SOFT SYSTEMS METHODOLOGY AND COGNITIVE MAPPING: 
A LINKAGE BETWEEN THE INITIAL PHASES OF SSM

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ABSTRACT
This paper discusses the features of Soft Systems Methodology (SSM) and Cognitive Mapping including how they can be used as combined analytical tools. The combination of these approaches is demonstrated in a case which investigates the complexity of compulsory school teachers’ use of digital technologies in their everyday practice. The research followed a focused ethnographic approach, based on observations and interviews, which allowed the researcher to collect rich empirical data that related to various stakeholder perspectives. These perspectives affect the everyday practice of the school teachers and their possibilities to combine use of digital technology in education and own teaching philosophy.

Through the combination of Cognitive Mapping and one of the SSM modelling techniques we demonstrate an approach that bridges the richness of the real world situation and the analytical phase of SSM. This approach advanced the understanding of underlying factors that contribute to the complexity of this particular situation and enabled insights which, if transferred to appropriate actions, may lead to an improved situation for involved stakeholders.

Keywords: Cognitive Mapping; compulsory education; focused ethnography; Technology Enhanced Education; Soft Systems Methodology; Systems Thinking

INTRODUCTION
Effective autumn 2011, all Swedish schools adopted the latest national curriculum for the compulsory school, preschool classes and the leisure-time centers, Lgr11 (Skolverket1, 2011a; b). One of the stated fundamental tasks and goals for the schools is to ensure that all students, when completing compulsory school, can use (modern) digital technology as a tool in search for knowledge, communication, creativity and learning (Skolverket, 2011b, pp.13-14). In April 2016, the Swedish National Agency suggested a national IT-strategy which forms the base for additions to steering documents related to use of digital technologies. These additions are clarifications which are to be implemented by July 2018. However, they may be implemented earlier, from July 2017 (Regeringskansliet, 2017).

Implementation of digital technologies in schools has been a priority in governmental policies. However, the implementation does not succeed by itself (e.g., Grönlund, 2014;
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Salavati, 2016); there are several interest groups involved that should cooperate to enable a coherent and effective implementation (e.g., Grönlund, 2014) and, thereby, to achieve a change process which includes digital technologies in everyday educational practices. For this reason a systems approach (Checkland, 2000; Checkland & Poulter, 2006; Reynold & Holwell, 2010) was adopted to enabled analyzing the complexity and multi-stakeholder interests in educational practice.

In addition to the multi-stakeholder aspect of the research it is also relevant to acknowledge the complexity of the teacher profession. How teachers perceive themselves as professionals, and what beliefs and values they have in relation to teaching and learning, influence teachers’ everyday decisions, and hence practice (e.g., Tondeur, et al., 2008; Korn, Stephen & Slikorski, 2012). The teachers can be: student-centered, which research indicate tend to be high-level technology users in their teaching, teacher-centered, which tend to be low-level users of digital technology in their teaching, or a hybrid (e.g., Tondeur, et al., 2008; Salavati, 2016). Additionally, teachers’ attitude and willingness, as well as knowledge of digital technologies and knowledge of subject content, pedagogy and learning have also an influence on their integration and use of digital technologies (e.g., Mishra & Koehler, 2006; Gaffney, 2010; Salavati, 2013). Further, external factors such as the school leadership, organizational culture and traditions influence and affect the complexity of teachers’ practice using digital technologies (e.g., Gaffney, 2010; Ottestad, 2013; Salavati, 2013). Hence, the complexity of the teacher profession required an approach which enabled understanding the worldview and the purposeful and meaningful actions the teachers perform in their everyday social context (Salavati, 2016).

A major challenge found when carrying out empirical research in this particular complex real world situation was representing and analyzing the rich and extensive data. This was addressed by applying Soft Systems Methodology (SSM). The techniques of SSM enabled handling the vast amount collected empirical material in a structured manner as well as enabled rich illustration of the complex situation. However, the challenge of bridging the representation of the rich empirical material and the analysis consisted. This was tackled by combining Cognitive Mapping and one of the SSM modelling techniques (Salavati, 2016). The combination enabled bridging the richness of the real world situation and the analytical phase of SSM. Cognitive Mapping simplified the SSM process both in terms of identifying a balanced level of abstraction and detail, and simultaneously staying within the scope and aim of the specific research.

