Framing in Educational Practices

Learning Activity, Digital Technology and the Logic of Situated Action

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Annika Lantz-Andersson

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Abstract

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An overarching ambition of this thesis is to study the *in situ* practices that emerge when technology becomes part of educational activities and, in addition, to examine what students' definition of such activities will be. By analysing students' concrete uses of digital technology in regular classroom practices, the study intends to demystify how digital technology co-determines activities in educational settings. A background of this interest is that there are many different claims in the literature and in the public debate regarding what learning will be like when such tools are used. Accordingly, the use of digital technologies is in this thesis studied from the perspective of student activities and rationalities. Analytically, this is done within a sociocultural perspective and, in addition, with the help of the conceptual distinctions of frame analysis. Empirical material have been collected via video recordings of secondary school students' engaging in solving word problems in mathematics presented by means of educational software. The analyses aim at scrutinizing what the presence of educational software in mathematics implies for the students' learning practices in situations when they encounter some kind of difficulty in their problem solving. The results, presented in three studies, show that for long periods of time the students' interaction involved not only the contents but also different functionalities and design qualities of the digital technology. The findings in this study thus point to the need to question the alleged benefits that surround the implementation of digital technologies. According to the empirical findings in the three studies presented in this thesis, along with knowledge from previous research, digital technology cannot be said to improve learning in any linear sense. Instead, educational activities involving the use of digital technologies imply a *different* way of learning with new possibilities and new problems; a different pedagogical situation and a different relation between the students and the contents.

Contents

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Annika Lantz-Andersson

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PART I

1. Introduction

The general background of this thesis is an interest in the encounter between digital technologies and educational practices. Educational tasks are intended to work in certain ways with specific goals, and the question is: what happens to task situations and educational activities when digital technology is used? Digital technologies are no doubt part of most activities in society, and there is considerable pressure to implement these technologies in educational practices. Many scholars refer to our present time as a Knowledge Society or Information Society. This does not, however, mean that knowledge has been of less importance during other periods but the difference is the enormous expansion of digital technology and the easily accessed information that have bearings on many aspects of our professional lives and leisure time (Hansson, 2002). To some extent, digital technologies are also making their way into classrooms but, as yet, relatively little is known about what kinds of learning practices these digital tools offer. This study contributes to the field of knowledge about digital technologies in educational settings with a focus on how activities with digital tools appear from a student perspective.

The implementation of digital technology in educational practices has been shown to be a trying mission. Despite enormous capital investments in ventures and projects with the aim of implementing digital technology in educational systems that have been executed world wide, the mission is far from being completed. As I will discuss later, many large-scale attempts to introduce digital technology have not been entirely successful or have even failed (cf. Cuban, 2001). Suggested reasons for this challenging process are, for example, that teachers are not used to and do not have adequate training in the use of digital technology, that digital technology does not meet the needs of education, that most applications are not produced with a classroom setting in mind, etc. The problem of implementing can also be viewed in the light of earlier media. By tradition, new tools tend to initially be approached with either suspicion or exaggerated promises of revolutionising schooling. Digital

technologies are no exception, and now face similar speculations and assumptions about a fundamental change in teaching and learning that surrounded the former media, for example, radio, television and video (Cuban, 1986; Dunkels, 2007; Karlsohn, 2009; Papert, 1984, 1993). The claims that surround the introduction of digital technologies in school, thus, include both promising possibilities and ominous concerns (Limberg, Alexandersson, & Lantz-Andersson, 2008; Linderoth, Lantz-Andersson, & Lindström, 2002; Postman, 1979; Selwyn, 1999). Many claims have been made about various matters and problems on different levels that the implementation of digital technologies is supposed to solve. In this thesis, I will present some of the claims made, examine them and relate them to the empirical findings of my study. The diverse argumentation concerning the benefits of digital technology indicates one difficulty in the field of educational research. One reason is that several of the findings emanate from more or less experimental studies or short-term interventions, which have been hard to replicate in an everyday school practice (e.g. Arnseth & Ludvigsen, 2006; Egenfeldt-Nielsen, 2006; Schrum et al., 2005). The study presented here contributes to the discussion in relation to earlier studies with a focus on *how* students reason when they *solve* tasks presented by educational software in a setting where digital technology is already used as part of the *ongoing, everyday practice*.

To be able to study the use of digital technologies on a student level and to be able to scrutinize how the activity appears from a student perspective, I have chosen two theoretical perspectives; a sociocultural perspective (Lave & Wenger, 1991; Vygotsky, 1934/1962, 1939/1978; Wertsch, 1998; Wells, 1999; Säljö, 2000) and the frame theory derived from Goffman's (1974/1986) micro sociological and interactional perspective. From a sociocultural perspective, the situated nature of human reasoning and learning is viewed as contextually dependent. Learning can also be seen as a side effect of the activities that we participate in. Given this basis, activities are created by the participants' interaction and action. In Goffman's (1974/1986) terms, people make sense of activities and situations by *framing* what is said and done in certain ways. The framing concept is a metaphor for how we define a situation and thereby make sense of the utterances, actions and events we encounter (Linderoth, 2004), something that usually is unproblematic and not reflected upon. According to this perspective, we understand activities that we attend to by using our previous experience of similar situations, even if the

activity we attend to is new to us. We more or less implicitly ask our selves "what is going on here?" (Goffman, 1974/1986, p. 8). And the answer to that question then forms the relatively shared understanding that we have with the other participants in the situation. Here, the framing is thus seen as constituting the activity and is fundamental for what is possible to learn in a certain activity. The meaning of an utterance, an action, or an event is dependent on how we have framed them in the specific activity and it helps us to interpret and understand and how to continue with the activity. In the light of the perspective adopted here, how the framing of the situation is negotiated by the participants in a certain activity is crucial for the researcher to consider in order to aim at understanding how the activity is understood by the participants. What the framing concept implies for this study, and how the sociocultural perspective and Goffman's interactional perspective have been incorporated in the study, will be further elaborated on later.

By studying how students frame what is said and done in learning activities when digital tools are used, it has been possible to point out certain interactive patterns. Empirical material have been collected through video recordings of secondary school students' engaging in solving word problems[2] in mathematics presented by educational software. Implications of word problems in mathematics will be discussed in the Background chapter and a detailed description of the specific educational software that the students in this study used can be found in the Research context chapter. From an analytical perspective, the issue of how students collaborate with school tasks in the context of educational software in mathematics classrooms raises various questions. For example, the focus could have been on an organizational level, on technological issues, on making a didactical analysis of the mathematical content, a comparison with traditional mathematical textbooks, etc. However, the focus here has been on students' activities when solving school tasks in relation to a digital tool and what kind of resources[3] are brought into play to handle the activities. The focus is not on the

[2] Word problems are tasks in mathematics that are formulated in ordinary language. This will be further discussed later on.

[3] The concept of resources as used in this research comprise e.g. prior knowledge, various communicative abilities, conceptual knowledge about the concrete setting, knowledge about how to use the various tools available, the prior utterance, the participants' background assumptions both of the issues talked about and about other persons involved, the socio-historically constituted context of institutions, etc. A further explanation of how the concept of resource is employed in this research can be found in the chapter "Theoretical perspectives on learning activities".

institution, the technology, the individual or the collective in isolation but the interplay between all these elements. What I will analyze is how the students engage in what Säljö (2004) calls "the activity of studying" (p. 491), while using educational software, rather than how they learn. The exact implications of this will be further explained in the text.

Aim

The aim of this thesis is to study activities in educational settings where digital technology is used on a regular basis. The analyses aim to scrutinize what the presence of educational software in mathematics implies for the students' learning practices. The study focuses on how utterances, actions and events are framed by the students when using the digital tool. More specifically, the focus is on the students' activity when solving mathematical word problems. The unit of analysis in the study is interaction among secondary school students when working with educational software, and how they reason and argue during such activities. In the Goffman (1974/1986) tradition, in which this thesis is written, this implies an interest in how the students frame utterances, actions and events and how they go on with their work at hand.

The following overall research questions have guided the study:

How do the students act and reason in the activity of solving mathematical word problems when using educational softwares in regular classroom practices?

What happens in situations where students encounter difficulties in solving the word problems, and how do they resolve such problems and continue their work?

How can the learning activities, and the difficulties the students encounter, be understood in terms of frame theory and its conceptual distinctions?

Outline of the thesis

This thesis is divided into two parts. The first part consists of a background of the field of research along with a presentation and elaboration of the theoretical and methodological assumptions relevant to my study, a summary of the studies, a discussion and a summary in Swedish. The second part consists of the three studies in which the research is reported.

Part one consists of the following chapters:

In the 'Background' chapter, a picture starting in earlier research of learning in educational practices is drawn, together with a discussion on some of the specific implications when solving tasks in these practices. Research on the specific issue of solving mathematical word problems is then introduced, since the students in the studies are engaged in these kinds of tasks. The discussion of educational practices in general is followed by a presentation of research concerning the implications of the introduction of digital technologies in these practices. In this part, I discuss both claims that belong to a policy agenda and research on what the implementation and use of digital technologies looks like in schools. Finally, in this chapter, I discuss educational software as one specific part of digital technologies and point to some of the claims made about how these tools are said to change educational practices and contrast theses claims with empirical findings from earlier research.

In the chapter 'Theoretical perspectives on learning activities', I discuss some of the premises of the sociocultural perspective and the concepts from Goffman's frame theory, which are relevant in relation to my study. First of all, I give an account of how the two traditions are seen as complimentary followed by an explanation of frame theory and its conceptual distinctions, and in addition discuss some other concepts of importance for this study.

The 'Research context' chapter contains a description of the setting, the participants, and gives an account on the entire empirical material. This is followed by an explanation of how the video recording was done and a review of the educational software that the students used in the study.

The chapter on 'Research methods', starts with an account of the choice of video recording as a method. Thereafter, I describe how the analysis is performed and discuss the transcript model chosen in the three studies.

Chapter 6 consists of a summary of the studies and Chapter 7, is a concluding discussion of my findings and a final remark concerning the claims made by the market in relation to empirical findings. Chapter 8 is an extended summary in Swedish.

Part two consists of the following three studies;

I) Lantz-Andersson, A., Linderoth, J., & Säljö, R. (2008). What's the problem? Meaning making and learning to do mathematical word problems in the context of digital tools. *Instructional Science*. Published online: http://dx.doi.org/10.1007/s11251-008-9050-0

II) Lantz-Andersson, A. (2009). The power of natural frameworks – Technology and the question of agency in CSCL settings. *International Journal of Computer-Supported Collaborative Learning, 4*(1), 93-107.

III) Lantz-Andersson, A., & Linderoth, J. (2008). *In the presence of absent designers – Students' frame- clearing processes when solving word problems in the context of educational software*. (submitted 2008, in review for publication)

Definition

There are many ways to describe the field of IT and learning (Bell, 2007; Lievrouw, 2004). There are research traditions that refer to themselves as Electronic-learning (or E-learning), Computer assisted instruction (CAI), Technology supported education/learning (TSL), computer-supported-collaborative-learning (CSCL) etc.[4] What learning is studied in relation to is also described differently, for example, as cyberculture, new technology, digital culture, digital media, information society, new media, the Internet and so on, or as Silver (2004) puts it; "Fill-in-the blank studies" (p. 56). One can argue that the different etiquettes refer to research traditions that are different, but that there are also many commonalities (Bell, 2007). In the following, I use the term *digital technology* to refer to a common element in all these traditions, which is that they study the use of technologies on a computer. This term is chosen in most cases to refer to the overall, general aspect of different kinds of such technologies. Digital technology will be used in a broad sense to discuss, for example, computers in educational settings and the term educational software is used to discuss the application used by the students in my study in a more specific sense.

[4] This study is written within the CSCL field of research, which will be further discussed later on.

2. Background

Introduction

This chapter starts with a general outline of the practice of learning and solving tasks in educational settings. This is followed by examples of studies of the specific practice of solving mathematical word problems in school since this was what the students did when the research was conducted in their school. Thereafter, a background view of the field of digital technologies in school is painted, by discussing the various claims that are made by different actors such as politicians, the market and policy documents, and relating these claims to empirical findings from previous research. Finally, there is a discussion of the pros and cons that are raised concerning educational softwares and possible reasons for the difficulties in implementing such tools as one specific part of digital technologies.

Learning activities

My interest is in what, from a sociocultural perspective, is called *mediation, sense-making* and *meaning making*. In line with Lave and Wenger (1991), learning is seen as "an integral and inseparable aspect of social practice" (p. 31). Learning is thus seen as *mediated* through the use of cultural tools such as writing, spoken language and various physical tools in relation to how people participate in routine activities, in communities of practice, for example, classrooms. In this study, it is the *activities* that the students engage in that are of analytical interest. In a Vygotskian (1939/1978) and sociocultural tradition, the local activity in which people develop understanding, meaning and operate is called *sense-making*. In the context of learning concepts, Vygotsky makes a distinction between *sense* and *meaning*, where sense refers to the manner in which people understand concepts in local practices and meaning refers to the more general lexical meaning. However, different authors use these different terms when referring to the development of local understanding. For example, Kress (2003) uses the term *meaning making* as a basis for understanding all interaction. In the following, I will refer to this as *learning activity* since what is studied is how the students engage in collaborative learning tasks and not what they learn. However, what is studied is activities where learning is seen as the consequence. This is not only a theoretical orientation, it also has epistemological implications for the

assumptions concerning how people learn and appropriate various resources that facilitate their participation in different practices. I will start with a discussion of the specific institutional traditions and conditions that co-create the learning practices in educational settings.

Practices of learning in educational settings

By applying a socio-cultural-historical theoretical view of learning and development, the starting point for understanding the complex, continual and developing character of classrooms is to understand learning activities as social practices (Cole, 1996; Vygotsky, 1939/1978; Säljö, 2000). The social practices of schooling have emerged through history, and these practices include certain discursive procedures with many, both explicit and implicit, rules along with the habits of the teachers and, for instance, individual responses to the normative practice (Edwards & Mercer, 1987; Mercer, 1992). There are many control factors that govern educational practices such as curricula, the economy, the media, the ruling educational theories, etc., and continuous pressure is exerted by different actors, both external and internal. It is important to emphasize that in this tradition, a practice is not seen as static but as something that is established by the participant's interaction. Thus, the participants in educational practices are seen as co-creators of the practices through their mutual engagement in collective activities where they take part in a range of routines, habits, rules, physical tools, conceptions etc. which establish an understanding of the practice.

Studies of practices in educational settings have shown the complexity of the situations but have also criticised the artificial way knowledge is presented, disconnected from a natural learning place in the 'real world' outside school. The discussion about justifying pedagogical innovations, like digital technologies, that create tasks that are more 'authentic' or 'everyday' has to do with the desire to design formal educational tasks so that their solutions will have implications beyond the classroom (Petraglia, 1998).

> Educators and technologists have held out great hope for prospects of increased student engagement in activities that use multimedia, hypertext, and other electronic-based learning applications. These hopes have been largely rooted in the belief that new technological advances will enable educators to contextualize, and thus, bring authentic learning materials and environments into the classroom. (Petraglia, 1998, p. 5)

I have no intention of giving an extensive picture of the immense and divergent discussion about authenticity in educational settings here. However, in relation to this study, two significant issues connected to this discussion will be mentioned. The first has to do with the many promises of students' increased feelings of involvement and reality when working with digital technology, which I will return to further on. Another issue has to do with the sociocultural perspective taken in this research since activities in schools are, in this tradition, not seen as 'unauthentic activities' since all settings and all situations are seen as having their own specific implications for learning. Lave and Wenger (1991) emphasise that learning should be seen as *situated*, which implies that the contexts where the learning takes place are considered fundamental factors of human knowing. The practice of learning in school could then be considered to be another practice, neither more nor less authentic than that of other settings. The studies by Lave and Wenger (1991) have, in relation to these questions, had a significant impact on research on education, even though their studies were performed outside formal education. One reason is most likely that their conceptions of learning have been used "to furnish new metaphors for learning" (Lindwall, 2008, p. 34).

The sociocultural perspective involves studying and analysing the *activities* of learning, that is, to study how people interact with each other and various physical tools in the activity of appropriating knowing. These learning activities could be described as "exchanges between students, teachers and the milieu" (Brosseau, 1997, p. 3). This implies that the physical tools that are available in an activity, which in this study are represented mainly by the digital technology, are really important to consider when it comes to settling what kind of tasks we can solve (Wertsch, 1998, p. 29 ff). Tools, such as computers, are not considered neutral but as mediating certain world views, knowledge and values. Lave and Wenger (1991) emphasize that the activity and participation "involving technology is especially significant because the tools used within a cultural practice carry a substantial portion of that practice's heritage" (p. 101). The analytical focus in this thesis, however, is not the digital tool itself, but how it is used. For example, solving a multi-digit multiplication with decimals, may be perceived as trivial if we have access to a tool like a mini-calculator and the same task could be managed with some effort with the use of pen and paper, but would be a very trying task when doing it as mental arithmetic without any physical tools available (Säljö, Eklund & Mäkitalo, 2006). Another main position that follows this

perspective is that there is always learning, but not always the intended or planned learning.

Studies of learning activities from the perspective of the participants have shown the significance of contextual matters. For instance, research has shown that solving similar problems in different settings gives different results. A concrete illustration of this phenomenon is research on people calculating in grocery stores in order to compare prices, which was contrasted by the solving of similar tasks in classrooms with much poorer results (Carraher, Carraher & Schliemann, 1985; Lave, 1988; Saxe, 2002; Scribner, 1984). Hence, in understanding activities, the overall framing of utterances and actions provides the direction of attention and the relevance structure for the participants. This means that when a task is given within the context of a mathematics class, it will be framed within the frame of 'doing school' in a mathematic classroom, and the activity will be different from a situation in an everyday setting. Furthermore, Säljö and Wyndhamn (1993) showed that the same tasks were differently framed when presented within the context of different school subjects. Their study showed that a task was approached differently in a mathematics class compared to a social science class. What the above studies show is that the practices are different even though the mathematics is similar.

Solving tasks in educational practices

When a task is framed in educational learning environments, students often implicitly try to understand what is demanded. For instance Bergqvist (1999) discusses, in her study of student-guided collaborative work, that the students' achievement in school has to do with their beliefs of what the tasks in school entail. Moreover when students try to understand the underlying intentions, they often have an assumption that there is *one* way of solving the task that is the correct one. Other studies have also concluded that students frequently tend to aim at completing the tasks and assignments with as little effort as possible (Alexandersson, Limberg, Lantz-Andersson, & Kylemark, 2007; Krange & Ludvigsen, 2008). The students' main goals are in these cases to get tasks done and to be able to continue with another task. This orientation has implications for what becomes relevant in the activities. Krange and Ludvigsen (2008) argue that "it is only knowledge that is strictly necessary to solve the problem that is given attention" (p. 45). The foremost concern for

students is then to go on working, that is; "To solve the problem, with or without gaining knowledge" (Krange & Ludvigsen, 2008, p. 45).

The reasoning and action performed by the students can be seen as a response to what Brosseau (1997) has called the *didactic contract*, that is, the rules of communication established in educational settings that participants learn to identify and use as resources. The didactic contract implies, for example, that the teachers ask the questions and give the instructions and that the students answer the questions and perform the activities asked for. This implies that the students also answer the questions given in a exercise book or other teaching media, even if the questions as such are not consider relevant or do not make sense to them.

> Situations of the type that students normally encounter in class tend to present certain closed characteristics. For example, the teacher poses *a* question and all of the students are supposed to find *the* answer - the same one - so that the minute one student publicly produces the answer, all of the others stop looking for it. Furthermore, it is the teacher who pronounces the solution correct so that each student has only *one* chance per problem to attempt to find the solution. (Brousseau & Warfield, 1999, p. 16)

The view that questions in school have one correct answer is also a part of the didactic contract. Expressed differently, children become used to 'doing school' through their own experiences, and through this extensive socialization they also learn how tasks are normally organized. Even if this is a known dilemma in educational practices, and even if many actors make a great effort to change the procedural approach and focus on problem-based work in projects with information seeking, letting the students choose subjects to do research on, etc., it does not straight away change students understanding of school work (Alexandersson, Limberg, Lantz-Andersson & Kylemark, 2007). In my thesis, the general issue of the didactic contract has been studies in the context of students' engagement with digital technology in learning situations with word problems in a mathematics classroom. The study of students' learning activity in relation to word problems in mathematics was not a planned or deliberate choice but was merely due to the fact that this was what the students worked with at the time of conducting the study. For that reason, in order to understand the specific learning practice that these kinds of tasks offer, it is vital to shed some light on earlier research concerning this field of knowledge.

Students' activity when solving word problems in mathematical classrooms

In research on students' mathematics learning in the context of word problems, there is a vast amount of literature on learning that directly or indirectly addresses the issue of framing. What has been examined in these studies is how students engage in the activity of learning mathematics when solving problems that are formulated in ordinary language, so called *word problems*. Such problems are often seen as an important context for practising mathematics. A definition of a world problem is "the use of words to describe a (usually hypothetical) situation" (Verschaffel, Greer & De Corte, 2000, p. ix). The job the students are to do is to transform a sentence formulated in everyday language into relevant mathematical operations (Säljö et al., 2006). The answer to the questions raised in the sentence can then be found by applying mathematical operations to the numerical data available in the statement.

The activity of solving word problems is interesting to study since the students have to move between two symbolic codes: written language and mathematical symbolism and operations. They have to make use of both their mathematical knowledge and their linguistic knowledge. This holds true regardless of whether the word problems are presented in a traditional textbook or by educational software.

Word problems also reflect theories of learning that are deeply embedded in Western thought, which means that it is preferable that what students learn in school can be applied in the world outside school. This implies a belief in students' ability to dissociate themselves from the situation and from abstract characteristics of the activities in school, generalize about them and then transport them into other everyday settings where they can be simply applied (Lave, 1992).

> The very process of solving word problems takes its form directly from the theory of learning: abstracting out the numbers and operations from a situation, operating on them in abstracted form, drawing a conclusion or generalization about the results, then reinserting the result into the situation. (Lave, 1992, p. 76)

From a sociocultural perspective, the picture of transferring knowledge between different settings and situations can be questioned. As argued before, learning is seen as an interactive activity of participating in various cultural

practices and not as a process of transmitting knowledge to an individual learner. However, we evidently make sense of new situations with the support of previous experience. So even if the concept of *transfer* seems inappropriate since it denotes that 'something', that is, some sort of 'individual knowledge' could be carried over from one situation to another, it would be unthinkable that nothing keeps repeating itself as we move from one context to another context (Sfard, 1998). However, what we are able to do in one context does not automatically mean that we are able to do the same or a similar thing in another context, which has been apparent in research on mathematical word problems (Verschaffel et al., 2000).

