organizational structures that lead to greater success." (Forrester, 1961)

The System Dynamics modeling process is an iterative process. Models go through constant iteration, continual questioning, testing and refinement (Sterman, 2000). Results from a step may require changes in any earlier step. According to Sterman the process stages can be divided into the following five phases with and the according tasks:

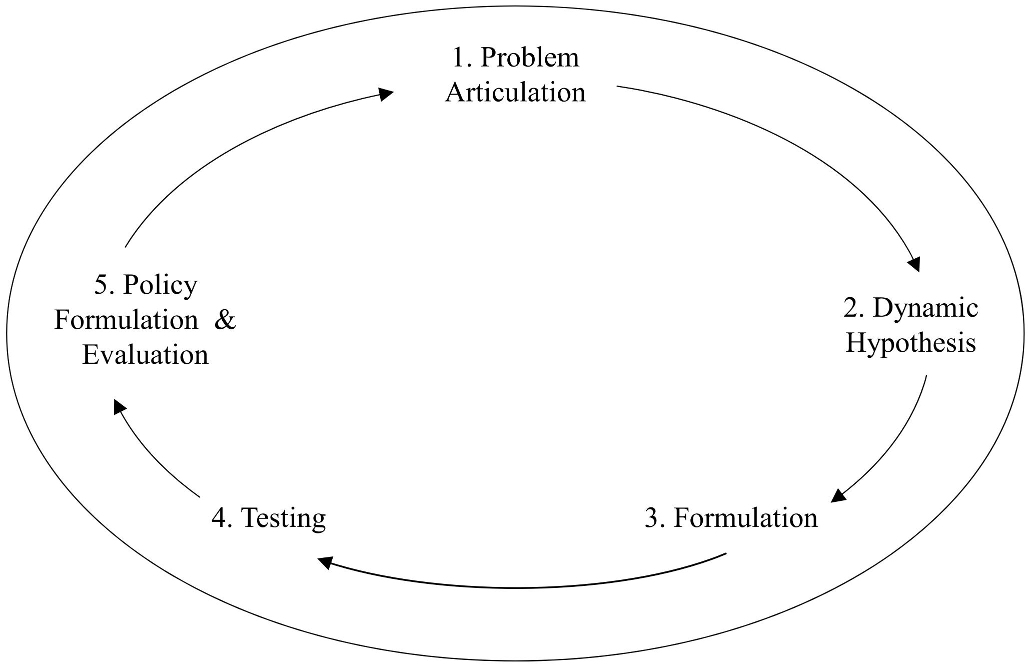


Figure 10: The figure shows the five phases of the System Dynamics Modeling Process, according to Sterman (2000).

1. Problem Articulation

- Theme selection: What is the problem? Why is it a problem?
- Key variables: What are the key variables and concepts that have to be considered?
- Time horizon: How far in the future should we consider? How far back in the past lie the roots of the problem?
- Dynamic problem definition (reference modes): Reference modes shall help to break out of short-term event-oriented thinking. A set of graphs and descriptive data should show the development of the problem over time: What is the historical behavior of the key concepts and variables? What might their behavior be in the future?

2. Formulation of Dynamic Hypotheses

- Initial hypothesis generation: What are current theories of the problematic behavior?
- Endogenous focus: Formulate a dynamic hypothesis that explains the dynamics as endogenous consequences of the feedback structure.

- Mapping: Developing maps of causal structure based on initial hypotheses, key variables, reference modes, and other available data. Used tools are
    - Model boundary diagrams,
    - Subsystem diagrams,
    - Causal loop diagrams,
    - Stock and flow maps,
    - Policy structure diagrams and
    - Other facilitation tools.

3. ***Formulation of a Simulation Model***

- Specification of structure, decision rules.
- Estimation of parameters, behavioral relationships, and initial conditions.
- Tests for consistency with the purpose and boundary.

4. ***Testing***

- Comparison to reference modes: Does the model reproduce the problem behavior adequately for your purpose?
- Robustness under extreme conditions: Does the model behave realistically when stressed by extreme conditions?
- Sensitivity: How does the model behave given uncertainty in parameters, initial conditions, model boundary, and aggregation?

5. ***Policy Design and Evaluation***

- Scenario specification: What environmental conditions might arise?
- Policy design: What new decision rules, strategies, and structures might be tried in the real world? How can they be represented in the model?
- "What if. . ." analysis: What are the effects of the policies?
- Sensitivity analysis: How robust are the policy recommendations under given uncertainties?
- Interactions of policies: Do the policies interact? Are there synergies or compensatory responses?

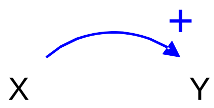
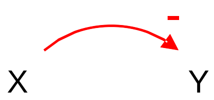
3.1.3 Tools

Causal Loop Diagram

Causal Loop Diagrams (CLD) are an important tool for representing feedback structures of a system. A CLD enables the modeler to (Sterman, 2000):

- quickly capture hypotheses about the causes of dynamics,
- capture and elicit the mental models of teams or even individuals and
- easily present important feedbacks that are responsible for a problem.

A CLD consists of variables that are connected with arrows representing a causal link between the variables. In the example in Figure 11 birth rate is influenced by the population and the fractional birth rate. Each causal link is designated by a polarity, either positive (+) or negative (-) to indicate how a change in the independent variable changes the dependent variable.

Symbol	Interpretation	Mathematical Formulation
	If X **increases (decreases)**, then Y **increases (decreases)** above (below) what it would have been.	$\frac{\partial Y}{\partial X} > 0$ In the case of accumulations, $Y = \int_{t_0}^{t} (X + \ldots) ds + Y_{t_0}$
	If X **increases (decreases)**, then Y **decreases (increases)** below (above) what it would have been.	$\frac{\partial Y}{\partial X} < 0$ In the case of accumulations, $Y = \int_{t_0}^{t} (-X + \ldots) ds + Y_{t_0}$

Feedback processes have to be considered to fully understand dynamics of system behavior besides relationships. Complex behavior mostly arises from interactions between parts of the system. But all dynamics arise from the interaction of just two types of feedback loops: positive or negative loops. A positive or even self-reinforcing loop amplifies the effects in a system. In the Cold War, the more nuclear weapons NATO deployed, the more weapons the Soviet-Union built, driving NATO to build still more. Positive feedback loops can also be found in economy: A company that lowers its price to gain market share might be faced with competitors responding the same way, forcing the company to lower its price again. Positive loops generate their own growth. Negative loops counteract. The less nicotine in a cigarette, the more cigarettes smokers have to consume to get the desired dose. The higher the price of a commodity, the lower the demand and the greater the production, leading to inventory accumulation and pressure for lower prices to eliminate the excess stock. The larger the market share of dominant firms, the more likely is government antitrust action to limit their monopoly power. These loops all describe processes that tend to be self-limiting, processes that seek balance and equilibrium. All systems consist of networks of positive and negative feedbacks. And the dynamics emerge from the interaction of these loops.(Senge, 1994; Sterman, 2000) Figure 11 shows a simple CLD and its feedback loops representing a population system. Loos are highlighted by a loop identifier that shows the type of feedback, that is either positive (reinforcing) or negative (balancing).

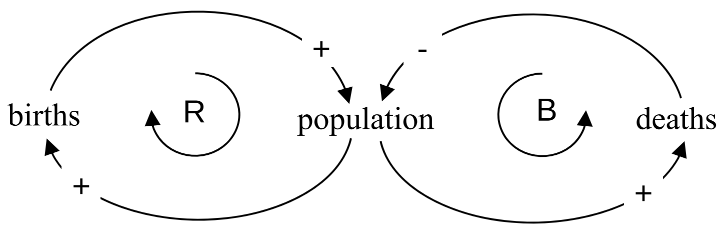


Figure 11: The figure illustrates the system behavior and feedback loops in a CLD.

Reinforcing Loops

Positive loops are self-reinforcing. In a reinforcing feedback system small actions can grow into large consequences (Senge, 1994). Applying the CLD in Figure 11 for a chicken population, more chickens produce more eggs, which increase the number of chicken that will produce even more eggs. This reinforcing feedback loop can be identified by the R in the loop. If the egg loop was the only one operating, the chicken population would grow exponentially. As no real quantity can grow limitless, there must be some limits to growth. These limits are identified in the following negative loops. (Sterman, 2000)

Self-correcting Loops

Negative loops are self-correcting or balancing loops. They counteract change. A balancing system seeks for stability. In a balancing system there is a self-correction that attempts to maintain some goal or target. Filling a glass of water is a balancing process with the goal of a full glass. In the chicken and egg example the growing population with its carrying capacity will be balanced by negative loops. E.g. the more chickens, the more road crossings will be there. Provided that there is traffic on the road, more road crossings will lead to fewer chickens. A growing chicken population causes more risky road crossings, which lead to a decrease in the chicken population. This balancing feedback is denoted by the B in the center of the loop. If road crossings are the only limiting factor affecting the chicken population, the chicken population would decline until it is zero. (Sterman, 2000)

Stock and Flow Diagram

Everyone feels familiar to stocks and flows. The inventory of a manufacturing company is the stock of products in the warehouse. The number of employees of the company is also a stock. Stocks are altered by inflows and outflows: the inventory is increased by the flow of production and decreased by the flow of sales. The employee stock decreases with quits, layoffs and retirements, and increases through the hiring rate. For a simulation of system behavior the causal loop needs to be transformed into a stock and flow diagram. Stocks are accumulations and characterize the state of the system and provide the information upon which decisions and actions are based. Stocks represent the memory of the system. They create delays by accumulating the difference between outflow and inflow to a process. Flows are rates that change stocks. Flow values are independent to previous states of the rate, but they depend on the connected stocks and other related variables. (Sterman, 2000)

The notation of a stock and flow diagram as it is shown in Figure 12 uses the following basic elements:

- Rectangles represent stocks or levels and can be seen as a container holding the contents of a stock.
- The flow is controlled by valves.
- Circles represent auxiliaries. They are used for calculating intermediary values.
- Sources or sinks for the flows are represented by clouds and are used for illustrating variables outside the boundaries of the model.
- Constant numerical values are represented by diamonds.

- A pipe (arrow) that points into the stock represents an inflow to the stock.
- Pipes pointed out of the stock represent outflows of the stock which is being reduced.
- Cause and effect arc illustrate the connection between a stock and an auxiliary or a constant, or between auxiliaries.

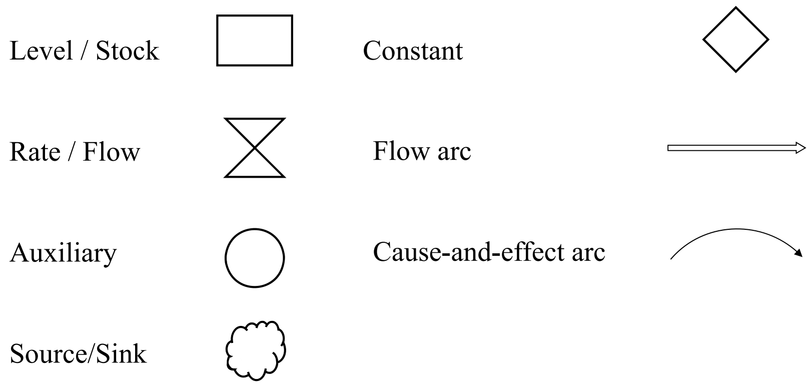


Figure 12: The figure shows the elements of the System Dynamics Stock and Flow Diagram Notation.

Based on stock and flow notation a CLD can be transformed into a stock and flow diagram. The stock and flow diagram in Figure 13 presents the result of the transformation of the CLD in Figure 11.

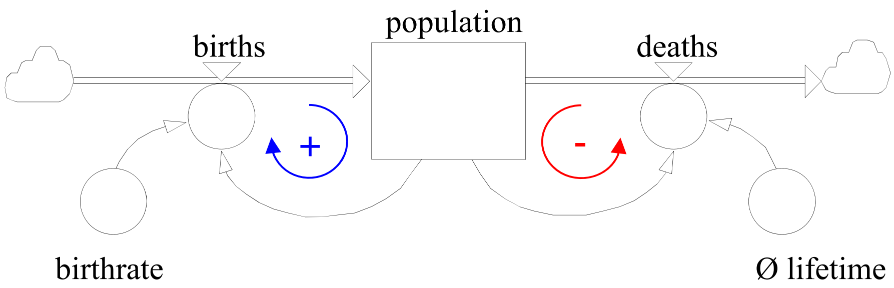
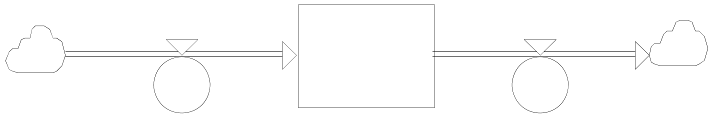


Figure 13: The figure shows the stock and flow diagram for the chicken and egg population illustrated in the CLD in Figure 11.

The stock and flow diagramming conventions were originated by Forrester (Forrester, 1961). As thinking in stocks and flows is based on a hydraulic metaphor Sterman suggested illustrating stocks as bathtubs of water. The quantity of water in the bathtub is the accumulation of the water flowing in and the water flowing out through the drain. (Sterman, 2000)

- Hydraulic Metaphor:

- Stock and Flow Diagram (SFD):



- Integral equation:

$$Stock(t) = \int_{t_0}^{t} [Inflow(s) - Outflow(s)]ds + Stock(t_0)$$

- Differential equation:

$$d(Stock)/dt = Net\,Change\,in\,Stock = Inflow(t) - Outflow(t)$$

Figure 14: The figure shows four equivalent representations for stock and flow structure, according to Sterman (2000).

There are four equivalent representations of stock and flow structures (see Figure 14). Although the hydraulic metaphor and the stock and flow diagram seem to be very conceptional, these representations contain exactly the same information as provide the integral and differential equation.

3.2 Sensitivity Model

3.2.1 Approach

Frederic Vester introduced the Sensitivity Model to provide a better solution to unsolvable problems so far. Complex, cybernetic system behavior that was not able to be explained using systems dynamics should be constructed with fuzzy logic applying an interactive process of understanding. Software was developed to support the process of generating a sensitivity model. Vester's approach of interconnected thinking and the software *Sensitivity Model Prof. Vester* (2001) is used for

- technology assessment,
- developmental aid projects,
- examination of economic sectors,
- city, regional and environmental planning,
- traffic planning,
- insurance and risk management,
- financial services and
- research and training.

The basis of the sensitivity model is the reduction of complexity to a manageable, but system relevant set of variables. The second level of the approach corresponds to the identification of patterns, and includes the analysis and visualization of interactions in the system. The main tasks in this level are the identification of various roles of variables in the system and the characterisation of the system behavior. Vester clearly points out that this approach differs from the System Dynamics approach in its interactivity and iterative mode. On the third level of the approach the biocybernetic evaluation takes place. The analysed system is evaluated particularly regarding to its viability: self-regulation, flexibility and controllability.

3.2.2 The nine Steps and Tools

Based on the above mentioned three levels Vester defined nine steps and the according tools (see Figure 15) to build a cybernetic model (Vester, 2001):

1. System description
2. Gather variables
3. Check for system relevance
4. Evaluation of interactions
5. Identification of the systemic role
6. Analysis of the system behavior
7. Cybernetics of scenarios
8. Policy tests
9. Systemic evaluation and strategy

In each step information can influence previous steps, therefore it can lead to further improve these steps, and additionally it can also lead to a more comprehensive view of the system behavior. As such the process is a very iterative and flexible one.

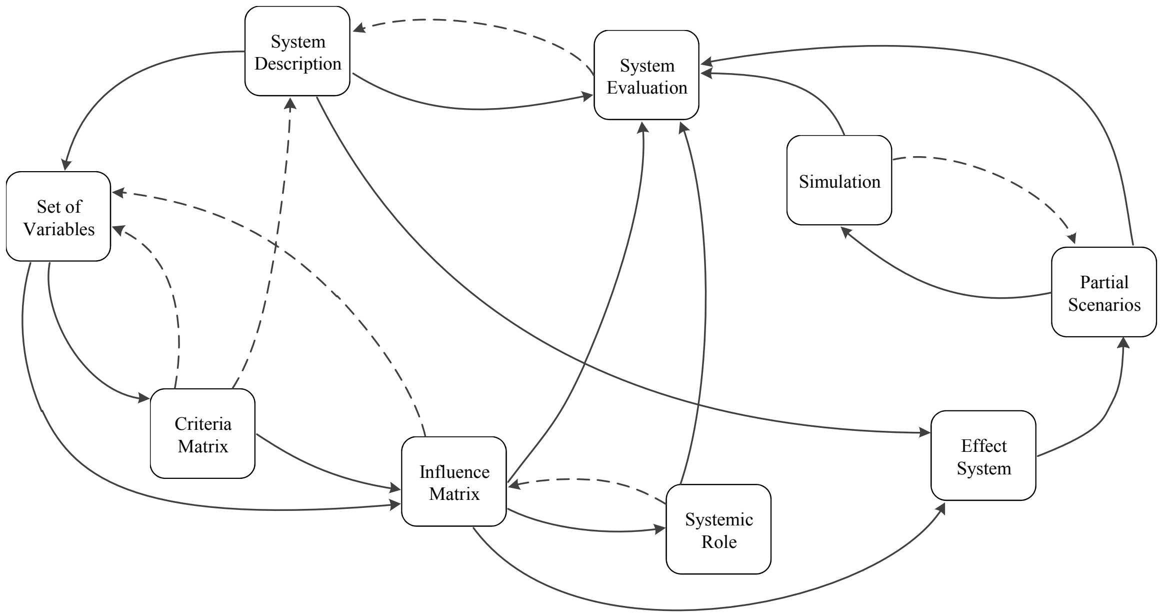


Figure 15: The figure shows the recursive structure of the Sensitivity Model, according to Vester (2001).

System Description

The goal of this step of the approach is to describe the system. This description is being updated during the development of the model according to the findings. Based on the idea to enhance the viability of the system sub-goals and system boundaries are defined. Within this step only participation of all persons concerned by later decisions will lead to a feasible understanding of the system. This avoids many mistakes coming along with the complexity of the system, e.g. insufficient definition of goals. The basis of this step are research material, results from financial or other professional reports, individuals' descriptions of a problem, desires and opinions.

Gather Variables

Based on the system description key variables relevant to system behavior are identified. These factors have to be flexible, but not fixed constants. Moderated brainstorming with all participants is an important technique to achieve an integrated view. Furthermore, comments on system behavior are logged for later decision. In this way besides quantitative data qualitative aspects can be considered.

Check for System Relevance

In this step the collected variables are systematically considered from different views. The participants of the system and their emotions have to be considered as well as economic tasks and other tasks. Furthermore relationship between the system and the environment are relevant. Infrastructure and communication channels, administration, laws and contracts are relevant too. This step requires to also checking the identified variables to represent not only a theoretical, but also a real system. Therefore the three entities of the physical category material, energy and information as well as variables that open the system to the boundaries have to be considered. All these aspects belong to the system and are collected in a criteria matrix (see Figure 16). This variable set provides answers to the system behavior.

Evaluation of Interactions

The first task within this step is to analyze the influence of each variable on the others with the purpose to leave the level of components and enter the level of interaction. As a tool for representing the impact of the variables the cross impact matrix (see Figure 17) is used. Besides the information about the existence of an influence the strength of impact is estimated. This step should be carried out in separate groups to be sure to get information about the system from different point of views. As such, objectivity is not a necessary requirement for the participants. Instead, especially for human relations subjective information is much more important than impartial information.

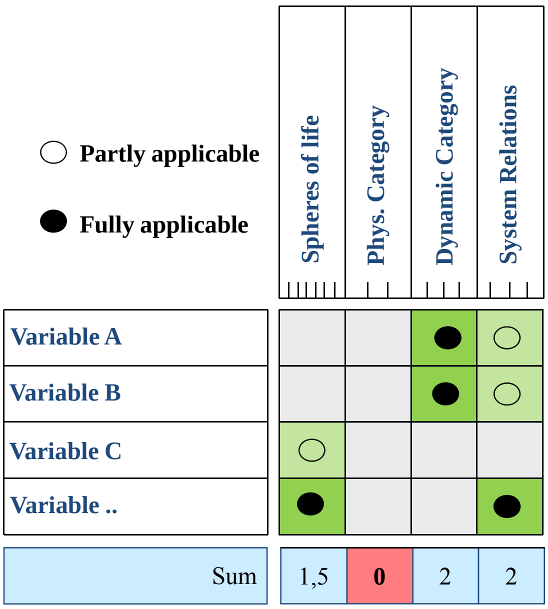


Figure 16: The figure shows the criteria matrix according to Vester (2001).

impact on	Variable A	Variable B	Variable C	Variable D	Active sum (AS)	Criticality = AS/PS
Variable A		1	2		3	1
Variable B			1	3	4	4
Variable C	1			1	2	0,3
Variable D	1		3		4	0,3
Passive sum (PS)	2	1	6	4		
Activity = AS*PS	6	4	12	16		

Figure 17: The figure shows the impact matrix according to Vester (2001).

Identification of the Systemic Role

Based on the impact matrix every variable in the system can be classified according to the basic values active, passive, critical and buffering (see Figure 18). From this classification one can learn which are the critical factors in the system, which variables are able to act as levers, which ones are the risk factors and which are measuring sensors or inert elements. This step can also illustrate the general behavior of a system: a system can be identified as inactive or even very active, hence this step will give the first strategic hints.

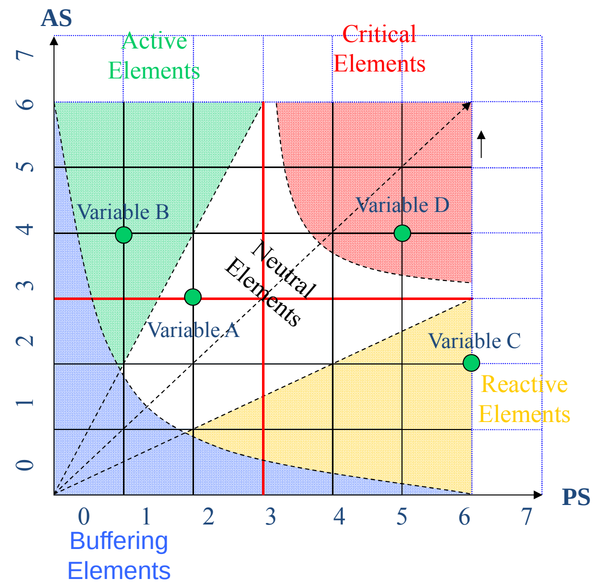


Figure 18: The figure shows the matrix used for the identification of the systemic role of variables according to Vester (2001).

Interpretation of the System Behavior and Feedback Cycles

From the first steps one can learn about the genetic reservoir of a system and its latent possibilities. This step will bring evidence to the system behavior and its dynamics. Through feedback analysis of the effect system dominant cycles are recognized. In this way one can recognize how contradictory influences regulate, or disturb each other, and how they are connected to others. The importance of particular variables to system behavior can be analyzed by deleting relationships or variables for a better understanding of the dynamics of the system.

Cybernetics of Scenarios

Based on the previous step many partial scenarios can be pulled out to be analyzed according to their cybernetics. This cluster-analysis enables a cybernetic examination of interesting areas for a better understanding of sub-areas and in succession of the whole system.

Policy Tests

For more statements about the behavior of the system simulations should be done. People who are interested in the system should participate in defining scenarios and simulations. To fully integrate them into this step full transparency is required to gather acceptance later in the process. Therefore the tests have to be defined in plaintext without any mathematical formulas. Following this approach the argumentation for strategies will not be a problem.

Systemic Evaluation and Strategy

Following these nine steps for system modeling a better understanding of system behavior is achieved. Questions arise that would never have been asked and the system is seen from other perspectives. The feedback analysis gives hints for strategies and the recursive nature of the process enables a more comprehensive view of the system. Based on the information about system cybernetics effective and efficient strategies can be identified by a common basis of participants due to the interactive approach.

3.3 Model Verification & Validation

Using simulation to solve problems and to aid in decision-making is increasing. Hence, it is important to demonstrate that model and results are correct. Addressing this requirement, model verification and model validation is applied. Model verification is defined as

> "... ensuring that the computer program of the computerized model and its implementation are correct" (Schlesinger et al., 1979)

and model validation is defined as

> "… substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model" (Schlesinger et al., 1979).