The focus of this paper is to present how Cognitive Mapping have been used as a linkage between the first and second phases of Soft Systems Methodology. This paper is structured according to the what, how and why of SSM’s simplified Root Definition (Checkland & Poulter, 2010). The Introduction of this paper acts as why Soft Systems Methodology in combination with Cognitive Mapping was applied in the case of advancing understanding of teachers complex everyday practice using digital technologies. The third section demonstrate what has been done in the investigation while the following section explain how SSM and Cognitive Mapping have been used together with Focused Ethnography which was applied as the data collection methodology. The paper is finalized by presenting the learnings and outcomes combining features of SSM with Cognitive Mapping.
WHAT WE HAVE DONE

As mentioned above a systems approach was applied exploring and analyzing varying worldviews and modelling purposeful human activity systems. The overarching aim was to advance understanding of the complexity of teachers’ everyday practice using digital technologies.

A systems approach is by e.g., Checkland (1981) described as useful to understand the complexity of the world. The real world is described by Checkland (2000; 2011) to consists of situations where humans attempt to take purposeful actions that are meaningful for them; in Soft Systems terms referred to as purposeful human activity systems (Checkland, 2000; 2011). Checkland (1981, p.111) describes human activity systems as “innumerable sets of human activities more or less consciously ordered in whole as a result of some underlying purpose or mission”. Human activity systems represent the viewpoint of humans as observers of the real world and their points of view which depend upon where observations are made.

Besides purposeful activity systems, worldviews are fundamental to the systems approach and have been central to this research case. Mingers (1980) describes the notion of worldview as capturing humans’ experience of the world in terms of purpose, knowledge, values, expectations, etc. which are developed in various ways including previous experiences. In Checkland’s earlier writings this is termed Weltanschauung. (Checkland, 1981).

To gain understanding and insight in the varying worldviews of the actors involved, we carried out quantitative data collection, applying an ethnographic approach. The upcoming subsection describe the empirical data collection process followed by reporting on the analysis process.

Focused Ethnography

The methodology for collecting empirical data followed a focused ethnographic approach (Knoblauch, 2005), also known as short-term ethnography (Pink & Morgan, 2013). Following the ethnographic approach, it enabled to gain first hand experience of what it means to be a human within a particular social and cultural context (Pole & Morrison, 2003; Madden, 2013). Ethnographical studies emphasize on observations of people in their natural occurring settings, seeking to build theories of culture and societies as well as theories of behavior and attitude of humans (Randall, Harper & Rouncefield, 2007; Madden, 2013). People are studied in typical circumstances, where they interact with one another in routine, or even ritualized, ways specific for that situation (Madden, 2013). The ethnographer carrying out ethnographic studies, besides taking a holistic approach to the study subject, also contextualizes the social settings and social relationships in a wider context, e.g., government policies, politics, wider economy, etc. (Tacchi, Slater & Hearn, 2003 p.9). This allowed us to gain broad understanding and enabled representations and analysis of varying purposeful human activity systems.
Observations and interviews were the methods used for collecting data from the everyday practice of the included actors. Four teachers from two different schools were observed, following their every step and everyday routines for approximately one week each. No specific observation guide was followed. Instead extensive notes on what was seen, learned and reflected upon were recorded. The interviews carried out with the teachers were formal but also informal as part of the observations. Further, school leaders of the participating schools as well as representatives from the department of education at a municipality in south of Sweden were interviewed formally following semi-structured interview guides.

Of importance, and one of the main characteristics of ethnography, is the emic and etic perspectives of human behavior. The emic perspective reflects the participants’, or the insiders’, points of view (Fetterman, 2010; Madden, 2013). The etic perspective, on the other hand, reflects the researchers’, i.e., the external, points of view (Fetterman, 2010; Madden, 2013). For the research conducted both the emic and the etic perspective of ethnographic research were used. The emic perspective, i.e., the participants’ perspective, was applied in the data collection and the first steps of the data analysis where the informants’ wordings and formulations were used. The etic perspective, i.e., the researchers’ perspective, permeated the entire research based on the ambitions of the research, i.e., advancing the understanding of teachers’ complex everyday practice when using digital technologies.

**Soft Systems Analysis**

To represent and analyze the empirical material Soft Systems Methodology (SSM) was used. SSM provided a structured approach to explore and illuminate the contextual and multi-dimensional complexity of the situation. The Soft Systems analysis was twofold where initially an SSMp analysis was conducted (cf. etic perspective) and thereafter an SSMc analysis (cf. emic perspective). The SSMp analysis addressed the process and intervention of the researcher, enabling to identify the purposeful focus for the SSMc, i.e., the content. These are described shortly towards the end of this subsection.