Various studies of mathematics in school have shown the difficulties the students have in understanding the tasks in such a manner that it is incorporated in their everyday knowledge (Verschaffel et al., 2000). A consequence of this is that students provide answers that are not consistent with the realities in the situations described. As mentioned earlier, some studies of everyday cognition show that people are much more successful at solving mathematical problems in an everyday setting than in a school setting due to the fact that the aims and the conditions of the practical activity lead to a reasoning that differs considerably from the formal, standardized and procedure-like activity in school (e.g. Carraher et al., 1985; Lave, 1988; Scribner, 1984). It is thus a question of a difference between solving problems in school mathematics and mathematics in an everyday setting. Irrespective of what kind of problem is presented in school, students have a tendency to understand it as a disguised mathematical task and tend to engage in calculations without attending to how the tasks should be modelled. Verschaffel et al. (2000) refer to this phenomenon as *suspension of sense-making*, implying that the educational context results in the students making assumptions about the nature of the problem and ignoring their everyday experience.

The concept of *suspension of sense-making* in word problems derives from studies conducted in line with the assumptions of the *didactic contract* (Brosseau, 1997) at the end of the 1970s and the beginning of the 1980s. These studies examine children's understanding of mathematics in school. In a classical study from Grenoble in 1980 (in Verschaffel et al., 2000), the following problem was presented to pupils aged seven and eight: *There are 26 sheep and 10 goats on a ship. How old is the captain?* A large majority of

the children were prepared to answer the question by, for example, adding the numbers without questioning the absurdity of the meaning of the word problem. A number of studies followed this. For example, the following question was given to 300 German children from preschool up to fifth grade: *Katja invites 8 children to come to her birthday party, which takes place in 4 days. How old will Katja be on her birthday?* (Radatz, 1983). The result showed an interesting relationship between the children's answer and the number of years they had attended school. In preschool and first grade, only 10 percent of the children were willing to answer the question, in the second grade 30 percent answered, and in third and fourth grade as many as 60 percent of the children answered the question. There was then a slight drop to 45 percent in the fifth grade. The conclusion was that the children's reply behaviour is highly dependent on how much school mathematics they had been exposed to. Younger children tried to analyse the problem while older children had learnt to see mathematics as a kind of game with artificial rules without any connection to the everyday life outside school, assuming that the figures in a word problem should be used to make some kind of calculation (Verschaffel et al., 2000). Schoenfeld (1991) wrote that "There is reason to believe that such suspension of sense-making develops in school, as a result of schooling" (p. 316) as a concluding remark in an article commenting on this research. Verschaffel et al. (2000) argue that tasks in mathematics that consists of word problems which are supposed to lead to a problem-solving thinking instead make the students recognize earlier experienced exercises and tasks, which make them act in a procedure-like manner.

In Verschaffel's and his colleagues' analysis (2000), they point out that the stereotype and artificial way that students act is a characteristic of all the studies. Students' suspension of sense-making is explained by pointing to certain underlying ideas and expectations that they employ when they are solving tasks that consist of word problems in a school setting. These ideas are also followed by other actors in the construction of word problems such as textbook writers, test developers, teachers, parents and educational software designers. These underlying assumptions are necessary to make the exercises of word problems function properly. The four main assumptions derived from the analysis by Verschaffel et al. (2000, pp. 59) can be described as follows.

The first assumption is that every problem presented by the teacher or in the textbook (or by the educational software) is solvable and makes sense. In order to solve the task, you have to accept the variables given.

The second assumption is that there is only one correct answer to every word problem, and this has to be a precise and numerical one.

Thirdly, you have to assume that the answer must be obtained by performing one or more mathematical operations with the numbers in the problem, and often with all of them.

Fourthly, assume that the task can be achieved by using mathematics that you have access to and that is suitable for you as a student.

It is thus important to emphasize that students are not seen as behaving irrationally but in accordance with their previous knowledge of the rules that guide the institutional setting of the school as a specific context and in accordance with their socialization in this school practice. This view is shared by a good number of the researchers in this field and is expressed by Verschaffel et al. (2000), like this:

> While our initial reaction to the first findings was one of amazement at the apparent irrationality of the children's responses, we progressively realized that this was a naive interpretation as we continued to study existing literature, and discussed the findings amongst our research associates and others in the course of conference presentations. A key insight was that behaviour that, at first sight, appears irrational can be seen as rational if considered against the background of schooling in general, and mathematics classroom in particular. (Verschaffel et al., 2000, p. 120)

Lave (1992) makes this issue even more explicit by emphasizing that the meaning of a word problem in mathematics is not in the mathematical parts of the task but in its role as a school activity.

> Thus, the meaning of word problems does not lie in their mathematical properties but in the role in the activity system of schooling, or dieting, or becoming a merchant in Venice in the 1500s. Different intentions, differently engaged, will impel action and give meaning to it in varied ways. (Lave, 1992, p. 89)

It is obvious that students regard the text in a word problem as a front for their mathematical modelling, and they sometimes do not even think that they should bother about the objects or situations that are described. Word

problems that are developed with the intention of making mathematical tasks in school closer to out-of-school situations, have sometimes been shown to be counterproductive. Besides the issue of the framing that guides students to simply perform some sort of routine modelling, the specific content of word problems has occasionally been shown to be absurd and artificial, for example, proposing prices that are totally inappropriate. This has added to students' ways of attending to the tasks by simply ignoring the situation described and not checking their answer for plausibility. Gravenmeijer (1997) even refers to word problems as "poorly disguised exercises";

> Most text-book word problems are nothing more than poorly disguised exercises in one of the four basic operations. In general, these problems seldom ask for more than one operation. So for the students, the name of the game becomes finding the proper operation and executing it. (Gravenmeijer, 1997, p. 390)

This is also noticeable in one of Palm's (2008) studies of students solving word problems. He compared students' work of conventional word problems with word problems that were especially constructed to be as close to an out-of-school situation as possible. In the experimental study, Palm concludes, that with these specifically developed word problems, so-called "authentic word problems", a change in the students answering was seen in some of the cases. That is, these specifically developed authentic word problems seemed to help the students somewhat to provide answers that "stem from total 'suspension of sense-making'" (Palm, 2008, p. 55). However, according to the perspective adopted here, it also confirms many of the previous studies, which shows the strong implication of the framing of educational situations in general and word problem solving in particular. Comments taken from Palm's (2008) interviews of students after solving an authentic word problem[5] about running may serve as an example. As will be seen from the following quotation, the students do not consider their everyday experience according to which short-distance runners have a completely different pace than long-distance runners, or they simply ignore this knowledge since they think that the teachers only want to see if they can calculate.

[5] The "authentic word problem" in Palm's (2008) research was formulated like this;
"There is an athletic competition on TV. You and a friend watch when the fastest man in the world, Maurice Green, wins the 100 m race in 10.00 sec. the next race you watch is the 10,000 m race, which is won by Haile Gebrselassie in 26 min. and 5 sec. What do you answer when your friend asks you: How long do you think it would take Maurice Green to run 10 000 metres (= 1 Swedish mile)?" (Palm, 2008, p. 44)

> To a follow-up question about if they were sure that their solution would be considered correct some students said "no" but that they did not think they had any other possibilities. Some other students were confident that their solution was correct. As one student put it: "they don't want to know how long time it will take, they want to know if I can calculate 10x100". Some students justified their solution by pointing to earlier experience. They claimed that in word problems one should consider exactly what is written in the task and nothing else. If they were supposed to make other consideration it would be stated in the task. (Palm, 2008, p. 52)

The intention of the above discussion about learning practices in school mathematics has been to illustrate the importance of students' understanding of what kind of resources they should make use of in solving certain tasks. It is interesting to note that students from different parts of the world, irrespective of different cultures and different educational systems share this tendency to exclude consideration of an out-of-school situation when solving word problems in a school context (e.g. Carraher, et al., 1985; Lave, 1988, 1992; Palm, 2002; Scribner, 1984; Verschaffel, et al., 2000; Wyndhamn & Säljö, 1997; Yoshida, Verschaffel & De Corte, 1997). For example, children in Japan, who are known to score very high in international mathematical tests, present the same so-called suspension of sense-making when it comes to solving word problems. This indicates that the implications of the specific learning practices of schooling are fairly universal and imply that students disregard what they know about the world when solving word problems irrespective of, for example, cultural, traditional and curricular differences.

In the context of word problems, another noteworthy aspect is the related discussion of *mathematisation* and *demathematisation* that refers to ideas about concretizing mathematics, which is contradictory to a central part of mathematics; to abstract and develop representations that are general. Thus, many arithmetic problems are not possible to concretize, which contradicts an educational striving for the concrete (Jablonka & Gellert, 2007). This discussion is clearly outside the scope of this thesis, however, it is worthy of note from the students' perspective, since they are sometimes supposed to translate the mathematical problems into a commonsense, concrete situation and sometimes they are not. The discussion about making mathematics concrete with word problems is additionally intriguing in relation to this study since some of the claims made about the benefits of using digital technology are that it will enhance reality and authenticity, something that will be further elaborated in the following paragraphs.

Digital technology in educational settings – issues and implementation

Digital technologies have been the subject of endless discussions among politicians, policymakers, producers of software, researchers, etc. and many claims have been made (e.g. Papert, 1980, 1993). This has made the field of knowledge problematic in several respects and this paragraph is an attempt to comment on the claims concerning the introduction of digital technologies in schools, before the mapping of previous research is narrowed down to consider educational software.

Analytically, digital technology can be understood as a new form of mediating tool that is used in most areas in society and, as a result, has also become important for education. According to the theoretical perspective adopted here, how we manage to solve tasks we face is to a large extent dependent on the resources that we make use of. As discussed previously, the practice of education implies certain ways of acting and communicating that students learn to identify and use as resources in their effort to fulfil expectations. Incorporated in this perspective is that how we manage to solve tasks is to a large extent also a question of how we make use of the physical tools available. The starting point of this study is that when a new physical tool is implemented in any situation, the tool itself is not a passive element; rather, it will co-create the activity of which it becomes a part. Learning in relation to physical tools is however, not a new concern, various types of tools and technologies have always been important for human learning (Sfard & McClain, 2002; Säljö, 2005). The physical tools that humans have made use of go back to simple stone tools, via different kinds of technical innovations, to the digital tools of today. Human development goes hand-in-hand with the invention of different physical tools, and various tools have changed human life in different ways (e.g. Hansson, 2002; Sundin, 2006). Tools have for ages been part of pedagogical activities, and we have learnt through the use of them (Säljö, 2008). Nowadays, the school settings comprise a quantity of different physical tools and teaching aids such as maps, calculators, whiteboards, computers, etc. But in another sense, the educational practice, consists of, for example, test situations without access to all the tools, which implies a view of knowledge as something located in the individual mind (Alexandersson & Lantz-Andersson, 2008). In other settings such as workplaces or other social gatherings, this view of knowledge has little relevance. The actual competences that are required are much more complex,

comprising a range of social, cognitive and manual skills and capacity. One aspect of this is our knowledge about and our capacity to master different physical tools (Säljö, 2008). In educational settings, the competence to master and to understand digital technology has at times become a new knowledge goal in its own right. In part, this makes the situation even more multifaceted, since there might be different and not always explicit goals functioning side by side. It is not always explicit whether the goal is to learn to master a specific digital tool or if the goal is to learn the content that the tool carries, or if it is both.

Even if the learning goals in relation to digital technologies vary, the arguments for introducing these tools in schools are often that society demands competences and skills for handling them in working life (Castells, 2001). However, the use of digital technologies also has implications for the learning practice, and one of the challenges when changing educational practices is to change the strong patterns of classroom activities that rely on long traditions, that is, the teachers lecturing and the students listening (Kuhlthau, Maniotes & Caspari, 2007; Macbeth, 2000). Digital technology implies that information is more easily accessed and has also brought with it new views of teaching and learning where the teachers sometimes have to assume new roles. *Lifelong learning* and an *emphasis on knowledge* are catchphrases in the political arena worldwide and enormous amounts of money have been invested in the implementation of digital technologies in educational settings. Digital technology actually has changed a lot of activities in our lives; the way we communicate, how we gain access to information, etc. However, a number of studies have shown that the implementation of digital technology has, as yet, not dramatically changed all activities in society, at least not the way that was expected and expressed in policy documents (Bell, 2007). History has shown that the introduction of various media has not entirely changed human activities and communication but, rather, modified earlier ways of acting and communicating. It could also be said that media such as radio, TV, video films, and as in this case, digital technology, have never fully replaced the old ones, instead gaps are established where space for the new tools are created. As Woolgar (2002) puts it, they will become a *supplement* rather than a *substitute*.

In order to show the complexity of the integration of digital technologies in schools one should also be aware of the fact that producers and developers

have an interest in announcing that such tools carry promising possibilities for solving a variety of problems and, at the same time, being innovative. Thus, "the educational technology field is grounded in the belief that technology and innovation will ultimately lead to improved learning outcomes" as Schrum et al., (2005, p. 204) put it. In this connection, it is crucial to reflect on what these arguments are related to, that is, what is the learning activity with digital technology compared with? Is it compared with the same amount of time spent on working with an exercise book, the same amount of time discussing with a teacher, or is it compared to experiences of expeditions in for example a museum, the woods, etc? The arguments are at times grounded in a technological conviction, and in relation to the number of studies it is problematic that they say very little about what happens in the learning activities (for overviews see e.g. Egenfeldt-Nielsen, 2006; Garris, Ahlers & Driskell, 2002; Ke, 2008).

The International Society for Technology in Education (ISTE) has produced a fairly comprehensive report on research on education and technology (Kozma, 2003). In their report, they emphasize the constructive effects that technologies are supposed to have;

> The information society refers to the potential that these technologies have to make education and health care more widely available, foster cultural creativity and productivity, increase democratic participation and the responsiveness of governmental agencies, and enhance the social integration of individuals with different abilities and different cultural groups. (Kozma, 2003, p. 2)

The report from ISTE contains 174 case studies from 28 countries in North America, Europe, Asia, South America and Africa. This overview contributes with an examination of trends in classroom practices and curriculum change with the unit of analysis determined as "innovative pedagogical practices that use technology" (Kozma, 2003, p. 3). As the focus in the research project is on changes, it has a normative tone and more or less implies that it has to do with constructive changes such as an interest in the role that digital technology could have in improving education and changing schools. The results from the studies show, however, that the constructive impact of technology will not come automatically. Rather, a significant number of the studies point to the complexity of verifying the relationship between digital technology and scholastic achievement.

Most actors agree on the necessity of implementing digital technology in schools, but their motives vary (for an overview and a further discussion, see Linderoth et al., 2002). There are partly arguments about a content to be learnt and partly competences that are sometimes called media or computer literacy (see Erstad, 2002, 2005 for a discussion and Pillay, Brownlee, & Wilss, 1999 for an example). These competences are both the straightforward skills of handling technical devices as well as metacognitive and reflexive abilities. With respect to the significance of digital technology in different areas of societal activities, the relevant question is not whether digital technology should or should not be implemented in schools, but rather *how* it will change learning activities.

Oversold and underused[6] – digital technologies in classrooms

Even though much research in recent times has shifted concerns from the benefits that are supposed to surround the implementation of technology to a focus on the learner and what the learner really does in connection with technologies (e.g. Cox & Marshall, 2007; Erstad, 2006; Pittman, 2005; Schneider & Foot, 2004; Watson, 2006), the claims that comprise constructive outcomes that digital technology involve are still salient in different policy documents. The quotation below from OECD's 2006 survey of 15-year old students' computer use in OECD countries[7] is an example of the fact that optimistic claims about the benefit of digital technologies are still being made.

> An effective use of ICT in schools can have an immediate positive impact on the schools' learning environments, for example by: creating more dynamic interaction between students and teachers, increasing collaboration and team work in problem-solving activities, stimulating creativity in both students and teachers, and helping students to control and monitor their own learning. Further, a successful use of ICT in schools can help students to develop skills, both specific to ICT and more generally, that will be useful for them in their future academic and professional lives. (OECD, 2006, p. 9)

[6] This is also the title of Cuban's (2001) review of computer usage in Californian schools.

[7] The OECD member countries of the 2006 survey are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

However, the implementation of digital technology in educational settings has not been as rapid as expected. Cuban's (2001) study of the use of computers in southern Californian schools showed that the use of computers in normal classrooms was not very frequent at the beginning of the 21st century and that both students and teachers used digital technologies much more during their leisure time than during the school day. This study showed that the few teachers who used computers for instructions at all, did so only rarely and infrequently. Cuban claims that the change that digital technologies were said to involve has not yet taken place.

> Although promoters of new technologies often spout the rhetoric of fundamental change, few have pursued deep and comprehensive changes in the existing system of schooling. The introduction of information technologies into schools over the past decades has achieved neither the transformation of teaching and learning nor the productivity gains that a reform coalition of corporate executives, public officials, parents, academics, and educators have sought. For such fundamental changes in teaching and learning to occur there would have to have been widespread and deep reform in schools' organizational, political, social, and technological contexts. (Cuban, 2001, p. 195)

In relation to this reasoning, the question is whether the issue is more about the fact that the expected changes have been blown up out of all proportion or whether other changes than the expected ones have taken place. Cuban argues that digital technologies are here to stay, which means that educational actors have to come to terms with them as educational tools, but in order to function the tools have to be related to the needs of the educational practice. Cuban's result has been confirmed by many other international studies (e.g. BECTA, 2004; Conlon & Simpson, 2003; Erstad, 2006; Hennessy, Ruthven, & Brindley, 2005; Kozma, 2003; OECD, 2006; Schrum et al., 2005; Selwyn, 1999; Watson, 2006; Younie, 2006) indicating that there is a difference between the expected use of digital technologies in school and the reality of their use in educational settings.

The above description is also parallel with the status of the implementation of digital technologies in Swedish schools (e.g. Alexandersson, Hurtig & Söderlund, 2006; Hanson, Säljö, & Ludvigsen, 2000; Karlsohn, 2009; Limberg et al., 2008; Limberg, Hultgren & Jarneving, 2002; Riis, 1998; Riis, Holmstrand & Jedeskog, 2000). In an historical outline of the different national projects and ventures with the aim of implementing digital technology in Swedish schools, Karlsohn (2009) draws a picture of how the

hopes for a modern educational system marginalized the critical reflections on digital technology in relation to learning in schools. Karlsohn (2009) furthermore highlights the difficulties in adopting these tools despite the many millions invested and argues that one reason for the difficulties might be just the lack of critical perspectives during the first phase of implementation.

In Sweden, a special role has been played by the so-called Knowledge Foundation, which was established in 1994 to regulate both the school ventures and research on IT and learning. An additional investment along these lines was the national programme for IT in Schools; ITiS, which was founded in 1998 with the aim of implementing digital technologies in Swedish schools. Within the framework of ITiS, all the municipalities in Sweden were offered the opportunity to participate and this participation was to be implemented over a 3-year period between 1999 and 2001 (Karlsohn, 2009). An evaluation of this IT venture shows that the introduction of computers in the daily activity of schools is a difficult and slow process (Eriksson-Zetterquist, Hansson, Löfström, Ohlsson & Selander, 2006). What is shown in this evaluation is that IT is often treated as a school subject, with an additive logic, preferably scheduled for certain classrooms at certain times and treated as a subject in itself (for an example of this discussion, see Alexandersson & Lantz-Andersson, 2008). The general observation is that digital technologies are not integrated in subjects and are not viewed as resources for subjects but often separated as something special, parallel with other activities and almost like a specific subject of its own with particular teachers. Consequently, it is also acceptable for teachers to reject the implementation and usage of digital technologies since they are not responsible for 'that subject'.

A conclusion of the research above is that the outcome of the implementation of digital technology is dependent on many different local factors such as classroom organization, personal characteristics of teachers and students, the school organization, personal characteristics of administrators, and national policies, international trends etc. Thus, technology itself does not necessarily result in innovative practices, but could be used in innovative ways. Kozma (2003) argues that "In the large majority of cases, teachers used *ordinary* technology to do *innovative* things. It was not the tools that were innovative but the pedagogical practices" (p. 79). This is also highlighted by Woolgar

(2002), who claims that the uptake and use depend crucially on the local social context. When reviewing the literature, it is obvious that the promising prospects and the enormous expansion of the implementation of digital technologies in schools have not yet been accomplished. However, this is not an unknown issue but has been pointed out by many researchers, Watson (2006), for example, states that "There remains therefore an interesting tension between the necessity of the enthusiasm of innovators, and the reality of implementation for all" (p. 204).

In spite of the difficulties in introducing digital technologies shown by Cuban (2001) and others, most actors consider the implementation both important and necessary. One example of this is the argumentation in favour of the role of digital technology by the European Union. The EU claims that one of the eight key competences for lifelong learning, which are considered necessary for an education system, is *digital competence*. The definition of digital competence in this document is a competence that will support students in taking part in and becoming active citizens in the Knowledge Society. Digital competence is further expressed as a competence that will assist citizens in using electronic media critically, at work and during their leisure time (Commission of the European Communities, 2005). One could even argue that digital competence is linked to basic issues of democracy in our present time (e.g. Drotner, 2001, 2008).

With this picture drawn, the discussion will be narrowed down to concern Educational Software as one specific part of digital technology that has been part of the subject of my analysis

Software products go to school

One of the settings where the uses of educational software and simulation tools were developed early on was in training aircraft pilots with flight simulators during the World War II (Hernwall, 1998). Thereafter attempts were made to develop some sort of machine-based training, but it was not until the 1990s that software products to some degree entered into educational systems in the western world. In Sweden, in an evaluation of the projects involving issues relating to IT in education Hanson, Säljö and Ludvigsen (2000), state that projects before the 1990s are different from the ones that are currently in progress. Most early IT projects aimed at creating multimedia learning materials with some degree of interactivity with the idea that students

should to a certain degree be able to use these means for self study and often with a specific skill in mind. These learning materials were at first stored on discs and then later on CD-ROMs. After the expansion of the Internet in the mid-1990s, most of the applications developed use the web environment. At this time, there was also a greater emphasis on developing pedagogical contexts by various IT means, such as platforms, to facilitate cooperation and communication.

As I have already discussed, the use of computers in school in a general sense is still not always part of an everyday activity and consequently this applies to educational software as well. Research has shown that relatively few teachers are integrating IT into subject teaching and far fewer use educational software on a regular basis (e.g. Hennessy et al., 2005). In Sweden, there are still a limited number of educational softwares on the market. For preschool children and children in primary school, there are a number of products originating from earlier edutainment applications and there is also some software developed particularly for special education. But when it comes to the market for compulsory school and upper secondary school, there is not very much. Most of the educational publishers, however, have digital complements such as web sites and sometimes complementary software attached to their textbooks (for an overview, see Myndigheten för skolutveckling, 2007). The effectiveness of educational software is still questioned by many researchers, and a common scepticism "lies in the lack of an empirically-grounded framework for integrating computer game into classrooms" (Ke, 2008, p. 1609). Below, I will examine some of the claims made and relate them to empirical findings from previous research and to the perspective adopted in this study.