The aim of the verification and validation process is to collect evidence of a model's correctness and/or accuracy for a specific scenario. Therefore verification and validation cannot prove that a model is correct and accurate for all possible conditions and applications. Though, it rather can provide evidence that the model is sufficiently accurate for a specific application. The process of validation and verification is completed when sufficiency is reached. (Thacker et al., 2004)

3.3.1 The Modeling Process

According to Sargent (1981) the modeling process (see Figure 19) contains the problem entity as the system, idea, situation policy or phenomena to be modeled. The conceptual model is a mathematical, logical or verbal representation of the problem entity that is developed for a particular study. The computerized model is the conceptual model implemented on a computer. Unlike the conceptual model which is developed through an analysis and modeling phase, the computerized model is developed through a computer programming and implementation phase. Inferences about the problem entity are obtained by conducting computer experiments in the experimentation phase. In this modeling process conceptual model validation is defined as determining that the theories and assumptions underlying the conceptual model are correct and that the model representation of the problem entity is reasonable for the intended purpose of the model. The next step is the computerized model verification. It is defined as assuring that the computer programming and implementation of the conceptual model is correct. Finally, operational validation is defined as the determination of the model's output behavior to be sufficient for the model's intended purpose at the intended application area. Data validity is defined as ensuring that the data that is necessary for building, evaluating and testing the model and conducting the experiments are adequate and correct. (Sargent, 2011)

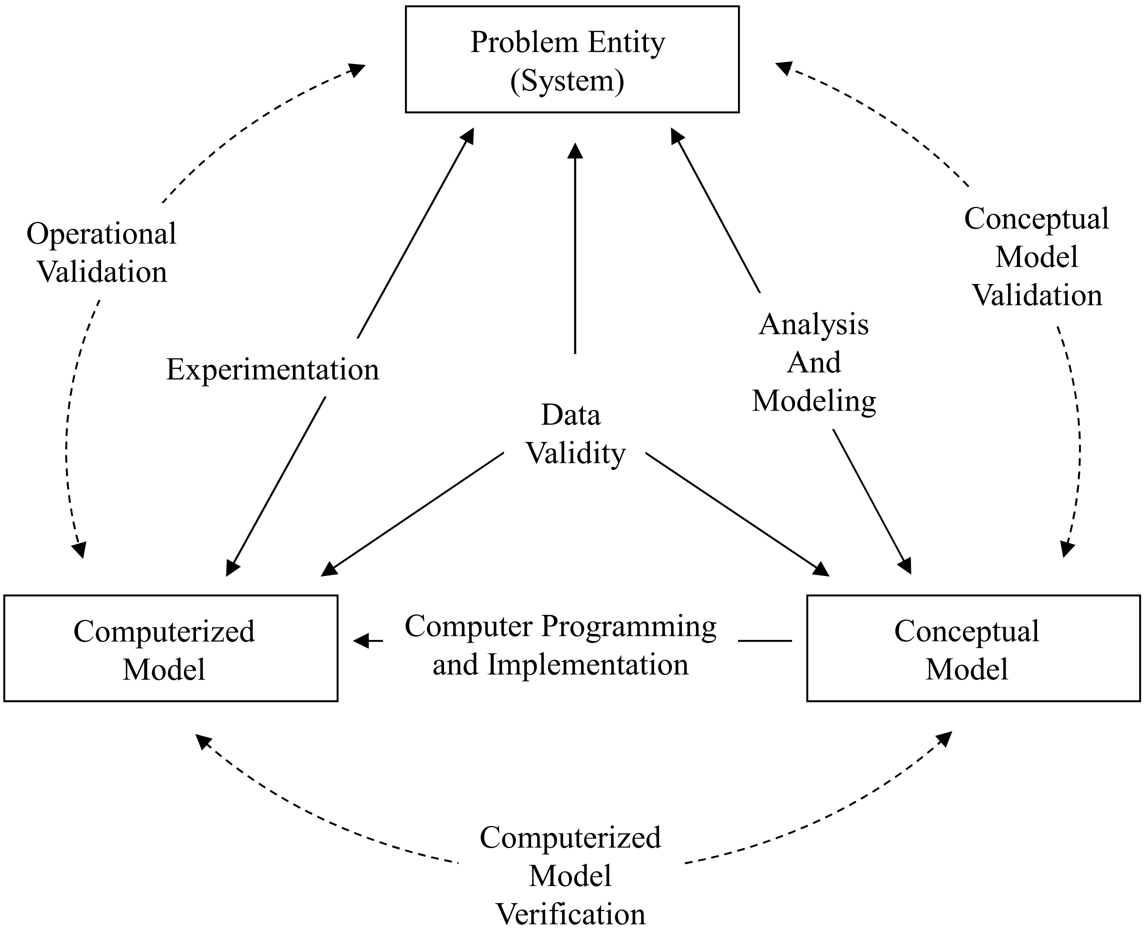


Figure 19: The figure shows a simplified version of the modeling process (Sargent, 1981, 2011).

For a better understanding of the relationship between verification, validation and the real world Sargent suggested a more detailed paradigm that shows the real world as well as the simulation world. He illustrated the processes of developing system theories and simulation models and the relationships of verification and validation to both of these processes (see Figure 20).

In the real world there is a system or problem entity that should be understood. System theories describe the characteristics of the system. They are developed by abstracting results from system observations and by hypothesizing from system data and results. Before that step system data and results are retrieved by conducting experiments. System theories are then validated by performing theory validation through comparing system theories against system data and results over the problem domain. In the simulation world the conceptual model is the mathematical, logical or verbal representation of the system; it is developed by modeling the system using the theories retrieved from abstracting and hypothesizing. The simulation model specification defines how the software should be designed and implemented. The implementation of this is called simulation model, which is used for running experiments on a computer. Simulation model data and results are retrieved by conducting experiments with the implemented system. Throughout the process of modeling several verification and validation steps have to be done. This starts with the validation of the conceptual model which includes that theories and assumptions underlying the conceptual model are checked for consistency with the system theories. During the software design specification verification has to assure that software design and the specification for programming and implementing the conceptual model is satisfactory. Implementation verification is assuring that the simulation model has been implemented according to the simulation model specification. (Sargent, 2007, 2001)

In order to assure correct and sufficient model verification and validation Sargent (2001) suggests performing the following eight steps:

- The model development team, model sponsors and model users shall agree about the basic validation approach and shall specify a minimum set of validation techniques to be used for the validation process.
- Early in the model development process the required accuracy of the simulation model's output variables should be defined.
- Assumptions and theories that underlie the simulation model shall be tested rigorously.
- Each model iteration shall at least go along with performing face validity on the conceptual model.
- The computerized model shall be used to explore the simulation model's behavior in each model iteration.
- At least in the last model iteration comparisons between the simulation model and system behavior or system output data should be performed for a few sets of experiments.
- The simulation model documentation shall include the validation documentation.
- If the simulation model is to be used over a period of time, develop a schedule for periodic review.

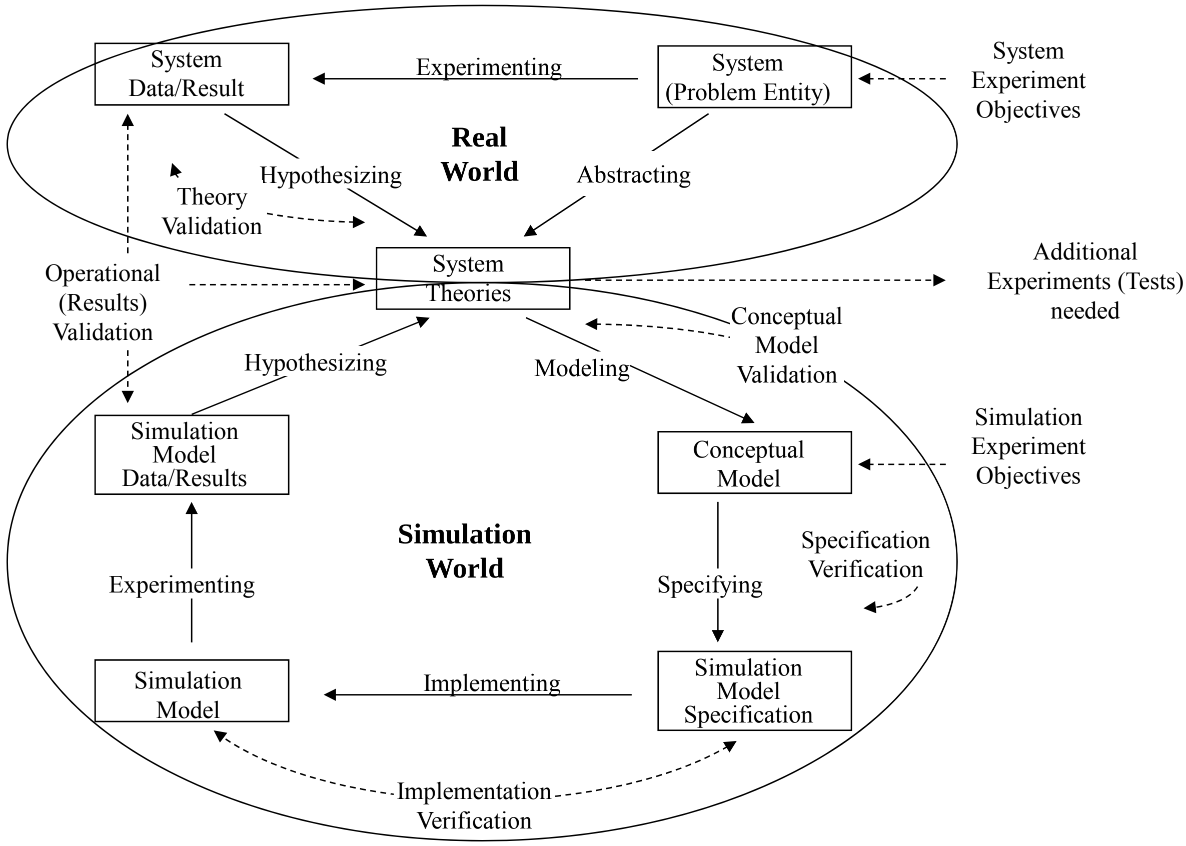


Figure 20: The figure shows real world and simulation world relationships with verification and validation (Sargent, 2001).

3.3.2 Techniques

In general, there are several validation techniques and tests that can be used for model verification and validation. These techniques and tests can be used either subjectively or objectively. “Objectively” means to use some type of mathematical procedure or statistical test, e.g. hypotheses tests or confidence intervals. It is suggested to use a combination of these techniques. (Sargent, 2011). Sargent (2011) described various techniques:

Animation

The model’s behavior over time is illustrated graphically, e.g. the movements of parts through a factory.

Comparison to other Models

Validated output results of the simulation model are compared to results of other validated models. Simple cases of a simulation model are compared to known results of analytic models or the simulation model can be compared to other validated simulation models.

Degenerate Tests

Model's behavior degeneracy is tested by appropriate selection of values of the output and internal parameters, e.g. does the average number in the queue of a single server continue to increase over time, when the arrival rate is larger than the service rate?

Event Validity

Events occurring in the simulation are compared to these of the real system and checked for similarity. For example, in a fire department simulation the number of fires can be checked.

Extreme Condition Tests

Extreme condition tests shall assure that the simulation model structure and outputs should be plausible for any extreme and unlikely combination of levels of factors in the system. E.g. in a production process simulation, zero input should result in zero output.

Face Validity

Knowledgeable individuals analyze the model whether the model and its behavior is reasonable, e.g. is the logic in the conceptual model correct and are the model's input-output relationships reasonable.

Multistage Validation

The combination of the three historical methods of rationalism, empiricism and positive economics leads to a multistage process of validation: (1) developing the model's assumptions on theory, observations and general knowledge, (2) validating the model's assumptions where possible through empirical testing and (3) testing the relationship between input and output of the model to the real system.

Internal Validity

Several simulation runs are done to determine the variability in the model. A large amount of variability might cause the model's results to be questionable.

Historical Data Validation

If historical data exists, part of it can be used for model building and the remaining data can be used to determine whether the model behaves as the system does.

Historical Methods

Rationalism, empiricism and positive economics are the three historical methods of validation. Rationalism assumes that everyone knows whether the assumptions of the model are true. Based on these assumptions logic deductions are used to develop the correct (valid) model. Empiricism requires that every assumption and outcome has to be empirically validated. In contrast, positive economics requires only that the model is able to predict the future; it is not concerned with causal relationships or mechanisms.

Operational Graphics

With operational graphics values of various performance measures over the simulation lifetime are visualized.

Parameter Variability – Sensitivity Analysis

The values of the input and internal parameters are changed to determine the effect upon the model's behavior or output. The same relationships should occur in the model as in the real system. This technique can be used qualitatively and quantitatively. Parameters that turn out to cause significant changes in the model's output are sensitive. These parameters should be made sufficiently accurate.

Predictive Validation

Comparisons are made between the system's behavior and the model's forecast to determine the predictability.

Traces

The behavior of different types of specific entities in the model are traced through the model to determine the correctness of logic of the model.

Turing Tests

Individuals who know about the operations of the real system are asked to determine the differences between the model and the real system.

4 Validation Concept of the Proposed Model

In order to proof validity of the proposed model several steps were done. As can be seen from Figure 21 the model building process was divided into model development, simulation, verification, validation and discussion of effects. In general this thesis provides a conceptual causal model and a simulation model that is built on the causal model. Furthermore this simulation model is used for model validation and for the discussion of effects. The case studies show the applicability of the model to explain the individual usage behavior.

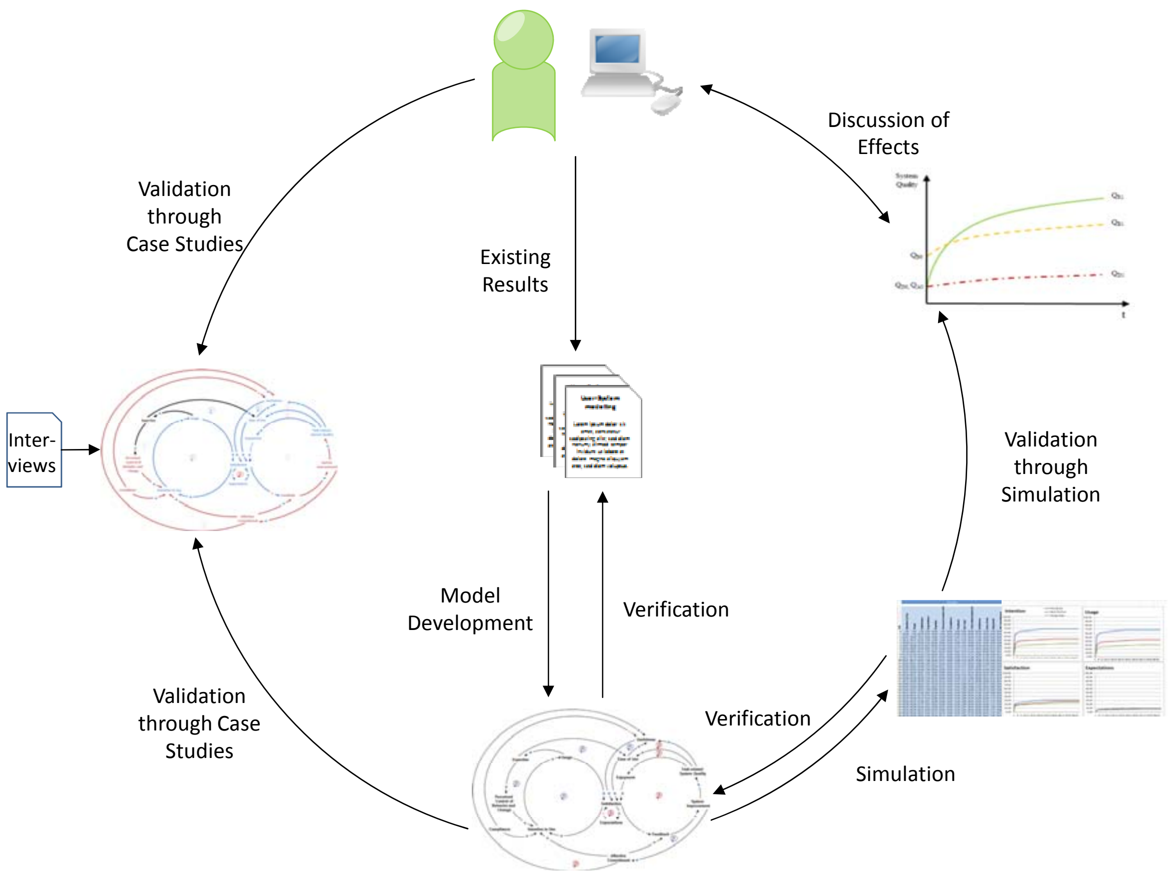


Figure 21: The figure shows the overall model building process underlying this thesis.

Model Development

The model development is divided into two parts: the extension of the Intention Model (see chapter 5.1 Model Core: Extended Intention Model) and the development of the Information System & Information Technology (IST) Behavior Explanation Model (see chapter 5.2.1 Adding Feedback (CLD)). Based on a profound literature research the main factors for using information systems and information technologies were identified. The factors and relationships underlying the model were identified, harmonized and extended to build a causal model that explains usage behavior on a regular basis. This second step added feedback to the Extended Intention Model and provided insight into the main drivers and barriers of continuous usage of ISTs. These driving forces and self-correcting effects for continuous usage of information systems and information technologies are presented in the chapters 5.2.2 Driving Forces and 5.2.3 Self-correcting Effects.

Simulation

The main reason for providing a simulation model is to give evidence to the validity of the causal model. Based on the causal model proposed in the previous stage and the strength of effects known from literature a simulation model was built using a combination of System Dynamics and the Sensitivity Model Approach (see chapter 6 Simulation Model to Explain Usage Behavior).

Verification

The verification of the proposed model was done in two steps. For the first, a literature review was done to find contradictory factors and relationships to verify that the model is based on a common basis. The second step included the verification of the simulation model. To provide evidence that the simulation model was implemented correctly according to the causal model degenerate tests, extreme condition tests, internal validation and operational graphics were used.

Validation

To ensure that the model is able to provide an explanation to the actual usage behavior validation is done in two steps. The validation of the simulation model was done by demonstrating the effects of known interventions (see chapter 7.1 Validation on known Effects of Interventions). According to corresponding literature user participation, user training and management support were found to support the individual usage behavior. The effects of these interventions also in the simulation model supported the individual usage behavior. To further provide evidence of the applicability of the model to explain the individual usage behavior case studies were done using semi-structured interviews.

Demonstration of Effects

This thesis, besides a causal model provides a simulation model that is not limited to be used for the validation of the causal model, but also for the demonstration of effects. Chapter 6.4 Simulation Model Results provides insight into several outcomes of the simulation and demonstrates performance measures that result from different processes of system implementation and the selection of alternative systems. To provide a deeper understanding for the effect of different system implementation strategies and system selection strategies several scenarios were investigated (see chapter 6.3 Simulation Scenarios). By varying the initial settings when implementing an IST the simulation demonstrates resulting performance measures and final system quality. Based on these outcomes, phenotypes were identified to indicate how different implementations work.

5 A Causal Model to Explain Usage Behavior

The introduced behavior explanation models aim at predicting initial usage of IST but they not include any negative emotions resulting from the adoption process. In a business environment to achieve the most of a system it has to be used on a regular basis. Users of systems are faced with doing their tasks in their work environment. Users have skills and capabilities and any change in the technical subsystem may cause the social subsystem to be disrupted according to the degree of change and innovation type (Ryan & Harrison, 2000). The proposed intention model serves as a basis for a feedback model to explain a user's IST usage behavior on a regular basis in his or her work environment. In this chapter the IST Behavior Explanation Model is built on the Extended Intention Model by introducing feedback. Furthermore, driving forces and self-correcting effects in the model are being analyzed.

5.1 Model Core: Extended Intention Model

The idea behind the Theory of Planned Behavior is that behavioral achievement depends both on motivation and ability (Ajzen, 1991). Behavioral intention is not only the result of rational thinking, but it is also affected by emotions; these may be positive (like satisfaction) or negative (e.g. uncertainty and anxiety). The proposed model includes these negative emotions. User's accomplishing tasks in an organization that has a specific structure using infrastructure to transform input into output – this setting represents a socio-technical system. As such a change in the technological subsystem is a change in the socio-technical system (Figure 22).

As The Theory of Planned Behavior represents the general determinants of intention the Extended Intention Model (see Figure 23) is based on Ajzen's Theory of Planned Behavior. It introduces an extended comprehension of perceived control of behavior and change. Furthermore, the model includes the factors intention to use that is determined by subjective norm, attitude and perceived control of behavior and change.

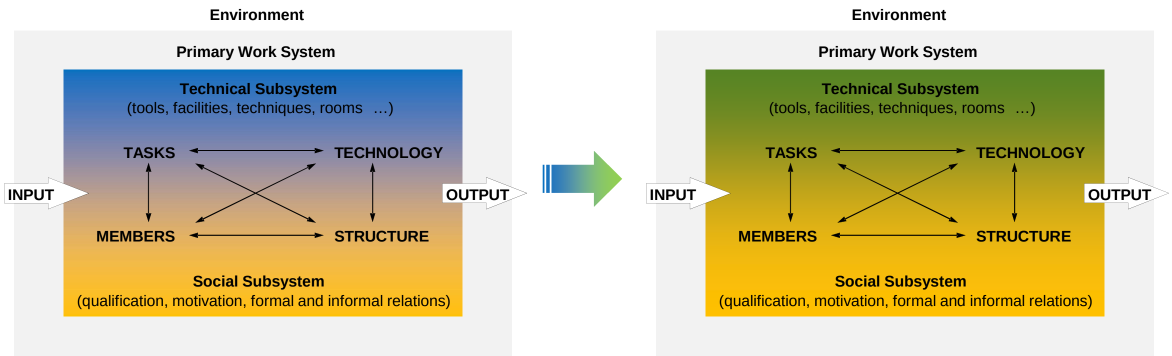


Figure 22: The figure shows the transformation of a socio-technical system into a new socio-technical system.

5.1.1 Intention to Use

Warshaw and Davis (1985) stated that intention refers to the degree to which a person has formulated conscious plans to perform or not to perform some specified future behavior. Intention is defined as a person's location on a subjective probability dimension involving a relation between himself and some action (Fishbein & Ajzen, 1975). In the Theory of Reasoned Action intention was found to capture the motivational factors influencing a behavior (Fishbein & Ajzen, 1975). They clearly stated that in the Theory of Reasoned Action the behavior in question is to be performed under volitional control. A behavior is said to be under volitional control, if the person can decide at will to perform it or even not to perform it (Ajzen & Madden, 1986). Ajzen (1991) introduced the Theory of Planned Behavior that introduced perceived behavioral control to overcome this limitation. Intention was used in several behavior explanation models as the key determinant for usage of system: Information System Success Model (DeLone & McLean, 1992, 2003), Technology Acceptance Model 1-3 (Davis et al., 1989; Venkatesh & Davis, 2000; Venkatesh & Bala, 2008) and the Theory of Planned Behavior (Ajzen, 1991), the Theory of Reasoned Action (Fishbein & Ajzen, 1975) and the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003). For the issues of predicting behavior Warshaw and Davis' definition of intention is used (1985) where intention refers to formation of plans towards a specific behavior.

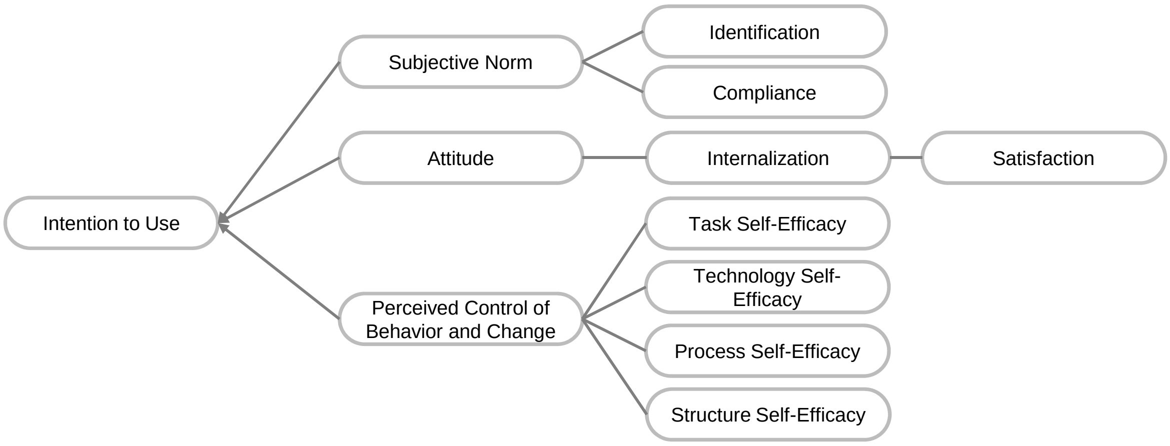


Figure 23: The figure shows the Extended Intention Model for predicting Information System & Information Technology usage intention in a business environment. It is based on Ajzen's Theory of Planned Behavior (1991).

5.1.2 Perceived Control of Behavior and Change

During the change within the socio-technical system the member is faced with emotions that can influence the behavior in question and might lead to non-performing the behavior due to anxiety or uncertainty. Bandura introduced the term self-efficacy, referring to one's beliefs about one's ability to perform a particular behavior (Bandura, 1986). Self-efficacy affects choices about which behaviors to undertake, the effort and persistence exerted in the face of obstacles to the performance of these behaviors, and ultimately, the mastery of the behaviors (Compeau & Higgins, 1995a). In a business environment there is also the possibility to enforce a specific behavior through rewards or punishment. For addressing this fact and the uncertainties related to it, self-efficacy is extended relating to the elements of socio-technical systems: tasks, technology and structure in the primary work system:

Task Self-efficacy (see Figure 24, highlighted no. 1)

The user is sure that he has the required skills to perform a specific task. Therefore he is sure to be able to accomplish the new or changing tasks with the available resources. Independent from which resources should be used for a task the user is convinced to be able to perform his tasks. Perceptions regarding task self-efficacy can therefore interact with technology self-efficacy, if there is only one system or process the task can be done with.

Technology Self-efficacy (2)

Technology self-efficacy refers to the user belief that he will be able to use the new technology or system in the socio-technical system to perform the tasks. The easier a system is to interact with, the greater is the perception of efficacy (Bandura, 1982) and control beliefs (Davis et al., 1989). Task self-efficacy may occur without technology self-efficacy when IST usage is voluntary and the task could be done without the new system, e.g. there is a second system the task can be done with.

Structure Self-efficacy (3)

The user is sure that although tasks and technology are changing he will be able to hold his role within business processes and the organizational structure. He is sure not to lose image and position within the organization. This kind of self-efficacy seems to be supported by task and technology self-efficacy, but refers to the change of processes in the task environment.

Process Self-efficacy (4)

Process self-efficacy refers to the overall perception of control of task execution in the primary work environment. The user is sure that he will be able to transform the given input into the desired output within the business process with given technology in a defined structure by doing his tasks. This includes the specific context for the task execution.

In Ajzen’s Theory of Planned Behavior perceived behavioral control refers to an individual’s confidence in its ability to perform a behavior and is therefore related to Bandura’s self-efficacy (Ajzen, 1991; Fishbein & Cappella, 2006). Therefore, as the presented self-efficacies relate both to control beliefs and fears of change these are combined to perceived control of behavior and change.

To provide an example regarding the four self-efficacies an example is introduced: a pilot handling a helicopter is supposed to accomplish the task of rescuing a casualty cooperating with a ground station. The technical subsystem is provided by the helicopter and further equipment at the ground station. The social subsystem is represented by the pilot and the co-worker at the ground station. In this situation task self-efficacy means whether the pilot is sure that in general he has the ability to rescue the person with the provided infrastructure and the systems implemented. Technology self-efficacy refers to the pilots beliefs about his ability to use a certain technology to rescue the person. Provided, that there are several helicopters the pilot could choose, technology self-efficacy could vary between different systems. Although systems are changing, the pilot is sure to be able to hold his position in the organization. This might be a result of strong task and technology self-efficacy, but could also be related to the pilot's strong position in the organization, that is not related to the content of any task. Process self-efficacy refers to the overall task execution in the environment. Therefore process self-efficacy can vary throughout different environments. The pilot might not be sure to be able to accomplish his tasks with the given infrastructure when fog rises.