Mingers and Taylor (1992) depict SSM as an approach which enables gaining understanding of people’s views and perspectives. Checkland himself states SSM to allow taking various and at times conflicting worldviews into account which facilitate understanding complex and ill-structured problematic situations (Checkland & Poulter, 2010). Exploring and advancing the understanding of the complexity of teachers’ everyday practices required a methodology, such as SSM, taking in and analyzing various worldview in order to gain a more holistic understanding. In the research carried out we followed the SSM Learning Cycle. The SSM Learning Cycle is described in four phases: (1) finding out about the real world situation, (2) creating purposeful activity models based on explicit worldviews, (3) questioning the perceived situation based on the models, and (4) taking action to improve (Checkland, 2000; Checkland & Poulter, 2006; Checkland & Poulter, 2010).

The modeling in the first phase, finding out, was based on the Rich Picture technique. Rich Pictures allows to capture rich representations of a real world situation without using certain system terms or following a rigid structure. This enabled a more holistic thinking.
about the situation (Jackson, 2003; Checkland & Poulter, 2006). As mentioned above one of the challenges of the research was representing the rich and extensive empirical data collected. SSM Rich Picture technique, in a simple and comprehensive manner, provided capturing and richly representing the complexity of the real world situation, including several actors and their worldviews. The ideal of Rich Pictures is to provide an easily understandable overview and insight into the complex situation. However, for this research a high detail-level was chosen in order to be as close as possible to the perceived real world situation. Figure 1 illustrates the Rich Picture which represents and illustrates the complex real world situation of teachers’ everyday practice using digital technologies.

![Rich Picture of teachers' complex everyday practice using digital technologies](Salavati, 2016)

The Rich Picture depicts the teachers in the center, the municipal IT-unit at the top left, the municipal representatives at the left and the school leaders at the bottom left. The top of the picture illustrates the home environment of the teachers while the right-center illustrates the classrooms and varying ways of working with digital and traditional technologies. The teachers’ philosophy of teaching is presented at the right top corner in a blue sphere. The bottom right of the picture exemplify varying student groups and how they use digital technologies.

Based on the Rich Picture, the second phase of the SSM Learning Cycle, the modeling, was carried out creating PQR-statements, CATWOE and Activity Models (Checkland & Poulter, 2010). PQR stands for what, how, and why with the aim to capture the transformation, which are further evolved in the CATWOEs and Root Definitions. CATWOE is a mnemonic representing Customer, Actor, Transformation, Worldview,
Owner and Environmental Constraints. Activity Model delineates the activities needed to describe the transformation process presented in the CATWOE and PQR.

For each teacher, school leader and representative, initially a Cognitive Map was created and, based on that map, PQR-statements were developed in line with the SSMp analysis. Building on the PQR-statements, CATWOE and thereafter Activity Models were developed which enabled a more detailed analysis. These were later used to question the real world situation and by that contribute to a debate about change (e.g., Checkland, 2000; Checkland & Poulter, 2006). The modelled Purposeful Activity were based on the roles and perspectives of the actors.

As stated in the beginning of this section the Soft Systems Analysis and use of SSM was twofold, initially conducting an SSMp analysis and thereafter an SSMc analysis. Checkland and Winter (2006) as well as Checkland and Poulter (2006; 2010) describe SS Mp and SSMc, short for the process of using SSM and short for the content of the problematic situation, respectively. Since a study, according to Checkland and Poulter (2010, p.213), “can be thought about, and planned, using models relevant to doing this”, SSM was used for deciding how to carry out the study.

Initially a SS Mp analysis was carried out based on a Cognitive Map focusing on the researcher and the aim of the research. Based on the Cognitive Map several PQR-statements were developed, which enabled identifying what was considered relevant for further analysis of the study content and why these were relevant. The Cognitive Map was based on the initial understanding of the collected empirical material. The outcome of the SS Mp resulted in both “Primary Task” and “Issue Based” PQR-statements (Checkland & Poulter, 2010, p. 222-223). Particularly the Issue Based statements guided the SSMc analysis, which next was carried out. Based on the Cognitive Maps created for each actor a number of PQR-statements were developed and thereafter CATWOE and Activity Models was created. How these models have been created, and how they draw upon each other, is presented in the upcoming section, however first an overview of Cognitive Mapping is given.