Educational software in school – pros and cons

As pointed out earlier, the argumentation surrounding educational software in relation to subject areas covers a diversity of claims. The most common concerns qualities that lead to facilitated learning, for example, that students who used specific software showed significantly higher learning scores than students who did not use it (e.g. Chang, Sung & Lin, 2006; Wentling, Parkz & Peiper, 2007). Facilitated learning is also claimed to be due to different multimodal representations (e.g. Aldrich et al., 1998; Cairncross & Mannion, 2001; Rogers & Scaife, 1998). Another example is that it is said to be easier to individualize since it is argued that multimedia products support different

learning styles (Crosby & Iding, 1997). A third example concerns the pedagogical benefits of virtual reality, simulations and the type of three-dimensional graphics that is a characteristic of computer games. In these kinds of applications, the representations are said to be very lifelike and, in combination with interactivity, they are claimed to offer a 'realistic' and 'authentic' learning environment (e.g. Barab, Thomas, Dodge, Carteaux & Tuzun, 2005; Harper, Hedberg & Wright, 2000). A fourth example concerns the increased motivation that is supposed to follow when the content is structured like a game or presented in graphic environments (e.g. Barab et al., 2005; Malouf, 1988; Prensky, 2001). Some claims go as far as to assert that digital technology in the shape of computer gaming has changed the new generation's way of learning, concluding that it is almost necessary to use 'game like' teaching aid to get the desired effect of education (Gee, 2003; Prensky, 2001). These arguments are the basis of the phenomenon *edutainment*, which now is called *serious gaming*[8] (Egenfeldt-Nielsen, 2006). Parallel with the didactical arguments, educational software has been described as having constructive effects on the organisation of learning environments, for example, increasing dynamic, innovative and flexible teaching and helping teachers organize their teaching and save time (Waldman, 1997). These organisational benefits are also often highlighted by the producers (Lantz-Andersson, 2005).

Since educational software is designed in different ways, it is natural that they are described as having different benefits, but one criticism is also that research has searched for and/or evaluated the "wrong things", as Cox and Marshall (2007, p. 66) put it. They argue that researchers have been "looking for improvements in traditional processes and knowledge instead of new reasoning and new knowledge which might emerge from the ICT use" (Cox & Marshall, 2007, p. 66). Many researchers simply suggest that studies of educational software have failed to produce evidence that the digital tools resulted in a change in the learning activities (e.g. Egenfeldt-Nielsen, 2006; Garris et al., 2002; Gerjets & Hesse, 2004; Ke, 2008; Pollard & Pollard, 2004; Roblyer & Knezek, 2003; Strudler, 2003; Vogel et al., 2006). Consequently, a discussion about the degree to which such benefits can be generalized is necessary. Furthermore, there are a number of studies that suggest that the use

[8] It is worth noting the transformation of the concept where the connotation first was associated with the entertaining elements involved, whereas it now relates to the withholding seriousness.

of educational software can be quite problematic and the actual experience of using the technology is something very different from the hypothetical arguments. For instance, Cox and Marshall (2007) have shown that evidence from previous large-scale studies of the impact of IT on students' learning give limited information on the possible effects on the deep structure of students' thinking and acting. Laurillard (1998) and Lowyck, Elen and Clarebout (2004) found that free exploration of multimedia software was problematic, Ivarsson (2004) suggests that interactivity can be a problem rather than a resource for learning, since the students were found to be often more confused by the animations of gravitational phenomena than when they reasoned in the context of static images, and Richardson et al. (2002) and Lowe (2004) point out that multimodality can be problematic due to multiple interpretations and distraction of focusing.

Other studies have shown that the users do not primarily focus on the represented phenomenon in the interactive representations; hence the game experience is not always a matter of representation[9] (Alexandersson, Linderoth & Lindö, 2001; Linderoth, 2004). Moreover, in their study of computer-supported science education, Krange and Ludvigsen (2008) suggested that game narratives could distract rather than motivate. Thus, it has been difficult to prove that educational software has had significant effect on students' learning and that learning practices will be improved by digital technology. Clearly, this is a difficult and challenging question to answer. What could be said, however, is that it is quite different to be a student in an educational practice where there is an extensive orientation towards digital technology compared to a mere traditional setting with few digital tools available.

Since educational software is still not integrated in general in educational settings, when it is used the focus on the technology itself takes up time and space at the expense of the subject in question. That is, technical issues

[9] On another level, in a different context, Sherry Turkle (1995) pointed out that some dimensions of reality could be viewed as lost in the culture of simulation. She pointed especially to two different effects that simulations have on culture, the *Crocodile effect* and the *Disneyland effect*. The *Crocodile effect* is the notion that virtual occurrences with all their aesthetics and dramaturgy may become more attractive than real life. *The Disneyland effect* is that some cultural phenomena, like amusement parks, are so obviously artificial or virtual that simulations in a sense can seem more real. More recent studies also point to this fact, that is, that the claimed increased reality is complex.

concerning how to handle different applications take time from the content. This is possibly one of the reasons for the slow process of implementing educational software in school activities. Other criticism concerning educational software has to do with the fact that these applications are not really at the forefront of research on learning and education (Garris, et al., 2002), and few developers base the design of their educational software products on established learning theories (Kebritchi & Hirumi, 2008). Instead, they tend to consist of traditional question-and-answer drills wrapped in a new form, which, for example, is discussed by several researchers in "ICT, Pedagogy and the Curriculum" (Heppell, 2001);

> Perhaps worst of all they see the criminal waste of using a wonderful learning and creative tool to deliver multiple-choice drill and practice questions that ensure a compliance with yesterday's curriculum. (Heppell, 2001, s. xviii)

The development of educational software, though, is now moving toward more innovative applications that take advantage of the opportunities offered by digital technology. Garris and his colleagues (2002) argue that "The challenge is to adapt game features for instructional purposes, to engage the game cycle that sustains self-directed interest, without squeezing out what is enjoyable about games in the first place" (p. 459). Due to the complex situations in classrooms, however, part of the knowledge that we have today about educational software is based on research on applications that the research projects have developed and implemented themselves. This means that the settings of the studies are not necessarily part of a natural context, which gives the knowledge a somewhat hypothetical character (e.g. Arnseth, 2004; Hennessy, et al., 2005; Schrum et al., 2005).

> Real schools and classrooms are messy and complex, and myriad factors contribute to each experience of a particular classroom, including individual attributes of the educator and learners and the subculture of any particular school. Experimental designs are often isolated from classroom realities, and results do not fit neatly into authentic teaching situations. (Schrum et al., 2005, p. 204)

The rationale of these studies is to produce knowledge based on the assumption that the kind of application they test will be implemented in an every-day educational context in the future. However, according to Arnseth and Ludvigsen (2006), the positive results that have been achieved in experimental studies have rarely been replicated when the same technology has been introduced into regular classroom settings. Furthermore, the

imagined future implementations of some of the products are unlikely since they are extremely costly (see Moore, 1995, for a discussion). The problem of replicating experimental findings is debated among many researchers who emphasize the necessity of studying *how* technologies are used in activities (e.g. Iding, Crosby & Speitel, 2002; Krange & Ludvigsen, 2008; Lagrange Artigue, Laborde & Trouche, 2001; Luppinici, 2007; McCormick & Scrimshaw, 2001; Schliemann, 2002; Säljö, 2004; Tolmie, 2001, Woolgar, 2002). The following quotation by Schliemann (2002) concerning the subject of mathematics may serve as an illustration of this notion.

> Given the complex interaction between the use of tools and the development of reasoning and learning, the question that should concern educators is not how powerful or effective cultural tools are in promoting learning, but rather what teaching practices and classroom interactions can promote meaningful learning and understanding of mathematical principles and relations embedded in cultural tools and representations. (Schliemann, 2002, p. 302)

These are the basic reasons for designing this research project as a study documenting and analysing the activity of solving tasks in the context of educational software *as a routine*, *in an ongoing practice*.

Defining educational software

An important aspect of this discussion is that it is rather difficult to define what educational software is due to the large quantity of different applications and digital devices. Attempts to classify and define educational software have been made by many actors at different levels during decades. In Taylor's (1980) early outlines for understanding the application of computing in education, he states three modes of usage. The first mode is the computer as a *tutor* containing a subject and functioning as a schoolbook and the second is the computer as a *tool* for word processing, calculations, etc. The third mode in Taylor's (1980) outline is the computer functioning as a *tute*, that is, the computer is to be tutored, i.e. programmed by the student (p. 2 ff.). This last functioning as a tutee was emphasized by Papert (1980) in his development of the LOGO language and its application in teaching computing and mathematics to young children. The vision that everybody should learn to use computers by learning how to programme has, however, now been abandoned by most actors. When it comes to Taylor's first two modes, both the computer as a *tutor* and the computer as a *tool*, have implications of learning being regarded as a simple transformation process where the use of a computer would automatically transfer knowledge to the user, which would lead to

some sort of individual outcome. From a sociocultural perspective, both these ways of conceptualising the role of computers in relation to learning are believed to be inadequate (e.g. Crook, 1994; Stahl, 2006; Säljö, 1998; Wegerif, 2007). Crook (1994) argues, following Wertsch (1998), that a third approach would be to consider the computer as a *mediational means*, with an emphasis on the use of computers being "supportive of the collaborative experience of learning" (Crook, 1994, p. 228). In line with this approach, another branch of the learning sciences called CSCL (Computer-supported collaborative learning) emerged in the 1990s and is now a rapidly evolving field that is undergoing continuous change. Studies in the field of CSCL combine the ideas of collaborative learning in small groups with support of technology. Empirical studies in the CSCL field of research have formed the starting point for the field of knowledge of this research. These studies emphasize the collaboration among students and cover a broad collection of studies of e-learning of various kinds, not only as distance learning, but also face-to-face learning, either synchronously or asynchronously (Stahl, Koschmann & Suthers, 2006).

The research methodology in CSCL could be categorized into two main approaches; systemic and dialogical (Arnseth & Ludvigsen, 2006). The main focus of the systemic approach is on the learning outcomes of individuals while the dialogical approach focuses on interaction between the participants and their use of various resources and tools. The basic analytical assumptions of this study are in line with the assumptions of the dialogical approach of CSCL field of research, implying a focus on the learning practices of collaborating groups.

The picture so far indicates the value of studying the activity of using digital technology in settings where it is a part of the practices of schooling. Van Eck (2006) states that this is vital in order to learn anything about what it means that digital technology is a part of the learning activities, which research so far has had difficulties in doing.

> By the time there were enough studies to evaluate and review, the quality and diversity of the different implementations made it difficult to draw any meaningful conclusions. Once again, it seemed there was "no significant difference" between classrooms that used technology and those that did not. Once again, we had mistaken technology use for technology integration. (Van Eck, 2006, p. 30).

The focus of this study is, in accordance with the CSCL tradition together with the conceptual distinctions of Frame theory (Goffman, 1974/1986), on how utterances, actions and events are framed in relation to digital technologies. Using Stahl's (2006) formulation of the role digital tools play in the interaction, the educational software "plays an **intermediate** role in the **midst** of the collaboration" (p. 16).

In the following paragraphs, I will elaborate my theoretical points of departure followed by the implications of contextual and methodological approaches.

3. Theoretical perspectives on learning activities

Introduction

In this chapter some of the premises of the sociocultural perspective and the concepts from Goffman's frame theory, which are relevant in relation to my study, are discussed. It starts with an elaboration considering the themes of the two traditions that are regarded congruent. This is followed by a presentation of the concepts from Goffman's frame theory that are applied in the research. This presentation is made on the basis of the conceptual distinctions that have been significant for the three studies and it should not to be seen as a complete account of Goffman's extensive theory.

The framing concept and sociocultural perspective

As has already been briefly presented, the theoretical basis of the present study consists of theories within the socio-cultural-historical perspective (Lave & Wenger, 1991; Säljö, 2000; Wells, 1999; Wertsch, 1998; Vygotsky, 1934/1962, 1939/1978) and the frame theory that originated from Goffman's (1974/1986) micro sociological and interactional perspective. An important link between these traditions is that they share basic assumptions about how knowledge is developed *in practices* and *in interaction*. The relationship between the traditions is also seen in the understanding of how people establish their identities in terms of operating in the practices that they participate in, which is central in both Lave and Wenger's (1991) and in Goffman's (1974/1986) view. Furthermore, both research traditions share the same analytical focus, which is on the interaction individuals have with other people using various resources and physical tools. Combining these traditions is also in line with the classification of theoretical traditions by Greeno, Collins and Resnick (1996) that have had an influence on the field of knowledge of educational psychology. In their classification, these two traditions are seen as belonging to the situated/pragmatist-sociohistoric perspective. The classification by Greeno et al. (1996) implies that research traditions that have contributed to the situated perspective, e.g. ethnography, ecological psychology and situation theory, are included in the

situated/pragmatist-sociohistoric perspective. Given the basis for considering the importance of studying the situated, local practices to understand activities, the sociocultural perspective and concepts derived from Goffman's theory are, thus, in line with this argumentation, seen as complementary.[10]

The focus on how activities are understood by the participants is one important point of intersection between the sociocultural perspective and Goffman's perspective on social interaction. This implies that actions, events, and utterances do not speak for themselves but, rather, depend on the how the participants have understood them, which in Goffman's terminology would be called *framing*. Within the sociocultural perspective, learning is seen as developing through participation in cultural and dialogical activities and could also be seen as a side effect of the activity that we take part in. How an activity is constituted is then fundamental for what is possible to learn. Communication with others is the most significant component that contributes to learning (Vygotsky 1934/1962; Wertsch 1998; Säljö, 2000, 2005), and in order to understand each others' utterances we have to share the basis of how that utterance is supposed to be understood. The way in which we interpret the context of a situation largely determines what we say, but what we say also plays a part in determining the situation (Wells, 1999). Learning activities are in this sense dependent on how the participants in the social practices *frame* what is said and done in the situation.

In the works of Goffman, the concept of *framing* implies a *definition of a situation* which the participants in the situation more or less share with each other. The *framing* in an activity can be seen as the participants' mutual answer to the question "what is going on here?"(Goffman, 1974/1986, p. 8). In Goffmans words, framing means that the individuals "locate, perceive, identify, and label" (1974/1986, p. 21) occurrences in the specific activity and situation. We relate events, actions and utterances to the way we understand a situation, and framing becomes a resource for giving meaning to our experiences.

[10] The sociocultural perspective and concepts derived from Goffman's micro sociological theory have been integrated in other studies, e.g. Goodwin (1996, 2003b, 2007), Coupland and Coupland (2000), Rystedt (2002), Linderoth (2004), Linell and Thunqvist (2003), Mäkitalo (2006) and Buchbinder (2008). Some of these studies will be further discussed later on.

> Given their understanding of what it is that is going on, individuals fit their actions to this understanding and ordinarily find that the ongoing world supports this fitting. These organizational premises – sustained both in the mind and in activity – I call the frame of the activity. (Goffman, 1974/1986, p. 247)

The interpretation of a situation is something that is shaped and reshaped over and over in interaction. During the framing activity, participants deal with *conflicts of framing* and *frame breaking* and this leads to temporary established *frameworks*[11]. These established frameworks guide participants in their activities. This is however, often implicit and something that takes place more or less without reflection. "Most of us are seldom conscious of the extent to which even the simplest communication depends on complex interpretive processes" as MacLachlan and Reid (1994, p. 1) argue. They further claim that interpretative activities of this kind "depend in turn on various kinds of framing" (MacLachlan & Reid, 1994, p. 1). According to Goffman, framing is understood as a dynamic and interactional concept for describing the participants' activities of defining what is going on. It is seen as a natural way for people to understand what is going on in activities, and through that understanding co-create the activity. The framings create structures for what people think they are doing when they talk to each other; it is thus seen as an interactive activity (Tannen, 1993, p. 6). Studying activities from the participant's perspective relates to how situations are studied within the sociocultural traditions with, for example, the intention of understanding what is possible to learn in the situations. In both the sociocultural tradition and Goffman's perspective on social interaction, the individuals are seen as active agents in understanding and shaping the world, not as passive recipients. Rather, the individuals, the context and the physical tools create the learning practices and form an indivisible unit of description. The fundamental basis of this study is thus, as declared earlier, the view of learning as social activity embedded in the practice in which the learner participates (Lave & Wenger, 1991, Säljö, 2000, 2005; Wells, 1999; Wertsch, 1998). Furthermore, in line with this perspective, social practices are not predefined or given but something that the participants create and recreate through interaction. By employing different positions and performing different actions, the participants keep up various activities. However, the creation of the practices is by its social nature not static, which means that we

[11] The implications of these concepts will be discussed further on

continuously negotiate and renegotiate the conditions for the situation, which in turn makes a socio-historical change possible.

Framing and social interaction

Goffman's framing concept can be traced to Bateson's (1972/2000) descriptions of animal play. In Bateson's observation of otters and monkeys, he noticed that they do not only fight but they also *play the game of fighting*, and what they do is dependent on how they frame actions in the situation. The animals implicitly answer the question: is it a game or is it a real fight? In order to mutually frame actions and cries, so that the situation will be understood as a game, they give different kinds of signals. Framing is, hence, according to Bateson's definition, the activity of categorising these signals or actions.

> The first step in defining a psychological frame might be to say that it is (or delimits) a class or set of messages (or meaningful actions). The play of two individuals on a certain occasion would then be defined as the set of all messages exchanged by them within a limited period of time… (Bateson, 1972/2000, p. 186)

Bateson's classical example displays the necessity of framing the actions and sounds in a situation in a certain way, in order to interpret what kind of activity takes place. For example, a monkey needs to know whether a push from another monkey is within the framing of play or the framing of fighting (Tannen & Wallat, 1987). To be able to understand an utterance, the participants in the communication, both the speaker and the listeners, create a common understanding of the framing. They have to know if the framing, for example, implies joking, irony, seriousness, play, etc. In trying to understand how to frame, participants seek to comprehend the dynamic relationship between the other people and the physical tools in activities.

The framing concept has been applied in various fields of research (Benford & Snow, 2000) such as psychology, linguistics, anthropology, ethnography and sociology with slightly differences in meaning (for an extensive overview, see Tannen, 1979). Studies that have employed Goffman's concept of framing deal, for instance, with interaction in encounters where there is a power imbalance among the participants, for example, communication between a doctor and a patient (Coupland & Coupland, 2000; Tannen and Wallat, 1987, 1999), in studies of children's understanding of illnesses which is displayed in play (Buchbinder, 2008) and in studies of interaction between

unemployed people and vocational guidance officers (Linell & Thunqvist, 2003; Mäkitalo, 2006). These studies show the participants' efforts to balance between different frameworks and how the shift of framings is handled in interaction. There are also a number of studies that use the concept of framing in activities and interaction in relation to digital technology (Aarsand; 2007; Hoyle 1993; Linderoth, 2004; Peterson, 2008). For example, in Linderoth's study of the activity of computer gaming, the framing concept was used to identify structures in the meaning that emerged in children's interaction. The children related what they saw on the screen and transformed and/or dissociated this with aspects of the world outside the gaming situation. This was done by the children's shifting of different frameworks for handling the objects on the screen. The conclusion of this study was that, depending on the framing, the children were engaged in different activities. Thus, there are a number of studies that deal with the concept of framing in understanding the diversity and variety of social interaction.

A critical element of how we frame in situations is that it is dependent on earlier experiences and how we relate these experiences to the activity at hand. These earlier experiences also support what we expect certain situations to be understood as, described by Tannen[12] (1979) as "the power of expectations".

> The only way we can make sense of the world is to see the connections between things, and between present things and things we have experienced before or heard about. These vital connections are learned as we grow up and live in a given culture. As soon as we measure a new perception against what we know of the world from prior experience, we are dealing with expectations. (Tannen, 1979, p. 138)

The more familiar you are with the components in a field of activities, for example, the school, the easier it will be for you to act in it (Säljö, 2000). This also implies that framing in activities is constrained by social structures and social organisations, that is, individuals are limited and not able to frame in situations entirely as they wish. According to Goffman (1974/1986), in many cases individuals do things "in relationship to cultural standards established for the doing and for the social role that is built up out of such doings" (p.

[12] Tannen (1979) bases her assumptions more on cognitive psychology and the schemata concept in her interpretation of the framing concept, I use her arguments here to illustrate the anticipation of framing certain situations in certain ways.

662). In line with this reasoning, Goffman argues that institutions often play important roles in the framing activity. The implication of this for my study is that in educational settings the framing is not entirely negotiable due to the educational practices that involve certain rules and certain communicative patterns. The 'didactical contract' (Brosseau, 1997), which I discussed earlier, is an illustration of how the framings in educational situations include certain obligations. Goffman (1974/1986) argues that there are certain overall aspects that are part of every framing activity that have a bearing on the possible ways of framing situations. He assumes that "there is a main activity, a story line, and that an evidential boundary exists in regard to it" (Goffman, 1974/1986, p. 564). According to the findings of this study, this means that defining the activity as 'doing school work' functions as a superordinate in relation to defining the activity as 'problem solving'. Thus, the framing in institutional practices is not merely local but embedded in education as a practice. In recent studies of students' task solving in school, parallel findings are put forward by Greiffenhagen (2007), who points out that school tasks also guide students to specific ways of framing, which they have learnt are productive. The conclusion is that there are certain aspects in every situation that shape the framing of what is said and done. Individuals then learn through participation in these different settings. Learning should then be seen in relation to how the surrounding world functions, what it demands from us, what kind of physical tools are available and what kind of sociocultural experience we have (Säljö, 2005). Instead of starting with a notion of a definition of a situation, "we must start with the idea that a particular definition is *in charge of the situation*" (Goffman, 1961, p. 133).

When framing in a certain way, in a situation, it is also important to remember that there are ways that the utterances, actions and events are *not* framed as. Activities of framing "omit as well as include, and the omissions of potential problem definitions, explanations, evaluations, and recommendations may be as critical as the inclusions in guiding the audience" (Entman, 1993, p. 54). The definition of a situation could then be seen in the opposite way, that is, what the situation is not defined as. Goffman (1961) states that "Instead of beginning by asking what happens when this definition of the situation breaks down, we can begin by asking what perspectives this definition of the situation excludes when it is satisfactorily sustained" (p. 19). The following paragraph deals with situations where the framing implies some sort of difficulty.