Self-efficacy in general refers to an individual's confidence in its ability to perform a behavior; this definition was also used for the term perceived behavioral control in the Theory of Planned Behavior. Based on this idea the term is extended to perceived control of behavior and change to cover also control beliefs related to the change in the socio-technical system, represented by the self-efficacies related to structure and process.

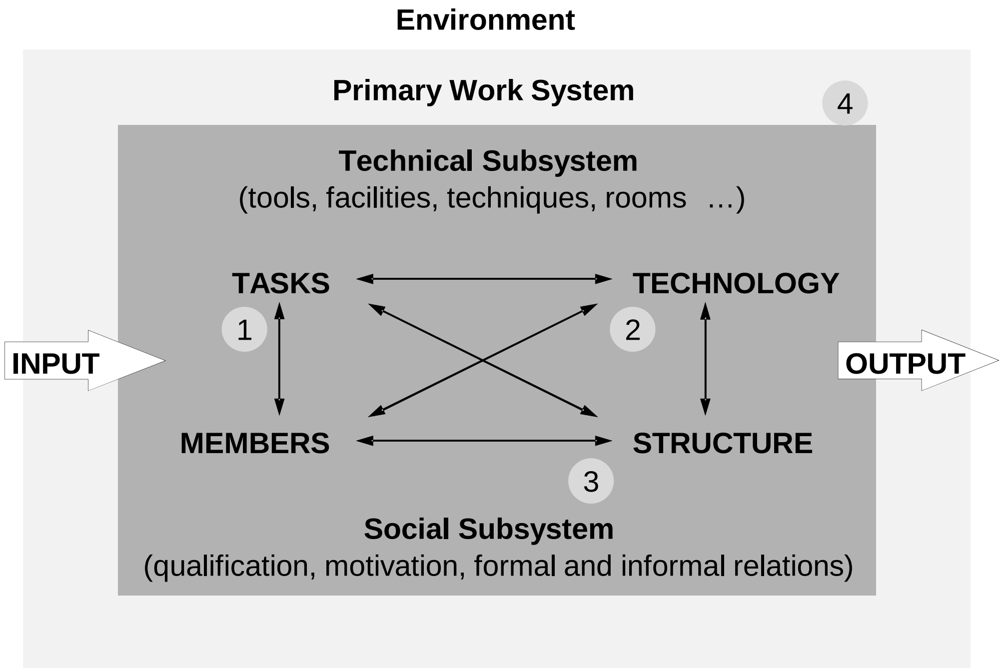


Figure 24: The figure shows different self-efficacies in the context of a socio-technical system: (1) Task Self-efficacy, (2) Technology Self-efficacy, (3) Structure Self-efficacy and (4) Process Self-efficacy.

5.1.3 Attitude

As already defined in Ajzen's Theory of Planned Behavior (1991) attitude toward the behavior refers to the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question. It represents how an individual feels about the behavior to be consistent to one's goals. This is consistent to the definition of internalization that occurs when system users adopt behavior because of its content that they find congruent with their own personal values (Malhotra & Galletta, 2005).The personal values and goals may be task-related or related to other personal goals (e.g. carrier-driven goals) and reflect the personal attitude towards intention to perform a specific behavior, because the content of the behavior in question is useful to the solution of a problem (Kelman, 1958). Fulfillment of task-related and other personal goals leads to satisfaction and can therefore influence intention. Satisfaction in general results from a subjective comparison of expected and received attributes (Andreasen, 1977; Day, 1977; Oliver, 1981).

5.1.4 Subjective Norm

Subjective norm is already used in the Theory of Planned Behavior, the Technology Acceptance Model 1-3 (Davis et al., 1989; Venkatesh & Davis, 2000; Venkatesh & Bala, 2008) as well as in the Information System Success Model. Subjective norm was defined as the perceived social pressure to perform or not to perform a behavior in question (Ajzen, 1991). According to Kelman’s definition of compliance, where an individual performs a task because he wants to achieve a favorable reaction from another person or group, subjective norm and compliance turn out to be congruent. The behavior is then performed to gain awards or approvals and avoid punishments or disapproval. Performing the behavior is obviously externally/extrinsically motivated. Another form of accepting influence is identification – an individual wants to establish or maintain a satisfying self-defining relationship to another person or group (Kelman, 1958). The behavior is then performed not because of its content, but because it is associated with the desired relationship.

5.2 The Information System & Information Technology Behavior Explanation Model

5.2.1 Adding Feedback (CLD)

The individual behavior is a result of one’s perceptions of the environment, the processing of perceptions and the individual’s emotions. Based on the Extended Intention Model the factors that influenced initial behavior were found to also affect continuous usage behavior. As human beings learn from their experience these perceptions are also related to previous interactions with a system and the emotions related to it. Influence factors were combined or separated according to their meaning and definition to show negative and/or positive relationships to address these dynamics and feedback processes. According to the Extended Intention Model the causal loop diagram does not represent any objective factors. It rather represents an individual's perceptions. Figure 25 shows the result of adding feedback to the Extended Intention Model. Figure 26 shows the sources of the relationships and indicates relationships resulting from literature, relationships that were modified from literature and newly introduced relationships.

Intention to Use affects Usage

According to the main theories regarding IST usage, acceptance and adoption presented in chapter 2.3, intention to use causes usage (DeLone & McLean, 1992, 2003; Venkatesh & Bala, 2008; Ajzen, 1991). System use was already used as a determinant in the Information System Success Model (DeLone & McLean, 1992, 2003) and the Technology Acceptance Model 3 (Venkatesh & Bala, 2008). Usage is defined the amount and manner of system use. Intention also in the Theory of Reasoned Action (Fishbein & Ajzen, 1975) is a central factor. This theory refers to intention as to capture the motivational factors influencing a behavior (Fishbein & Ajzen, 1975; Ajzen, 1991). Though, some meta-analysis found intention to be a poor predictor of behavior (Ajzen, 2011). Ajzen (2011) stated that a possible reason for the weak predictive power of intention results from the relatively strong effect of the user's general capacity to override or inhibit impulses. In general the main behavior explanation theories rely on two different definitions of intention. Besides the above mentioned definition of intention stated by Fishbein & Ajzen (1975), Warshaw and Davis (1985) defined intention to capture the degree to which a person has formulated conscious plans to perform or not to perform some specified future behavior. The second definition not only represents the motivation. It also covers the aspect that the behavior is planned in general and that the intention that underlies this behavior might also be affected by pressure. To cover the factors related to work environment where actual behavior is not only the result of motivation, the second definition is used for the further purpose of this work.

Internalization is represented by Satisfaction and Affective Commitment

Internalization affects individuals because of the importance of the behavior to one's goals and personal values (Kelman, 1958, 1961). These may be task-related and therefore end up in satisfaction retrieved from using a specific IST. Other personal goals and values might not be affected because of the content, but because the behavior in question is good for achieving other personal goals like career relevant ones. This internalization of the behavior in question together with identification is represented by affective commitment, as it turned out that internalization and identification have the same type of relationship to other factors. Satisfaction was defined as the net feeling of pleasure or displeasure that results from aggregating all the benefits that a person hopes to receive from interaction with the information system (Seddon, 1994). Both, satisfaction and affective commitment have positive effects on the intention to perform a specific behavior – to use a system (Malhotra & Galletta, 2005). Therefore, both satisfaction and affective commitment are positively related to intention to use.

Satisfaction and Expectations influence each other

Oliver (1997) found that satisfaction is influenced by the expectations one builds. Expectation therefore has a moderating role in the IST Behavior Explanation Model. Expectations provide the baseline or reference level for an individual to form an evaluative judgment about a specific product or service and are defined by Oliver (1981) as beliefs with weighed with an evaluation of outcomes; for the first, an individual forms an initial expectation of a specific product or service prior to system use; second, the individual uses the product or service; third, based on the individual expectations and perceptions of the outcome the individual forms its satisfaction (Bhattacherjee, 2001). For the context of this study expectations represent beliefs towards the outcome that serve as a basis for the later evaluation of the system. This includes the expectations prior to system use as well as adjusted expectations later in the adoption process. While expectations prior to system use are based on others' opinions or information disseminated through mass media, expectations after initial system use are tempered by the user's experience (Fazio & Zanna, 1981). This is confirmed by Bem (1972) who states that individuals continually adjust their perceptions and expectations as they acquire new information about the behavior in question by observing others and their own behaviors. Thus, adjusted perceptions provide the new basis for further evaluation and formation of satisfaction. High satisfaction with a system leads to an increase of expectations and high expectations tend to lower satisfaction. A high baseline level or expectation tends to enhance an individual's satisfaction, while low expectation reduces consequent satisfaction (Bhattacherjee, 2001). Therefore satisfaction is positively related to expectations and expectations are negatively related to satisfaction. These two relationships tend to provide a stable level of satisfaction.

Usefulness, Ease of Use and Enjoyment are the Determinants of Satisfaction

Satisfaction was first defined by Locke (1976) as a pleasurable or positive emotional state resulting from the appraisal of one's job. In the context of consumer satisfaction Oliver (1981) defined satisfaction as the summary psychological state resulting when the emotion surrounding disconfirmed expectations is coupled with the consumer's prior feelings about the consumption experience. For the context of information system & information technology usage Seddon (1994) defined user satisfaction as the net feeling of pleasure or displeasure that results from aggregating all the benefits that a person hopes to receive from interaction with the information system. He added that each user has a set of expected benefits or aspirations for the information system - to the extent that the system meets or fails to meet each of these aspirations, the user is more or less satisfied. Satisfaction relates to one's needs, for IST those are usefulness, usability and pleasure (Jordan, 2000). In the context of technology acceptance those three constructs are consistent to the definitions of usefulness, ease of use and enjoyment. In the IST adoption and acceptance research perceived usefulness has proven to be one of the main determinants of intention to use (Davis et al., 1989; Karahanna et al., 1999; Venkatesh, 2000). Many studies also used the ease of use construct to explain the adoption and usage of IST by determining users' attitude towards technology adoption and usage (Davis et al., 1989; Venkatesh & Davis, 2000; Venkatesh & Bala, 2008). As user's satisfaction is a type of affect (Czepiel & Rosenberg, 1977; LaTour & Peat, 1980) perceived ease of use influences satisfaction in a positive way (Thong et al., 2006). According to Jordan (2000) there is a third construct affecting satisfaction: pleasure/enjoyment. Enjoyment was defined by Venkatesh & Davis (2000) as the extent to which using a specific system is perceived to be enjoyable, aside from any performance consequences resulting from system use. In motivation theory any behavior is explained using two types of motivation. One is said to be intrinsically motivated to perform an activity when he receives no apparent rewards except the activity itself (Deci, 1971), while extrinsive motivation refers behaviors that result not from reasons inherent in the behavior but from instrumental reasons – extrinsically motivated behavior is undertaken to attain an end state that is separate from the actual behavior (Vallerand, 1997). As follows from these definitions perceived enjoyment can be seen as an intrinsic motivation (Davis et al. 1992) and behavior that is intrinsically motivated affects intention to use (Venkatesh, 2000; Van der Heijden, 2004;) through satisfaction. The fulfillment of instrumental and non-instrumental needs results in satisfaction – hence, usefulness, ease of use and enjoyment have a positive effect on satisfaction.

Ease of Use affects Usefulness

According to Davis (1989) usefulness includes user's assessment of the following aspects:

- accomplish tasks more quickly,
- improve the performance,
- improve the productivity,
- enhance effectiveness on the job,
- make the job easier to do and the
- overall usefulness in the job.

From these aspects one can learn that ease of use is one of the construct items of usefulness, because ease of use influences user's perception about usefulness (Davis et al., 1989; Davis, 1989; Venkatesh & Davis, 2000). Improvements in ease of use may also be instrumental, contributing to increased performance or decreasing effort. To the extent that increased ease of use contributes to improved performance, ease of use has a direct effect on usefulness. Hence, ease of use and usefulness are viewed as distinct, but related constructs. Therefore, ease of use is positively related to usefulness.

Usage enables Satisfaction

DeLone and McLean defined usage as a determinant of satisfaction. This relationship was long discussed (Seddon, 1996, 1997), as using a system does not imply that the user is satisfied with the result of using the system. Seddon (1994) argued that it is not correct to assume that success follows system use. The opposite of failure is success; it is often assumed that unused systems are failures. Hence, it is frequently assumed that heavily used systems are successes. Seddon argues that the critical factor for success is not system use, but benefits that should result from system use. To overcome this misleading argumentation usage is used as an enabling factor for satisfaction, as it results from perceptions *after* system use. Therefore the relationship indicates that usage is a variable that enables satisfaction in a process sense. Satisfaction therefore is not relevant for initial intention to use, as satisfaction occurs not until first usage of a system.

Usage of a System improves Expertise

In a cognitive learning process the user benefits from using a system as he or she learns how to handle it and thus usage of IST improves an individual's expertise with systems. However, experience is not necessarily efficacious in the acceptance of new information technologies (Agarwal & Prasad, 1999). Moving to dissimilar technology could offset positive gains due to experience (Agarwal & Prasad, 1999). With respect to this fact expertise is defined as an individual's competence about systems and technology similar to the system or technology in question. It results from prior experience with similar systems and is determined by the individual ability to learn about a system in a given situation. An individual may learn from using a system as well as from observing system usage.

Expertise affects Perceptions about Ease of Use and Control Beliefs

Expertise can improve perceived control of behavior and change as knowing how to use a system reduces an individual's uncertainties regarding the system in specific and regarding the process of transforming an input into an output in general. These control beliefs are not only the result of past experience with the behavior, but also of second-hand information about the behavior in question and experience of acquaintances and friends and colleagues (Ajzen, 1991). Expertise with the system in question or similar systems also improves an individual's perception about ease of use beliefs about an IST (Agarwal & Prasad, 1999). Although it was believed that expertise is also associated to perceived usefulness it turned out that there is no effect of expertise on usefulness (Agarwal & Prasad, 1999).

Compliance has a negative Impact on Usefulness

According to Markus and Keil (1994) when exercising compliance, users are not adequately motivated to do what the system may enable them to do. It is also possible that such systems may make it harder to do what they are really motivated to do. Galletta and Malhotra (2005) suggested that absence of perceived usefulness may be more apparent in case of self-determined volitional system usage activities. It is all the more likely to happen if such activities are perceived by the system user as irrelevant or as unnecessary obstacles in fulfilling self-valued goals (Lewis et al., 2003). Galletta and Malhotra (2005) confirmed in an empirical study that compliance has a negative influence on user's perception about usefulness of a system.

Task-related System Quality contributes to Usefulness, Ease of Use and Enjoyment

The perceptions of usefulness, ease of use and enjoyment result from a given system quality. As using the IST is process in a socio-technical system, a new construct is defined as task-related system quality from the user's point of view. It represents the system quality relating to specific tasks the user has to accomplish with the system in the primary work environment. This includes user-defined criteria like response time that is taken to deliver the information that is needed. For evaluation of this criteria objective measures can be used. This definition is important to clearly distinguish user's perceptions about perceived usefulness (to which degree is this system useful to accomplishing tasks) and the task-related system quality (how does the system perform according to the criteria that are relevant to the user). It follows from this definition, that different users may have different criteria that is relevant for evaluating their perceived task-related system quality. Of course, if a system achieves a high task-related system quality according to user-defined criteria, it seems clear to achieve a good perception of usefulness too. Therefore, positive relationships between task-related system quality and usefulness, ease of use and enjoyment are created. DeLone and McLean (1992) collected a number of metrics that can be used for evaluating system and information quality, e.g.:

- Data accuracy
- Data currency
- Database contents
- Ease of learning
- Convenience of access
- Human factors
- System accuracy
- System flexibility
- System reliability
- System sophistication
- Integration of system
- System efficiency
- Resource utilization
- Response time
- Importance of information
- Relevance of information
- Informativeness of information
- Understandability of information
- Readability of information
- Clarity of information
- Information format
- Information appearance
- Information content
- Information precision
- Information conciseness
- Information sufficiency
- Information completeness
- Information reliability
- Information currency
- Information timeliness
- Information uniqueness
- Information comparability

Compliance enforces Users to intend System Usage

Rewards and punishments may enforce intention to use a system, as users feel under pressure or feel motivated to gain rewards for using the system. As such, compliance is positively related to intention to use. The influence of subjective norm, represented in the model as compliance, was confirmed by Venkatesh & Bala (2008)

Affective Commitment enhances Perceptions regarding Usefulness

Given intrinsic interest in self-satisfying use, users may perceive it as a solution to their problem or congenial to satisfaction of their needs. Hence, they are willing to invest greater effort in learning and using the system. Internalization of new system usage behavior is therefore characterized by a positive influence on perceived usefulness. (Malhotra & Galletta, 2005)

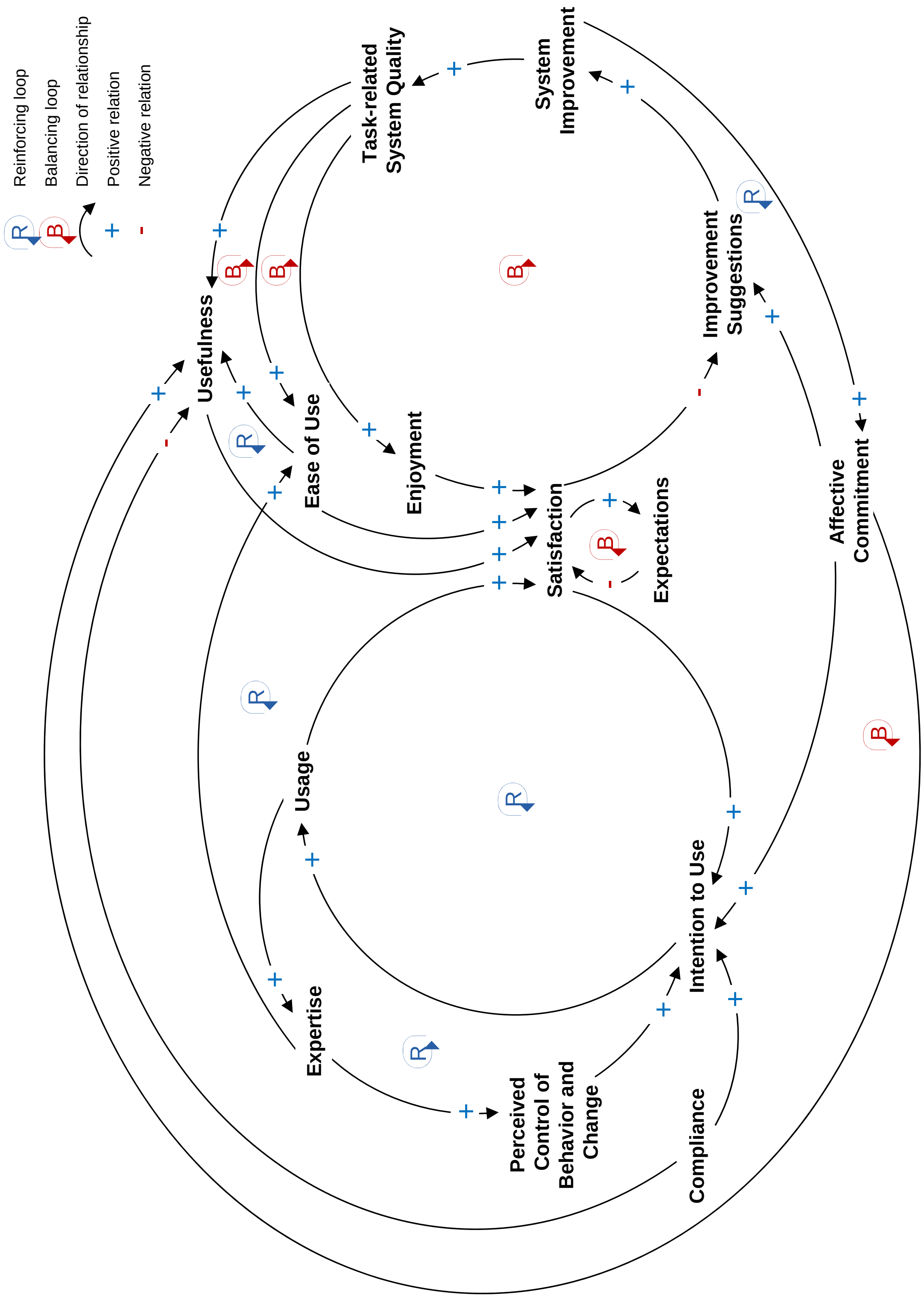


Figure 25: The figure shows the IST Behavior Explanation Model that links variables with relationships and shows the type of relationship.

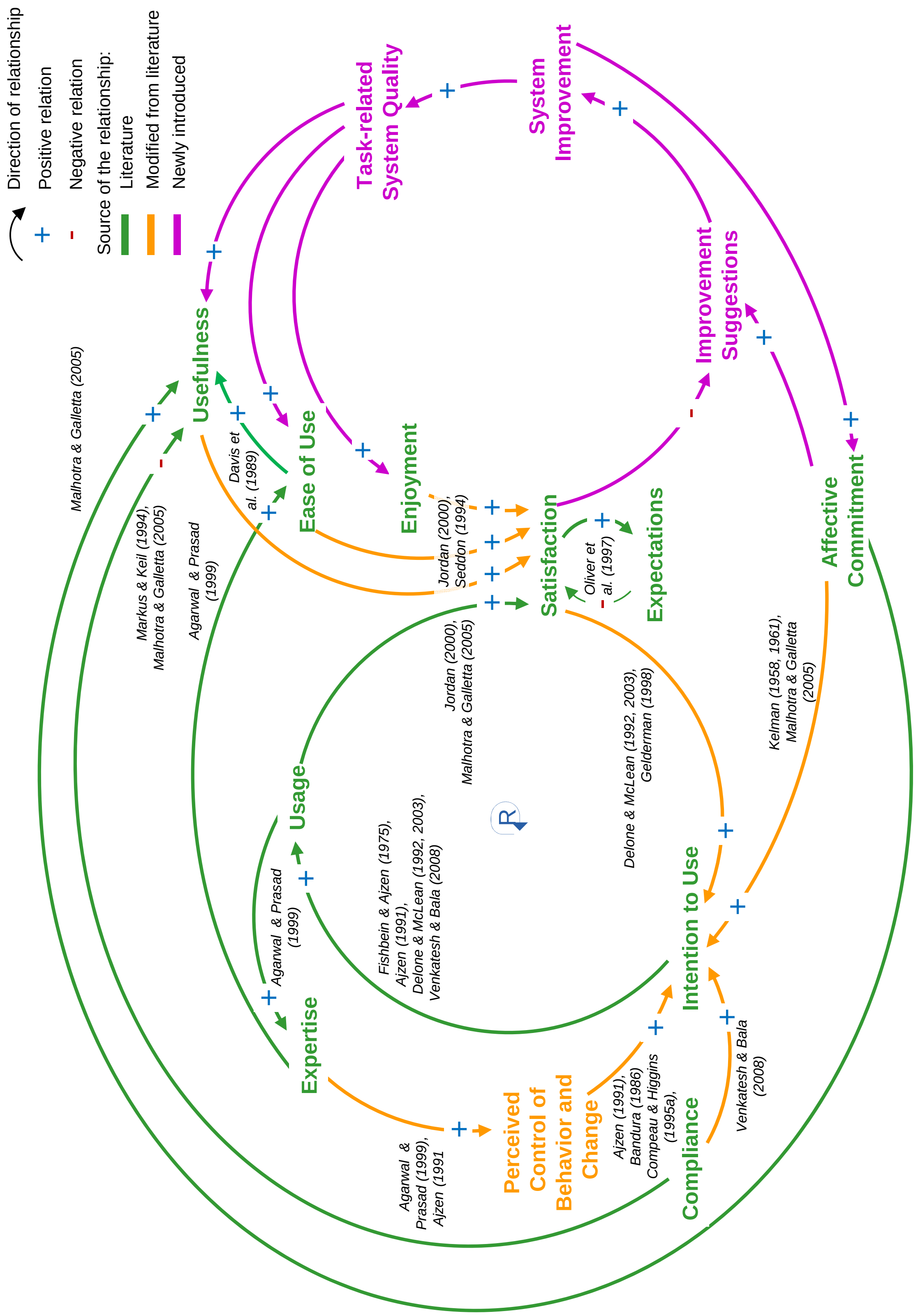


Figure 26: The figure shows the sources of relationships in the IST Behavior Explanation Model. It includes relationships found in literature, relationships that were modified from literature and new relationships.

Improvement Suggestions result from dissatisfied Users and Users contributing to Task-related System Quality

With the intrinsic interest in self-satisfying use, users want to achieve better task-related system quality by suggesting improvements to system engineers, because they are interested in achieving their goals in an easier or better way. Though, feedback not only results from users that want to add value to task-related system quality because of their commitment to system use – there might be users that are unsatisfied and therefore complain about bad usefulness or ease of use. The more satisfied users are, the less complains will be caught by the system engineers. In contrast, unsatisfied users will by trend formulate more complaints, which leads to a negative relationship between satisfaction and improvement suggestions. The improvement suggestions provided by unsatisfied or committed users can be transformed into better task-related system quality, provided that there are resources to invest in system improvements.

System Improvement has a Positive Effect on Affective Commitment

When users recognize their complaints about bad task-related system quality or suggestions for improvement ending up in actual system improvement, they perceive respect by knowing that feedback is taken seriously. As a response to the confirmation that individual improvement suggestions will result in activities delivering better system quality identification will increase due to the fact that there are resources invested in implementing one’s suggestions.

5.2.2 Driving Forces

Analyzing the CLD in Figure 25 the following five loops can be identified:

Usage is a weak Driver for Satisfaction

The loop Intention to Use → Usage → Satisfaction → Intention (see Figure 27) is a positive or self-reinforcing loop. In the IST Behavior Explanation Model usage acts not only as an enabler, but also as a weak driver for satisfaction. This is the main reason for the existence of a reinforcing loop between intention to use, usage, satisfaction and intention to use. The more a user is intended to use a system, the more he or she will use the system, leading to greater satisfaction. Satisfaction in turn improves an individual’s intention to use a system, as by using the system one’s needs are satisfied. On the other hand, a decrease of usage will lower satisfaction and even intention to use which in turn leads to a decrease of usage. As the effect of usage on satisfaction was found to be weak, even the loop has a low reinforcing effect.