Cognitive Mapping

Cognitive Mapping originates in the field of psychology and the work of Kelly (1955) on Theory of Personal Constructs (Eden & Ackerman, 1998; Westcombe, et al., 2002; Eden, 2004). It emerged out of Systems Methodologies, and specifically Operational Research (OR), mainly due to the work of Colin Eden (Westcombe, et al., 2002; Reynold & Holwell, 2010). Within OR, Westcombe, et al. (2002, pp.3) describe Cognitive Maps as “a two-dimensional directed graph [...] that represents the way in which a person defines an issue”. Cognitive Mapping is a formal modeling technique with rules for understanding how humans make sense of their world (Eden, 2004).

The maps are characterized by a hierarchical structure with a goal statement positioned at the top of the hierarchy (Eden, 2004). The nodes consist of short texts, ideally 8-10 words in imperative form and, as far as possible, are based on the wording expressed by the individuals (Westcombe, et al., 2002). The arrows are unidirectional where the node, or statement, at the tail of an arrow is the cause, or influence, for the node at the arrowhead.
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(Eden, 2004). Eden (2004) argues that despite the simplicity of Cognitive Maps, they should not be considered as word and arrow diagrams, or mind-maps. According to Westcombe, et al. (2002), Cognitive Maps help, to see a bigger picture which other representations or conversations cannot; the maps enable understanding of cause and effect relationship between nodes within that specific context, including the worldview of the person. The maps enable getting close to the world of the person of interest (Eden, 2004).

In the research context, that is, teachers’ use of digital technologies in everyday practice, Cognitive Mapping was used as initial models to map different actors’ thinking. Figure 2 presents four out of eight Cognitive Maps drawn.

Figure 2. Cognitive Maps (Salavati, 2016)

Cognitive Mapping enabled to map and represent how a person thinks about a problem, situation or issue, which was beneficial for bridging the representation of the empirical material and the analysis. The hierarchical node structure of the Cognitive Map enabled identifying the hierarchy of the PQR statements in the Purposeful Activity modelling. One node on one level represents one R (why), the nodes on the level below represents the P (what) and the nodes below to that represent the Q (how). The combination of PQR and Cognitive Mapping is described in greater detail in the upcoming section.

HOW WE HAVE DONE

The empirical material collected, both observation and interviews, was transcribed verbatim and sent to each informant for verification to avoid any misunderstanding.

Based on the collected empirical material a highly detailed Rich Picture was developed (Figure 1). The Rich Picture was hand drawn, using sketching application, in order to maintain its traditional nature. The hand drawn approach was also applied for the Activity Models. The purpose to hand draw the SSM models is, as argued by Checkland (Checkland & Poulter, 2010), to convey an organic impression. Hand drawn models is argued to look more human and attractive as they can be seen as working diagrams and part of a learning process rather than conveying an impression of blue prints when straight lines and angles are drawn (Checkland & Poulter, 2010).

As stated above, initially a SSMp analysis was conducted of the research process. The Cognitive Map for the SSMp built on an initial understanding of collected empirical material and findings from previous research and other literature. The Cognitive Mapping
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was initiated by adding the overall research aim at the top and thereafter three nodes were identified which contribute to achieve the overall research aim. This process of identifying nodes on lower level, which contribute to achieving higher level nodes, was carried out until no additional relevant nodes could be identified. Figure 3 illustrates the Cognitive Map (a) and two of the PQR-statements (b & c) of the SSMP analysis.

**Figure 3. SSMP analysis (Salavati, 2016)**

In the Cognitive Map the lower level nodes include more detail about how the researcher understands achievement of a higher level node. Echoing the example by Salavati (2016, p. 160-161) the node ‘illustrating the current situation of teachers’ use of digital technologies in everyday practices’, presented at the right side of Figure 3, is based on the lower levels, such as ‘find out about the situation by making a Rich Picture which includes analysis 1-3’ and ‘describe the teachers changed status’. As the next step, based on the Cognitive Map, PQR-statements were identified. The translation of the Cognitive Map to a PQR statement is as follows:

R (why) = illuminate and advance the understanding of the complexity of teachers’
everyday practice using digital technologies;

P (what) = illustrate the current situation of teachers’ use of digital technologies in everyday practice, and;