Shifts of framing, frame conflict and frame clearing

One main focus in this study is on situations when the participants' interactions are guided by some sort of difficulties concerning how to define the situation, or when there are conflicting understandings. In research within this field, it is quite common to study so-called *breakdown* situations, that is, situations where there is a halt in the activity, and an uncertainty about how to continue is displayed. In a sense, the notion of a breakdown might be too strong since it is not a total collapse of the participants' interaction but more a pause or a change in focus, which enables the researcher to understand what is problematic, and through this develop knowledge about what is needed for activities and interaction to continue smoothly. By studying situations where the framing becomes problematic, it is possible to reveal things that are implicit and taken for granted. Goffman (1974/1986) suggests that in situations where the framing is somehow problematic, we end up in uncertainty about how to continue and how to act in the situation;

> The concern, rather, is the special doubt that can arise over the definition of the situation, a doubt that can properly be called a puzzlement, because some expectation is present that the world ought not to be opaque in this regard. (Goffman, 1974/1986, p. 302)

What Goffman suggests is that when we face situations that we logically should be able to define, but the options to consider are so numerous, we end up not knowing how to understand the situation. One example taken from my Study I and Study II (cf. below), which illustrates a conflict of how to frame utterances, actions and events in the situation, is when the students have solved a mathematical problem and get the feed-back "incorrect". In these situations, they do not always know how to understand the nature of their incorrectness and do not know how to continue the activity. The results from these studies indicate that in the students' efforts to understand what is incorrect with solutions in digital environment, they sometimes operate with uncertainty, in-between framings of the mathematical content and framings of the digital design. This illustrates how mathematical learning with educational software results in framing problems. However, the results from my study imply that the students generally handle the framing shifts smoothly and they also develop framing abilities. This is also shown in Hoyle's (1993) study. She studied two boys who played video games, and noticed that they often framed the activity as a different activity more or less simultaneously. The boys could, for instance, play at being reporters of the game they played, at

the same time as they were the players. Hoyle (1993) suggests that there are often different and sometimes conflicting framings that guide activities, but that most of the time this is not a problem for the participants.

> For participants in interaction, framing is a resource for gracefully managing divergent tasks. These might be tasks that are normally thought of as conflicting (such as simultaneously competing and cooperating), or they might be tasks that simply require different displays of attention to interlocutors and to ideas (such as producing a monologue in specialized register and engaging in conversation). For the analyst, identifying the ways in which interactants manipulate frames helps to explain how discourse is at once anchored in literal experience yet not restricted by it. Identifying the outer frame of an activity, the points at which it is most firmly linked to the literal world, is only a starting point in exploring what is going on. More revealing of the nature of an activity, often, is the way in which participation frameworks, assembled out of such ordinary discourse elements as address terms and reference forms, are layered and mixed. (Hoyle, 1993, p. 142)

On occasions when the definition of a situation is too ambiguous for the participants, and they are uncertain about how the activity should be understood, participants often struggle to eliminate the ambiguity. They then try to clarify their own intentions and understandings in relation to the other participants. Goffman (1974/1986, p. 338) describes this as an activity of *clearing the frame*, an interaction pattern where the participants struggle to establish a mutual ground for their understanding. The ambiguity of the situation needs to be settled so that the work can continue and, as Goffman points out, this is done by actively examining the contexts. For the present research, which is shown in particular in Study III (cf. below), clearing the frame is an important dimension of their work.

The results of this study reveal that there is a multitude of ways of framing utterances, activities and events which result in temporarily established frameworks that have different qualities and different consequences for the activity. What framework the students try to maintain has to do with where the interaction takes place, what resources are made use of and the physical tools available. As Goffman puts it: “given their social identities and the setting, the participants will senses what sort of conduct ought to be maintained as the appropriate thing, however much they despair of its actually occurring” (Goffman, 1967, p. 105).

Different frameworks and their implications

I have argued for the use of the framing concept as a dynamic idea of how participants understand utterances, actions and events in activities. It has been emphasised that it is the *activity of framing* that is the focus of my analyses. The view of framing as a dynamic interactive concept is shared by many scholars (e.g. Aarsand; 2007; Buchbinder; 2008; Hoyle 1993; Linderoth, 2004; Linell & Thunqvist, 2003; MacLachlan & Reid, 1994; Tannen & Wallat, 1999). This is straightforwardly declared by MacLachlan and Reid (1994), who refer to Derrida's original statement "framing occurs, but there is no frame" (p. 6). They argue further that the concept of "framing" should be used since framing is an act that involves an agent "and therefore implies something more provisional, more negotiable than the substantive term 'frame'" (MacLachlan & Reid, 1994, p. 17). Nevertheless, the concept of framing as it was elaborated by Goffman has also been criticized for merely offering a static analysis of sequences of actions and interaction, that is, that frames are placed in a static way to surround situations (e.g. Denzin & Keller, 1981; Goodwin, & Goodwin, 2004; Scheff, 2005). This critique can be accounted for in relation to the sometimes ambiguous statements in "Frame Analysis" (Goffman, 1974/1986), which leads to a more static interpretation of the framing concept. Goffman himself, however, declared that this critique was misleading and in an article as a response[13] to this criticism, describing how the concepts are elaborated in "Frame Analysis", Goffman writes: "the body of the book deals, chapter by chapter, with a series of distinctive issues which speak to the implication of framing as a social process" (Goffman, 1981c, pp. 67-68). In Benford's and Snow's (2000) thorough review of the analytic utility of the framing concept for understanding social movements, they also emphasize the dynamic understanding of the concept;

> Taken together, research on the core framing processes indicate that collective action frames are not static, reified entities but are continuously being constituted, contested, reproduced, transformed, and/or replaced during the courses of social movement activity. Hence, framing is a dynamic, ongoing process. But this process does not occur in a structural or cultural vacuum. Rather, framing processes are affected by a number of elements of the socio-cultural context in which they are embedded. (Benford & Snow 2000, p. 628)

[13] Goffman rarely responded to any criticism, so the article; *A Reply to Denzin and Keller* (Goffman, 1981c) is an exception.

In this study, the concept is seen as a dynamic way for participants to understand activities. In describing the consequences of different ways of framing, I will, however, following Goffman, discuss the implications in terms of specific qualities that these different frameworks imply. By frameworks I thus mean the temporary definition of the situation that has been established through interaction of the participants. This could also be seen as consistent with MacLachlan's and Reid's (1994) understanding of framing as an activity together with the analytical possibility of describing qualities of frames or frameworks without understanding the concept as static. They state that a frame could be seen as "the result of an act of 'framing' and a superordinate set of frames as a 'framework'" (p. 17).

Goffman makes a distinction between *primary frameworks* and *keys* or *keyings*. Keys or keyings are constituted by frameworks that are dependent on an original, and have a primary framework as their basis. Goffman analyses various types of games and play by using the concepts of keyings. He argues that, for example, socio-dramatic play, like playing mothers and fathers has its obvious origin in family life. Another example of keying is Bateson's description of animals that are thought to be fighting but are instead playing.

Primary framework refers to established understandings of an ordinary event, which is an origin in itself, that are not dependent on some prior interpretation. Everyday situations and actions are generally framed within primary frameworks. Expressed in Goffman's words, a primary framework "is one that is seen as rendering what would otherwise be a meaningless aspect of the scene into something that is meaningful" (Goffman, 1974/1986, p. 21). The concept of primary frameworks and the two subclasses natural frameworks and social frameworks have been particularly valuable for this research when describing the temporary definition of the situation that was established through the students' interaction.

Natural frameworks and social frameworks

According to Goffman (1974/1986), primary frameworks consists of two broad classes: *natural frameworks* and *social frameworks.* The implications of these established frameworks are different in the way they help individuals to understand and interpret situations so that they become reasonable and comprehensible. The difference between natural frameworks and social frameworks is shown in what the situations will be seen as, and what

consequences this will have, which is seen in how the activity continues. When natural frameworks are established, the activity is considered to be a naturally occurring event with no human agency[14]involved. This definition of the situation implies that the situation is understood as purely natural and one that just happens. One typical example of established natural frameworks would be to understand the situation and its consequences in relation to the state of the weather.

> Natural frameworks identify occurrences seen as undirected, unoriented, unanimated, unguided, "pure physical". Such unguided events are ones understood to be due totally, from start to finish, to "natural" determinants. It is seen that no wilful agency causally and intentionally interferes, that no actor continuously guides the outcome. Success or failure in regard to these events is not imaginable; no negative or positive sanctions are involved. (Goffman, 1974/1986, p. 22)

Temporary established social frameworks, on the other hand, imply background understandings of the activity that "incorporate the will, aim, and controlling effort of an intelligence, a live agency, the chief one being the human being" (Goffman, 1974/1986, p. 22). If social frameworks are established, the participants' ability, motive, intent, intelligence, etc. play significant roles.

> What it does can be described as "guided doings". These doings subject the doer to "standards", to social appraisal of his action based on its honesty, efficiency, economy, safety, elegance, tactfulness, good taste, and so fort. (Goffman, 1974/1986, p. 22)

As an example, occurrences such as car accidents can then either be interpreted within natural frameworks or within social frameworks. If the incident is framed as natural frameworks, there will be no legal consequences since there is no one to blame. The episode would be seen as just happening due to a series of unfortunate circumstances and be understood as an accident. If, on the other hand, the incident is understood within social frameworks, the people involved play crucial roles. If the driver was blamed for what happened, like drinking and driving or wanting to hurt the victim on purpose, the incident could be framed as manslaughter or even murder. In such a situation, the driver would probably do anything to establish natural frameworks, since it would give him a completely different situated identity.

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[14] Human *agency* is used here in the sense of any human action, will, intention, ability, intelligence, skill, etc., that is to say anything that implies human influence.

The concepts of natural and social frameworks have been useful for this study in order to thematize how the students proceed with the activity. These concepts have elucidated qualities of the interactions of the students and the students' understanding of the situation. Particularly in Study II, these concepts illustrate sequences of interaction where the students' temporarily established frameworks meant that they understood the difficulties they encountered as having to do with features within the digital technology. When analysing how natural frameworks were established, it was shown that the students saw themselves as not being accountable for their lack of understanding of the difficulties they encountered. This meant that they could be excused from solving a certain task and go on to another task with a sense of 'face-saving'. These mechanisms, that is, impression management and face work are necessary elements in interaction and, according to Goffman, the ground for maintaining social order in society.[15] Face work is also something that individuals could achieve strategically.

> It has been suggested that the object of a performer is to sustain a particular definition of the situation, this representing, as it were, his claim as to what reality is. As a one-man team, with no teammates to inform of his decision, he can quickly decide which of the available stands on a matter to take and then wholeheartedly act as if his choice were the only one he could possibly have taken. And his choice of position may be nicely adjusted to his own particular situation and interests. (Goffman, 1959/1990, p.85)

[15] Goffman (1959/1990) also describes how we take on various roles in our attempts to adjust ourselves to different situations that occur both in the way we express ourselves and through other non-verbal communication patterns, gestures, etc. This sociological perspective, or dramaturgical perspective (Lemert & Branaman, 2005), implies that we play different roles and display different ways of presenting ourselves according to how we define the situation and according to the way we want to be seen. In our presentation of self, we try to maintain the role that we want to present ourselves in. According to Goffman, the self both has to do with what a person produces as a performance in social life and with what the person is able to perform, which is largely determined by the social status and resources to which a person has access. So in presenting ourselves, we perform and the performance contains both social rituals and strategic plays for us to deliver a desirable picture of ourselves. The social self is thus seen as a dramaturgical product of social interaction. The framing of the situation is closely connected with the concept of situated identity while the participants in my study "play the role" of being a student. In line with Goffman's approach (1964), identity is not seen as a fixed entity or as attributes of social structure such as age and sex, but as how people establish them self in the current activity. In contrast to a traditional perspective where identity has been seen as a rather stable structure located primarily in the individual's psyche or in fixed social categories, identity is seen as constantly created and re-created in interaction between people in a specific situation (Bucholtz & Hall, 2005; Gee, 2001; Holland & Lave, 2001; Roth et al., 2004; Sfard & Prusak, 2005).

The production of self, the situated identity and the presentation of self, is fundamental in Goffman's theory, and consists of the notion that all actions are inherently moral. However, Goffman is very distinct about the view of 'self' as a social product and not as the base line of social interaction. In that sense, the question in situations is not only *what is going on here?* but also *what is at stake here?* As already stated, the perspective adopted here implies that being a student is a specific role where the students use their prior understanding of how to interact in task situations.

> There is a relation between persons and role. But the relationship answers to the interactive system – to the frame – in which the role is performed and the self of the performer is glimpsed. Self, then, is not an entity half-concealed behind events, but a changeable formula for managing oneself during them. Just as the current situation prescribes the official guise behind which we will conceal ourselves, so it provides for where and how we will show through, the culture itself prescribing what sort of entity we must believe ourselves to be in order to have something to show through in this manner. (Goffman, 1974/1986, p. 573)

How we present ourselves, hence, is constituted through social action, especially language, and it is furthermore shaped continuously in interaction. This is done through the temporary roles and orientations that we assume and in the way others perceive us. In this sense, the roles we play are evolving in discourse at an interactional and relational level and changes during the interaction according to the need of the speaker and the listener, which means that we are dependent on how others read our actions and utterances. This again illustrates the parallel between Goffmans theory and the sociocultural perspective, where Goffman's view of how meaning is developed corresponds to the assumptions in Lave and Wenger's (1991) fundamental arguments about how we learn by participating in various communities of practices.

From a researcher's point of view, as interactive constructs, the roles we play or the way we learn to participate are also reasonably accessible and investigable (Sfard & Prusak, 2005). The introduction of digital technology in educational settings brings with it new ways for participants to interpret and respond in activities. From this perspective, these activities are not predefined but something that the participants create and re-create through interaction, involving contextual matters that emanate from the participants and the physical tools that are made use of. In the next paragraph I will give an account of the relation between frameworks contexts and resources in relation to how the concepts are used in the present study.

Frameworks, contexts and resources

The concept of context has been discussed and made use of in part differently and in part overlapping in relation to frameworks. When researchers refer to context as a concept for describing what is established in interaction, it serves a purpose that is parallel with the use of the concept of frameworks in this study. Even though different researchers emphasize somewhat different aspects of context as potentially relevant for understanding interaction, a main point of departure in recent research, which is in line with the starting point of this research, is that context is seen as something that emerge in interaction, rather than something that is predefined. An activity, cannot be properly interpreted, described or understood unless the analyst looks beyond the event itself at what is made relevant by the participants, for example, shared background assumptions, etc. (Goodwin & Duranti, 1992). Relevant contexts are developed in and through interaction and can be thought of as communicative constructs, that is, something that is constructed in communication (Linell, 1998). In this research, I have chosen to principally set out from Goffman's classical use of framing and frameworks but I have also used the concept of context in the studies to describe the practice that the participants co-create and act in. This warrants an elucidation of how the concepts are employed in the present concrete empirical research and analysis.

Goffman does not really elucidate the definition of context in relation to or compared with the concept of framing. Only occasionally does Goffman mention context and then often in passing, such as when he gives the following definition which is placed in brackets: "Indeed, context can be defined as immediately available events which are compatible with one frame understanding and incompatible with others" (Goffman, 1974/1986, p. 441). This implies that sometimes the participants' framing of utterances, actions and events intersects with what part of the context is made relevant for the participant to understand the situation. Goffman argues, in relation to scholars who emphasize the importance of discussing the context, that it is crucial to say something more about context than that it matters. He claims that "context itself is left as a residual category, something undifferentiated and global that is to be called in whenever, and only whenever, an account is needed for any noticeable deviation between what is said and what is meant" (Goffman, 1981a, p. 67). In an article discussing "Frame Analysis", Scheff (2005) argues that the concept of framing developed here could be seen as an "unpacking of

the ‘global and undifferentiated’ idea of context” (p. 384). Scheff (2005) states that “Frame Analysis” would be better understood if it had had the subtitle; “Defining Context”. The main problem, according to Scheff, is that Goffman does not clearly define what is meant by a frame and how frames relate to context. In elaboration of the concepts of framing in relation to context, Scheff argues that defining context is an empirical and not a conceptual problem.

One line of reasoning that corresponds to how the concept of context is employed in this research is Linell’s (1998) claim that it is better to talk about *contexts* in pluralis. Linell’s (1998) explanation of the use of contexts is that “a given piece of discourse is embedded within, or activates, a matrix of different kinds of contexts (or dimension of context)” (p. 128). The introduction of the concept of *contextual resources* by Linell (1998) is in line with the distinctions made in the present study. I would argue that in interaction there are various potential contexts that can be made relevant through the activities and utterances of the participants that will serve as contextual resources. These potential contexts or contextual resources could, for example, be the prior utterance, the concrete setting, the various physical tools available, the participants’ background assumptions both as regards the issues talked about and as regards the assumptions about other persons involved, the socio-historically constituted context of institutions, knowledge of language, etc. Contexts can be understood as resources participants use for framing utterances, activities and events. For this study, this implies that the parts of the context that become relevant emanate from the participants. I as a researcher thus have to be aware of what in the activity is made relevant by the participants. I have not used contextual resources as concepts in the three studies, but I am aware that this is another parallel way of conceptualising what is made relevant in interaction. In the present research, the concept of resources is used to describe what the students make use of in their definition of the situation. Thus, objects, actions and utterances are not seen as having a meaning in themselves but are given meaning by the *resources* the participants make use of in their framing and by the *tools* available. A discussion of how the concepts of resources and tools are used in the three studies follows in the next paragraph

Resources and tools – means for interaction

In the sociocultural perspective, actions are *mediated* by the tools and resources we use. We are never in direct contact with the world, there are always *mediating* tools or resources in-between humans and the world (Vygotsky1934/1962). All kinds of tools and resources assist us since when we apply them we can do a lot more than would be possible without them, and our actions also change in relation to the tools we use. Wertsch (1998) uses the terms *mediational means* and *mediated action* to describe this process of bringing tools into play. He argues that we often make use, quite unreflectively of different resources and tools. An example given is the resources used when we multiply two three-digit numbers. If we cannot write them down and make a calculation, (e.g. make use of tools such as a pen or resources such as our knowledge of mathematical dispositions) or use a calculator, that is, use resources and tools that we usually do, we have a problem (cf. Säljö, Eklund & Mäkitalo, 2006). Consequently, we instinctively use different resources to solve problems and these resources have often become invisible to us.

> In this sense, we are unreflective, if not ignorant, consumers of a cultural tool. The extent to which our performance relies on it, however, quickly becomes clear when it is not available. (Wertsch, 1998, p. 29)

What we know, and what kinds of problems we can solve, is to a large extent determined by the resources and physical tools we have at our disposal in a particular practice (Wertsch, 1998). Following the research traditions that have guided this study, mediation is a feature of human interaction. In this study, the concept of *framing* is used as the main entry into the analysis and mediation is seen as one aspect of framing and the concept *resource* points to the mediational means that are used in situations. The concept of framing thus becomes an analytical tool where I as an analyst seek to understand how the students make use of various *resources* and *tools* in the activity and by means of that aim at understanding how utterances, actions and events are *framed*.

4. Research context

Introduction

This chapter gives an account of the empirical material, which forms the basis of the analysis conducted in the three studies, and an outline of the additional empirical material in the research as a whole. This chapter also contains a description of the setting, the context of the filmed sessions and information on the specific software that the students in the study used. Finally, there is an outline of the reasons for choosing the sessions of the mathematical sessions as a point of departure for the analyses in the three studies.

Empirical material

This research was conducted within the framework of the Research Project DID (Design and Implementation of Educational Software), which was a three-year research assignment at the Department of Education, University of Gothenburg. Project DID was financed by LearnIT, the Knowledge Foundation's (KK) research programme, which aims in the long-term to build up a body of knowledge in the area where learning meets information and communication technology.

The empirical material in this project[16] consists of video recordings of students working in pairs or in threes with educational software. This material includes 16 video films, each lasting about 60 minutes. In all, 34 students participated; 16 girls and 18 boys.

	Mathematics 10 sessions	English 6 sessions	Students in all sessions
Girls	10	6	16
Boys	12	6	18
Students	22	12	34

Figure 1. Students in the filmed sessions

[16] In the three studies, I have only used excerpts from the video films where the students worked with the VETA learning game in the subject Mathematics. The reason for choosing these sessions is elaborated on in a separate paragraph further on.

In order to obtain the empirical material needed to analyze interaction and activities in relation to the educational software, the participants had to collaborate. The dynamic process can only be made visible by studying the interaction between individuals on the one hand and the interaction between the individual and the computer on the other. This is the reason for requesting that the students collaborate on the same task, on one computer, during the filmed sessions.

To be able to understand an activity, it is useful to gain as much knowledge as possible about the participants and the settings. There are certain insights that can be attained by simply asking the participants but hardly by analysing the videos. Accordingly, in many cases it is valuable to use other methods such as formal and informal interviews, participant observation, etc. since it is not possible to obtain all the necessary information solely by means of the video films.

> Without a sense of the social and technical resources on which the participants rely, it would be difficult to understand many of the activities in which they engage. Some of these resources can be recovered through video, others require extensive observation and discussion with participants. (Heath & Luff, 2000, p. 22)

Mercer (2008) takes this line of argument even further by suggesting that the activity of learning in school can only be understood as a long-term trajectory and that more attention "should be given to the temporal dimension of classroom dialogue both empirically and theoretically" (p.33). He dismisses methods for analysing discourse "in which the analyst simply attends to the relationship between contributions made by participants in one recorded conversation, without applying available information about previous related interactions and historically contextual knowledge shared by the participants" (p. 56). In order to reach a deeper understanding of the activities in the specific social and cultural practice of this study, supplementary empirical material has been collected. In addition to the 16 filmed sessions, the research includes five taped interviews with teachers in Mathematics and English as a second language, four group interviews with students, two taped interviews with designers and producers of educational software, two filmed lessons and seven observed lessons. The research projects as a whole also include empirical material from a specific learning environment in Sweden called Learning Centre. This is a place were most students have an individual curriculum for their studies and where a certain portion of the education is

organized as distance learning. The empirical material from the Learning Centre consists of four taped group interviews with students, two taped interviews with teachers, 11 taped sessions from Religion lessons, two taped sessions from lessons in Mathematics and one taped lesson in Swedish as a second language. In addition, there are also field notes, photos, screenshots, etc. All additional empirical material has served as a background resource for me as a researcher to acquire a more comprehensive understanding of both the practice where the software is used and the educational software as such.