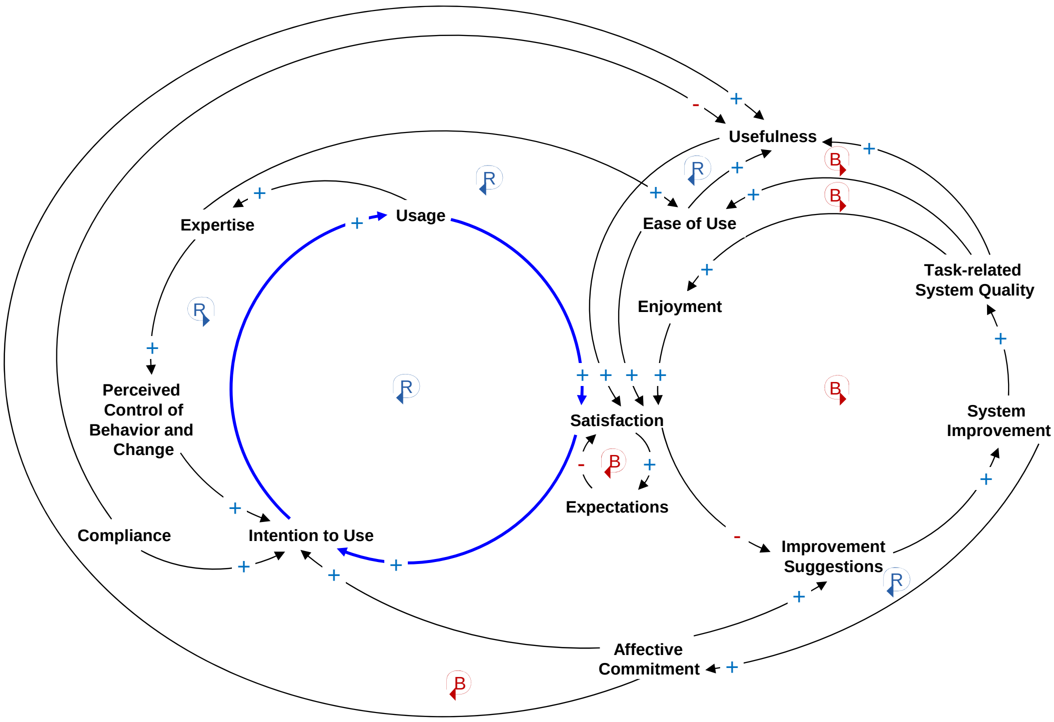


Figure 27: The figure shows the IST Behavior Explanation Model with the bold reinforcing loop that illustrates that usage is a weak driver for satisfaction.

System Learning improves Usage via Ease of Use and Satisfaction

The loop Intention to Use → Usage → Expertise → Ease of Use → Satisfaction → Intention to Use (see Figure 28) is a positive or self-reinforcing loop. An individual's intention to use a system improves usage of the system, leading to more experience about how to use the system. A better expertise leads to a better perception of ease of use, which improves one's satisfaction and in turn leads to an improved intention to use. By learning how to use a system users improve their personal perceptions about how easy a system is to use, what drives their intention to use the system continuously.

System Learning improves Usage via Usefulness and Satisfaction

The loop Intention to Use → Usage → Expertise → Ease of Use → Usefulness → Satisfaction → Intention to Use (see Figure 29) is a positive or self-reinforcing loop. As ease of use can improve usefulness, a better expertise with systems improves also usefulness. Via ease of use and usefulness expertise therefore influences satisfaction, which in turn improves the intention to use.

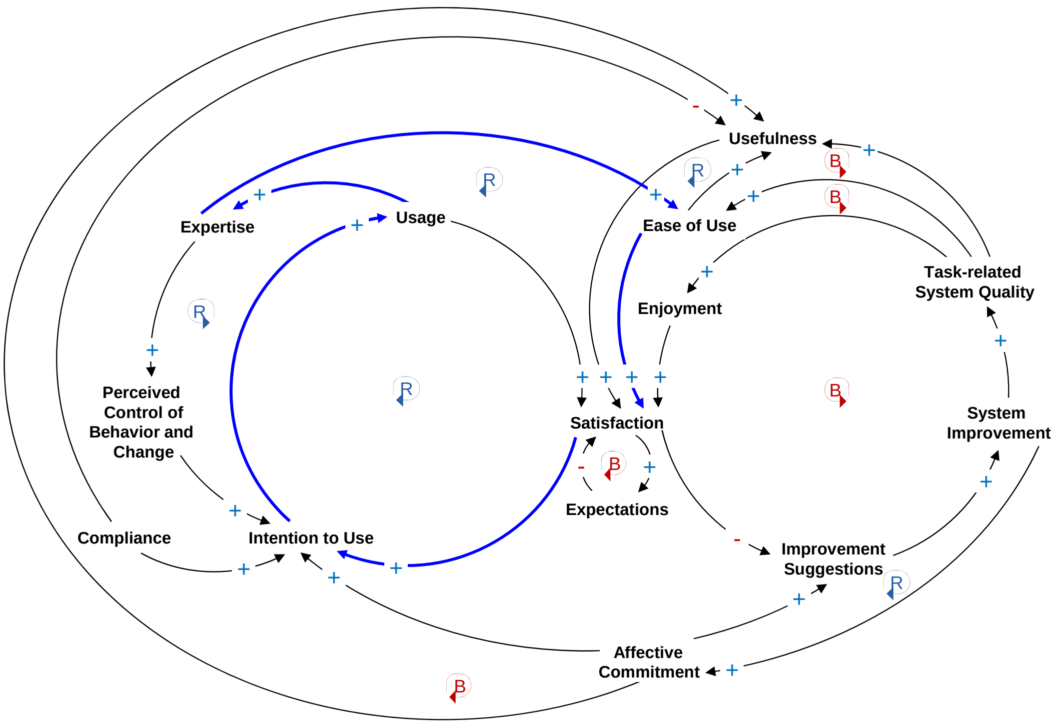


Figure 28: The figure shows the IST Behavior Explanation Model with the bold reinforcing loop that illustrates that system learning improves usage via ease of use and satisfaction.

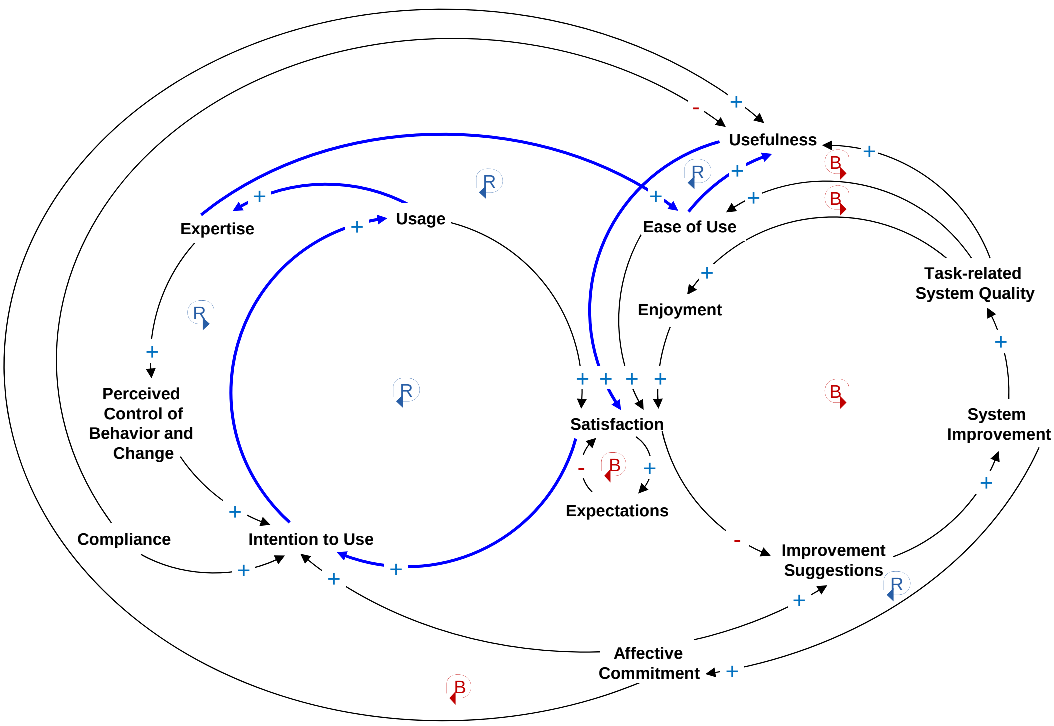


Figure 29: The figure shows the IST Behavior Explanation Model with the bold reinforcing loop that illustrates that system learning improves usage via ease of use, usefulness and satisfaction.

System Learning improves Usage via improved Perceptions of Control

The loop Intention to Use → Usage → Expertise → Perceived Control of Behavior and Change → Intention to Use (see Figure 30) is a positive or self-reinforcing loop. The user gains expertise from usage of the system, which reduces anxieties regarding the transformation process and improves perceived control of behavior and change. This leads to an increase in intention to use. This loop improves the individual intention to use a system by gaining expertise and strengthening control beliefs.

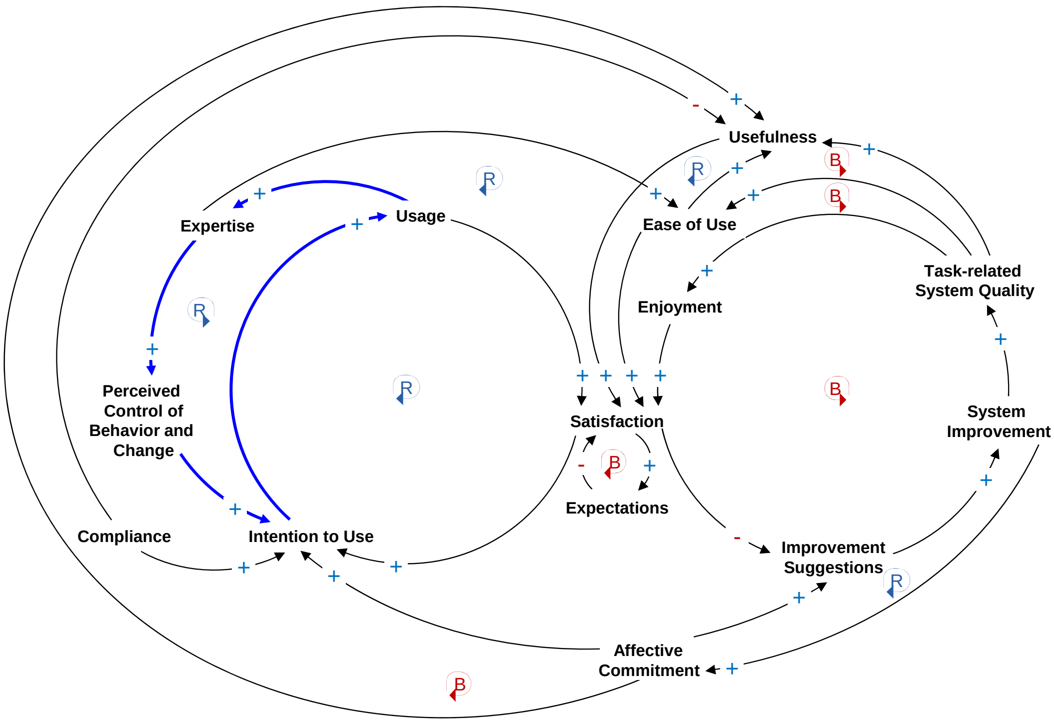


Figure 30: The figure shows the IST Behavior Explanation Model with a bold reinforcing loop that illustrates that system learning improves usage via improved perceptions of control.

Implemented Improvement Suggestions force further Improvement Suggestions

The loop Improvement Suggestions→ System Improvement → Affective Commitment → Improvement Suggestions (see Figure 31) is a positive or self-reinforcing loop. Suggestions that can be transformed into system improvement leads to improved affective commitment which in turn leads to more improvement suggestions. This loop shows that users who feel committed to the system will bring in improvement suggestions that can lead to even more system improvement.

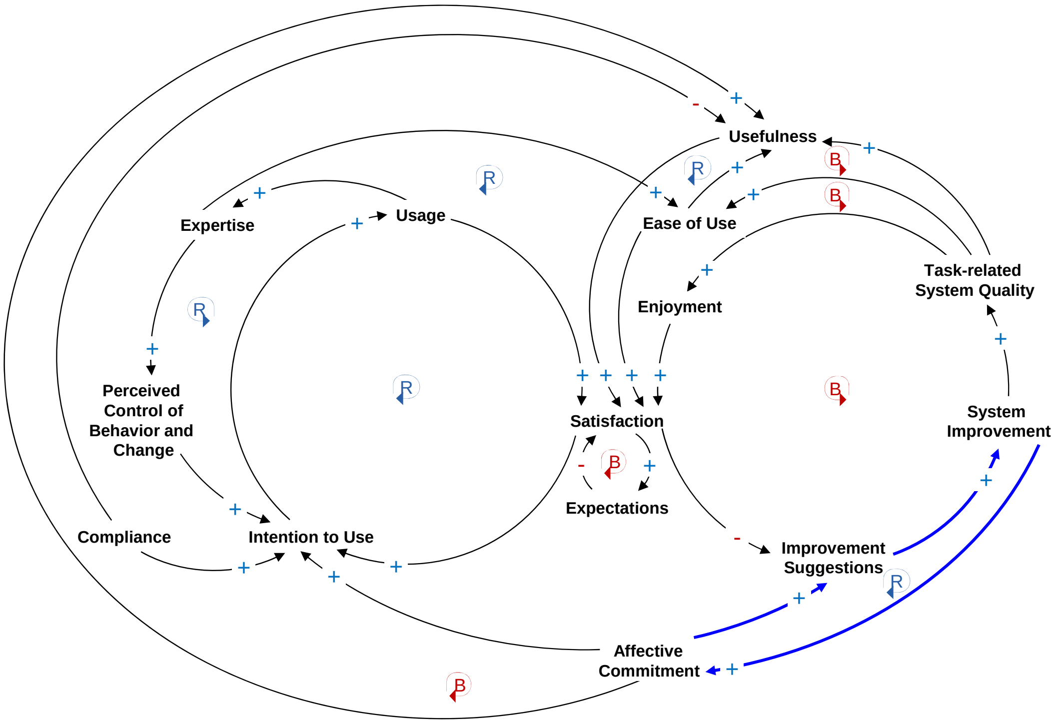


Figure 31: The figure shows the IST Behavior Explanation Model with the bold reinforcing loop that illustrates that implemented improvement suggestions force further improvement suggestions.

5.2.3 Self-correcting Effects

From analysis of the CLD in Figure 25 according to negative feedback loops the following loops were identified:

Expectations limit the Growth of Satisfaction

The loop Satisfaction → Expectations → Satisfaction (Figure 32) is a negative or self-correcting loop. An increase in satisfaction leads to an increase in expectations and this in turn leads to a decrease of satisfaction. This loop limits the growth of satisfaction.

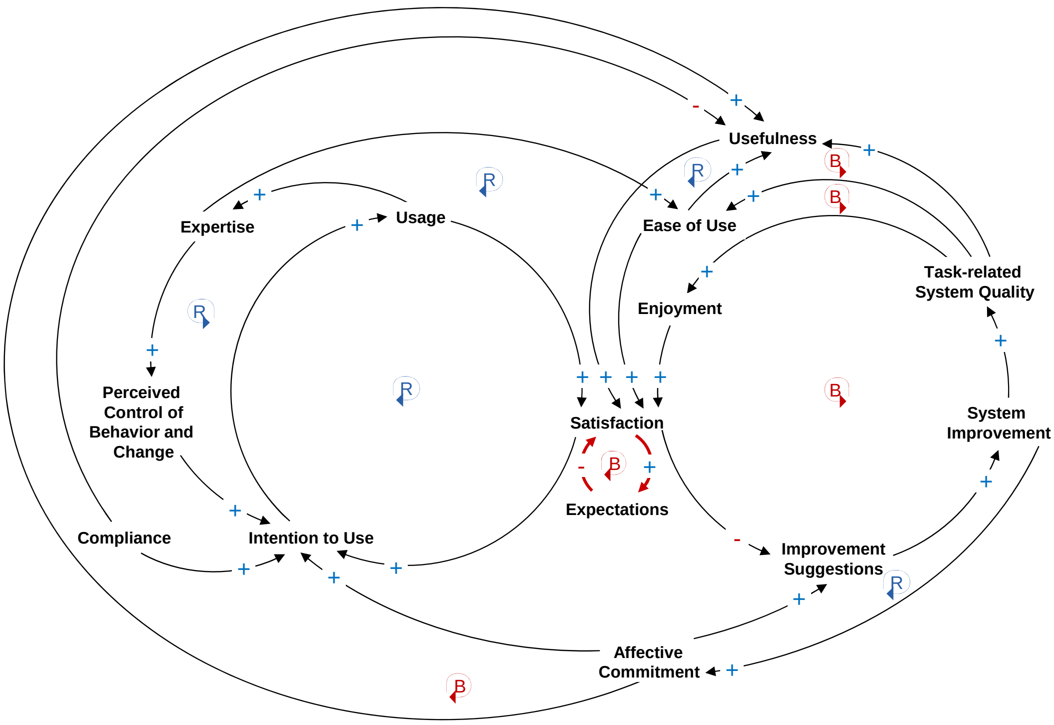


Figure 32: The figure shows the IST Behavior Explanation Model with the bold balancing loop that illustrates that expectations limit the growth of Satisfaction.

Task-related System Quality is limited by Satisfaction via Enjoyment, Ease of Use and Usefulness

There are several balancing loops that affect satisfaction:

- Task-related System Quality → Enjoyment → Satisfaction → Improvement Suggestions → System Improvement → Task-related System Quality (see Figure 33),
- Task-related System Quality → Usefulness → Satisfaction → Improvement Suggestions → System Improvement → Task-related System Quality (see Figure 34),
- Task-related System Quality → Ease of Use → Satisfaction → Improvement Suggestions → System Improvement → Task-related System Quality (see Figure 35) and
- Task-related System Quality → Ease of Use → Usefulness → Satisfaction → Improvement Suggestions → System Improvement → Task-related System Quality (see Figure 36).

The loops are negative or self-correcting loops. An increase in task-related system quality by trend leads to an increase in enjoyment, usefulness and ease of use, which improves user's satisfaction. This in turn reduces user's improvement suggestions as there is less to complain about, and so even system improvements decrease. This way an improvement of task-related system quality results in stagnating task-related system quality. On the other hand a decrease in task-related system quality will lower satisfaction via enjoyment, usefulness and ease of use, which in turn leads to unsatisfied users that will complain about a bad system. If these improvement suggestions lead to an increase in system improvement activities task-related system quality will increase. These four loops limit the growth of task-related system quality.

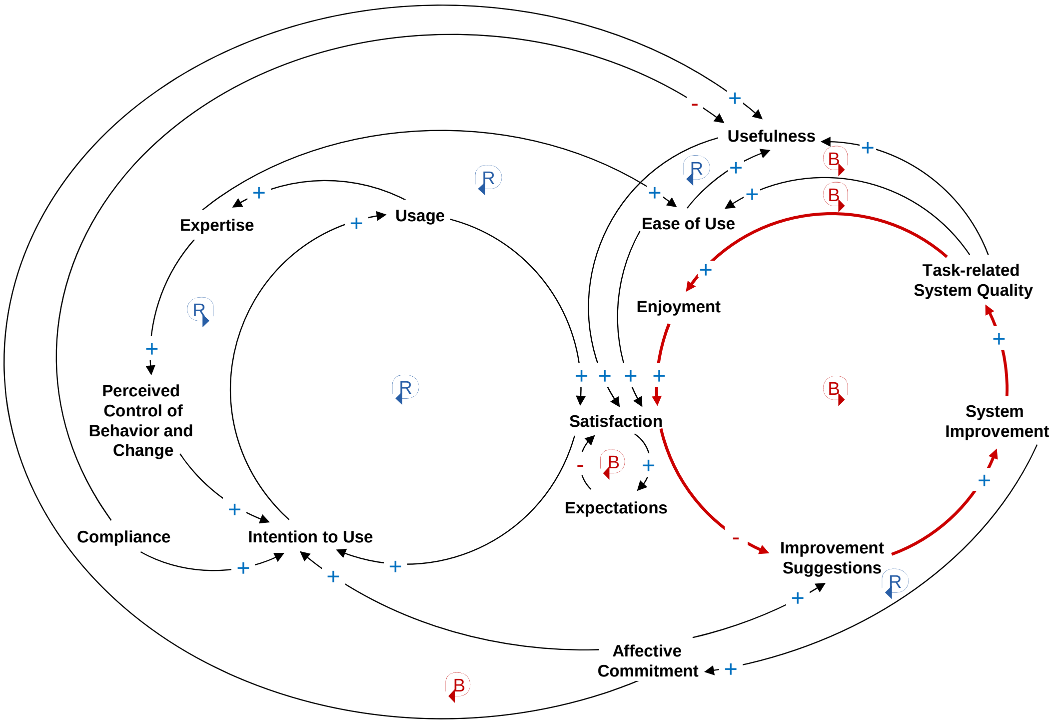


Figure 33: The figure shows the IST Behavior Explanation Model with the bold balancing loop that illustrates that task-related system quality is limited by satisfaction via enjoyment.

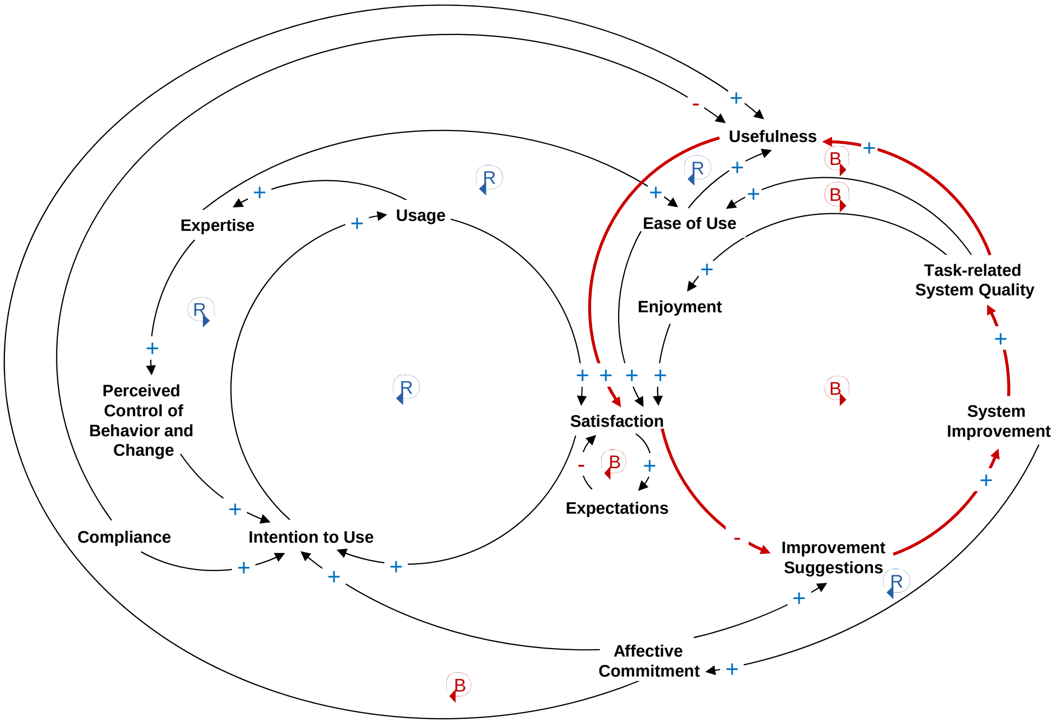


Figure 34: The figure shows the IST Behavior Explanation Model with the bold balancing loop that illustrates that task-related system quality is limited by satisfaction via usefulness.

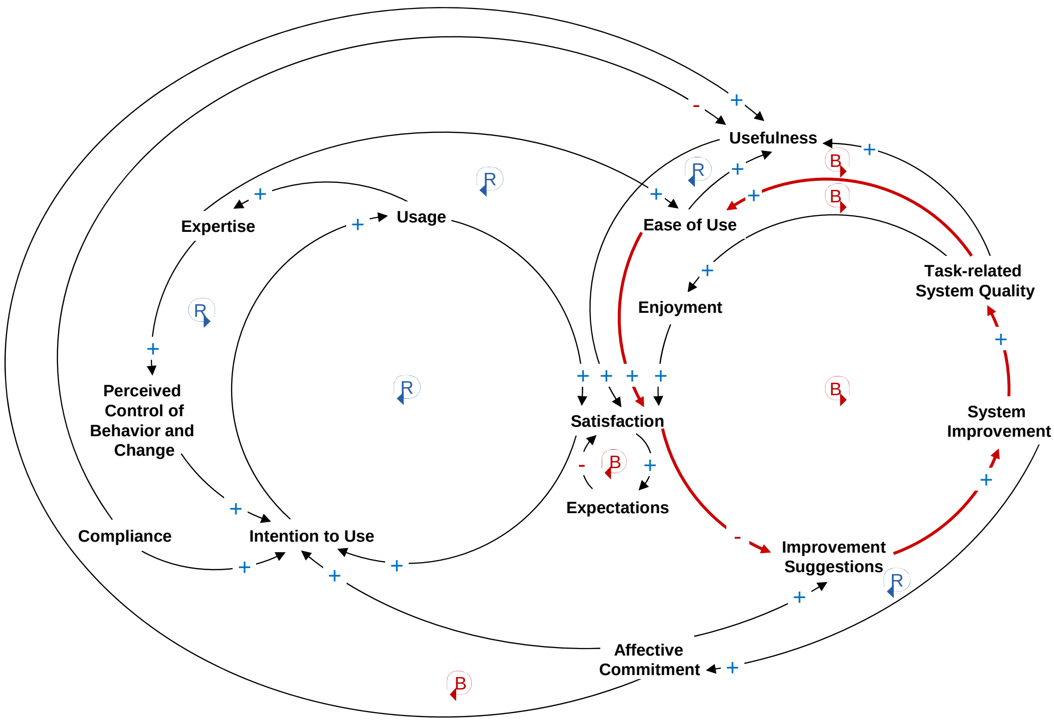


Figure 35: The figure shows the IST Behavior Explanation Model with the bold balancing loop that illustrates that task-related system quality is limited by satisfaction via ease of use.