Q (how) = find out about the situation by making a Rich Picture and including analysis 1-3

It should be noted that the order of the PQR elements was changed in the Cognitive Map. It should be read RPQ. The change has been made in order to find the correct relation between the what (P), the how (Q) and the why (R), as well as acknowledging that each higher level node can have several lower level nodes. This implies that each R (higher level node) can have several P’s (lower level nodes) which in turn can have several Q’s (lower level nodes). Further, it is possible for a P to become a R in a second PQR statement focusing on a lower level of detail. The combination and ordering of R, P and Q are chosen
based on what is most central and relevant for the aim of the modelling and overall research aim.

The same procedure and logic was applied for the Cognitive Maps in the SSMc analysis. The Cognitive Mapping and Purposeful Activity Models in the SSMc analysis was based on the collected research material represented in the Rich Picture.

For the teachers the Cognitive Maps represented two focuses, their philosophy of teaching (illustrated with blue color in Figure 2 a;b) and the use of digital technologies (illustrated with black nodes and arrows). Both focuses were chosen to be illustrated within the same map. The reason to do so was to visualize a more complete and comprehensive understanding of the specific teachers’ worldview and how they define and make sense of the particular context.

Based on the PQR-statements identified in the SSMp analysis, relevant PQR-statements for the varying actors for the SSMc analysis was identified in the individual Cognitive Maps for further modelling. The modelling then continued following the SSM guidelines for building Purposeful Activity models (Checkland & Poulter, 2010, p. 220).

**LEARNINGS AND OUTCOMES**

In order to evaluate and reflect on learnings and insights gained combining SSM and Cognitive Mapping, based on a Focused Ethnographical data collection, Checklands’ LUMAS model was used (Checkland, 2000; Checkland & Poulter, 2010). Learning for a User by a Methodology-informed Approach to a Situation, abbreviated as LUMAS, is a generic model based on the three elements of user, methodology and situation as perceived by the user of the methodology (Checkland, 2000; Checkland & Poulter, 2010). These three elements are linked and interacting with each other when a user who is knowledgeable about a methodology perceives a problem situation and uses that knowledge of the methodology to improve the situation (Checkland, 2000). Checkland (2000) argues this generates new learning and experience for the user, and it can also lead to enrichment and modified appreciation of the methodology (Checkland, 2000; Checkland & Poulter, 2010).

The learning gained applying a system approach to this complex case, and especially combing the initial analytic steps of SSM and Cognitive Mapping resulted in handling and coping with the real world complexity and enabled communicating this complexity. Moreover, in the research carried out the notion of purposeful human activity systems supported understanding the multi-dimensional perspectives of teachers’ complex real world situation.

As stated by Checkland and Winter (2006), we confirm that SSMp enabled us to organize our thinking of carrying out the analysis of the real world situation, to clarify what should to be done and how without getting deeply absorbed in the complexity of the situation. The SSMp also enabled handling the difficulty of keeping the emic and etic perspectives apart. The difficulty of not allowing the etic (researchers’) thoughts and understanding to be included in the emic (participants’) understanding was simplified by having a Cognitive Map based on the research aim and process (SSMp). Combining Cognitive Mapping and
SSMp (see Figure 3) enabled to design the focus and emphasis for the SSMc analysis – i.e., avoiding to become too detailed or too abstract in the modelling.

Applying Cognitive Mapping extended the linkage and provided bridging between first phase (representing the situation) and the second phase of SSM (building Purposeful Activity Models). Using PQR statements identified through Cognitive Mapping allowed identification of relevant levels of modeling as well as creation of more holistic understanding about how varying systemic models were interconnected.

As a final reflection, one of the biggest strengths of SSM, in addition to serving as a structured way to represent, analyze and describe complex, messy situations, is its foundation in Systems Thinking. The Systems Approach enabled to see more than a number of parts in isolation within the “digital-technology-in-education whole”; it enabled also to see the relationship between the parts and the emerging properties when looking at the situation as a collective whole.

ACKNOWLEDGEMENTS
Initially the authors would like to acknowledge Mark Westcombe at Lancaster University for raising our interest in Cognitive Mapping in a SSM context. Additionally, we acknowledge professor Christina Mörtberg for giving valuable support and guidance in the original research which this paper builds upon. Finally, we thank professor emeritus Peter Checkland for inspiring ideas throughout the years.

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