The setting

The setting of the study is an upper secondary school located in a small town in western Sweden. The school is the only upper secondary school in the town, and it has most of the national study programmes. The students who participated in the study all attended a study programme called "The open program", which meant that the students did not choose the social studies programme or natural sciences programme until their second year. The aim of this programme was that the students should be able to try out various different techniques and different applications such as different media in their learning activities. One of the characteristics of this was that the students all had access to a portable computer and the building was equipped with a wireless web connection. At time of conducting the study, the students were working with one of the most widespread educational software products in Sweden.

The filmed sessions

The students in this study worked with the software they use in their regular instruction. The video-recordings took place in a room adjacent to the classroom, where the students worked with the educational software during their regular classes, and the teachers regularly entered the room and interacted with the students. During most sessions, there were three cameras in use. One captured the screen, a second one captured the students from the back in order to document their non-verbal activities (pointing to the screen, etc.), and a third one captured the activities from the front in order to be able to see the students' expressions and to facilitate following the conversation.

All kinds of interventions have a bearing on activities, however, the students usually worked together on one computer (due to other circumstances) and sometimes in the group room where the recording took place, so interference

with the ordinary school activities mainly consisted of the cameras. For that reason, the cameras were placed in the room and the researchers left the room during the filmed sessions. This was done in line with the arguments by Heath and Hindmarsh (2002), “to ensure that the participants are distracted as little as possible by the recording” (p. 17).

The students worked in pairs, except for two sessions when there were three students in each group. The films have been synchronized into one film, where the different camera-angles are visible at the same time as is shown in the screen shot below.

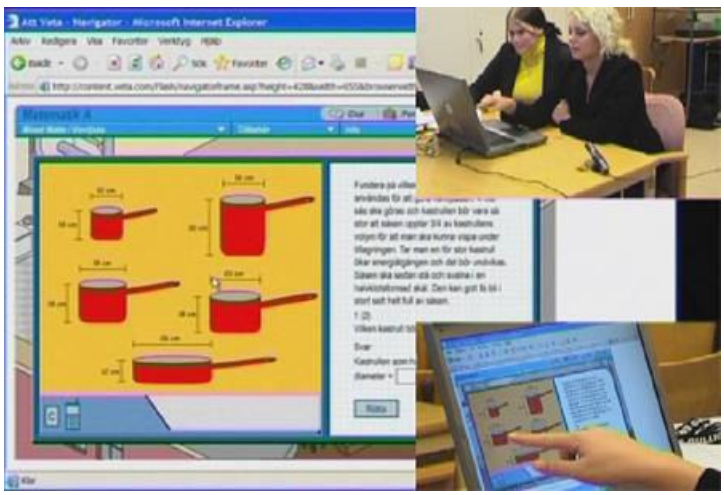

Figure 2. Screenshot from one of the edited video films, no.6

Research ethics

Before the study was carried out, a meeting was held with the headmaster and all the teachers concerned, where the exact dates when it was convenient to carry out the different parts of the study were decided on. Thereafter, the students were informed about the research both verbally at a meeting before the study started and in written form where the aims of the research were described. The students’ parents were also informed in a letter explaining the research. It was emphasized that all participation was voluntary. The research has followed the ethical code of the Swedish Research Council.

Educational software in the context of the present study

When it comes to defining educational software, there is currently a rather common and general definition that presupposes that almost all digital equipment used by students and teachers in an educational situation could be called educational software (Selander & Svärdemo-Åberg, 2009). In this tradition, educational software could be anything from calculators, digital cameras, word-processing software like MS Word, the web browser, various multimedia tools like PowerPoint, interactive whiteboards, etc. To indicate that the broad definition is used, the term "digital learning resources"[17] (Myndigheten för skolutveckling, 2007) is now frequently used in Sweden. The educational software in this study is more narrowly defined as software products produced for schools with learning a specific subject as the primary purpose, software that has a relationship with an educational textbook, and is the bearer of educational content. This definition has been an important aspect since in many other applications where the relation to educational practices is relatively weak while in educational software especially produced for these settings, both the content and the technique are adapted to fit the specific practices of school.

The web-based and interactive educational software, which the students in this study worked with, is called *Learning Game*. It was produced for the upper secondary school level and adults. The producer, VETA (in Swedish this literally means KNOW), is the largest company developing web-based educational software for upper secondary schools in Scandinavia. This Swedish commercial company[18] was established in 2000 and specialises in offering education in mathematics, physics, language, nursing and healthcare education. On its website, it is emphasized that there is a need for teaching aids that allow people to study on their own terms and at the same time be amused. On VETA's website in English, the text suggests that the students who have used the software are very optimistic and the learning game is described as a new form of educational software for a more "flexible organisation";

> VETA Learning Game is a modern learning material that creates new possibilities for a more "flexible organisation". Research show that students are very positive

[17] In Swedish; Digitala lärresurser
[18] Among the owners are Svenska Kommunförbudet, Lernia, Skandia, Svenska kommuntjänstemannaförbundet (SKTF), Metall and Kommunal.

with VETA Learning Games, their experience is that they where more engaged and showed better results. (http://www.veta.com/skola.php)[19]

All the games produced by this company follow the guidelines, the curricula, the syllabi and the grading criteria set up by the Swedish Board of Education. The learning games consist of a number of modules. A module in Mathematics can, for example, be geometry, whereas in English they are more thematically organised. One module consists of assignments, theory sections, tasks, teacher's manual sections, and other design elements such as various help buttons. When they use the educational software, the students work with problem-based assignments in a story-based game context. The story-based assignments consist of one or more tasks where the students help different characters to solve problems. However, there are few connections between the game parts and the learning parts and the game components mainly work as a reward for educational activities having been completed.

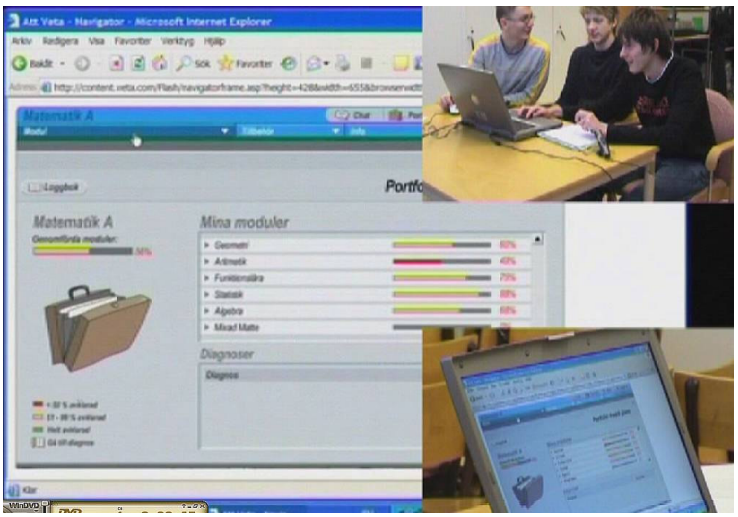

Figure 3. Screenshot showing the students checking how many percent of the different modules they have finished, film no.7 (this table is also available for the teachers)

In the software, there is a special section called the *Theory Section* which is a design element found 'outside' the part where the students regularly solve

[19] Accessed 27-02-2005, VETA has, as of Autumn '08, closed down their business and website.

tasks. This element contains formulas, concepts and other information related to the tasks. The Theory section is structured in accordance with modules for the course as well as being based on more specific content.

> In the *Theory section* the students are able to deepen their subject knowledge. Here the students receive sufficient information to solve the assignments in the different modules. The assignments work as a motivator for the students to deepen their understanding through reading the theory.[20] (http://www.veta.com/skola.php[21], my translation).

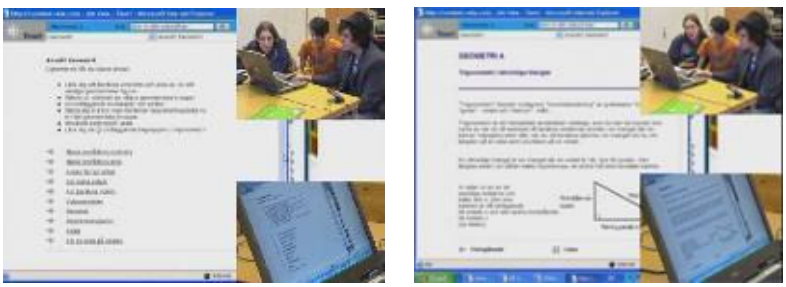

Figure 4. Examples of students entering the Theory section, to get help to solve the task, film no.10

In the software, the information is presented both in text and in spoken form, and there are different options for the students to get further help via theory sections and various kinds of help buttons. The digital tool also includes a variety of sounds, still or animated graphics and film segments. When the students have written an answer, there is a key to press to correct the answer. A particular topic concerning the correction issue, in the context of mathematical learning, is that while working on the assignments, students have no answer book where the correct answer is available. Instead, when they enter their solution, they only receive feedback on whether their response is correct or not. When the response is incorrect, there is no additional information about what is wrong. Hence, there is no feedback in the system on what kinds of mistakes have been made. The reason for bringing up this specific topic is that when analysing, it was shown to be of significance for

[20] In Swedish: ”I teorin kan eleven fördjupa sina ämneskunskaper. Här får eleven tillräcklig information för att lösa uppdragen i de olika spelmodulerna. Uppdragen fungerar som en motivator för eleven att fördjupa förståelsen genom att läsa teorin.”
[21] Accessed 2005-02-27, VETA has as of autumn 08 closed down their business and website.

the students' work since in mathematics exercise books in Sweden there is generally an answer book section (Swedish: Facit). This implies that Swedish students are used to checking their calculations by comparing them with the answers given in the Facit. The fact that the students were used to working in a specific way had consequences for how they acted when this way of working was not possible.

In the software, there is a specific section with instructions for teachers, were they also can check the work their students have done and their marks in the diagnosis that follows each part.

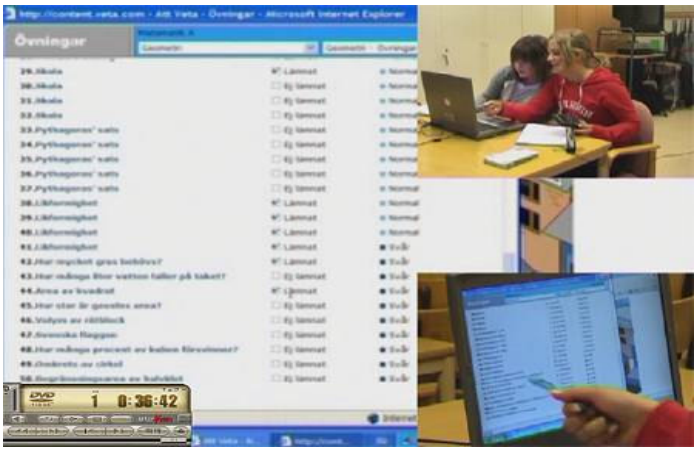

Figure 5. The students check what tasks they have done, film no. 4 (this table of completed tasks is also available to the teachers)

The company declares that they address "teachers and schools that are looking for tools to facilitate teachers' work and to release time for the most qualified parts of a teacher's job." (http://www.veta.com/skola.php[22] , my translation). Another benefit mentioned on the website is that it enables teachers to spend more time on the quality part of a teacher's job. It is argued on the website that upper secondary school and adult education have difficulties in making the available supplies suffice. The argument is that the students often have varying needs and different previous knowledge and that

[22] Accessed 2005-02-27, VETA has, as of autumn '08, closed down their business and website.

it is often very difficult for teachers to find enough time for all their students and cope with the variety of needs.

> Students have a right to be satisfied with their education and the results they achieve. With VETA Learning Game, the students become involved and their prospects of reaching the knowledge goals are increased at the same time as the teacher's work situation is facilitated. (http://www.veta.com/skola.php[23], my translation).

The picture drawn above, that is, the description of the software from the producer's perspective, clearly shows that it is grounded in a normative agenda. Words like flexibility, facilitation, motivation, involvement and joy are buzz words that are used to describe the benefits of this educational software. The phrases flexibility and facilitation of teachers' work belong more or less to the organisational agenda whereas the concepts of motivation, involvement and joy, can be related mainly to pedagogical benefits. However, it is not clear on what basis they make these claims, but the statements are undoubtedly based on arguments that consist of the belief that technology per se will ultimately lead to improved learning outcomes (cf. Schrum et al., 2005).

Reasons for selecting the mathematical part of the educational software as the main empirical material

In the setting where the study took place, VETA learning games were used in the subjects Mathematics and English. In this study, I have not analysed the material used in English, the motive for this being that the video sessions in Mathematics were more adequate, for two reasons in particular. The first reason has to do with external conditions. In the setting of the study, the use of the educational software in Mathematics was mandatory, and the students used it instead of a traditional textbook, whereas in English they used the educational software as a supplementary teaching aid in combination with various other materials, textbooks, etc. As a consequence, the use of the software in English differed from the use of the mathematics part of the software. The fact that the English part of the software was used only occasionally was obvious from the students' activities where they often

[23] Accessed 2005-02-27, VETA has, as of autumn '08, closed down their business and website. In Swedish: "De studerande har rätt att känna sig nöjda med sin utbildning och nå resultat. Med VETA Lärospel väcks elevernas engagemang och ökar deras möjligheter att nå kunskapsmålen samtidigt som lärarens arbetssituation kan underlättas."

jumped from task to task and, if they encountered difficulties, they simply skipped the task and chose another, which is interesting, but not a focus of this study. Being able to scrutinize how the students framed utterances, actions and events in the activity and what role the educational software played in the interaction would then have been quite difficult. This is the first reason why all three studies deal with the students' work with the educational software in the subject of Mathematics. The second reason is more deliberate and intentional since there is a long tradition of software products consisting of mathematical tasks, and digital tools have perhaps played a particularly significant role in mathematics. Oldknow and Taylor (2003) claim that technologies are inevitably here to stay in educational settings and argue that this applies especially to the subjects of Science and Mathematics. This has to do with a tradition in the subjects where different physical tools have been in use for a long time, for example, advanced technological calculators. Maths and Science teachers are also often among the early adopters of digital technology and are thus often experienced users of various educational digital tools.

5. Research methods

Introduction

This chapter starts with an account of the reasons for choosing video recordings as the main method of this research. This is followed by a clarification and a description of how the analysis of the empirical material is performed, where also pros and cons of the choice of transcript model are discussed. Finally, there is a brief note on issues of translation and a discussion of the principles for selecting the specific excerpts in the studies.

Video recordings

Video recording was chosen as the main research method since it is suitable for analysing interaction in concrete activities between participants and various physical tools, such as computers, and at the same time capturing what happens on the screen. The well-known analyst of school practices Erickson (2006) argues that in educational research video recording is now becoming quite common and that this has to do with an "interactional turn" (p. 177); a turn towards a recognition that various phenomena (e.g. learning and teaching, morality in school, bullying, learning outside school, etc.) are interactionally constituted. This implies that the focus of research is on social interaction in situations where they occur and that the "fine grained information about the actual conduct of social interaction comes best from making audiovisual recordings of it from which either detailed transcriptions of the interaction can be prepared and analyzed or careful moment-by-moment coding can be done" (Erickson, 2006, p. 177). Using other kinds of methods, for example, note-taking or on-the-spot coding, means that speech details and aspects of behaviour will be lost. Video recording has the advantage of permitting "permanent records of the social world to be examined and re-examined in the light of different research questions" (Goodwin, & Heritage, 1990, p. 289). The films give, besides the talk-in-interaction, extensive additional information concerning other modes such as gestures, facial expressions, body movements, etc., which are all very valuable signs in the analysing process (Kress, 2003, 2004). In analytical work with video recordings, it is possible to transcribe the interaction with additional information about, for example, facial expressions and, in this study, what is visible on the screen. In this way, it is possible to scrutinize

what in the environment becomes the focus of the students' current orientation (cf. Goodwin, 2003a).

One of the advantages of using video recordings is that the unprocessed empirical materials on film are available for the research community in a way that field notes are not (Silverman, 2001). It is possible to show the video-recordings to other researchers who will be able to discuss and criticize the analysis based on the sequences where they originated, that is, "to present and discuss materials on which observations and analysis are based" (Heath & Luff, 2000, p. 21). When performing the analysis of the present study, the video films were subjected to shared watching, scrutinizing, discussing, and analysing in various seminars and workshops.[24] Even if it is a time-consuming method, the advantages of being able to watch the videotapes over and over, from different perspectives and with other researchers, are obvious (Duranti, 1997). However, even if video films have many advantages as analytical material, it is important to note that recordings only represent a part of the activity and do not give the only full and 'true' picture of the course of events. The positions of the cameras more or less reflect the interest of the researcher and there is, of course, a risk that significant aspects of the activity are missed (Lindwall, 2008). In this research, three cameras are used in an effort to reduce the number of crucial actions and events missed in the activity.

Analysing the video films

When analysing the utterances and actions of the students when they solve tasks presented by educational software, Goffman's (1974/1986) theoretical ideas offer analytical and theoretical concepts for dealing with activities from the participant's point of view (cf. Aarsand, 2007). The analyses focus on what the participants are doing and what they are saying (Widdicombe, 1998).

[24] For example, in the seminars held by The Network for the Analysis of Interaction and Learning (NAIL).
NAIL is a central part of the Linnaeus Centre for Research on Learning, Interaction and Mediated Communication in Contemporary Society (LinCS). The main purpose of the network is to collaboratively perform detailed analyses of social interaction by regularly organising data sessions, workshops and seminars. The focus is on rigorous analytical work, mostly in the spirit of ethnomethodology and conversation analysis. Although the principal aim of the network is to provide opportunities to jointly perform analyses, a secondary aim, closely connected with the first, is to discuss and elaborate on issues concerning the relations between social interaction and descriptive accounts, analysis of interaction and theories of learning; descriptive accounts and instructional design. These general issues are discussed in the light of empirical material and specific research projects, rather than in the abstract.

It is by scrutinizing how the participants interact, that is, how they act in accordance with the temporarily definition of the situation that I, as analyst can account for what kind of framework has been established. To analyse a situation with the concept of framing means freezing an activity and searching for some sort of cue in the interaction as to what the frozen activity means to the participants.

Interaction Analysis (Jordan & Henderson, 1995) is the method used in this empirical study, where the aim has been to study the students' utterances, actions and events in the activity in relation to the software at hand. With its roots in ethnography (especially participant observation), sociolinguistics, ethnomethodology, conversation analysis (CA) and other traditions that also include nonverbal resources in interaction, the aim of Interaction Analysis is to identify how the participants make use of various resources in the complex social and material context in which they act. One important assumption in Interaction Analysis that corresponds with the socio-cultural tradition is that knowledge is not seen as something that is localized in each individual's head, but as situated in the interaction between participants in specific practices. Interaction Analysis is also consistent with Goffman's[25] (1974/1986) micro sociological theory in regarding interaction as a job; an activity that participants perform in order to accomplish something, and in the assumption that research should focus on how participants create meaning in this activity. The analyses are, thus, based on how the participants understand each other's utterances and actions.

[25] Goffman did not elaborate very much on methodological issues and this is also something he has been criticized for (e.g. Goodwin & Goodwin, 2004; Scheff, 2005; Schegloff, 1988; Williams, 1988). But in "Frame Analysis", there are instances where he claims that it is of utmost importance to ground the analytical work in the small elements of interaction on a micro level. Goffman argues that his "concern over the years has been to promote acceptance of this face-to-face domain as an analytically viable one-a domain which might be titled, for want of any happy name, the interaction order – a domain whose preferred method of study is microanalysis." (Goffman, 1982, p. 2)

Analyses of studies within conversation analysis (CA)[26] and ethnomethodology[27] tradition that emphasize the necessity of attending to the details of interaction in order to understand social phenomena have inspired the analytical work of my research (e.g. Goodwin & Heritage, 1990; Macbeth, 2000, 2004; Sacks, Schegloff & Jeffersson, 1974; Saxe, 2002; Schegloff, Jefferson, & Sacks, 1977). The analytical focus of those studies is on how actions and speech get their meaning in relation to the preceding and subsequent utterances in the context where these occurrences take place. Several scholars have made use of Goffman's theories in combination with conversation analysis and ethnomethodology. For example, Maynard (1991) argues that by developing Goffman's theory with this more in-depth analysis of interaction, the temporality of social life is better understood. He claims that "If ethnomethodological theorizing shares with Goffman a concern for analysing of the intrinsic organization of everyday life, therefore, it incorporates in addition a sensitivity to the contingencies that actors experience according to the temporal unfolding of actual events" (Maynard, 1991, p. 279). Goodwin (e.g. 1996, 2000, 2003b, 2007) is another example of a researcher who has used Goffman's theory in combination with conversation analysis in a number of studies of how people participate in communication and activities. Goodwin's studies place emphasis on the importance of studying not only the communication but also other interactive behaviour such as body movements, gestures, etc. For example, the use of the concept of embodied participation framework in the interaction of a father who is helping his daughter to do homework (Goodwin, 2007) shows the significance of how the participants position their bodies when organizing the

[26] Conversation Analysis shares the assumption with Interaction Analysis that knowledge and action are social phenomena, situated and developed in interaction based on empirical studies that focus on participants' communication and action in an activity, were the aim is to analyse and understand how the participants create meaning. The concept of Interaction Analysis has been employed here since it presents a major opening towards the non-verbal actions and the tools that are made use of in the interaction. Furthermore, the use of Interaction Analysis provides a focus that goes beyond the conversation as such and takes an interest in the meanings of the interaction thus what the activity means to the participants.

[27] The term ethnomethodology was initially used by Garfinkel (1967). This sociological discipline studies how people make sense of the world by studying the interaction without employing psychological or sociological explanations. I have no intentions of giving a thorough definition of ethnomethodology or comparing it with Goffman's approach here. The point is that in several respects, the theories share the same basic assumptions but there are also differences. Schegloff (1988) argues, for example, that one of the differences between Goffman's way of analysing and ethnomethodology is that Goffman is more issue driven and ethnomethodology is empirically driven.

activity. In another study where gestures made by a man with aphasia are scrutinized, Goodwin (2003b) points to the importance of analysing interaction within its specific frameworks in order to understand the meaning of the gestures. Another example is Evaldsson's (2005a, 2005b, 2007) studies of how children create meaning and maintain social order in school contexts, where the analyses are performed by combining Goffman's micro sociology with the conversation analysis tradition.