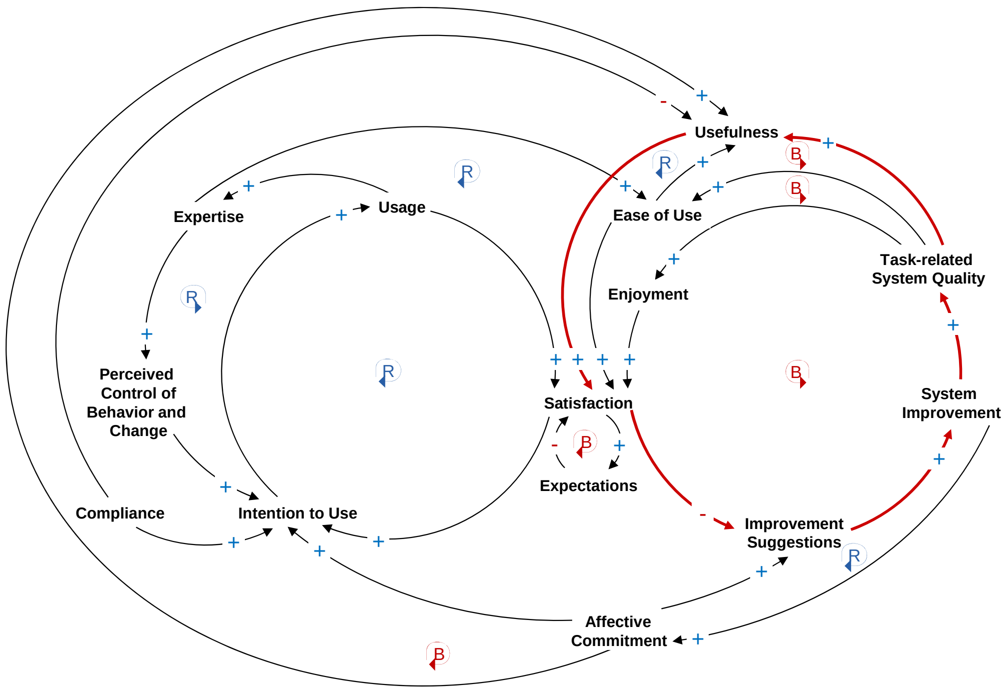


Figure 36: The figure shows the IST Behavior Explanation Model with the bold balancing loop that illustrates that task-related system quality is limited by satisfaction via ease of use and usefulness.

Improvement Suggestions are limited by Satisfaction

The loop Improvement Suggestions → System Improvement → Affective Commitment → Usefulness → Satisfaction → Improvement Suggestions (see Figure 37) is a negative or self-correcting loop. Increasing improvement suggestions (IS) lead to more IS and an increase in affective commitment, causing better usefulness and satisfaction lowering the number of IS. On the other hand a decrease in IS lowers System Improvement and affective commitment and so even usefulness and satisfaction. This leads to an increase of IS. This loop limits improvement suggestions due to the regulating effect of satisfaction.

Improvement Suggestions again are limited by Satisfaction

The loop Improvement Suggestions → System Improvement → Affective Commitment → Intention to Use → Usage → Satisfaction → Improvement Suggestions (Figure 38) is a negative or self-correcting loop. Increasing improvement suggestions lead to more system improvement and affective commitment that increases intention to use and system usage and even satisfaction. This in turn lowers improvement suggestions. On the other hand a decrease in improvement suggestions lowers system improvement and might also lower affective commitment and even intention to use and usage. The decrease in system use leads to an increase in improvement suggestions due to the decrease of satisfaction. This loop limits the growth of improvement suggestions by satisfied users.

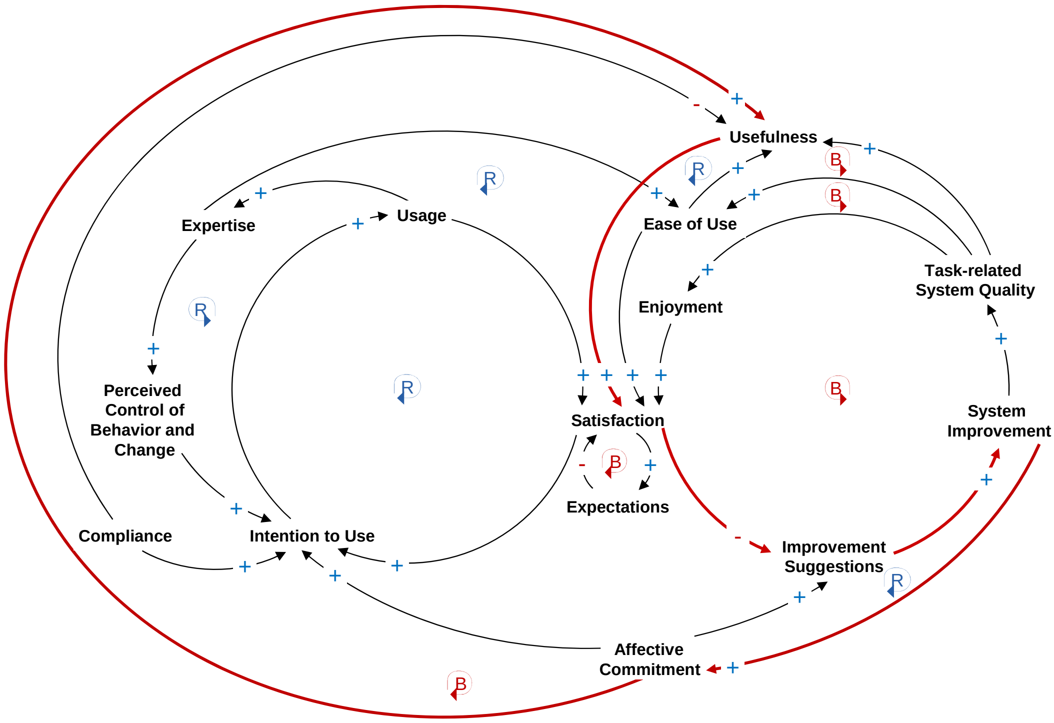


Figure 37: The figure shows the IST Behavior Explanation Model with the bold balancing loop that illustrates that improvement suggestions are limited by satisfaction.

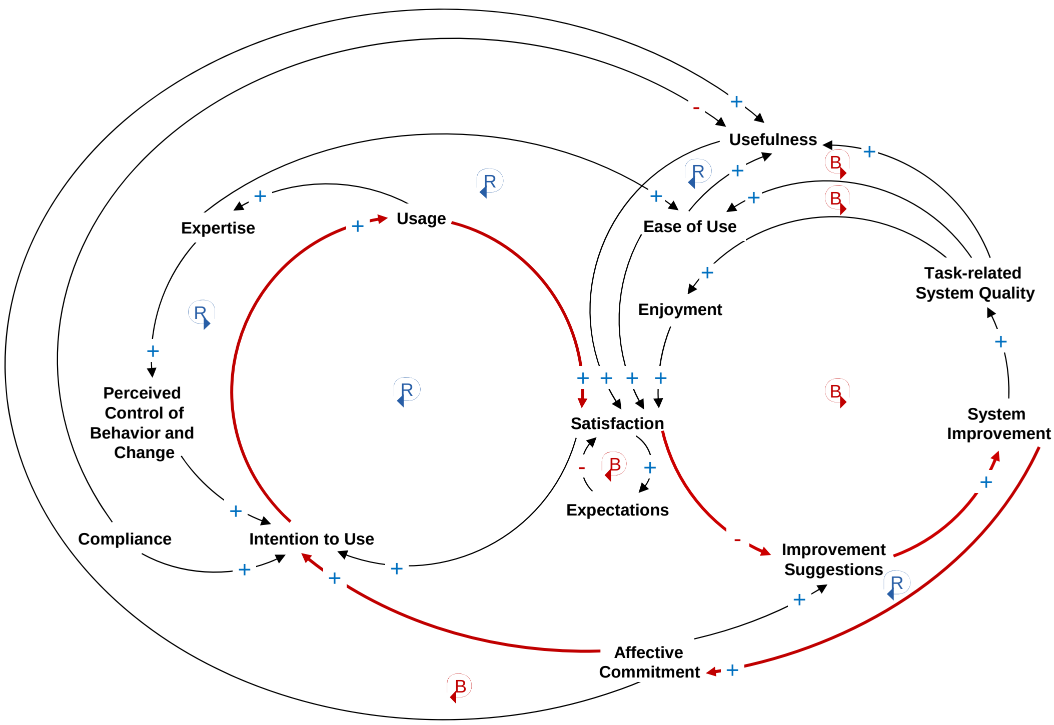


Figure 38: The figure shows the IST Behavior Explanation Model with the bold balancing loop that illustrates that improvement suggestions again is limited by satisfaction.

6 Simulation Model to Explain Usage Behavior

In this chapter the simulation part of this thesis is discussed. It includes the simulation approach, the scenarios used for the simulation, the simulation results and observations from literature that were simulated to show the effect of interventions. The simulation is conducted to provide evidence for the causal model that is based on literature research. Furthermore, the main reasons for continuous usage and performance issues will be identified.

6.1 Simulation Approach

The causal loop diagram of the IST Behavior Explanation Model provides the conceptual model for the simulation. The conceptual model had to be redefined for the implementation of variables and relationships to specify the simulation model. Furthermore each relationship was analyzed according to its impact on the dependent variable to achieve realistic system behavior results. These values relate to research concerning IST acceptance, usage and success. There is evidence that the importance of variables shifts throughout the adoption process (Venkatesh & Davis, 2000). Though, for a simplified model, constancy of impact and linearity of relationships is assumed. As there is no unit of measure for individual perceptions, all variables are represented as relative values, e.g. as task-related system quality refers to user defined criteria regarding optimal support for accomplishing tasks; task-related system quality variable has a value of 100 % if the criteria are completely satisfied. Usage refers to the maximum amount of usage that is desirable in the socio-technical system for accomplishing tasks. According to this concept the variables are represented in the simulation model as follows:

For verification that the simulation model represents the real world problem, degenerate tests, extreme condition tests, internal validation and operational graphics were applied. After validation and verification several experiments were conducted to analyze the output of various system settings. Finally, activities that are known from literature to motivate the individual IST adoption were used to demonstrate the validity of the model. Based on a number of scenarios various settings at the system implementation were analyzed and compared according to their effect on performance and final task-related system quality.

6.2 Simulation Model

The IST Behavior Explanation Model serves as a basis for the simulation model. In order to perform the simulation several steps were taken:

- Step 1: Identification of variables representing accumulated values
- Step 2: Transformation of the causal loop diagram into the adjacency matrix
- Step 3: Development of an impact matrix
- Step 4: Definition of calculation formula and setting initial values

6.2.1 Identification of Variables representing Accumulated Values

Some of the variables are accumulated over time by improvement or impairment. Modeling this dependency on previous values these variables had to be identified to be considered in the simulation. For the following variables a relationship to itself was found:

Expertise

Expertise grows from usage of the system and depends on the expertise the user had before. User's expertise with the system in question or similar systems is not 'consumed' through the influenced variables ease of use and perceived control of behavior and change. Although these two variables do not indicate an outflow there might be other variables that could do so like forgetting which would lower user's expertise.

Task-related System Quality

For the mathematical model a certain initial task-related system quality is set. It is influenced by only one variable: system improvement. The assumption is placed, that task-related system quality always benefits from system improvement which adds to task-related system quality. This includes the awareness that task-related system quality will never decrease.

Affective Commitment

For affective commitment the influencing factor is system improvement. But, like task-related system quality, system improvement adds to affective commitment. On the other hand affective commitment affects intention to use, but this influence does not lower the original value of affective commitment, as it is non-consumptive.

6.2.2 Transformation of the Causal Loop Diagram into the Adjacency Matrix

In order to represent the relationships in a mathematical model an adjacency matrix was created. Therefore the CLD was interpreted as a directed graph. The influence factors served as the nodes in the matrix and the value from variable X to variable Y indicates existence and type of relationship.

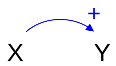
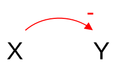
Representation in the CLD	**Representation in the Adjacency Matrix**	**Interpretation**
	0	There is no causal relationship between two variables.
	1	There is a positive relationship from X to Y.
	-1	There is a negative relationship from X to Y.

Table 3: The table shows the transformation of the CLD into the adjacency matrix.

Based on the relationships that were found in the model development stage (see Figure 25) and the transformation of the relationships the adjacency matrix (see Figure 39) was created:

Relationship from > to v	Intention to Use	Usage	Satisfaction	Expectations	Expertise	Perceived Control of Behavior and Change	Compliance	Feedback	Improvement Suggestions	Task-related System Quality	Usefulness	Ease of Use	Enjoyment	Affective Commitment
Intention to Use	0	0	1	0	0	1	1	0	0	0	0	0	0	1
Usage	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Satisfaction	0	1	0	-1	0	0	0	0	0	0	1	1	1	0
Expectations	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Expertise	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Perceived Control of Behavior and Change	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Compliance	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Improvement Suggestions	0	0	-1	0	0	0	0	0	0	0	0	0	0	1
System Improvement	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Task-related System Quality	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Usefulness	0	0	0	0	0	0	-1	0	0	1	0	1	0	1
Ease of Use	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Enjoyment	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Affective Commitment	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Figure 39: The figure shows the adjacency matrix representing the relationships according to the causal loop diagram.

6.2.3 Development of an Impact Matrix

For the ability to calculate values for variables over time the influence of variables has to be redefined according to the strength of impact. Following the structure of the adjacency matrix an impact matrix was developed based on the strength of the relationship resulting from literature and argumentation. The classification that was followed for declaring the strength of impact was defined as:

Strength of Impact	Upper limit of weight
Extremely weak impact	0,1
Weak impact	0,4
Moderately strong impact	0,8
Strong impact	1

Table 4: The table shows the classification of weights used for the impact matrix.

The impact matrix in Figure 40 shows the impact weight between variables. The impact weight defines how a change in the independent variable impacts the dependent variable. The categorization of values was done according to literature on acceptance, usage and success of IST. The concrete values that were used for the simulation result from model testing and adjustment.

Impact of > on v	Intention to Use	Usage	Satisfaction	Expectations	Expertise	Perceived Control of Behavior and Change	Compliance	Feedback	Improvement Suggestions	Task-related System Quality	Usefulness	Ease of Use	Enjoyment	Affective Commitment
Intention to Use	0	0	0,7	0	0	0,3	0,8	0	0	0	0	0	0	1
Usage	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Satisfaction	0	0,1	0	1	0	0	0	0	0	0	0,5	0,5	0,1	0
Expectations	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Expertise	0	0,2	0	0	0	0	0	0	0	0	0	0	0	0
Perceived Control of Behavior and Change	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Compliance	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Improvement Suggestions	0	0	0,03	0	0	0	0	0	0	0	0	0	0	0,5
System Improvement	0	0	0	0	0	0	0	0,2	0	0	0	0	0	0
Task-related System Quality	0	0	0	0	0	0	0	0	0,1	0	0	0	0	0
Usefulness	0	0	0	0	0	0	1	0	0	0,6	0	0,2	0	0,5
Ease of Use	0	0	0	0	0,15	0	0	0	0	0,6	0	0	0	0
Enjoyment	0	0	0	0	0	0	0	0	0	0,2	0	0	0	0
Affective Commitment	0	0	0	0	0	0	0	0	0,01	0	0	0	0	0

Figure 40: The figure shows the Impact Matrix that indicates how a change in the independent variable impacts the dependent variable.

Strong impacts were found for the effects of:

- Affective commitment on intention to use: internalization and identification represent attitude as well as a part of subjective norms that form intentions. These two variables are the motivational part in the Theory of Planned Behavior that additionally includes control beliefs limiting the intention to use. As so, the positive effect of internalization and identification are assumed to be strong.
- Intention to use on usage: In several explanation models for system use and system success, e.g. the Theory of Reasoned Action (Fishbein & Ajzen, 1975), the Theory of Planned Behavior (Ajzen, 1991), the IS Success Model (DeLone & McLean, 2003), the Technology Acceptance Model 1-3 (Davis et al., 1989; Venkatesh & Davis, 2000; Venkatesh & Bala, 2008) and the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003), intention was found to be a strong predictor of system use.

- Expertise on perceived control of behavior and change: control beliefs result from the individual perception about how well to perform with the given technology in the task environment in a new process structure. Due to the cognitive learning process these uncertainties regarding task, technology, structure and process are reduced improving the perceptions about control of behavior and change. Therefore the new transformation process is not any more perceived to be hard to perform. The improvement of control beliefs through the learning process confirms a strong effect of expertise on perceived control of behavior and change.
- Compliance on usefulness: punishment may create internal resistance to using a specific system. That can lead to the perception that the system in question might not be that useful for performing tasks, as the management means punishment is the only way to ensure system use. Malhotra and Galletta (2005) showed that the effect of compliance on usefulness is significant especially at initial system use.
- Expectations on satisfaction and satisfaction on expectations: The perceptions about how a system satisfies needs relates to an individual's expectation. Actually, after initial use the expectations are aligned to satisfaction, as from previous use it is known what can be expected. Due to this alignment of the variables to each other the strength of impact is defined as strong.

Moderately strong impacts were found for the effects of:

- Affective commitment on usefulness: Malhotra and Galletta (2005) showed that there is a moderately strong positive influence of identification and internalization on usefulness.
- Satisfaction on intention to use: From the Theory of Reasoned Action (Fishbein & Ajzen, 1975) and the Theory of Planned Behavior (Ajzen, 1991) it is known that attitude, that is represented in the Extended Intention Model as internalization, is a moderately strong predictor for intention to use.
- Usefulness and ease of use on satisfaction: Regarding IST the domains of needs are usefulness (functionality), ease of use (usability) and enjoyment (pleasure). As satisfaction is the result of meeting these needs, but has to be compared to individual expectations, the effect is defined as moderately strong.

- Task-related system quality on usefulness and ease of use: task-related system quality was defined as the system quality relating to specific tasks the user has to accomplish with the system in the primary work environment from the user's point of view. As a result of these user defined criteria usefulness and ease of use have to be strongly dependent on task-related system quality. Though, perceptions of usefulness and ease of use are more an evaluation of interrelated criteria rather than a comparison of hard facts, the individual perception of usefulness or ease of use can suffer from low fulfillment of only one criteria. Therefore the effect of task-related system quality on usefulness and ease of use is defined as moderately strong.
- Affective commitment on improvement suggestions: People that are interested in using a better system engage in developing useful ideas to improve system quality. Compared to the effect of satisfaction on improvement suggestions this is the dominant source for feedback. This is due to the fact, that only a small number of unsatisfied users has the desire to formulate complaints. Marketing experts suggest that in an optimistic assumption only 10 % of unsatisfied customers communicate complaints to the organization.
- Compliance on intention to use: In a work environment the management has the power to force people to use a system through rewards or punishments. As a last consequence of not using a system there always exists the opportunity of quitting the employment.

Weak impacts were found for the effects of:

- Perceived control of behavior and change on intention to use: Uncertainties regarding the system transformation process can inhibit the behavior in question. As such uncertainties operate as barriers to the adoption of behavior especially at initial use. Besides this operation as a barrier perceived control of behavior and change is not assumed to be a dominant influence factor of intention to use.
- Usage on expertise: Using a system improves the overall expertise with technology and systems similar to the system in question. Though, one-time use adds little to expertise we could gain from all similar systems and technology. As this learning improves only system and technology expertise that is related to the tasks, this effect is defined as weak.

- Improvement suggestions on system improvement: There are several forms of feedback: positive reports about system use, complaints about system quality and system and task integration and suggestions for improvements. Not all types are predestined to be useful for system improvement activities and some feedback might not be used for improvements due to system limits. Therefore the effect of improvement suggestions on actual system improvement activities is defined as weak.
- Expertise on ease of use: Compatible experience with similar systems or the system in question improves one's perceptions about ease of use (Agarwal & Prasad, 1999). Even learning how to use a system improves the individual perception about ease of use. Though, to a greater extent the perception about ease of use depends on the perceptions of task-related system quality.
- Task-related system quality on enjoyment: In this work the focus is on IST that is used in a business environment, where enjoyment has no dominant role. According to this, a weak relationship between task-related system quality and enjoyment is assumed.
- Ease of use on usefulness: As ease of use does not contribute to all construct items of usefulness the overall impact of ease of use on usefulness is defined as weak.

Very weak impacts were found for the effects of:

- System improvement on affective commitment: System improvement activities are assumed to have low impact on affective commitment as the impact is limited to identification.
- Usage on satisfaction: As the relationship between usage and satisfaction has only enabling character the relationship is defined as very weak.
- Satisfaction on improvement suggestions: Marketing experts suggest that in an optimistic assumption only 10 % of unsatisfied customers communicate complaints to the organization. Due to this small number of unsatisfied users the relationship is assumed to be very weak.
- Enjoyment on satisfaction: In the business environment task-related system quality is assumed to have low impact on satisfaction as the primary goal is to provide useful systems supporting the business processes, enhancing the overall performance. Based on this reason the impact of enjoyment on satisfaction seems to be low.

- Expertise on ease of use: Agarwal and Prasad (1999) found that the impact of experience with similar systems has a significant, but low effect on the perception of ease of use.
- System improvement on task-related system quality: System improvement activities are the only way to enhance task-related system quality. Though, to achieve a noticeable enhancement many improvement activities have to be done. Therefore the impact of system improvement on task-related system quality to be very weak.

6.2.4 Definition of the Calculation Scheme and setting initial Values

The simulation illustrates system behavior over time. As such the calculation formula needs to demonstrate the trend over time for each variable. Due to the lack of validated data each relationship was assumed to be linear. For calculating values that were not identified to be accumulated over time the following formula is used:

$$v_{i,t+1} = \sum_{j=1} v_{j,t} * w_{ji} * r_{ji}$$

Equation 1: The equation shows the calculation scheme for non-accumulative variables.

With $v_{j,t}$ as value of variable *j* at time *t*, w_{ji} as impact parameter of *j* on *i* and r_{ji} as relationship indicator defining the relationship from *j* to *i*. Variables that were identified to represent accumulated values were calculated as follows:

$$Stock(t) = \int_{t_0}^{t} [Inflow(s) - Outflow(s)] ds + Stock(t_0)$$

Equation 2: The equation shows the general structure of flows.

The calculation of inflows was done in two different ways according to the effect of independent variables on dependent variables:

- only improvements of influencing variables lead to an improvement in the dependent variable, and
- dependent variables benefit from any positive value of an independent variable.

Equation 3 shows the application of these two types for the calculation of inflows of the accumulated values expertise ($Inflow_{Expert}$), task-related system quality ($Inflow_{TrSQ}$) and affective commitment ($Inflow_{ACom}$). Again, w_{ji} acts as impact parameter indicating the strength of influence of *j* on *i*. As every system improvement (SI) enhances the task-related system quality, every state of system improvement directly adds to task-related system quality. The same argument is valid for affective commitment, as every system improvement enhances an individual's affective commitment. A different type of calculating the inflow is used for expertise. In case that usage (U) remains constant for t_{i-2} and t_{i-1}, expertise in t_i does not change too. Only improved usage leads to better expertise. This difference in inflows leads to the following calculation scheme for expertise, affective commitment and task-related system quality.

$$
\begin{aligned}
Inflow_{Expert}(t) &= (U(t-1) - U(t-2)) * w_{U,Expert} \\
Inflow_{TrSQ}(t) &= SI(t-1) * w_{SI,TrSQ} \\
Inflow_{ACom}(t) &= SI(t-1) * w_{SI,ACom}
\end{aligned}
$$

Equation 3: The equation shows the calculation of inflows for the accumulated values expertise, task-related system quality and affective commitment.

Additionally boundaries for these values were defined to ensure the relative nature of this simulation. For instance, task-related system quality can only reach 100 % of the maximum task-related system quality the user defined. Even system improvement activities can only be done when the maximum of task-related system quality has not yet been reached. In order to run the simulation initial values have to be set. These settings were chosen to compare the various situations and show effects in the IST investment process.

6.3 Simulation Scenarios

In this section the scenarios that are used in the simulation are introduced. Based on initial situations representing the state at the beginning of the system usage stage the individual usage behavior is simulated and analyzed. As such especially differences in initial and potential task-related system quality and affective commitment were investigated. All else equal, each of these three variables is varied in three variants resulting in 27 scenarios (see Table 5).

Scenario	*Initial TRSQ*	*Possible Improvement Rate*	*Affective Commitment*
1	High	High	High
2	High	High	Medium
3	High	High	Low
4	High	Medium	High
5	High	Medium	Medium
6	High	Medium	Low
7	High	Low	High
8	High	Low	Medium
9	High	Low	Low
10	Medium	High	High
11	Medium	High	Medium
12	Medium	High	Low
13	Medium	Medium	High
14	Medium	Medium	Medium
15	Medium	Medium	Low
16	Medium	Low	High
17	Medium	Low	Medium
18	Medium	Low	Low
19	Low	High	High
20	Low	High	Medium
21	Low	High	Low
22	Low	Medium	High
23	Low	Medium	Medium
24	Low	Medium	Low
25	Low	Low	High
26	Low	Low	Medium
27	Low	Low	Low

Table 5: The table shows the 27 scenarios that were used for the simulation.

Initial task-related system quality (TRSQ) refers to the TRSQ at the beginning of system use. In contrast, potential TRSQ relates to the highest possible TRSQ that can be achieved through System Improvements and is defined by an improvement rate that bases upon the initial TRSQ. Potential TRSQ is limited by the user defined criteria that define the maximum of TRSQ. Different settings in affective commitment represent the variance in individual attitudes.

6.4 Simulation Model Results

Achieving the potential TRSQ

For the investigation the finally achieved TRSQ is compared to the potential TRSQ. From Figure 41 one can learn that at the end of the simulation a great number of settings achieves the potential TRSQ. Actually, 63 % (17) of the scenarios reached the full potential TRSQ. Six scenarios (22 %) achieved 81 – 95 % of their potential and two scenarios showed a final TRSQ that is between 61 and 80 % of their potential. Only two scenarios manifest an achievement of 50 to 60 % of their potential TRSQ.