In the present study, Goffman's concepts and an additional sensitivity to details in interactions, derived from some lines of reasoning within conversation analysis, have been employed in the analysis of the empirical material. This means that the participants' assumptions and understandings, which are visible in the talk, have been central to the analysis (Jordan & Henderson, 1995; Coupland, & Coupland, 2000). The basis of the analysis is the implication that linguistic cues and ways of talking provide evidence and signal the shifting of frames (Tannen & Wallat, 1987). The talk and the interaction are recognized as more than a means of sharing thoughts:" it is a social mode of thinking, a tool for the joint construction of knowledge by teachers and learners" (Mercer, 1996, p. 374). Talk is not seen as abstract sets of words or meanings but as a practical, social activity located in settings and occurring between people (Potter & te Molder, 2005). This implies that the analyses performed in this research are focused more on what happens in forms of both verbal and physical responses or when an utterance is expressed, than the language per se. Schegloff (2007) argues that instead of focusing on what the talk is about, that is, the topic of an interaction, the focus should be on what happens when an utterance is expressed. He states that "it is important to register that a great deal of talk-in-interaction – perhaps most of it – is better examined with respect to action than with respect to topicality, more for what it is *doing* than for what it is *about*" (Schegloff, 2007, p. 1). Schegloff gives an example of an utterance like "Would somebody like some more ice tea?" which then would be better understood as "doing an offer" than as "about ice tea". Goffman also deals with talk as doing something in "Replies and responses" (1981b). As an example, he uses the utterance "Do you have the time?" which is not really a question about whether the addressee knows the proper time or not, but a request to get to know what time it is. In a chapter of the book "The ethnography of communication", Goffman (1964) argues that utterance "of course submit to linguistic

constraints (as do meanings), but at each moment they must do further job, and it is this job that keeps talk participants busy" (p. 136).

When analysing the students' utterances and action, the notion of turn-taking and the uptake of earlier statements as a basic form of organization for conversation have been considered. The basis of analysis has been the assumption that an utterance get its meaning from how it is taken up, that is, how it is responded to by the other participants. This implies that an utterance cannot be analysed in isolation, but must be seen as a response to a prior action, a prior utterance, etc. Nilsen and Säljö (2009) imply that every utterance could be viewed as a basis of the previous and the following utterance in a specific situation. They state that each utterance is simultaneously a response to what has been said and creates a platform for continued interaction. This sequential organization (Sacks, Schegloff & Jeffersson, 1974; Schegloff, Jefferson, & Sacks, 1977) forms the basis of the analysis in this research when trying to understand how the students understand and orient towards each other. The response is then seen as the indicator or 'proof' of how the first utterance is understood by the participants. "It is a systematic consequence of the turn-taking organization of conversation that it obliges its participants to display to each other, in a turn's talk, their understanding of other turns' talk" (Sacks, Schegloff & Jefferson, 1974, p. 728). These assumptions correlate with Goffman's (1981a) idea that interaction can be structured in pairs of response–referents[28]. By studying responses, and what they are responses to, it is possible to discern what was relevant for the speaker and thus analyse how the participants framed the utterances in the activity. Speech, actions and events must, thus, be seen as elements of interaction that are dependent on each other. All occurrences could be the focus of the interaction, regardless of whether they are performed by the participants or by the circumstances in the activity, for example, by feedback from the software (Linderoth, 2004). Statements also have the

[28] Goffman (1981b) claims that the notion pattern for interaction developed by Harvey Sacks of "adjacency pair", that is, one utterance that temporally follows directly on the other; a couplet or a minimal dialogic unit, instead should be considered as a structure of *responses*. In interaction, the issue is sometimes not that the recipient agreed with what they have heard, but only agree with the speaker as to what they have heard and to describe this interaction as "question-answer" or "statement-reply" is not always adequate. The term response is, according to Goffman, more appropriate. Responses are seen as dependent on earlier statements or activities in the interaction and every statement is uttered in relation to how the speaker has framed in the situation and the occurrence in the interaction before. But this discussion is clearly outside the scope of this thesis.

possibility of introducing new factors, contradicting earlier interaction and in that way breaking the framing.

According to Goffman (1981b), responses have four qualities. Firstly, they are seen as originating from the individual and as deriving from something previous in interaction. Secondly, responses tell us something about the position of the speaker in relation to the interaction. Thirdly, they draw up the boundaries of and articulate what it is that is occurring. Fourthly, responses are displayed in order to get attention from others in relation to being assessed, appreciated and understood at the specific moment (Goffman, 1981b, p. 35). By focusing on responses when analysing, it is possible to discern what the focus was and what was of significance in the previous interaction. This means analysing by reading the transcripts backwards and forwards, since the meaning of an utterance or an act is shown in how it is perceived by the other participants in the activity. In this analytical work of reading and trying to understand the transcripts, it is, however, of importance to repeatedly return to the video films, in order to study the talk in the vivid interaction.

> At one level of analysis, then, the study of writable statements and the study of speaking are different things. At one level of analysis the study of turns at talking and things said during one's turn are part of the study of face-to-face interaction. Face-to-face interaction has its own regulations; it has its own processes and its own structure, and these don't seem to be intrinsically linguistic in character, however often expressed through a linguistic medium. (Goffman, 1964, p. 136)

In line with Goffmans' arguments above, which parallel Linell's (1994) reasoning, the implication for this study is that the video films are regarded as the empirical material and the transcriptions are considered to be a working material that has been processed by means of interpretations and analyses. Thus, "Transcription does not replace the video recording as data, but rather provides a resource through which the researcher can begin to become more familiar with details of the participants' conduct" (Heath & Hindmarsh, 2002, p. 19).

Transcription of the video films

When transcribing and presenting the video recordings, there are many alternatives and many choices to make. It is not possible to represent everything that happens in an activity, consequently there is always a selection of what to include and what to omit in the transcriptions.

Interactions are full of nuances which mean that it is not possible to make a totally complete transcription. This implies that transcriptions differ in precision, however, it is not only a question of details, different transcription models choose different dimensions for representation. Thus, transcripts are dependent on the theoretical basis and the aim of the study (Linell, 1994) and should reflect the specific interest of the researcher.

Ochs (1979) discusses transcription procedures with a focus on difficulties in using conventions of adult models of interaction when transcribing 'small-children's languages behaviour'. Her general claim concerns the contradiction in wanting to represent as much as possible of the verbal and non-verbal behaviour and at the same time being selective and not too detailed because that would make the transcript difficult to follow and assess.

> Ideally, we want our transcript to meet practical as well as theoretical considerations. We want our transcript to express the relation between nonverbal and verbal behavior as accurately as possible: We want it to encode not only prior and subsequent behaviors, but coocucurrent and interoccurrent behaviors as well. We do not want a transcript that discourages the reader from integrating verbal and non verbal acts. On the other hand, we want a readable transcript, one that displays clearly and systematically utterances and contexts. (Ochs, 1979, p. 59)

In the present study, I have chosen to organize the transcripts in a system with columns derived from Suchman's (1987) 4-column transcript, elaborated and discussed by Jordan & Henderson (1995) and further developed by Linderoth (2004). The reason for organising the transcripts this way is because they represent the connection between the communication, the activity that the participants perform such as writing, gestures, pointing, etc., and the activity on the screen. This 5-column system[29] makes it possible to document participants' talk and actions as well as the activities on the screen. Moreover, this transcription model supports the analysis that is based on uptakes and responses and on what the talk is doing. Furthermore, this organisation is chosen in an effort to make the conversation readable, even for persons not used to read transcripts of talk. Following Linderoth's (2004) transcription system, no coding to indicate intonation, tone of voice, laughter, etc., or

[29] In study III, the empirical material is presented with an additional first column to display the time, since it was considered of importance to elucidate that this was in the very initial activity of unpacking a task. This should also be seen as a development of the transcription systems used in the studies.

pauses in seconds, has been used. Instead, indications of various shifts in voice have been made in square brackets, and only if something in the response indicates any implication of this. Parallel speech is also indicated in square brackets, and pauses have been described if they were considered important for the analysis. Another reason for choosing this transcript system is to facilitate the course of events for a reader. It is also a consequence of Goffman's criticism concerning the formalism in some of the conversation analyses, the meticulousness of which risks neglecting the main purpose of the interaction analysed.

When transcribing the video recordings, there are several issues to consider. However, the purpose of the study as a whole must be set as the primary concern when making various decisions on displaying the talk as text. Linell (1994) claims that there are two demands that have to be considered when transcribing. The first concerns "authenticity", that is, the transcription should be related to the verbal situation. The transcript should then present what is said and as far as possible how it is said. This means that the transcript should not follow the rules, grammar etc of the written language. Linell's second demand concerns "practicality" and has to do with the fact that the question of details must be seen in relation to the object and aim of the study and also in relation to making the transcription readable. A major element of analysing in the present study is the speech, and as a consequence of this all statements are transcribed. The transcripts should be read from left to right, which means that the utterances in column three are made in the same sequence of time[30] as activities performed by the participants in column four and in the same sequence as the events happening on the screen, which are described in column five. The turns should, thus, be read in order from left to right. In the fifth column, the description is limited to changes on the screen for space reasons and the picture and the task on the screen is described, and often also illustrated by a screen dump (as below), before the excerpt is presented. The columns contain:

- Turn in the excerpt
- Participants' fictitious names
- Participants' speech, exclamations, sounds, etc.

[30] Note that to answer the research questions of the studies carried out here, it has not been considered necessary to account for an exact time in number of seconds, as is frequently the case in CA transcripts, e.g. to indicate exactly where in a coherent utterance a key is pressed.

- Activities in the room
- Activities on the screen.

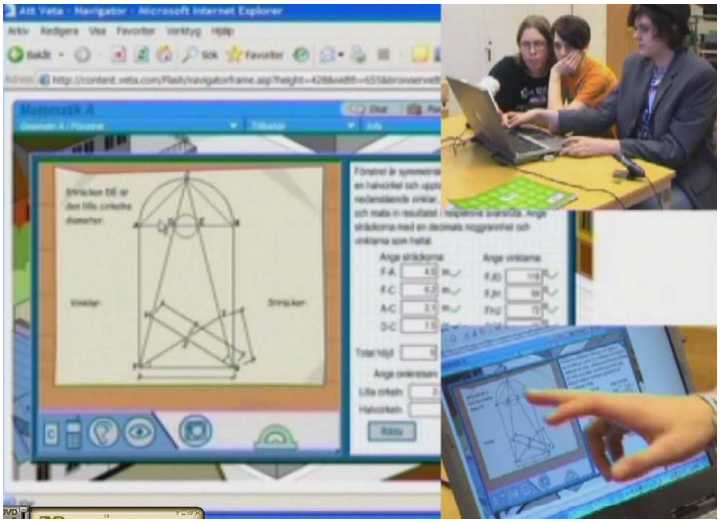

Figure 6. Screenshot of video material displaying the picture on the screen of the transcript below

Turn	Name	Talk	Activity in the room	Activity on the screen
1	Hans	it [the computer) might be so stupid so it wants the circumference of a whole…half circle? [giggles] circle	Enters the sum of the whole circle	
2	David	no! [inaudible]	Presses the correct button	Gets "incorrect" answer
3	Hans	no, it wasn't that stupid		
4	David	what… seven comma one		
5	Johan	[giggles] may I ask , who is it in this context?	Johan looks at Hans	
6	David	Johan!		
7	Johan	is it the computer? [giggles]	Gesticulates with his hand	
8	Hans	computer [said in unison, giggles]	Hans looks at Johan	
9	David	Johan!		
10	Johan	is it the computer that decides? [giggles]		

Figure 7. Example of transcript from one of the mathematics sessions (this excerpt is analysed in Study I)

Irrespective of which transcript convention is chosen, each format has its advantages and its disadvantages. According to Bucholtz (2007), the variation of transcripts could be understood as a kind of linguistic variation. Bucholtz (2007) argues that the discussion would be more fruitful if it was not a question of tracking down inconsistencies in the different transcription systems, which would be an exercise too easily accomplished. Instead it should be about a deepening of the discussion to allow researchers to focus on their own transcription choices in relation to the consequences of it for analysis and representation and to make this explicit in the texts. That the transcription system chosen in this research does not follow CA conventions, thus, has certain advantages and certain shortcomings. The effort to provide the transcriptions in a more reader-friendly format for people uninitiated in the CA transcript conventions has to be reflected upon in relation to the fact that CA transcript conventions are now well established in educational research. The choice of, for example, omitting variations of tonal nucleus, accelerating tempo, measurable pauses, etc. of the utterances that did not seem to make any differences in analysing might be of help for reanalysis by readers who do not have access to the video recordings. The transcription system here could then be criticized for determining in advance what details are important, leaving out of certain things that might hinder a reader's understanding, in agreement or disagreement with the analyses.

A development of the transcription model is that in Study III an additional first column to display the time is added. Another consideration concerning future transcription models is to use more visual representations in relation to the transcription to make it easier for readers to understand the non-verbal activities (see e.g. Mondada, 2003; Ivarsson, 2007; Lindwall, 2008; Greiffenhagen & Watson, 2009). From a methodological standpoint, there are advantages in separating utterances from other sorts of information. However, it also involves problems, for example, when the orientation is left-to-right, the text presented to the left tends to capture the reader's attention before the text to the right. In this case, utterances are given a preliminary reading without any non-verbal actions, which are added later (Ochs, 1979). For the column transcription system chosen here, the utterances are what are most important when analysing so this choice is intentional. The main reason for not choosing a CA transcript is due to the major aim of the research, which has been to analyse what meanings the utterances, actions and events had to the participants and not the structure of the interaction.

A note on translation of the empirical material

In translating what the students said from Swedish into English, the essence of what the students said has been considered. In many cases, the translations have been done word for word and with respect to the specific activity, that is, in an effort to use translated words that seemed suitable for the context at hand (Duranti, 1997, p.154 ff). The Swedish expression has also been translated into a colloquial informal English expression since the empirical material consists of communication between 17-year-old students. Aarsand (2007) describes this as "finding the English words that 'correspond' to the Swedish ones" (p. 43). As I see it, finding a *corresponding word* is, per se, not possible, which is the main dilemma. This is another reason for performing the core analysis in relation to the video films and in relation to the original language.

Principle of selection

In first a preliminary mapping of the whole empirical material was performed. In this phase, several interesting interaction patterns appeared. This mapping was done as a first analysis in relation to the participants' interaction in sequences where the presence of digital technology seemed to play a significant role. One pattern that was further explored was when the students experienced some kind of difficulty. This is the main focus of Study I. This pattern became the focus for additional analysis since the way the students continued after an experienced difficulty was found to be of interest. The students displayed patterns of ambiguity; sometimes they searched for the answer in their own actions and sometimes they considered the answer to be in the technology. These findings are mainly described in Study II. A third pattern concerns the participants' unpacking interaction with the digital technology. That is, on occasions when they try to understand what the tasks entail. In doing this, their awareness of the design of the educational software seemed to be of significance, which is essentially the contribution of Study III.

The case-based excerpts in the studies are chosen because they are informative and distinct in relation to demonstrating an existing phenomenon that is represented in various ways in the material. In selecting cases that were typical and representative of the activity, the aim was to illustrate frequently occurring interaction patterns that appeared when the students engaged with the digital tool. The emphasis was on choosing themes that were recurrent and

served as answers to the research questions in an expressive way. Sometimes, a typical case works well to illustrate something but at other times, unusual cases help to illustrate matters that might have been overlooked in typical cases. In the studies presented here, the excerpts given are examples of patterns that occur frequently in situations containing some sort of difficulty. The main reason for choosing excerpts that display some sort of difficulty is not only to reveal the difficulties as such but to point to certain aspects that are required for the activity to continue smoothly, as argued earlier. When studying interaction and learning activities where there are none or few breakdown situations, these aspects might be hard to find. The results of the analyses of these occasions presented in the three studies are summarized in the following chapter.

6. Summary of the Studies

Introduction

The analyses in the three studies have been carried out chronologically with a specific interest in exploring how digital tools, such as educational software, contributes to structuring students' reasoning and learning practices when solving word problems in mathematics.

The first study (Lantz-Andersson, Linderoth & Säljö, 2008) is explorative in the sense that it sets out to map the activity as a whole. The other two (Lantz-Andersson, 2009; Lantz-Andersson & Linderoth, 2008) can be seen as a deepening and an extension of the initial findings. The overall and shared results of the three studies are that the educational software co-determines the learning activities that students engage in and that the digital environment adds to the complexity and introduces new dimensions for the students to consider.

One of these dimensions is that the educational software seems to invite iterative computations that did not necessarily rely on an analysis of the problems to be solved. It was shown that when facing some kind of difficulty, the students regularly operated within the frameworks of the software, testing various answers in a trial-and-error manner in their effort to reach the correct answer.

Another finding, which applies to the research as a whole, was that the digital tool seemed to contribute to the phenomenon that has been referred to as *suspension of sense-making*. These observations are significant in the sense that in the argumentation for the use of digital technology in general, a common claim is that such digital tools contribute to the authenticity of the learning environment.

A summary of the three studies that illustrates some of the different ways the digital tool becomes a part of the activity follows below.

Study I

What's the problem?
Meaning making and learning to do mathematical word problems in the context of digital tools.

The aim of this study was to illustrate the role that the software played as a mediating cultural tool in break-down situations. The focus of the analysis was on interaction patterns that appeared when students engage with the digital tool and experience some kind of difficulties in solving various word problems in mathematics. The students have to consider the interconnectedness of several elements: the narrative in the word problem, the mathematics to be used and the role of the software in the problem solving. In this study, some of these interrelationships are shown in order to contribute to the understanding of what kind of learning such digital tools contribute to. The excerpts are examples of situations where the students encounter some kinds of difficulties in their problem solving, and where they do not get the result they expect. The study provides a detailed analysis of 8 excerpts from 4 different sessions of, in all, 9 students' work with educational software.

In the first session described, the word problem is about VAT, value-added tax. This is a classical exercise in this context in the sense that it implies a shift in the reference of the value used for making the calculation. The task the students are to solve is to calculate how much VAT is included in the price of a cup of coffee costing SEK 15. What they do is calculate 25 per cent (instead of the correct 20) of the price and arrive at the incorrect answer SEK 3.75 (25 per cent of SEK 15). The students are, however, convinced that this is correct and they do not understand the incorrectness of their answer. At first, they repeatedly write their answer of SEK 3.75 in the answer box. Then they try to write the answer in fractions, considering the software's syntax sensitivity. Finally, they discuss the possibility of an error in the answer function and leave this task to go on to another.

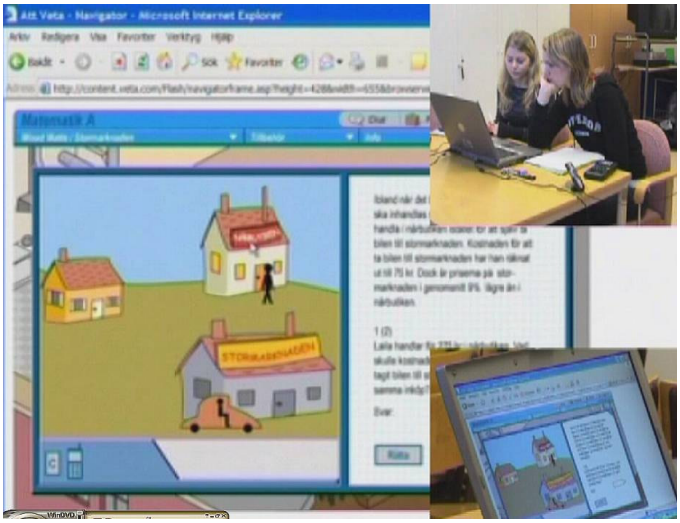

Figure 8. Students working on a word problem from Study I, film no.8

In the next session described, the word problem is about how much one needs to shop from the supermarket, where one has to go by car, in order to make it profitable instead of buying groceries at the local shop. The correct answer in this word problem is SEK 833.50. The students model correctly using a calculator and get the answer 833,3333. When they write 833 as the answer, the feedback they receive is that the answer is incorrect. Following this, they discuss how to proceed, and they try 834. From an analytical point of view, the problem here is that the girls do not think in terms of SEK. They are temporarily operating within a purely mathematical framing. When the unit is SEK, the relevant unit here is 0.5. This is an example of what Verschaffel et al. (2000), refer to as suspension of sense-making, since the girls do not consider the implication of the fact that the sum should be expressed in SEK where the relevant approximation is 0.5. Then the students test the sum with decimals using both a dot and a comma in view of the known syntax sensitivity of the software. Finally, they bring up the issue of a potential answer book error.

In the third and forth session, the word problem is geometry and the students are supposed to measure different distances and angles of a window.

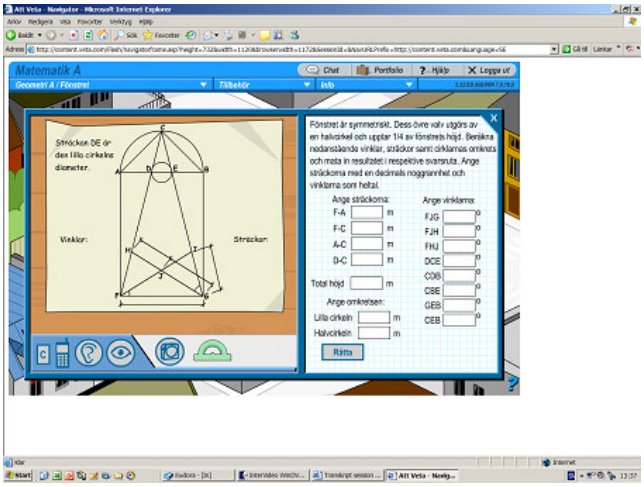

Figure 9. Screen dump from the word problem in Study I, sessions three and four

The third session illustrates an example of the students' awareness of the software's syntax sensitivity, which is shown in their discussion about whether it matters if one uses a dot or a comma. It is also an example of suspension of sense-making since they do not consider the different measurements of the height of the window and all the various distances in boxes that they have corrected in relation to the new ones they model. The final session is an illustration of the students' discussions of answer book errors when they do not understand the nature of their incorrectness. The excerpt shows how they try to calculate the circumference of half the circle at the top (see figure 8) but they forget to include the diameter so they receive "incorrect" as feedback.

The results from this study show that in break-down situations, when the students hesitate in the interaction and when they do not get the result they expect, they end up being uncertain about how to continue and how to act in the situation. The students, thus, showed that they had difficulties in how to frame in the situation; had they themselves performed an incorrect modelling or did the difficulties lie in the digital design? Using Goffman's (1974/1986) terminology, the students experienced a conflict in how to frame the events in the situation in a relevant way. In this study, the ambiguity of how to interpret the nature of the incorrect answer runs through the entire problem-solving activity, and the students were uncertain about the framing that was relevant in order to understand the feedback they got.

When students received feedback that their answer was not correct, they were forced to reconsider. The manner in which they did this was a) to check their interpretation of the problem, that is, the modelling issue, b) to check whether the digits and calculations were in order, or c) to enter into the framing of the software and begin to consider various features of the syntax or whether the answer function could be incorrect.