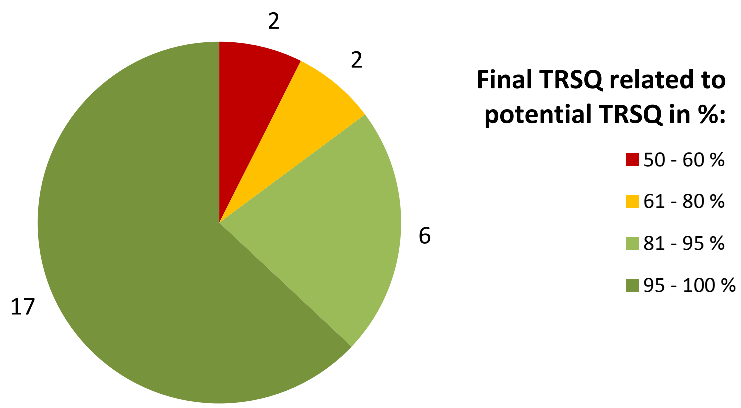


Figure 41: The chart shows the achievements of potential TRSQ in the simulation run. 17 scenarios reached 95 – 100 % of the potential TRSQ.

Commitment is the Crucial Factor for Achieving the Potential TRSQ

The scenarios vary in initial and potential task-related system quality and in affective commitment. Figure 42 shows that high initial task-related system quality does not imply achieving the best TRSQ possible. There are scenarios with medium initial TRSQ resulting in a better final TRSQ than scenarios with high initial TRSQ – the same with medium and low initial TRSQ. As shown in Figure 43 affective commitment has a strong impact on the achievement of the best possible TRSQ. All scenarios with high Affective commitment result in achieving the potential TRSQ, as can be seen in the diagonal. In cases where medium affective commitment does not result in achieving the potential TRSQ, a very slow increase in TRSQ is observed. At the end of the simulation these cases therefore have not reached the potential TRSQ. High affective commitment resulted in achieving the full potential of TRSQ irrespective of the initial TRSQ. This is contrary to the results of low affective commitment that prevented to reach the full potential of TRSQ. Scenarios with a medium commitment did not reach the potential TRSQ where the possible improvement rate was high – to reach the full potential these scenarios would need much more time.

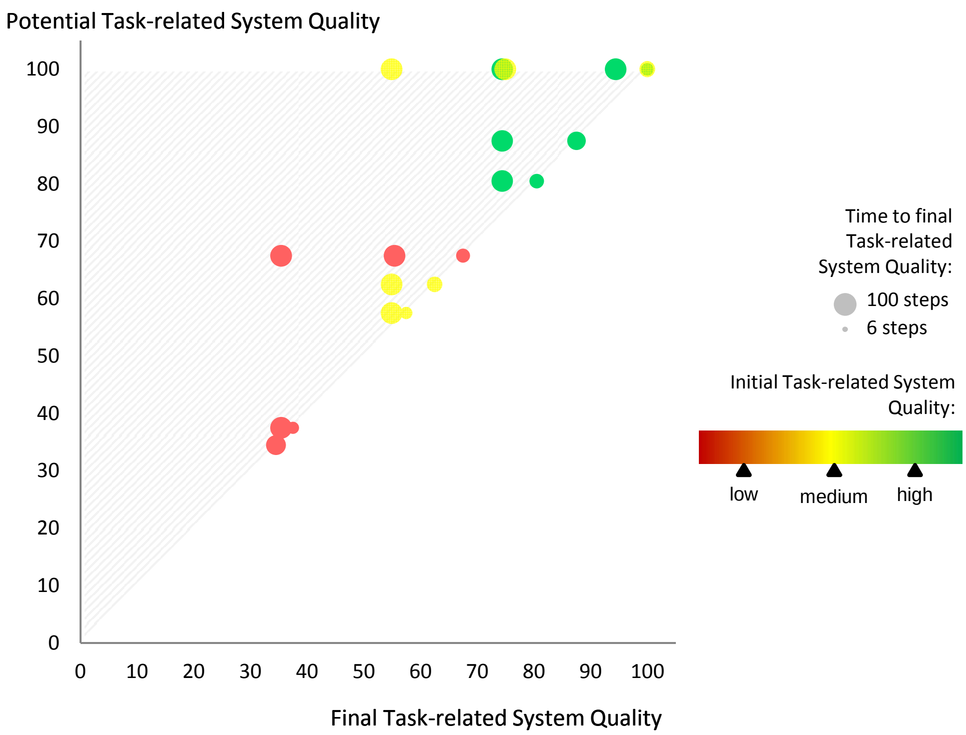


Figure 42: The chart shows the scenarios' initial, potential and final TRSQ and the time consumed to reach the final TRSQ.

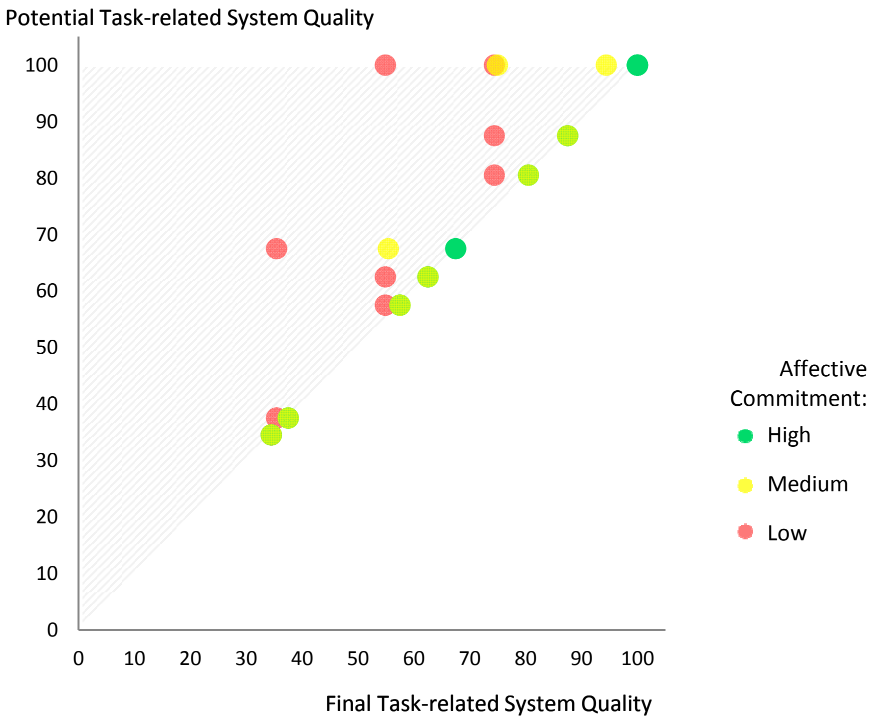


Figure 43: The chart shows the scenarios' potential and final TRSQ and affective commitment.

Reaching the Plateau of Productivity

As shown in Figure 42 and Figure 43 scenarios result in different final task-related system qualities. Some of the scenarios that reach the potential TRSQ need much more time to reach a stable state of quality (see Figure 44). TRSQ relates to user-defined criteria and so accomplishing tasks is done with the optimal system, only if the system achieves 100 % of TRSQ. This implies that productivity is optimal not before reaching the final TRSQ. Figure 44 illustrates that scenarios with a high affective commitment reach the stable state first. How soon users will be able to work with the best TRSQ depends on affective commitment first and second on the initial TRSQ.

$$PI = \left(\frac{TRSQ(t_F) + TRSQ(t_0)}{2} * t_F + TRSQ(t_F) * (t - t_F)\right) * \frac{U_F}{1000}$$

$$PI = \left(\frac{t_F}{2} * (TRSQ(t_0) - TRSQ(t_F)) + t * TRSQ(t_F)\right) * \frac{U_F}{1000}$$

Equation 4: The equation shows the calculation scheme for the Total Performance Index.

Finally comparing the overall performance of these scenarios for the simulation run time a performance indicator is defined. The Total Performance Index PI depends on the final task-related system quality $TRSQ(t_F)$, the initial task-related system quality $TRSQ(t_0)$ and the point in time the final TRSQ is reached t_F, the final usage U_F and the complete simulation time t (see Equation 4). As shown in Figure 45 the best performance is achieved with high initial and potential TRSQ and high affective commitment. Providing high affective commitment, even with medium initial TRSQ, but a high potential a high Total Performance Index was realized. The lower affective commitment the lower the difference in the Total Performance Index between low, medium and high potential TRSQ.

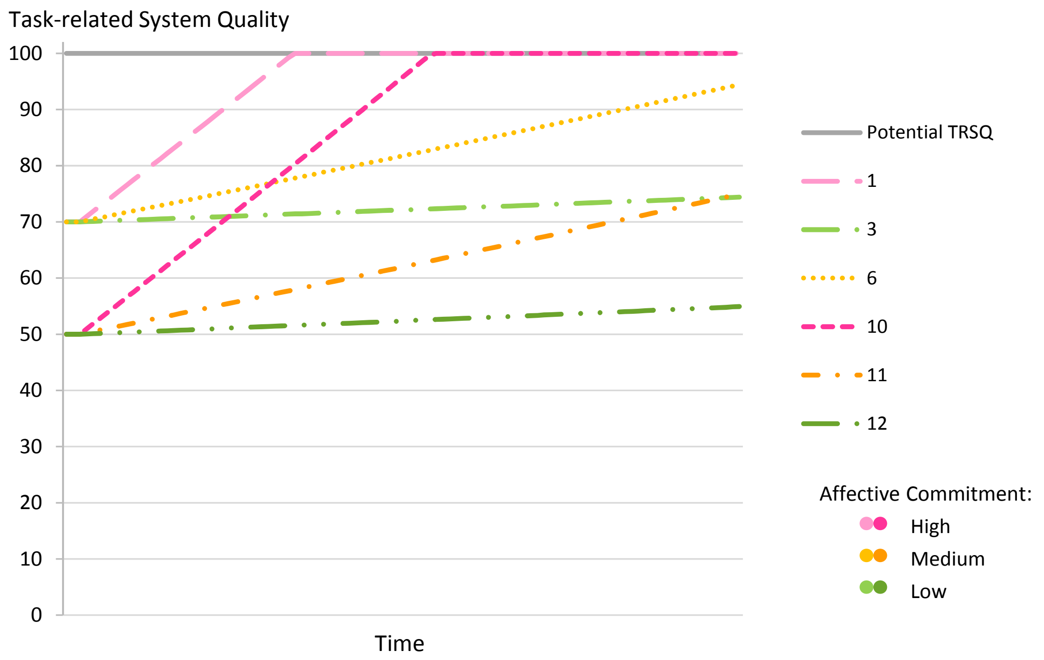


Figure 44: The figure shows task-related system quality over time for scenarios featuring a potential task-related system quality of 100 %.

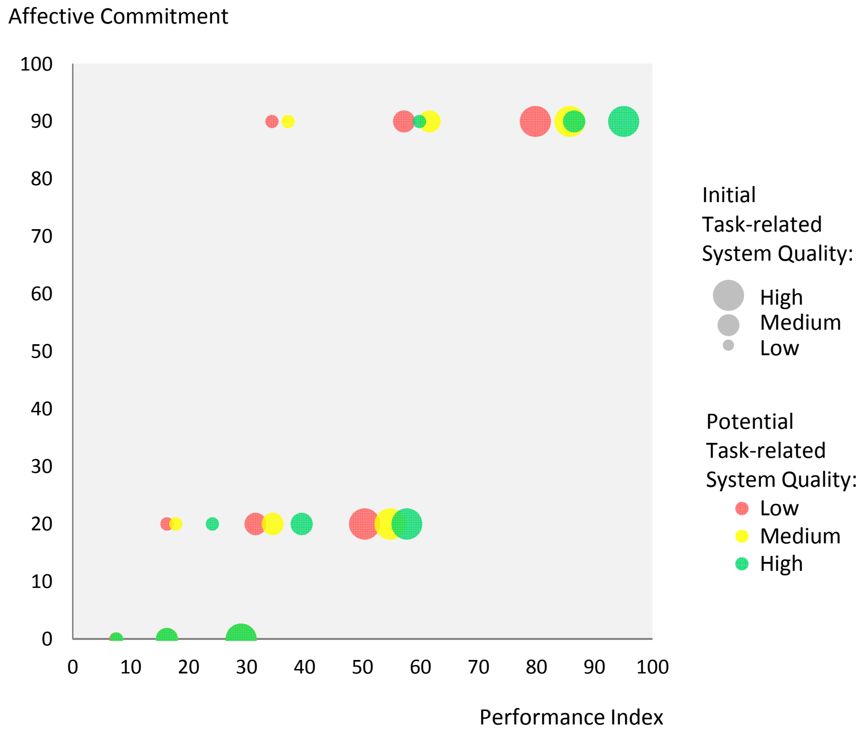


Figure 45: The figure shows the Total Performance Index of the 27 scenarios based on affective commitment, potential and initial task-related system quality.

Phenotypes arising from the Evolution of Task-related System Quality

From Figure 45 it is obvious that there is a scenario with high initial and potential TRSQ, featuring a moderate PI due to the low affective commitment. Due to this anticlimax the scenario is denoted as *Dying Swan*. Although there were high investments in high initial and potential TRSQ the scenario achieved only a PI of 29. A better result is realized with medium initial and potential TRSQ and high affective commitment. This scenario achieved a PI of 62 and is therefore defined as *Best Practice*. Moderate investments in initial TRSQ with a moderate potential and high affective commitment result in high usage (see Figure 46) and a high PI. Nevertheless, there is a scenario that achieved surprising results. The *Rising Star* with medium initial TRSQ, but high potential TRSQ and high affective commitment achieved a PI of 87. Only the scenario with high initial and potential TRSQ and high affective commitment resulted in a higher PI (95). As shown in Figure 46 Best Practice and Rising Star show the same usage level, whereas Dying Swan is languishing at a very low usage rate. Figure 47 illustrates that Rising Star and Best Practice reach their potential TRSQ very soon, whereas Dying Swan at the end of the simulation has still not reached its potential.

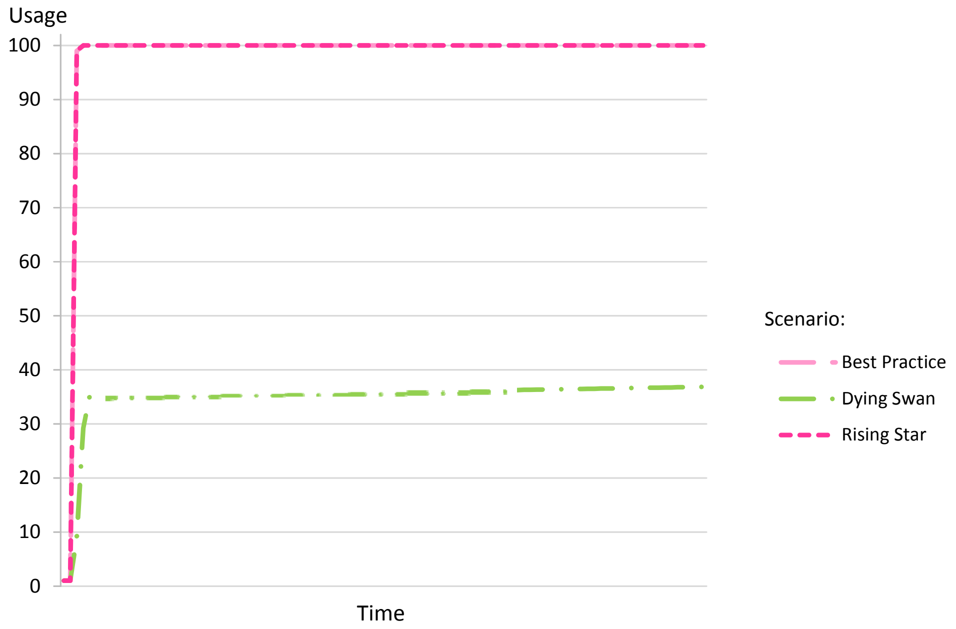


Figure 46: The figure shows usage over time for the three identified phenotypes Best Practice, Rising Star and Dying Swan.

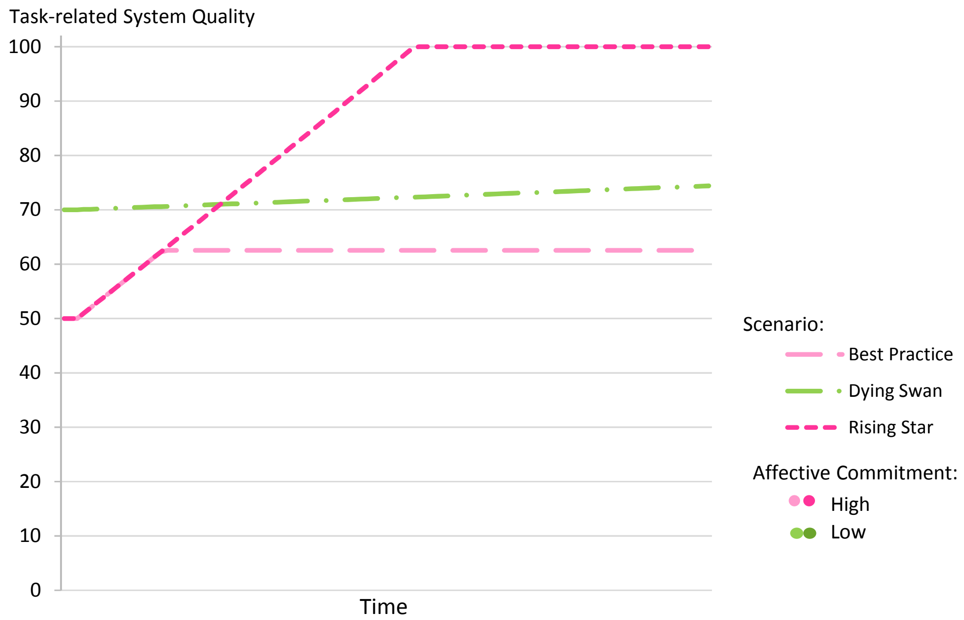


Figure 47: The figure shows TRSQ over time for the three identified phenotypes Best Practice, Rising Star and Dying Swan.

7 Model Validation

7.1 Validation on known Effects of Interventions on Usage Behavior

Much research has been done on managing the transformation of socio-technical systems and activities supporting the individual IST adoption process. In this section selected activities will be introduced and their effects are explained to provide evidence to the ability of the model to explain the effects of interventions and the according usage behavior.

7.1.1 The Effect of User Participation

User participation mostly is defined as the extent to which users or their representatives carry out assignments and perform various activities and behaviors during the system development process (Barki & Hartwick, 1994). In recent years this definition was extended to also include communication as another domain of user participation (Hartwick & Barki, 2001). For the purpose of this thesis participation is extended not in the meaning of its domains, but in the process sense: Users can participate in all stages of the IST investment process. In the analysis and planning phase users can help to identify criteria relevant to the selection and evaluation of the IST. For the evaluation of costs and benefits users can improve to identify hidden costs, e.g. learnability. Dix et al. (2004) suggested a number of techniques that can be used in the analysis and planning phase that can be categorized in experimental evaluation, observational techniques, physiological response evaluation and query techniques. In the selection phase users can be integrated into the decision making process and in the implementation phase they can help with integrating the system in the process and infrastructure landscape as well as testing the implemented system. Furthermore, in the post-implementation phase users use or even have used the system and give feedback about how well it works and how the system can be better aligned to tasks and infrastructure.

User participation is not only an issue of being social. It rather puts the emphasis on a real business agenda. Improved communication with future users can help to define goals that have to be met when implementing an IST (Remenyi & Sherwood-Smith, 1999). It can help to further redefine the future process by people who are aware of advantages and challenges emerging from the current process and infrastructure. User participation provides the needed domain knowledge for implementing a system that should enable productivity benefits (He & King, 2008). This enables a better process and task alignment of the system to be implemented and avoids the risk of a technologically driven implementation. Furthermore, clear communication with future users reduces anxieties and uncertainties that come along with the transformation process and leads to realistic expectations. People can be convinced that they will benefit from usage of the implemented IST, e.g. through an easier or fast task achievement or improved task results. User participation in the other phases of the investment process cultivates a greater sense of control, increases motivation and reduces resistance toward change (Rondeau et al., 2006; Amoaka-Gyampah & White, 1993; Jiang et al., 2000). The described advantages resulting from user participation can be demonstrated in the IST Behavior Explanation Model aiming on enhancing affective commitment, initial TRSQ, establishing realistic expectations and improving perceived control of behavior and change Figure 48 illustrates the effects towards.

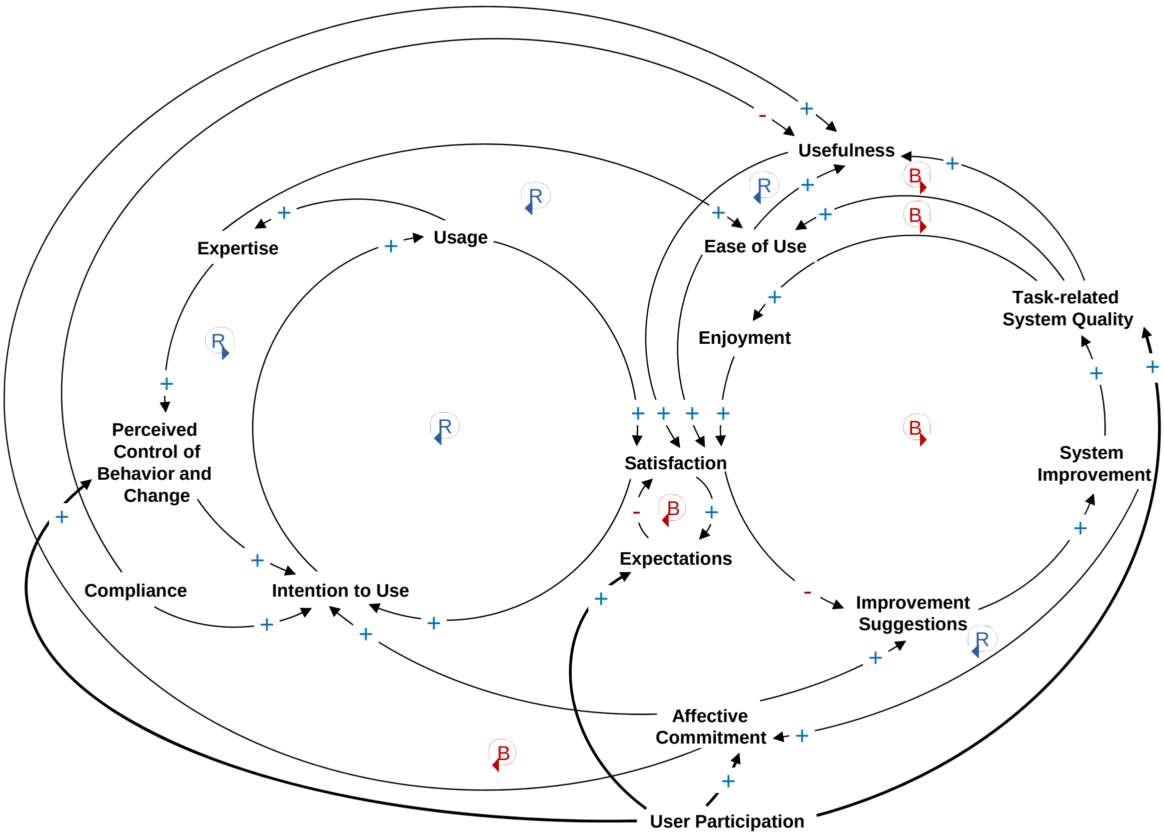


Figure 48: The figure illustrates the effects of user participation in the IST Behavior Explanation Model.

7.1.2 The Effect of User Training

Training is one of the most pervasive methods (Gupta et al., 2010) to enhance an individual's productivity and communicate organizational goals. Besides improving the individual performance there are task and organizational related questions that are answered at different levels to provide effective training (Nelson et al., 1995):

Level	**Content**		
	Person	**Task**	**Organizational**
Individual	What knowledge and skills do specific individuals need to learn for effective performance?	What are the knowledge and skill requirements necessary for the accomplishment of specific tasks by an individual?	How do the goals of an individual affect or constrain performance motivation to learn, or training effectiveness?
Sub-Unit	What skills mix is needed for successful job performance within a given work group, e.g., interpersonal skills, teamwork skills?	What activities, technologies, and behaviors should be trained for effective task performance within a given subunit?	How do work group goals and culture affect or constrain performance or training effectiveness?
Organizational	How does the organization tie human resource planning (i.e., HR analysis, skills inventories, forecasting of work force demand and supply, and forecasting of skill mix) to strategic planning?	What are the core work processes and technologies of the organization?	How do organizational goals, objectives, and resources affect whether and where training is needed?

Table 6: The table shows the content levels for training needs (Nelson et al., 1995).

Providing training sessions to users enhances their performance with the newly implemented system. By using the system and improving one's expertise with it anxieties related to task and technology are reduced and control beliefs are enhanced. User training furthermore improves users' commitment to system use as they learn how to benefit from using the system, e.g. the system makes their tasks easier or improves performance. Offering user training sessions prior to the system implementation avoids time consuming self-learning by doing in the post-implementation phase. Furthermore possible system design mistakes can be identified and the system's alignment to tasks and business processes can be enhanced. The described advantages ascribed to user training affect expertise, perceived control of behavior and change, affective commitment and task-related system quality (see Figure 49).

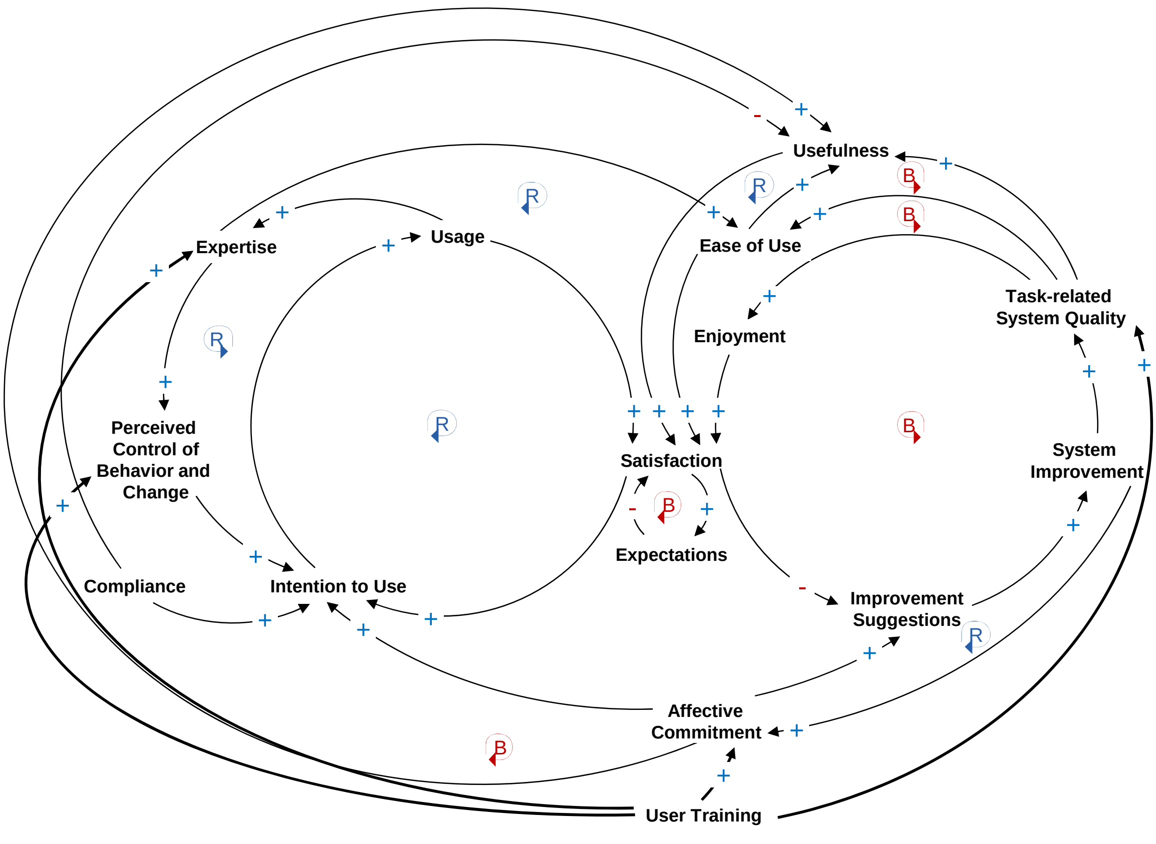


Figure 49: The figure illustrates the effect of user training in the IST Behavior Explanation Model.

7.1.3 *The Effect of Management Support*

Management support implies that the implementation of the system is relevant not only for a part of the organization, but also for (upper) management and therefore is relevant to the entire organization. (Díez & McIntosh, 2009) Furthermore, affective commitment can be enhanced due to the relevance of the system implementation for particular units as well as for the entire organization and therefore for the business processes and tasks. However, a lack of management support might lead to assumptions that system implementation is not of dominant relevance to the management and to the entire organization. Therefore a lack of managerial support of the system implementation might lead to questions like the following: "If it's not important for them, why should it be relevant for me?". Managerial support in the IST explanation model works through affective commitment (see Figure 50).

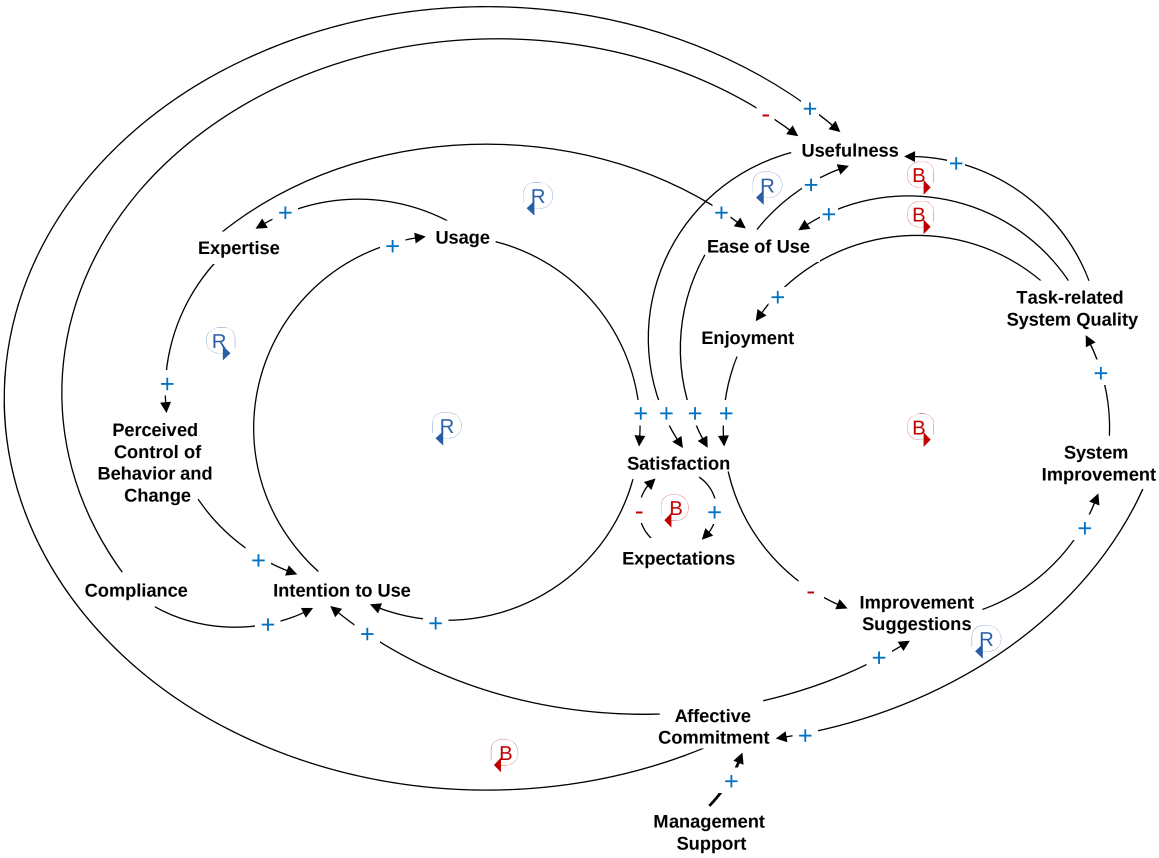


Figure 50: The figure illustrates the effect of management support in the IST Behavior Explanation Model.

As shown in Figure 51 with the same system quality in mind user participation leads to phenomenal performance values. Besides the effect on affective commitment, users participating in the investment process provide the opportunity of identifying mistakes in the transformation from the existing socio-technical system to a new one. Nevertheless, user training as well as management support focus on improving affective commitment and as such result in moderate performance values. Compared to the scenario with no interactions that should support the individual adoption process all activities presented in this chapter resulted in much better performance values.

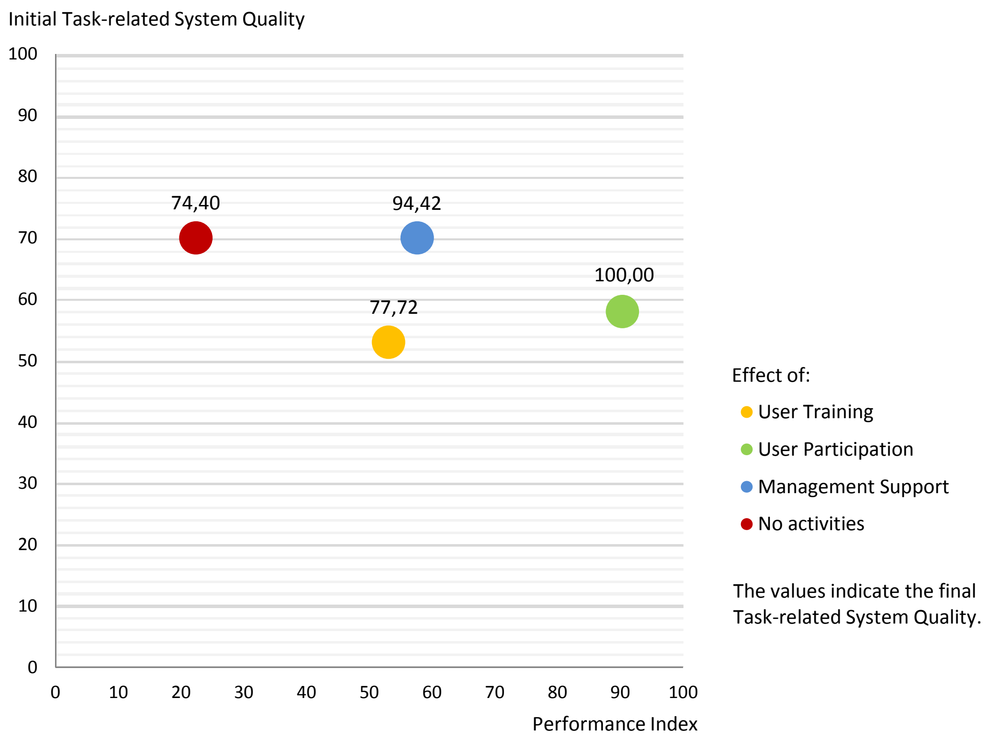


Figure 51: The figure shows the effect of user training, user participation and management support on the final task-related system quality and the Total Performance Index.

7.2 Validation on Case Studies

7.2.1 Case Study Approach

A case study was done to illustrate the applicability of the model for real-world cases. Three cases were selected based on user characteristics and system characteristics. For the case studies companies in the industry were contacted. The users that were interviewed witnessed the investment process and could accomplish at least some of their tasks using the IST in question. The system is available for the users and users know about the system application areas. The interviews were conducted at users' work places outside office hours. By doing so the users were able to speak free about the investment process, system usage and their perceptions. A guideline served as the basis for the semi-structured interview. The guideline was developed with several measurement scales that are known from literature. Measurements that were used are:

- Intention to Use, used in Malhotra & Galletta (2005),
- Perceived Ease of Use and Perceived Usefulness, used in Davis et al. (1989),
- Satisfaction, used in Liao et al. (2009),
- Compliance and Affective Commitment, used in Malhotra & Galletta (2005) and
- Task-related System Quality, metrics were provided in DeLone & McLean (1992).

The interview was analyzed using the investment process structure to understand user's perceptions during the process: Analysis and planning, evaluation of costs and benefits, selection and implementation and finally post-implementation evaluation. The IST Behavior Explanation Model was used to illustrate the perceptions of the user. The answers of the users were analyzed and the strength of each variable was classified to show the active loops working within the model. For further illustrating the strength of variable in the model they were categorized into four levels.

7.2.2 Case Study A: Changing Decision Styles

Christian is 35 years old and has been working as design engineer in the automotive industry for the last seven years. He attended the school for Higher technical education (HTL) and studied Automation Technology at the University of Applied Sciences. Christian has a good expertise regarding Information Technologies & Information Systems. He is a very good expert with CAD systems, as he has been using them for 15 years. From 17 years of using Microsoft Office he has a good expertise too. Christian thinks his expertise is good regarding the simulation tool ANSYS Maxwell[1] and he has been using the system for more than 7 years. Even with Mathcad[2], which he has been using for 14 years, Christian is convinced to have very good expertise. For the case study a CAD system was selected. The system has been used a year before the interview was conducted. The previously used system was a completely different system, providing a different user interface and other modules and functions. Christian is using the new CAD system for his daily tasks. He belongs to the group of engineers that are using the system. Besides this group of users there are the heads of departments that use the system for

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[1] http://www.ansys.com/

[2] http://de.ptc.com/product/mathcad/

checking drawings and simulation results. Christian experienced the five phases of the investment process as follows:

Analysis and Planning:

The user group 'engineers' was not integrated in this stage of the process and the planned system transformation was not communicated to the engineers at this stage. The management decided to change the engineering tools because of license costs and because of the desire to use one CAD system throughout all locations and offices. As a basis for the decision financial aspects as well as usage-relevant data should be considered.

Evaluation of Costs and Benefits

In this stage of the investment process the engineers were integrated to evaluate alternative systems regarding following criteria:

- Learnability of the system
- Applicability for the main tasks:
    - Design of drawings
    - Enhancement of existing elements and modules (designed with the previous CAD system)
    - Simulations
- Compatibility with the technical infrastructure

All engineers used the opportunity of using demo versions to gain insight into alternative systems and they appreciated the opportunity to give feedback. The informal evaluation results were communicated personally to the head of department. Evaluation of the alternative tools was done by an administrative department, by the head of the engineering department and by the engineers. The evaluation of the engineers led to the result that the two alternative systems were easy to learn. System *A* and *B* enabled to view drawings that were created with the previously used system. Both systems do not support modification and enhancement of these drawings and therefore even do not support simulation for these elements and modules. Regarding the compatibility with technical infrastructure for system *A* a new product data management had to be implemented and new hardware had to be acquired. Christian was sure not to have an issue with learning the new system. He was sure still to be able to accomplish his tasks and he was sure that the structure in the department would still be the same after the system transformation. Though based on the evaluation he did, he was sure, to need more time for the same results due to the compatibility issues.

Selection and implementation

At this stage the engineers attended courses for the new system. The course took place at a time, where a new prototype had to be developed – all engineers were stressed about this timing. Although the engineers argued for keeping the old CAD system, system *A* was chosen by the management. The preparation for the implementation was done by the IT department and included the acquisition of new computer hardware and the installation of the new product data management system and the new CAD system. Usage of the new CAD system was prescribed by the management. On the new computers the previously used CAD system was not installed any more.

Post-Implementation Evaluation

Christian, like the colleagues, is using the system for drawing new elements and modules. He suggested some improvements that enabled a better collaboration with all locations. Due to compatibility reasons in all headquarters there are still computers with the old CAD system available on it for view, enhancement and modification of drawings that were created with the previously used system. Christian is not working on such a computer, but has the possibility to switch to a computer with the old CAD system installed, when there are old drawings to modify. Users working on these systems still use the old CAD system for the construction of new elements and modules as they are more used to the system. Christian is sure, that implementation of the new CAD system does provide financial advances but not provide any improvements for processes. In general, Christian believes that the new system has a high quality, but relating to the tasks he is accomplishing with the system, there would be much room for improvement. Up to one year after the implementation of the new system there were no activities regarding evaluation of the investment by the management.

Figure 52 illustrates the results of the semi-structured interview. It shows Christian's perceptions at the time the interview was conducted. The variables were colored according to the perceptions at the start of usage and the effects and relevance that influenced the variable. Each arrow was colored according to the influencing factor. Relationships that turned out not to be relevant for the application of the model were removed for the illustration. There are no strong loops, but two moderately strong ones:

- Usage is a weak driver for satisfaction: Intention to Use → Usage → Satisfaction →Intention to Use and
- Satisfaction and expectations influence each other: Satisfaction → Expectations → Satisfaction.

The application of the model for Christian's perceptions shows his sources of intention to use: due to his perception of the system being moderately useful he uses the system on a regular basis for his daily tasks. By easily learning how to use the system he improved his control beliefs regarding task and technology self-efficacy. Process self-efficacy turned out to be very low, as it takes him too much time to modify drawings that were created with the old CAD system. For the first, affective commitment seemed to be very low as management asked for an evaluation, but did not consider it for decision making. The changing decision style resulted in low initial affective commitment. Affective commitment later on was improved as Christian learned about the System Improvements that were done due to his suggestions.

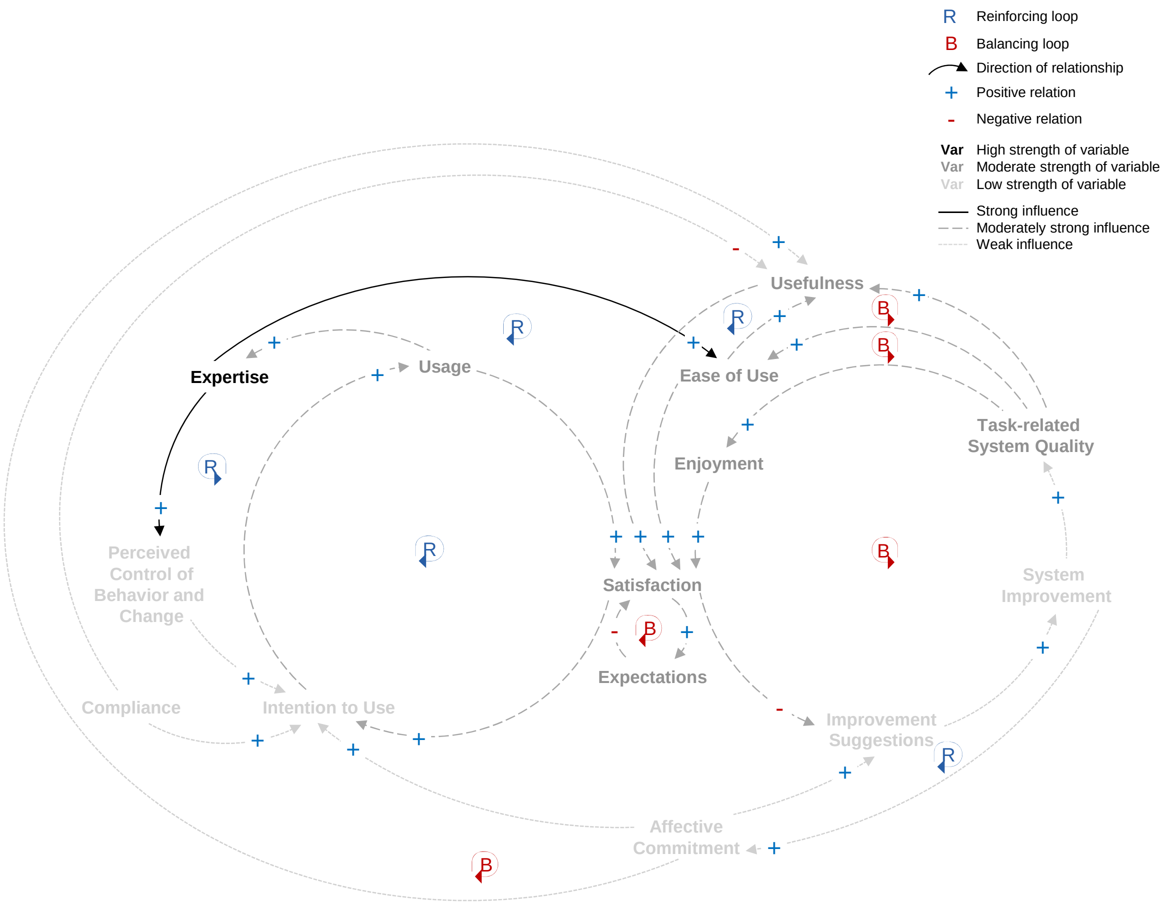

Figure 52: Application of the IST Behavior Explanation Model, Case A: Christian, User of a CAD system.

7.2.3 Case Study B: Overlooked System Requirements

Hubert is 29 years old and has been working as a salesman in an industrial enterprise for the last four years. He graduated in Business Economics at the University. Hubert has a good expertise regarding Information Technologies & Systems and is an early adopter of IST in his private life. Christian has a good expertise in SAP as he has been working with the system for more than 7 years. From using Microsoft Office for 14 years Christian has a very good expertise regarding these applications. Christian has a moderate expertise with project management software from 4 years of using it. For the case study a CRM system was selected. Two years ago the company decided to manage customer related data by implementing a CRM system. Before implementation of the new tool salesmen structured the information in different ways, e.g. Microsoft Outlook, Word, individual databases. Hubert uses the system for his daily tasks. Besides the salesmen upper management uses the system. Hubert experienced the five phases of the investment process as follows:

Analysis and Planning:

Although some of the salesmen already implemented a CRM system developed by themselves, the user group 'salesmen' was not integrated at all in this stage of the process, but the planned system implementation was communicated to them. The company implemented a system as the upper management wanted to get rid of the various ways the information about customers was kept. The second reason for implementing a CRM was that they often had appointments with customers, but did not have all the relevant data. At this stage Hubert was convinced that the implementation of a CRM system was a great improvement for the sales department.

Evaluation of Costs and Benefits

In this stage of the investment process the salesmen were not integrated at all.

Selection and implementation

The salesmen were informed about the selected system and that there were three alternatives that had been evaluated by upper management. Some of the older salesmen were afraid of losing their job as information about their customers is their business and they might have been substituted by younger employees. This perception was strengthened by the fact that there was no further interaction with the upper management regarding this system implementation. Before the system was implemented the salesmen had a brief introduction into the system, as they felt it was easy to use and no detailed course is necessary. During the introduction the salesmen who had already implemented their own CRM system mentioned the advantages of their system. The other salesmen were irritated as they were not sure which solution would have been to prefer. The implementation of the system was done by the in-house IT department. There did not occur any incidents.

Post-Implementation Evaluation

Hubert is convinced that the tool is appropriate for managing customer information. He uses the tool for his daily tasks and before customer meetings he uses the tool to be up to date. Hubert is convinced that individual software would have provided more advantages, but he did not suggest any improvements, as this was done by colleagues without any improvements. From Hubert's point of view upper management should be satisfied with the information that is provided by the salesmen.

Usage of the system Hubert perceives as volitional, and all salesmen are using the system, as it was assigned by the upper management. The salesmen do not have to be afraid of punishment if they would provide the desired information. The individual solution that was developed by some of the salesmen is not used any more, but the salesmen who developed it suggested many improvements. Unfortunately the system was not improved at all. Some of the salesmen still have their ring binders with information about the customers, but do provide the same information with the new CRM system.

Figure 53 illustrates the results of the semi-structured interview. It shows Hubert's perceptions at the time the interview was conducted. The variables were colored according to the perceptions at the start of usage and the effects and relevance that influenced the factor. Each arrow was colored according to the influencing factor. The CLD shows no strong loops, but five moderately strong loops:

- Usage is a weak driver for satisfaction: Intention to Use → Usage → Satisfaction → Intention to Use,
- System learning improves usage via improved perceptions of control: Intention to Use → Usage → Expertise → Perceived Control of Behavior and Change → Intention to Use,
- System learning improves usage via ease of use and satisfaction: Intention to Use → Usage → Expertise → Ease of Use → Satisfaction → Intention to Use,

- System learning improves usage via usefulness and satisfaction: Intention to Use → Usage → Expertise → Ease of Use → Usefulness → Satisfaction → Intention to Use and
- Expectations limit the growth of satisfaction: Satisfaction → Expectations → Satisfaction.

The application of the model shows the reasons why Hubert is using the system for his daily tasks. As he easily learned how to use it, he improved the perceptions of control which in turn improved his intention to use the system. Additionally he finds the system useful and easy to use. Identification turned out to be high because Hubert is planning to apply as the assistant to the executive board. Probably this was the reason for not suggesting improvements too. Overall, Hubert's intention to continuously use the system seems moderately high.

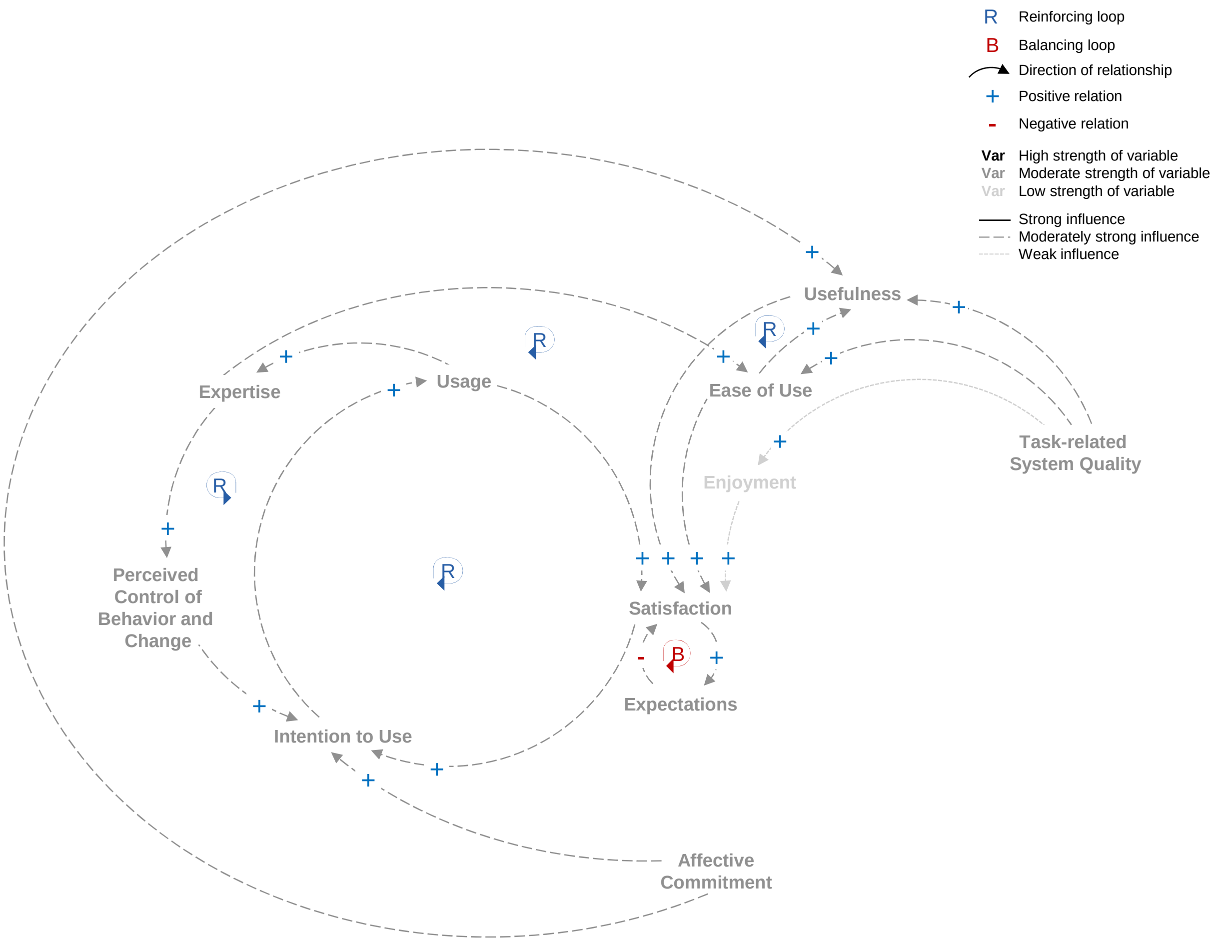

Figure 53: Application of the IST Behavior Explanation Model, Case B: Hubert, User of a CRM system.