In most of the excerpts in this study, the latter strategy dominated. The main result was that for long periods of time the students operated within the framing of the functionalities of the software, and, while doing this, understanding mathematics seems to play little or no role in their deliberations. This implies that many of their actions and interactions were devoted to speculation about the syntax features of the digital tool and to testing whether there was something wrong with the answer function. The students, hence, engaged in extensive meta-level talk that did not primarily take place within a mathematical framing but was, rather, geared towards considering various features of the design of the software.

Study II

The power of natural frameworks – Technology and the question of agency in CSCL settings

In the research reported here, the analysis is deepened in relation to the results from Study I and focuses on the qualities and hence the consequences of the different ways of framing the utterances, actions and events in breakdown situations. The empirical material consists of in-depth analyses of two students' interaction. The study is guided by questions of what rationalities are productive for the students' framing in the activity and what this implies for their continued problem solving and for their learning. The concept of *frameworks* (Goffman, 1974/1986) is introduced to display aspects of interaction with computer-supported work and interaction patterns that are valuable for understanding the consequences of the different ways the students defined the activity. When using these concepts, the analysis focused on the qualities of the different frameworks and what they implied for the students' continuing work.

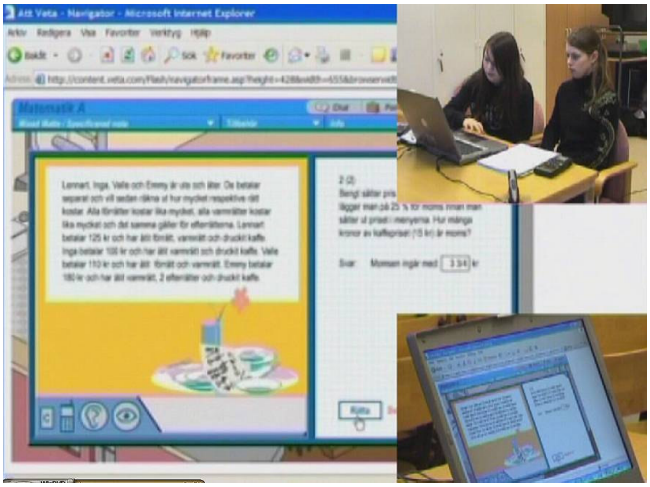

Figure 10. Screenshot from Study II, film no. 9

In the excerpts analysed in this study, the question of the target word problem is: *How many kronor of the coffee price (SEK 15) does VAT (value-added tax) consist of?* The context of this specific problem in the software is that of a restaurant. The students in the excerpts calculate 25% of the total sum of the coffee price (instead of setting up an equation or knowing that when counting the VAT "backwards," that is, when the VAT is already included, you multiply by 20%). They consider the right answer to be 3.75 (the correct answer is SEK 3). At first, the students operate under the assumption that they have made some kind of mistake. From an analytical point of view, this framing in the activity shows that the girls position themselves as being responsible for managing to solve the task. However, before long a reframing takes place and the girls discuss the solution in terms of the design of the software, and the issue is, then, not about their mathematical modelling. This is, for example, shown in their testing various options with the assumption that the software is sensitive to answers in decimals or by testing writing the answer in fractional numbers. Then they introduce the possibility of an answer book error, discussing their previous experience of these kinds of errors when they could not solve the lack of clarity by means of different modelling, because the error actually was in the functionality of the technology. With the agency understood to be in the design of the digital tool, it gives them the opportunity to postpone their understanding and to continue with their work. In educational settings, this finding is of importance because one of the foremost agendas for schoolwork is to get tasks done, and being

stuck on one task for a long time is neither desirable nor reasonable. By concluding the task by framing in this way, the students are able to continue their work on other mathematical tasks without considering their problem-solving skill and mathematical ability because the agency is understood to be in the technology.

Since there is no information about the nature of what is wrong and since there is no reciprocity in the technology, ambiguity and uncertainty are added to the activity. The students are placed in a situation where they face some information not given, and this implies they can draw a variety of conclusions (Goffman, 1983). The results presented in this study indicate that in the students' negotiation of how to understand the activity when they have 'got stuck', they sometimes search for the answer in their own actions and sometimes consider the answer to lie in the functionalities of the technology. This could analytically be understood as a continuous shift of establishing *social frameworks* or *natural frameworks* (Goffman, 1974/1986). In situations where the students temporarily establish social frameworks, they themselves played an active role in understanding the task. However, when they temporarily established natural frameworks, their difficulties were understood to be dependent, in Goffman's words, on natural determinants, which in this case is the design of the technology. The difference between which is employed is shown in how the students proceed with the task at hand. In repeated sequences, the students operated within the temporarily established natural frameworks, which made them disregard themselves as accountable for the lack of understanding of the educational content. In this way they interacted as if the unresolved problem had nothing to do with their own competence. When operating within natural frameworks, the computer and the educational software became agents outside their control. This implied that students simply faced a situation where they could 'blame' the circumstances and proceed with another task. Understanding a situation within established natural frameworks then became a legitimate way for the students to simply go on working with a sense of 'face-saving', without resolving the nature of the difficulty and with a renunciation of agency. From an educational point of view, the opportunity to learn about mathematical reasoning was missed. A conclusion drawn from this study was that the interaction could in this context be based on an understanding of the activity that diminishes human agency.

Study III

Interacting with absent designers – Students' frame-clearing processes when solving word problems in the context of educational software

The starting point of this study is students' work on unpacking tasks presented by educational software. The unpacking process of tasks, that is, the process whereby students negotiate about what the task entails, are important to consider in order to understand how they comprehend the task activity. Through in-depth analysis of this activity, when three students tried to understand what the task was about, the analysis aimed at displaying how they framed utterances, actions and events in the activity. Questions asked are how the students reasoned and acted in activities when they tried to unpack mathematical word problems in the context of educational software and if there were specific ways of framing that could be considered fruitful in their effort to unpack the tasks. The special analytical interest in this study was in situations where the students used different resources in order to understand the task they were supposed to solve, that is, when they engaged in an activity of *clearing the frame* (Goffman, 1974/1986, p. 338).

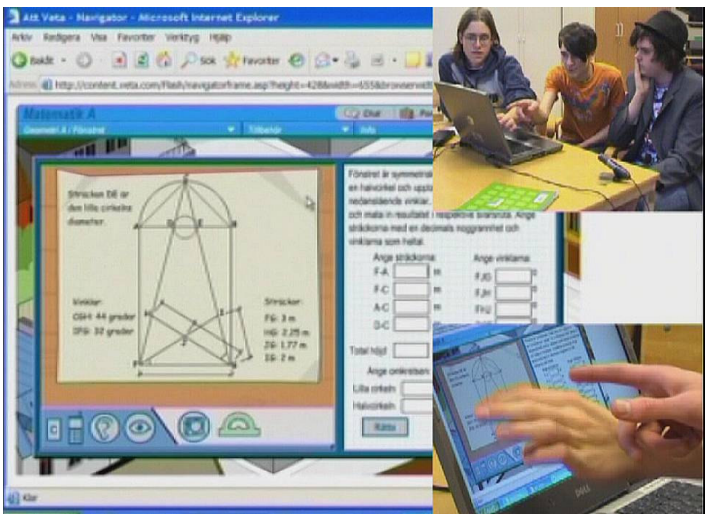

Figure 11. Screen dump Study III, film no. 10

The analyses are based on excerpts from the beginning of a lesson, where three students begin an assignment. The word problem presented by the educational software is about geometry and about measuring different distances and angles of a window. Some of the measurements are given (with the use of a virtual tool) and the task is to calculate the distances and angles of the window with the help of these given measurements and write the answers in the boxes on the right hand side. At first, the students negotiate about what the task really is about. When doing this, they start discussing what kind of formula they need in order to be able to perform the rest of the calculations. The students try to understand what concepts and methods would be relevant in this situation and their negotiations are about how to understand what this mathematical task is an example of, in a broad mathematical sense. They reach a temporary agreement that it is about trigonometry and right-angle triangles. Thus, they frame their further actions within this understanding of what the task is about and can continue their negotiation. When framing in the activity this way, it is argued that the students bring into play their trust in the fact that the design of the software supports the overall curriculum and the lesson structure.

Then, the students' communication is about reaching a common understanding of how the specific angles they are supposed to calculate in the problem are labelled. Since every corner is labelled with a letter, the angles have a three-letter name such as FJG and the question is how do they know which angle they should calculate? The result indicated that the educational software offers a number of meta-activities, that is, activities where the students related to not only their implicit question of *what is going on* but also what they *are expected to do*. These activities were more or less linked to the notion of the absent designer, which involved an implicit awareness of the fact that the educational software was developed, styled, or designed by someone. The main point made here is that the students are supported in their *frame-clearing* activity by trying to understand the designers' rationale. They are, thus, acting in relation to an absent designer, trying to take this non-present person's perspective, i.e. a form of perspective-taking that is shown to be of importance for their continuing problem solving. Engaging in the tasks when solving word problems in a digital environment in a way where you let your actions be guided by the absent designer is, in this study, shown to be a successful way of acting and interacting.

7. Discussion and concluding remarks

Introduction

Several themes have been addressed in this thesis. An overarching ambition has been to study the *in situ* practices that emerge when technology becomes part of educational activities and what will be students' definition of these situations. By studying the concrete use of digital technology in classrooms, this research thus aimed at demystifying the use of such tools in educational practices. A background of this interest is that there are many different claims regarding what learning will be like when digital technology is used. The empirical findings in the three studies describe phenomena in specific cases, but with knowledge from previous research, they serve to concretize what is often debated on an abstract level.

The reason for studying educational software *in use* by students is that the field of knowledge consists mostly of experimental environments and short-term interventions. In such studies, generally, extra resources such as researchers, experienced research staff and recent digital applications are part of the study, which is then conducted as something unusual and not part of an ordinary, everyday school activity. When these extra resources are withdrawn, a different picture of the activity often emerges. This is why the results from such studies are hard to replicate (e.g. Arnseth & Ludvigsen, 2006; Schrum et al., 2005). For this reason, the aim of this study was to observe student activity and the framings that they assumed to be relevant when using digital technology in an everyday school practice. In many ways, the results of this thesis indicate that the students habitually define their work according to a traditional school practice, where the overall agenda is often to search for ready-made answers and to get on with the tasks at hand (see also e.g. Krange & Ludvigsen, 2008). However, the findings, in addition, show that when the students engaged in the tasks presented by the educational software, their utterances and actions were not only about the content of the problems, but also about the digital technology. In other words, the students regularly talked, discussed and argued about different functionalities and design characteristics of the digital software as part of their mathematics learning.

Findings of the three studies

In the first study, the findings point to confusion in the students' framing when there is a breakdown in the situations. It is shown that the digital tool offers the students certain types of activities, for instance, iterative computations that do not necessarily rely on an analysis of the problems to be solved. This iterative procedure is, as pointed out earlier, quite common in the present research as a whole. One plausible reason for this is that it does not cost very much in terms of time and effort to enter new digits and repeatedly make new calculations. Another reason is that the software serves as a neutral partner, which does not react no matter how many times you write incorrect answers. In this way, the software can be considered to be a patient 'response-giver', but on the other hand it is a partner that is not able to adjust the feedback to the specific needs of a student, which can be said to be a major competence of teachers. This line of argument (which will be discussed further below) could then be placed in relation to arguments about self-instructional qualities that digital technologies are said to have. In the light of the empirical findings of this research such arguments could be questioned, since the lack of reciprocity in the technology, rather, is shown to bring ambiguity and uncertainty into the activity.

In Study II, the qualities of the different frameworks that the students temporarily establish are scrutinized and further elaborated. The results from this study show that technology makes it possible to frame events in the situation in such way that the agency is ascribed to the technology.[31] As when one of the students in Study II first says; `it might be mixed so that you should… no it doesn't say that you should write it with both` ('both' here meaning two digits as in fractional numbers). After having ruled that out, she says that it might be `an answer book error.` Here, it is shown that there is a possibility that students frame what happens in the activity in such a way that they do not consider themselves to be accountable for the fact that the answers they arrive at are not accepted by the

[31] Parallels could be drawn with Latour's (1996) suggestions concerning agency of nonhumans, where tools are seen as not being merely screens of our social life, but actually act as agents that do something. However, in drawing these parallels, according to the analysis presented here it is of utmost importance to emphasize that the agency within tools is agency and actions that have been translated and delegated to them by the users (Latour, 1994). Aarsand (2007) argues with reference to Poster (1995) that it is necessary to discuss where the roles of human activity end and where the role of the computer begins. Stating that "the distinction between subject and objects, or man and machine, is not given, but can be seen as a field in which this is negotiated" (Aarsand, 2007, p. 62).

computer as correct. These findings have relevance for the general public debate about digital technology in the school system, for decision-makers in their managing of the implementation of digital technology and most certainly for the way teachers engage in the activities. In framing events in the activity this way, the students miss opportunities to learn about problem solving but are also able to go on working and disregard the fact that they were not successful in solving the task.

The observation of *frame clearing* (Goffman, 1974/1986) in Study III showed that a specific resource is brought into play in the activity when the students try to understand what the task entails. How tasks and instructions in school are understood and negotiated among students is not a trivial process, it is of great importance for the task activity in educational settings and can, rather, be seen as a significant element in the development of knowledge and insights (Bergqvist, 1990; Greiffenhagen, 2007; Lund & Rasmussen, 2008). In Study III, it is shown how the students process the information in the task and try to understand how the absent designers had intended the tasks to work. For example, when one of the students says; `but, it's logical, how should they have drawn it otherwise?` when arguing about how the designers have marked different angles in a task. A related result is shown in Linderoth's (2004) research on framing in relation to the activity of playing computer games. The findings from Linderoth's study indicate that the design and structures of computer games are to be regarded as active elements and have a specific meaning in the gaming activity. For my study, this implies that the students pay attention to certain design qualities of the digital tool, which leads them to consider specific ways of working to be more relevant. To be able to participate competently in practices, it is important to be familiar with the structures of those activities. "Tasks are cultural and social constructions and there are certain cultural conventions of approaching and solving tasks" (Lund & Rasmussen, 2008, p. 409). This is an important prerequisite for solving tasks in educational settings, which becomes very obvious in relation to digital technology. The students are, hence, familiar with the fact that school tasks are usually developed in certain ways. When they do not come to agreement about how to understand the task, the strategy of looking at the task from the non-present designers' perspective becomes an important resource for them in their continuing understanding of what the task entails, for their continuing problem solving and, thus, for their development of knowledge.

The findings in the three studies show that some of the resources that are brought into play when digital technology is part of the educational activity are different from those that appear when this is not the case. The dilemma here for the educational institution and for the students is that digital technologies on the one hand offer opportunities to proceed more or less as they are used to, but on the other hand also offer new ways of working. From the students' perspective, digital technology becomes a new element in the learning activity that they also have to consider. The question is then *how* the learning activity using various digital tools will be changed. Thus, sometimes digital technologies offer completely new options but the long-term consequences of these options for learning are as yet not clear.

The contribution of frame theory and its conceptual distinctions in understanding educational activities with digital tools

By analysing interaction with the support of the conceptual distinctions of frame theory, it has been possible to thematize the resources that are employed in the students' learning activities with digital tools. It is shown that when the students frame what happens in activities involving working with mathematical tasks presented by educational software, they bring more resources (such as for example knowledge about functionalities and the design of the tool) into play than just mathematical knowledge. Didactical design, digital design and the specific conditions that this technology brings about imply specific grounds for framing and for solving the tasks. In this thesis, this is studied on occasions when students run into some kind of difficulty. The analysis shows that in these situations the students are often uncertain about how to frame utterances, actions and events in the activity. However, this uncertainty is quickly settled and a mutual understanding of the activity is developed. Even if what we see is a break of framing, the overall definition of the situation of doing schoolwork is still intact. Goffman (1974/1986) argues that "every setting has its moments when participants may momentarily break frames" (p. 383), and these kinds of minor frame breaks, rather, "seem to ensure the continuity and viability of the established frame" (p. 382). This implies that the overall definition of the situation of 'doing school work' is stronger than the changes a new digital tool involves.

The struggle to maintain the activity and thus reaching a common definition of the activity is shown to be of major importance for the students. The students are concentrated, even if they are not motivated, almost as if they are driven by the proverbial phrase 'the show must go on'. In Goffman's theory, the desire to continue with the activities is central; he argues that even a person who "mutters, jokes, or responds with sarcasm to what is happening in the situation is nevertheless going along with the prevailing definition of the situation – with whatever bad spirit" (Goffman, 1961, p. 133). When considering activities from the perspective of *situated self*, which is the basis of all interaction according to Goffman, it can be seen that continuing the activity also means being a 'competent student'. In line with this reasoning, it is not only in order to keep the activity going that participants act in accordance with the working consensus, because, as also articulated by Warfield Rawls (1987), "violating it would upset the interaction upon which the maintenance of 'self' depends" (p. 140).

Agreeing on how to frame utterances, actions and events in the situation, and thereby supporting the progress of the activity, is the main goal for the students. In doing this, the shift of framing gives the students extra spaces where they can go on working without taking into consideration their mathematical knowledge. With the conceptual distinctions of frame theory, it has been illustrated that the students frequently engage in questions about the functionalities of the digital tool. It is shown that the use of the tool implies different ways of reasoning. What they at the same time learn about mathematics is, in the light of this study, often unclear. This means that the relation between the use of these kinds of digital tools and the long-term learning of problem solving in mathematics is something that needs to be further attended to. How knowledge in mathematics, as it is conventionally understood, grows out of this practice is thus an open question.

Authenticity and the concept of 'suspension of sense-making'

Another issue, which has been discussed in the literature, concerns the manner in which digital technology presents a more authentic working environment for students. In the specific context of learning problem solving in mathematics, this issue has been discussed in terms of the authenticity of so-called word problems. However, the claims made about increased

authenticity and reality do not correspond with the results of this study. The findings in this study, rather, indicate that the medium that presented the word problem had little significance when it comes to the students' experience of the mathematics in the text of the tasks. The results presented here are, thus, congruent with conclusions from previous research implying that formal educational practices lead to what in the literature is referred to as *suspension of sense-making* (Verschaffel et al., 2000) in the students' answering activity. This means that students solve the problems without using their 'out of school' experiences. However, I would also argue, from a theoretical perspective and considering my empirical results, that the concept of *suspension of sense-making* (Verschaffel et al., 2000), in the context of solving word problems, appears to be problematic. Even if the way the concept is used by most researchers does not imply that students suspend sense-making in all respects, the connotation of the understanding of the concept needs some discussion. The point of this concept is that the students disregard the semantics of the sentences they read and the references to real world activities. And the very purpose of word problems is to describe a mathematical problem in written sentences that relates to real word issues. In my view, *disregarding* or *suspending* the references to the real world events, or empirical reality, in the problem, could instead be seen as *another way* of making sense of the problem. The concept of suspension of sense-making could then be understood as a *variation of sense-making*, since there is sense-making at all times, but perhaps not that intended. This entire set of problems illustrates that there are many different ways, conflicting and partially overlapping ways, in which students can make sense of problems of this kind. In this specific research, this means that the digital technology also becomes a contributing element. Reflecting on the functionalities of the software, as the students in my study did, is a kind of sense-making as well. With the perspective adopted here, there is, thus, never any total *suspension* of sense-making, since disregarding the intended way of solving a problem is just *another way* of making sense of a task, in a specific situation.

Regarding the discussion about making school tasks in general, and mathematical word problems in particular, more 'authentic', Lave (1992) takes a different perspective. She argues that trying to make the word problems more 'authentic' or more like situations outside school, as for example Palm (2008) suggests, is not how this issue should be handled. Lave's (1992) conviction is that the key to solving the problem of suspension

of sense-making in students' involvement in relation to word problems is not by means of realism. Instead, she suggests two new viewpoints that are implied by the theory of situated learning. One viewpoint implies a shift from relations that seem so prominent because of their theoretical and institutional history, that is, a shift from the dualistic view of 'concrete' or 'abstract' in school maths towards a different distinction between things that do and do not engage learners' attention and give meaning to the activity they engage in. The other viewpoint is that the ongoing mathematic activities in classrooms should be regarded as valuable end products, in contrast to the view that math must be 'everydayed' (Lave, 1992).

> The real trick may not be one of finding a correspondence between everyday problems and school problems, but making word problems truly problematic for children in school – that is, part of a practice for which the children are practitioners. (Lave, 1992, p. 88)

The conclusion is then that instead of trying to make word problems, and perhaps school tasks more generally resemble tasks in life outside school as much as possible, the tasks should be regarded as school tasks with a value of their own. As discussed earlier the practice of schooling has its own implications for learning, and is with this perspective regarded as an everyday practice for the students. The result of my studies indicate that the use of digital technology does not make the tasks more 'authentic' in a senses that the activity of solving them became more like solving tasks in other settings. Following this reasoning, and bearing in mind the findings of this empirical research, efforts should, hence, not be focused on making the tasks to resemble imaginary tasks of an out-of-school situation, but rather on designing them with an emphasis on how they could be made interesting for the students to solve.

Rhetorical claims and empirical findings

The implementation of digital technology in educational systems has been part of the schooling system over many years and in particular over the last twenty years. The pressure on the educational system, from policy makers of both the private and the public sector, to implement digital technology partially has to do with a desire to get people accustomed to this technology. Since a large part of the younger generation already seems to have adopted it to a great extent in their leisure time, offering opportunities for all to learn how to handle digital tools also becomes a democratic issue. The picture

drawn of young people today is that they are "thought to be adept with computers, creative with technology and, above all, highly skilled at multitasking in a world where ubiquitous connections are taken for granted" (Pedró, 2007, p. 244). There is, however, a huge diversity of semiotic resources and uses, which leads to the importance of highlighting issues of what kind of knowledge will be vital and who will have the knowledge that is required in life in the future. This is something, from my point of view, that society cannot delegate to parents or economic forces and this gives strong motives for implementing these tools in educational practices (see also Drotner, 2001, 2008).

In research, there is a growing interest in what the young generations' experiences of digital technologies imply for education. One example of this is "New Millennium Learners" – a global project at OECD's Centre for Educational Research and Innovation. In a meta-review of this project, Pedró (2007) suggests that education is challenged because young peoples' intensive use of digital technologies in their spare time, which has implications for their intellectual skills, will change their lifestyles and thus make the contrast between practices in and outside schools even larger. Such statements are however expressed in more guarded terms by many researchers (see e.g. Arnseth & Ludvigsen, 2006; Cox & Marshall, 2007; Egenfeldt-Nielsen, 2006; Erstad, 2006), and with the perspective adopted here; the manner in which people use digital technologies for leisure activities in their spare time is not viewed as the same as their use of such tools in relation to school activities, since all activities are situationally dependent (Lave & Wenger, 1991). The students who participated in the present study belong to a generation where most of them probably use digital technologies outside school. However, there are no indications in the findings that their experience of digital technologies in their spare time mattered. The empirical findings show that students are more likely to act in accordance with being participants in an educational practice and adapt the digital tools to this practice.