7.2.4 Case Study C: User-triggered Innovation

Andrea is 48 years old and has been working as a salesperson in a company that serves as supplier for an OEM (original equipment manufacturer) for the last thirteen years. She studied Mechanical Engineering at the University. Andrea has a good expertise regarding Information Technologies & Systems. She has a good expertise in SAP as she has been working with the system for more than 10 years. From using Microsoft Office for over 20 years Andrea has a good expertise regarding these applications. She has a very good expertise with project management software from 4 years of using it and is an expert in CRM systems. For the case study a CRM system was selected. Four years ago the company implemented a new CRM system. Before the new tool was implemented a previous version of this implementation was used. Andrea experienced the five phases of the investment process as follows:

Analysis and Planning:

Andrea heard about the new version of the CRM system from a friend her who was using the new version at work and who recommended the new version. She investigated the new features, tried the easy to learn demo version and was convinced that it would improve the processes. Therefore she suggested the acquisition of the enhanced CRM system to the head of department. The head of department asked her to evaluate the CRM system in use and the enhanced version.

Evaluation of costs and benefits

Andrea evaluated both systems regarding technical and process related aspects:

- Process improvements with the new CRM system, e.g. mobile use of the system, and
- Compatibility of the new CRM system with the system in use.

Andrea was responsible for the evaluation of the tool and so she invited her colleagues to try the demo version and give feedback. Most of her colleagues used the opportunity of giving input after they tried the demo version too. Andrea and her head of department had an appointment for a presentation to demonstrate the results of her investigation. The head of department was very interested in the results, as he uses the CRM tool too by generating input and output. Besides the newer version of the CRM system that was already in use no other system was evaluated. The evaluation of costs was done by the in-house IT department.

Selection and implementation

Based on the information retrieved from the last process stage Andrea's head of department decided to update the CRM system. The implementation was done by the in-house IT department and the system transformation completed without any problems, the previous version was removed.

Post-Implementation Evaluation

Andrea perceived that the system was very easy to learn, as menu navigation was nearly the same as in the previous version. Andrea is sure, that the decision was right for the sales department. She is very proud of being the one that had the idea to acquire the new system. Even her colleagues benefit from using the new system. A year after system implementation her head of department talked to her about the improvements that were achieved by using the new system: mobile access to the new system was easier and rights management was improved. He and all of the salespersons were satisfied with the acquisition of the CRM system and are using the system for their daily tasks. Neither Andrea nor one of her colleagues had any suggestions for system improvements up to now as task-related system quality fulfilled all demands. Andrea did not perceive any pressure to enhance usage of the system; there were also no rewards for using the system.

Figure 54 illustrates the results of the semi-structured interview. It shows Andrea's perceptions at the time the interview was conducted. The factors were colored according to the perceptions at the start of usage and the effects and relevance that influenced the factor. Each arrow was colored according to the influencing factor. The CLD shows five strong loops:

- Usage is a weak driver for satisfaction: Intention to Use → Usage → Satisfaction → Intention to Use,
- System learning improves usage via improved perceptions of control: Intention to Use → Usage → Expertise → Perceived Control of Behavior and Change → Intention to Use,
- System learning improves usage via ease of use and satisfaction: Intention to Use → Usage → Expertise → Ease of Use → Satisfaction → Intention to Use,
- Expectations limit the growth of satisfaction: Satisfaction → Expectations → Satisfaction.

- System learning improves usage via usefulness and satisfaction: Intention to Use → Usage → Expertise → Ease of Use → Usefulness → Satisfaction → Intention to Use and

Through all of the process stages Andrea was convinced that the implementation of the system will result in better performance, better preparation for customer meetings and decrease the effort. As her perceptions about task-related system quality were very good, she was satisfied with the system and therefore did not suggest any improvements. Although she had high expectations her satisfaction did not suffer from that, as expectations were realistic and aligned to the results of usage. As the system transformation was just an update of a previous version Andrea had strong control beliefs regarding task, technology and process. As she was integrated in the investment process she was sure that the structure in the organization would not affect her in a negative way.

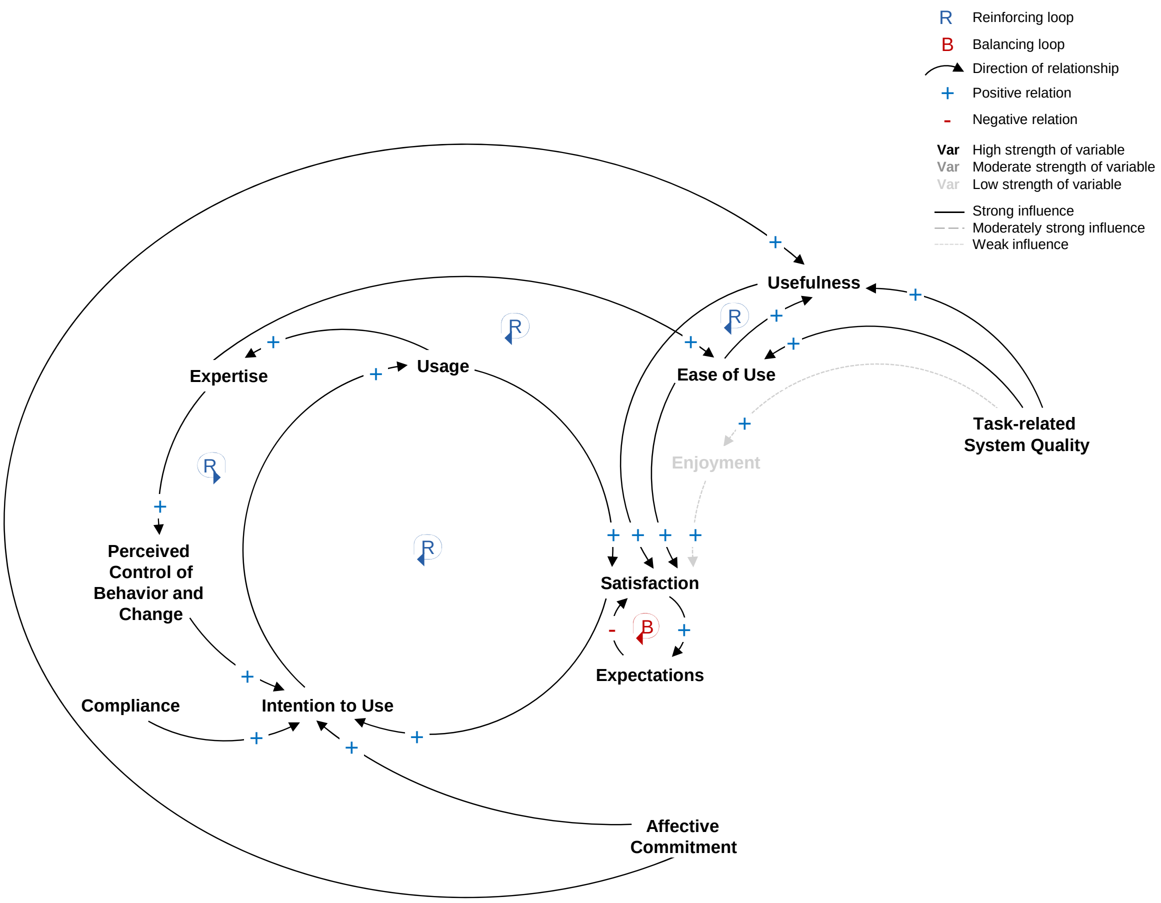

Figure 54: Application of the IST Behavior Explanation Model, Case C: Andrea, User of a CRM system.

8 Conclusion

In a business environment to derive benefit from Information Technology & Information System (IST) it is especially important that the system is used. As existing behavior explanation models are not able to explain continuous usage of IST this theses is done to thoroughly examine the individual usage behavior in the work environment. Based on a general description of approaches to explain success, acceptance and usage of Information System & Information Technology in the work environment relevant relationships were identified. An Extended Intention Model was developed including control beliefs and anxieties following from the perspective of socio-technical systems. The Extended Intention Model served as a basis for the IST Behavior Explanation Model that was developed by an extensive review of different approaches ranging from psychological and sociological research as well as research about Information System success, adoption, usage and acceptance. The main reasons for continuous usage of IST in the work environment were found to result from feedback from previous usage experiences. Feedback from previous usage acts as driving forces in the model. A simulation of the model proved affective commitment to be a crucial factor for usage of a system as well as for task-related system quality to be improved. It turned out that moderate investments and high affective user commitment can result in better system performance than high investments with low affective user commitment. This proved the presumption that high investments in good system quality do not provide a guarantee for high performance. Furthermore, affective commitment can be enhanced by integrating users in the investment process, providing training or managerial support. In the investment process for information system and information technology management often places interventions to stimulate usage of a system, such as user participation, user training or management support. Especially User Participation proved to enhance affective commitment, task-related system quality and the individual usage behavior. In the further course of this thesis three case studies demonstrate the applicability of the IST Behavior Explanation Model to investigate the individual usage behavior. The causal model was used to illustrate the factors affecting usage of a system. Furthermore, the main barriers and driving forces for continuous usage of an information system or information technology were identified.

8.1 Research Questions

Answering research question no. 1 "*Is it possible to create a model that explains the individual usage behavior of Information System & Information Technology in the work environment?"*, it can be stated, that the model introduced in this thesis includes the essential determinants of usage of an Information System & Information Technology for explaining the usage behavior at an individual level. The reasons for usage, adoption and success of Information System & Information Technology are analyzed and described very well in literature. Applied to the field of business IST none of the models is able to explain usage behavior on a regular basis. The model developed in this thesis provides a conceptual basis for the explanation of continuous usage behavior. The applicability of the IST Behavior Explanation Model was demonstrated with three case studies that were conducted in different industries to present that individual usage behavior can be analyzed using the IST Behavior Explanation Model and furthermore identify the driving forces or barriers to continuous usage of a system.

Answering research question no. 2 *"Which known effects of interventions for motivating the individual usage behavior of IST can be explained using the model?"*, it can be said that activities intended to motivate individuals to use a system or technology are a dominant topic in change management. User participation, user training and management support were supposed to positively influence the individual adoption process. These three interventions were investigated to provide evidence that they enhance the performance of a system. It was observed that all three interventions had a great effect on task-related system quality and usage of an information system or information technology. In addition it became visible that user participation has the strongest effect as it affects several determinants in the IST Behavior Explanation Model.

8.2 Future Research

The developed simulation model provides a basis for analyzing investment processes to identify the driving forces by applying the IST Behavior Explanation Model. For the first this application gives insight into how different Information Systems & Information Technologies develop in the post-implementation phase and provide benefit to the organization through continuous usage of the system. Additionally a comparison of system performances provides a basis for the decision making process. Furthermore, interventions shall be analyzed based on their effect on the determinants of the system to ensure that efforts are in direct relation to the outcome. In that context a wide range of interventions that are assumed to positively influence the usage of IST are to be determined. This would provide the opportunity of supporting the system architecture and change management. The simulation model enables the investigation of effects and the comparison of different systems. It is based on a number of studies indicating the strength of relationships. Though, it is presumed and partly proven that the importance of determinants to intention to use and usage shift throughout the usage process. To accurately predict the individual usage behavior the strength of relationships has to be refined and introduced into further releases of the simulation model. This could also give insight into possibilities for simplification of the IST Behavior Explanation Model.

The presented model is used for explaining usage behavior for IST in a business environment. With respect to other change management application areas, future research shall provide evidence, if the model is applicable for other areas with restricted free will such as changes in business processes.

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10 Publications and Conferences

A Conceptual Model Explaining IT/IS Usage Behavior. In J. J. (Jong Hyuk) Park, H. Chao, M. S. Obaidat & J. Kim (Eds.), *Computer Science and Convergence* (pp. 405-413) Springer Netherlands.

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Social aspects in the decision making process for IT investment. Talk in: Forschungskolloquium Techno-Ökonomie Graz-Leoben-Wien, 19.11.2009

A Conceptual Model explaining IT/IS Usage Behavior

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Abstract. Information Systems and Information Technology have become a crucial success factor for business environments. To ensure optimal use of Information Systems it is especially important to understand usage behavior and factors influencing their adoption by an organization. In recent decades some models have been developed to describe information technology and information systems (IT/IS) usage behavior under voluntary or mandatory conditions focusing mainly on technological or task-related perspectives. These models however can not explain observed phenomena like underperformance of technologically optimal information systems or over-performance of suboptimal systems. In an attempt to close this gap we present a causal model integrating both human and social change processes as well as feedback factors affecting the usage of IT/IS on a regular basis. We further show implications for the system adoption process in a business environment.

Keywords: IT/IS usage; acceptance; usage behavior; commitment; causal loop.

1 Introduction

In the field of IT/IS, to predict acceptance, usage and success many models were proposed [1-6]. Ajzen's theory of planned behavior (TPB) explains motivational based behavior [1], the technology acceptance model (TAM) is intended to predict user's acceptance towards technology in both volitional and mandatory settings. TAM is able to predict about 40% of system use. It misses out negative emotions regarding technology and emotions related to the process of implementing a new technology [1] as well as TPB. Additionally, most of the models do not provide information about the types of relationships.

2 Research Objectives

With this study we aim to explain the IT/IS usage behavior at an individual level with respect to the possibility of enforcing IT/IS usage in organizations. Moreover even the technological and social change processes are taken into account. In a business environment users usually are not decision makers. Users have to get along with the available system or perhaps have to decide whether to use it or not. Furthermore changing organizational structures and processes resulting from IT/IS implementation often unsettle employees. With the proposed model we show implications for the individual IT/IS adoption process in a business environment.

3 Methodology

In a literature review we considered articles related to the various models explaining IT/IS usage, acceptance and success. A synthesis of these models and studies which focus mainly on specific relationships led to the main behavior model. Based on the behavior theories Motivation Model, Theory of Planned Behavior [7, 8] and the behavior theories in relation to IT/IS usage and acceptance TAM [4] and IS Success Model [3], we developed an Extended Intention Model. We use System Dynamics to put components into perspective and add loops to explain business IT/IS usage at an individual level.

4 Existing Behavioral Models and its factors

In this paper we build on the relevant main behavior models explaining either behavior in general or especially targeting IT/IS usage behavior and will therefore review them in brief. These models are Theory of Planned Behavior, Technology Acceptance Model, IS Success Model and the Motivation Model. In the following we give a brief explanation of the models and its factors.

4.1 Behavioral Models

The *Theory of Planned Behavior* suggests that an individual's intended behavior is determined by the attitudes toward a specific behavior, subjective norms and control beliefs regarding the behavior [1]. TAM [4] examines the effect of perceived usefulness and perceived ease of use on intention to system use. It includes task and technology related determinants. References [2, 3] proposed the *IS Success Model*. It suggests that any organizational or individual benefits are determined by usage and user satisfaction. This model neither includes any individual differences nor emotions related to the process of change. The *Motivation Model* [8] suggest that any behavior is related to extrinsic or intrinsic motivation [8, 9].

4.2 Factors in Behavioral Models

In these existing models the main factors are: intention, attitude, subjective social norms, motivation, perceived behavioral control, system usage, satisfaction, usefulness, ease of use and enjoyment. Additionally several studies show a relevant effect of commitment [7, 10, 11]. The core element is the *intention* to perform a specific behavior. It results from motivational factors indicating the willingness how hard to try and how much effort to spend to perform a behavior [1]. *Attitude* is the individual's evaluative or affective response to a specific object [7] or a behavior in question and affects the intention to perform a behavior [1]. Intrinsic and extrinsic sources *motivate* to perform an intended behavior. The more motivated an individual is the more likely is the behavior in question [8]. Intrinsic motivation covers the engagement for pleasure and satisfaction. Extrinsic motivated behavior is performed due to instrumental reasons [8], e.g. attaining rewards or avoiding punishments [9]. Someone can even be motivated by *subjective social norms*. These refer to the degree to which an individual perceives that most people who are important to him think he should or should not use the system [1, 6, 7, 12]. *Perceived behavioral control* (PC) is the emotional response to the difficulty of performing a behavior [1, 13-15]. Reference [16] found self-efficacy, requisite resources and technical support to determine PC. The absence of PC control refers to any negative emotional attachment regarding the task in question that requires a specific behavior, e.g. lack of resources. User *commitment* describes the user's psychological attachment to system use [10]. Rather than just complying with the beliefs of other's the user wants to comply following its own beliefs. There are three types of commitment, each satisfying different personal goals. Internalization relates to behavior adopted because of its content, that is evaluated to be consistent to the user's own personal goals [10]. Identification occurs when the user adopts a behavior not because of the content, but he wants to achieve a satisfying, self-defining relationship to other persons or groups. Identification and Internalization are subsumed to affective commitment. In compliance, the content and the salience of relationships are irrelevant. The adopter of a particular behavior wants to achieve a favorable reaction [3, 8, 10, 11, 17, 18]. According to the definition of motivation [8] this kind of commitment pertains to extrinsic motivation that is regulated from outside the individual user [10]. *System usage* is defined as the amount of system use by the individual user. As satisfaction refers to prior usage of IT/IS, from the perspective of a causal model system usage only acts as an enabler for satisfaction. In consumer behavior *satisfaction* is determined by user's experiences/perceptions and the expectations the consumer established [20-22]. In the field of IT/IS user satisfaction is defined as the net feeling of pleasure or displeasure that results from a specific interaction with the information system [23]. According to this definitions user satisfaction requires usage prior to the evaluation. Satisfaction reflects the hierarchy of consumer needs: Functionality, Usability and Pleasure [24] and is mediated by the expectation of success [20, 25]. *Usefulness* is considered as the perceived usefulness from the user's perspective and is always related to the user's tasks. It includes the items Work More Quickly, Job Performance, Increase Productivity, Effectiveness, Makes Job Easier and Is Useful. Reference [26] proposed task-technology fitness as an appropriate evaluator for meeting user's needs. Therefore we conclude that perceived usefulness copes with the ability to support user's tasks. *Ease of use*, refers to "the degree to which a person believes that using a particular system would be free of effort." This follows from the definition of "ease": "freedom from difficulty or great effort" [4]. *Enjoyment* is related to stimulating, beautiful and pleasurable system attributes[24]. *Expertise* is related to the level of education [27] and describes an individual's characteristics of domain experience [27, 28], prior similar experience with and knowledge about technologies and systems in general and especially regarding the IT/IS in question. These models do not provide any insight into individual reactions to social and technological change processes. Therefore we have to extend these models and factors described above to be applicable to a business IT/IS context. They provide the basis for our extended behavior model which we present in the following.

5 An Extended Intention Model as a Basis for Business IT/IS Usage

Based on the TPB factors, IT/IS usage intention underlies subjective norms, attitude and perceived behavioral control (Figure 1). Subjective norms are formed by the extrinsic reinforcement of compliance; another form of subjective norm is Identification [12]. Additionally to this extrinsic type of motivation employees can be intrinsically motivated, that is, when users use the system because usage of the system satisfies them and helps them to achieve goals, e.g. accomplish tasks. With respect to user's uncertainty and self-efficacy the intention model is extended with the perceived control of change which is subsumed with perceived behavioral control to perceived control of behavior and change (PCBC).

Fig. 1. An extended IT/IS usage intention model based on Ajzen's TPB [1]

The uncertainty when introducing new IT/IS is expressed in its opposite, self-efficacy, which refers to the ability to deal with uncertainty in a changing socio-technical system breaking up processes and organizational structures. Based on Sydow's model of a socio-technical system [29], that includes the items Task, Technology, User and Role in the primary work environment, we define the uncertainties: **Task Self-Efficacy** (User - Task)**:** The user is aware that he has the required skills. He is sure to be able to accomplish the new or changing tasks with the available resources. **Technology Self-Efficacy** (User - Technology)**:** The user is sure that he will be able to use the new IT/IS. **Structure Self-Efficacy** (User - Role): The user is sure, that although tasks and technologies are changing he will hold his role within the organizational structure. **Process Self-Efficacy:** Process self-efficacy refers to the overall control of task execution in the primary work environment. The user is sure that he will be able to transform the given input into the desired output within the business process. As all these self-efficacies regard to both control beliefs and fears of change we combine these to the perceived control of behavior and change (PCBC). Similar to perceived behavioral control directly related to the behavior in question, PCBC affects the psychological attachment regarding a specific behavior and therefore the intention to use.

6 An Extended Behavior Model for Business IT/IS Usage

By putting all building blocks together (factors, motivation models and polarities of relationships) we can finally construct an extended behavior model for business IT/IS usage. Figure 3 presents relationships between the system variables and the type of relationship, which is related to the causal loop diagram notation. "+" refers to a positive relationship: increasing the value of a variable increases the value of the related variable. On the other hand "–" represents a negative relationship, indicating that a modified value of the independent variable causes the value of the related variable to change in the other direction [30]. Based on the presented intention model the types of relationships and feedback loops are added to form the causal model. Additionally we add the following relationships:

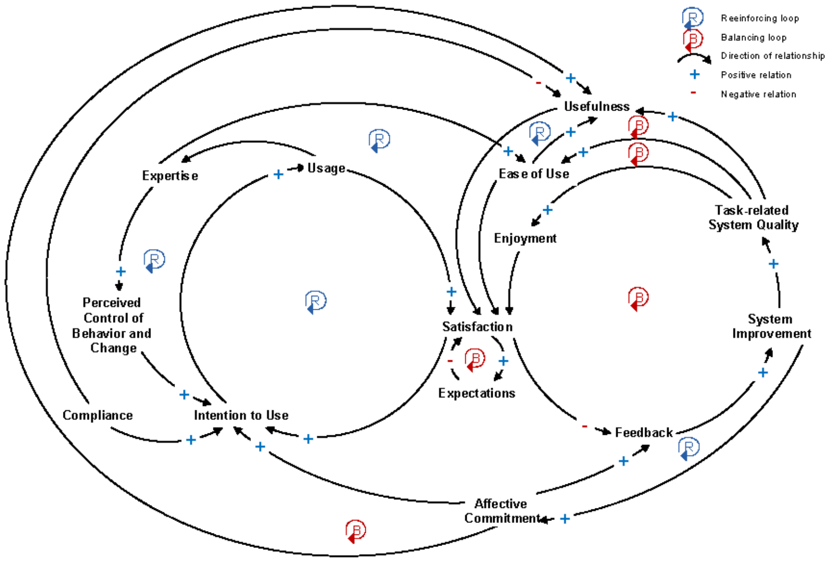

Fig. 1. The Business IT/IS usage behavior model shows the factors and the feedback loops

Using the system enhances user's expertise with the IT/IS and in general with technology through the cognitive learning process (Usage is positively related to Expertise). This familiarity and experience [1] with IT/IS improve task and technology self-efficacy (Expertise is positively related to PCBC). Similar prior experiences and expertise with the new IT/IS enable greater learning and a more positive perception of ease of use [12, 27, 31] (Expertise is therefore positively related to Ease of Use). [24] defined the overall needs to be functionality, usability and pleasure (enjoyment). The fulfillment of personal needs results in satisfaction. Thus the higher usefulness and ease of use the higher the satisfaction [23]. According to this concept enjoyment improves satisfaction too [32-34] (Usefulness, Ease of Use and Enjoyment are positively related to Satisfaction). A good non-subjectively defined task-related system quality will by trend lead to high usefulness and ease of use. Even enjoyment can result from a good task-related system quality (Task-related System Quality is positively related to Usefulness, Ease of Use and Enjoyment).

According to [4] ease of use enhances usefulness (Ease of use is positively related to Usefulness). Missing satisfaction in the best case brings users to complain (Satisfaction is negatively related to Feedback). Another possibility to gain feedback is to drive it through affective commitment. When users commit to a good system quality they are engaging more in system improvement (Affective Commitment is positively related to Feedback). In case of the availability of resources this feedback can be transformed into system improvement leading to a better task-related system quality and a higher commitment. Due to affective commitment users will invest greater effort in learning and using the system and find it more useful [10]. Even compliance can enforce intention to use [35]. On the other hand it was found to reduce perceived usefulness and ease of use [9, 10].

8 Analyzing the Model

The model consists of five reinforcing and four balancing loops. In a reinforcing loop starting from one factor and going around the loop ends up in increasing the value of the factor. E.g. increasing Intention to Use enhances Usage of the system, which in turn enables Satisfaction, which will increase Intention to Use. The second reinforcing loop includes Intention to Use, Usage, Expertise, PCBC. Intention to Use enhances system Usage, that leads to improved Expertise. As Expertise reduces the anxieties regarding the new technology and the modified task, PCBC is improved, which in turn leads to higher Intention to Use. Expertise also occurs in the third reinforcing loop: better Expertise leads to the perception that the system is easier to use, improving Satisfaction, which leads to a higher Intention to Use, Usage and improved Expertise. As Ease of Use is improving Usefulness, a fourth reinforcing loop can be identified (Expertise, Ease of Use, Usefulness, Satisfaction, Intention to Use, Usage). From the fifth loop Affective Commitment turns out to be a driver for System Improvement.

In a balancing loop increasing one factor and going around the loop ends up in decreasing the original value of the factor (or vice verse). E.g. high Expectations tend to lower Satisfaction, which in turn over time leads to reduce expectations. The other balancing loops encourage feedback from dissatisfied users. Providing that there are enough monetary and human resources and knowledge for system development, feedback can yield to system improvement activities, which improve the Task-related System Quality. As Usefulness, Ease of Use and Enjoyment result from Task-related System Quality and end up in Satisfaction, three balancing loops can be identified.

Identifying these reinforcing loops it is obvious that there are several factors driving IT/IS usage and few factors limiting IT/IS usage. PCBC represents the anxiety and uncertainties regarding the change in a socio-technical system. The lack of PCBC may inhibit the intention to use and therefore usage of the system and is therefore absolutely required for intention to use. Even usage is limited to the amount that is useful to accomplish tasks in the primary work environment. Bringing users to comply decreases the perceptions about usefulness of a system and therefore lowers the impact of one main driver of Intention to Use, which is Satisfaction. As we found the relationship between Satisfaction and Feedback to be rather weak, Affective

Commitment enables greater System Improvements than it can be achieved by dissatisfied users. As Usage only acts as an enabler to Satisfaction, the reinforcing loop obviously is a rather weak one.

9 Future Work

The model presented in this paper integrates technological and task related issues as well as the human and social change processes. Feedback factors were identified demonstrating that continuous usage of IT/IS is a consequent evaluation process of individual positive and negative perceptions. The causal model enables the identification of barriers to IT/IS implementation success and therefore offers the opportunity to soften impeding factors and reinforce motivating factors. Nevertheless IT/IS usage in business environment remains a complex field of investigation. Future work has to be done to validate the conceptual model further using comparative, detailed case studies throughout industries. This will provide possibilities to support an optimal IT/IS implementation process. Further strategies have to be identified to ensure the individual adoption of IT/IS in an business environment.

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