Moreover, this study shows that there is still just as much need of a supporting person in educational activities as there was earlier. Since analysing the role of the teachers has not been part of this study, the teachers' interactions with the students are not part of the selected sequences. However, this does not mean that the teachers were absent during the activities. In other sequences of the empirical material, the teachers interacted frequently with

the students. It is also important to bear in mind that my study is not a complete account of the students' work with a digital tool. What has been studied in particular are situations where the students encounter some kind of difficulty. Since the focus has been on situations that involve some sort of dilemma or problem for the students, the support of a teacher would have been significant. Thus, the difficulties the students encountered in the situations presented in the three studies could probably in many cases have been solved with a competent teacher present. The point of choosing sequences where the students worked without support from teachers is to relate the findings to the claims made on the kind of jobs tools like this are said to do, implying that they are more or less 'self-propelled'. What the findings of this study instead indicate is that educational software is not self-instructional; the activity still requires interaction with a knowledgeable person – a teacher. Claims about the self-instructive advantages of digital tools must be evaluated in the light of scientific research, since this kind of marketing basically gives a much too simplified picture of learning.

As regards other claims made about the constructive impact of using digital technologies in school, such as added motivation, involvement, etc. that would lead to increased learning, they have not been possible to verify. Research has not yet shown that digital technologies improve learning in any linear sense (Arnseth & Ludvigsen, 2006; Cox & Marshall, 2007; Egenfeldt-Nielsen, 2006; Erstad, 2006; Ke, 2008; Schrum et al., 2005). It is also interesting to note that applications such as educational software are not used on a wide scale in educational settings in spite of high hopes and considerable marketing efforts. One illustration of this is what happened to the company that produced the software studied in this research. This company was established with large funds to distribute these kinds of digital tools in upper secondary school and adult learning environments. While I was carrying out my study, they were not successful in introducing the software on a large scale, and as a result they closed down the company and removed their website. The point is not to enter into discussions about the reasons for this specific company's economic situation, but it serves as just another testimony of the difficulties of implementing digital technologies of this kind. Rather, this points to the need to question the alleged benefits that surround the implementation of digital technologies touted by the industry and the producers of these kinds of tools. When looking for reasons for the difficulties in implementing digital technologies in schools, one of the key issues is most

probably that implementation has so far not been accompanied by paying attention to the specific workplace conditions of educational practices and the digital tools have not been related to the needs of these practices (Cuban, 2001).

The suggested benefits (e.g. flexibility, facilitation, motivation, involvement and increased learning) for the learning activity that educational software of this kind are said to deliver thus give a simplified picture of a much more complex activity. Some of these arguments in the literature and in the public debate are based on a metaphor of learning as a straightforward transfer process. "Too often, technology is viewed as a way of automating education and reducing costs, without changing the traditional view of education as the transfer of facts from an authoritative source to a relatively passive student's memory" (Stahl, 2009, p. 2). However, developing people's ability to read, write and do arithmetic does not consist of presenting information to them. To learn these basic skills is to learn highly artificial codes that need to be broken down. The solution could then not be to transport the contents from one teaching aid to another in the belief that this will make the learning activity better, faster, more vivid, etc. As put forward by Laurillard (2009), what it takes *to learn* will not necessarily change significantly, even though the media and the technologies used in the educational activities differ. It is interesting to note that the metaphor of 'improved learning' is so strong even though it has not been proven by research. Instead, many of the results from previous research parallel the findings of this research; the learning activity will be *different*. The implementation of digital technology in learning activities implies that new demands are made on both students and teachers. Thus, learning activities with the use of digital technologies imply a different way of learning with new possibilities and new problems; a different pedagogical situation, a different relation between the students and the content and a different situation for the teachers.

Thus, digital technology does not change educational practices as has been predicted by market forces promoting IT. This is, however, not surprising, as Säljö (2004) states: "If the new technologies were to function as they are described by designers, this would in most cases imply a rather dramatic shift of education as a social practice" (p. 492). Education is based on traditions stretching back thousands of years and if it had been as simple to change certain prerequisite and solve certain problems in this practice by merely

implementing new technology, it would have been done a long time ago. As in the case of other media (e.g. radio, television, video, etc.), unrealistic expectations were raised, which were not met. It then seemed as if the implementation of the media was not successful and the entire project was regarded as a failure. This could, however, also be viewed from another perspective; these technologies are not adapted to the practice on which institutional educational systems are based. Every practice has its own logic and way of working that cannot be subordinated to the technologies, instead the technologies have to be integrated into the conditions of this practice. Looking at the long succession of inventions that were supposed to change education, it is obvious that the issue is not about the different media and technologies being worthless as teaching aids, rather that they have not been integrated into the conditions of the educational practices. The digital tools, thus, have to be fitted into existing educational practices (cf. Greiffenhagen, 2007; Hernwall & Arvola, 2008; Kebritchi & Hirumi, 2008; Selwyn, 1999; Sutherland et al., 2004; Younie, 2006). In a recent article, Laurillard (2009) argues that it is important to define pedagogical challenges to technology and to drive technology towards what learners need. She suggests that in order to create activities out of interdependencies between educational practices and digital technologies, we have "…to use what we know about what it takes to learn, and build this into a pedagogical framework with which to challenge digital technologies to deliver a genuinely enhanced learning experience" (Laurillard, 2009, p. 5).

The pressure from politicians, authorities, policy makers and the market with more or less well-grounded suggestions about how digital technologies should be used to solve pedagogical problems must be scrutinized and questioned. It is important to bear in mind that digital technology was not invented to facilitate learning. Moreover, it is important to be aware that market interests play a part in these technological convictions, since digital technologies are said to make educational practices more efficient and rational with benefits for both the economy and the development of society. Findings like the ones in this study thus form an important counterargument in relation to such claims. In other words, empirical findings like these are needed as a critical opposite pole of claims containing rhetorical pedagogical arguments more or less belonging to an 'edutainment discourse', where knowledge is regarded as an item for sale and exploitation. Formal education is in general a regulated practice governed by various rules, curricular demands and often also

regulated by a strict time schedule. If the purpose is to transform educational practices to into a more flexible, motivating and engaging learning practice, it cannot be achieved unless there is an intense collaboration with educators. Digital technologies then have to be transformed in such a manner that they accord with the goals and ambitions of educational practices. The students' focus should still be on learning specific issues or developing certain abilities but doing it *by means of* the digital technology, that is, their way to understanding is *via* technology. The question is then how to integrate digital technologies in classroom practices in such a manner that they become embedded in the institutional ideology.

8. Summary in Swedish

Framing i undervisningspraktiker – Lärandeaktivitet, digital teknologi och logiken i situerad handling

Inledning

Bakgrunden till denna avhandling är ett intresse för mötet mellan etablerade, lokala skolpraktiker och digital teknologi. Idag används digital teknologi i de flesta verksamheter i samhället och däribland även i många skolsammanhang. Ännu så länge finns det dock relativt lite kunskap om vad som sker i aktiviteten när elever arbetar med digitala verktyg. Traditionellt har nya medier som införts i utbildningssammanhang omgetts av antingen misstänksamhet eller löften om att de kommer att revolutionera undervisningen (Cuban, 1986; Karlsohn, 2009; Papert, 1984, 1993). Digitala verktyg är inget undantag utan omges nu av antaganden av liknande karaktär, det vill säga att användningen av dessa verktyg kommer att innebära en fundamental förändring när det gäller lärande och undervisning (Limberg, Alexandersson & Lantz-Andersson, 2008; Linderoth, Lantz-Andersson & Lindström, 2002; Postman, 1979; Selwyn, 1999). I denna sammanläggningsavhandling bestående av en kappa och 3 artiklar[32], presenteras en del av dessa påståenden och relateras till de empiriska resultaten från studierna. För att kunna studera hur lärandeaktiviteten med digital teknologi ter sig för elever har två teoretiska perspektiv antagits: ett sociokulturellt perspektiv (Lave & Wenger, 1991; Vygotsky, 1934/1962,

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1939/1978; Wertsch, 1998; Wells, 1999; Säljö, 2000) och Goffmans (1974/1986) teorier om *ramverk* och *inramning*[33] av sociala situationer.

Bakgrund

De påståenden om vinster som digital teknologi sägs innebära är diskutabel på flera sätt och den bas som forskningen vilar på är långt ifrån entydig. En anledning är att stor del av forskningsresultaten kommer ifrån mer eller mindre experimentella studier och kortsiktiga försöksverksamheter som har varit svåra att upprepa i en ordinär skolpraktik (Arnseth & Ludvigsen, 2006; Egenfeldt-Nielsen, 2006; Ke, 2008). Detta bland annat då denna typ av experiment eller försöksverksamheter ofta har inneburit att stora resurser i form av forskare och expertis medverkat aktivt i situationen, där också specifika digitala verktyg använts och aktiviteten då blivit något utöver den löpande, dagliga skolaktiviteten. När sedan studien upprepats i en ordinär klassrumssituation så har inte samma resultat uppnåtts (t.ex. Arnseth & Ludvigsen, 2006; Schrum *m fl.,* 2005). Studien som presenteras här bidrar till den vetenskapliga diskussionen i förhållande till tidigare forskning, genom att studera hur de digitala verktygen *används* av elever i en miljö där verktyget redan är en del av *den dagliga verksamheten*. Fokus är på *hur* elever resonerar och agerar när de arbetar med uppgifter i ett digitalt läromedel. Utgångspunkten är således att studera vad som sker på en samspelsnivå när ett digitalt verktyg används och sedan relatera det till den skolkultur där det ingår.

Inom forskning om lärande har det blivit allt mer vanligt att lägga vikt vid den situation som den lärande befinner sig i. Med bakgrund av det ges inledningsvis i kappan en bild av hur skolan som social praktik innebär att vissa både implicita och explicita normer, traditioner och regler, för med sig speciella sätt att arbeta och lära (Edwards & Mercer, 1987; Mercer, 1992). Åtskilliga studier har visat att när elever skall lösa uppgifter i skolan tenderar de att försöka förstå vad uppgifterna går ut på och uppfattar ofta att det finns ett rätt svar, och de löser uppgifterna med så lite bemödande som möjligt (t.ex. Alexandersson, Limberg, Lantz-Andersson, & Kylemark, 2007;

[33] I svenska studier förekommer begreppet både oöversatt som ’framing’ och översatt som ’inramning’. Jag har valt att använda den svenska termen, förutom i titeln och när jag använder Goffmans specifika begrepp: *social frameworks*, *natural frameworks* och *clearing the frame*. Det är dock viktigt att poängtera att inramning i detta sammanhang inte ses som något statiskt utan som en aktivitet där dynamiken i interaktionen betonas, vilket också var Goffmans avsikt.

Bergqvist, 1999; Krange & Ludvigsen, 2008). Detta förfarande kan förstås i relation till vad Brosseau (1997) har kallat *det didaktiska kontraktet*, det vill säga de kommunikativa regler som etableras i undervisningspraktiker och som elever identifierar och använder som *resurser*[34] i sitt arbete. Det didaktiska kontraktet innebär, till exempel, att det är läraren, läroboken eller det digitala läromedlet som ställer frågor och ger instruktioner och eleverna svarar och utför aktiviteterna även om de inte upplever dem som relevanta eller meningsfulla. I detta sammanhang är det viktigt att poängtera att med det sociokulturella perspektiv som antas i denna studie, ses lärande som s*ituerat*, det vill säga vad och hur vi lär är till stor del beroende av *var* vi är och *vilka verktyg* som finns att tillgå i situationen. Som exempel kan nämnas studier av hur människor löser matematiska problem för att jämföra priser i en mataffär, vilket komparerats med studier av hur liknande uppgifter utförda i ett klassrum fungerat, där det sistnämnda gav mycket sämre resultat (Carraher, Carraher & Schliemann, 1985; Lave, 1988; Saxe, 2002; Scribner, 1984).

Det empiriska materialet består av videodokumentation av gymnasieelever som arbetar med ett digitalt läromedel och löser ’benämnda uppgifter’[35] i matematik, det vill säga vad de kallar ’lästal’. Det var inte ett medvetet val att studera elevers aktivitet i förhållande till detta innehåll, utan har sin grund i att eleverna vid tidpunkten för studien arbetade med denna typ av uppgifter i det digitala läromedlet. Syftet med benämnda uppgifter är att elever skall uppfatta matematiken som konkret och vardagsnära. Det finns omfattande forskning kring benämnda uppgifter och stor del av den tidigare forskningen har visat att elever har svårigheter att lösa denna typ av problem (för en ingående översikt, se Verschaffel, Greer & De Corte, 2000). Det vill säga, elever har svårigheter att hantera relationen mellan det som i ord beskrivs som ett problem och hur de skall lösa det matematiskt. Ett särskilt problem som uppmärksammats i detta sammanhang kallas i litteraturen för *suspension of sense-making* (ung. åsidosättande av sunt förnuft). Innebörden av uttrycket är att elevers resonerande och agerande står i kontrast mot deras vardagliga erfarenheter. (Verschaffel *m.fl*., 2000). Forskningen har sin grund i en klassisk

[34] Begreppet resurser som det används här innefattar, till exempel tidigare erfarenhet, förförståelse av skolpraktiken, kommunikativ förmåga, kunskap om hur man använder olika redskap osv.

[35] Benämnda uppgifter är matematiska uppgifter som formuleras med en text. Det vill säga, uppgifter där en hypotetisk situation beskrivs. Beskrivningen innehåller att antal fakta och en fråga som skall besvaras med hjälp av dessa fakta. Eleverna skall då omvandla texten som är formulerad på vardagligt språk till en relevant matematisk lösningsmetod.

studie från Grenoble, 1980, där elever i sju-åtta års åldern fick svara på följande fråga: *Det finns 26 får och 10 getter på en båt. Hur gammal är kaptenen?* (i Verschaffel *m.fl*., 2000, s. 4). En majoritet av eleverna svarade på frågan genom att till exempel addera siffrorna utan att fundera över det absurda i uppgiften. Därefter följde ett antal studier med liknande resultat. Slutsatsen från studierna är att elever har lärt sig att skolans matematikuppgifter ser ut på speciella sätt, vilket gör att de löser talen på ett mekaniskt sätt utan att reflektera över om det som beskrivs är rimligt eller ens möjligt att lösa. Diskussionen om att matematik blir mer konkret genom benämnda tal är särskilt intressant i förhållande till föreliggande studie eftersom påståenden om ökad konkretisering och realism ofta finns med i debatten kring de vinster som digital teknologi sägs föra med sig (t.ex. Barab, Thomas, Dodge, Carteaux & Tuzun, 2005; Harper, Hedberg & Wright, 2000).

Syfte

Syftet med avhandlingen är att studera aktiviteter i undervisningssammanhang där digital teknologi används i den ordinarie undervisningen och att undersöka vad det betyder för elevers lärande att de använder ett digitalt verktyg. Analysen syftar till att studera vad som görs relevant i interaktionen mellan gymnasieelever i lärandeaktiviteter där de använder ett digitalt läromedel och löser benämnda uppgifter i matematik. Fokus i analyserna är på hur eleverna resonerar och agerar i dessa situationer. I relation till ramverksteorin (Goffman, 1974/1986) innebär det ett intresse för hur yttranden, handlingar och händelser i aktiviteten ramas in av eleverna samt vilka resurser de använder för att hantera aktiviteten och för att aktiviteten skall fortgå.

Frågeställningar

- Hur resonerar och agerar gymnasieelever när de löser benämnda uppgifter som presenteras av ett digitalt läromedel i en reguljär klassrumspraktik?
- Vad händer i aktiviteten när eleverna har svårigheter med att lösa uppgifterna, hur löser de dessa svårigheter och hur går de vidare med sitt arbete i dessa situationer?
- Hur kan dessa lärandeaktiviteter och de svårigheter som eleverna hamnar i förstås med hjälp av de begreppsliga distinktionerna i ramverksteorin?

Teoretiska utgångspunkter

För att beskriva de situerade aspekterna av elevernas lärandeaktiviteter används dels ett sociokulturellt perspektiv på lärande (Lave & Wenger, 1991; Vygotsky, 1934/1962, 1939/1978; Wertsch, 1998; Wells, 1999; Säljö, 2000) och ramverksteorin med ursprung i Goffmans mikrosociologiska och interaktionella perspektiv (Goffman, 1974/1986). Givet utgångspunkten att det är nödvändigt att studera den situerade, lokala praktiken för att förstå en aktivitet, ses de två traditionerna inom ramen för denna studie som komplementära. Att kombinera dessa traditioner är också i enlighet med Greenos, Collins och Resnicks (1996) klassificering av det utbildningsvetenskapliga kunskapsfältet, där perspektiven betraktas som tillhörande det situerat/pragmatiskt, sociohistoriska perspektivet. Fokus på hur aktiviteter förstås av deltagarna är en viktigt gemensam utgångspunkt för det sociokulturella perspektivet och Goffmans ramverksteori. Enligt Goffmans ramverksteori innebär det att utsagor, handlingar och händelser inte talar för sig själva utan är beroende av en *inramning* för att få mening. Begreppet inramning betyder att en *definition av situationen* görs av deltagarna och att deltagarna ofta delar denna och tar den för given. Inramningen kan då ses som en aktivitet och som deltagarnas gemensamma svar på frågan; ”vad är det som pågår här?” (“what is going on here?”, Goffman, 1974/1986, s. 8). Att rama in kommunikation och handling i situationer bör förstås som något människor gör för att skapa mening, som vanligtvis är oproblematiskt och som vi inte reflekterar över.

Inramningsbegreppet är således en analytisk metafor för hur vi definierar situationer och genom det skapar mening av det som sägs, görs och händer i en aktivitet (Linderoth, 2004). På vilket sätt yttranden, handlingar och händelser i en aktivitet ramas in är också grundläggande för vad som är möjligt att lära i en specifik aktivitet. I enlighet med den sociokulturella traditionen och ramverksteorin är kommunikation och språkanvändning helt centrala och utgör länken mellan deltagare i en praktik. När det gäller lärande är det således avgörande vilka *resurser* (t.ex. tidigare erfarenheter, kommunikativa förmågor, förväntningar, kunskap om specifika begrepp etc.) och *verktyg* (t.ex. en miniräknare, en linjal, ett digitalt läromedel etc.) människor har tillgång till, behärskar och kan utnyttja. Ju mer välbekant man är med de olika delarna i en praktik, till exempel en skolpraktik, desto enklare är det att agera i den (Säljö, 2000). Detta innebär att inramningen i olika praktiker också är begränsade av de speciella sociala strukturer som skapas

och upprätthålls inom olika praktiker, vilket betyder att deltagare inte är totalt fria att definiera aktiviteten som de vill. Att eleverna i studien deltar i en matematiklektion i en skolmiljö har således betydelse för hur de resonerar och agerar och vad som görs relevant i aktiviteten. Detta perspektiv på logiken i situerade handlingar är en utgångspunkt för hur begreppet inramning skall förstås (Goffman, 1974/1986).

Studiens kontext

Videoinspelningarna skedde på en gymnasieskola i en mellanstor stad i västra Sverige. De 34 eleverna som är filmade kommer från fyra klasser som samtliga läser ett gymnasieprogram som kallas 'Öppna Programmet', vilket innebär att första året är öppet och inte förrän år två väljer de om de skall läsa Samhällsprogrammet eller Naturprogrammet. Eleverna får disponera en bärbar dator och i hela byggnaden finns trådlös uppkoppling. Videoupptagningen gjordes i ett arbetsrum som låg vägg i vägg med det ordinarie klassrummet. De elever som filmades fick arbeta med samma avsnitt i VETAs[36] digitala läromedel i matematik och engelska som de annars skulle ha gjort under det aktuella arbetspasset. Empirin till de tre delstudierna kommer ifrån matematiklektioner eftersom det digitala läromedlet i matematik användes fullt ut som ersättning för en lärobok i matematik. Läromedlet i engelska däremot användes som ett komplement till flera olika typer av läromedel.

VETAs digitala läromedel som kallas för Lärospel, är ett webbaserat läromedel som bygger på Skolverkets kursplaner och består av ett antal moduler. En modul i matematik kan, till exempel vara geometri, medan modulerna i engelska är mer temauppbyggda. Alla moduler utspelar sig i en miljö med en huvudkaraktär och olika bifigurer, där eleverna skall lösa storybaserade uppdrag som består av en eller flera uppgifter. I uppdragen möter eleven en virtuell mentor som ger tips och ledtrådar om hur uppgifterna kan lösas.

[36] VETA var ett utbildningsföretag som specialiserade sig på breda utbildningar i form av webbaserade lärospel, i språk, vård- och omsorgsarbete, matematik och fysik, bl.a. fanns ett lärospelskoncept och åtta lärospel; Engelska A och B, Svenska som andraspråk A och B, Vård- och omsorgsarbete, Matematik A och B, Fysik A. Lärospelen följde Skolverkets kursplaner och ledde till betyg på gymnasial nivå. VETA AB ägdes av Svenska Kommunförbundet genom Förenade Kommunföretag, Skandia, Lernia, Kommunal, Metall och SKTF.(http://www.veta.com/) VETA har under hösten 2008 upphört med sin verksamhet, tagit bort webbsidorna och existerar inte längre som digitalt läromedel.

Studiens metod

Empirin består av totalt 16 filmade sessioner[37] på vardera ungefär 60 minuter. Vid varje session användes tre kameror där en kamera fångade dataskärmen, en kamera filmade eleverna framifrån för att lättare följa samtalet, åskådliggöra ansiktsuttryck osv. och en kamera filmade eleverna bakifrån så att pekningar på skärmen etc. blev synliga. Filmerna har sedan synkroniserats och redigerats tillsammans så att alla tre kameravinklar är synliga samtidigt. Det empiriska materialet består dessutom av kompletterande material som intervjuer med både elever, lärare och producenter av digitala läromedel, filmade lektioner, samt ytterligare empiriskt material från ett Lärcenter[38]. Det kompletterande materialet har fungerat som en bakgrund i förståelsen av aktiviteterna, men det är videofilmerna som varit underlag för analyserna.

Videoteknologi har använts eftersom det anses lämpligt för analyser av interaktion mellan deltagare samt mellan deltagare och olika verktyg, till exempel datorer, då man förutom uttalanden också har möjlighet att analysera skeenden på skärmen och deltagarnas handlingar (Goodwin, & Heritage, 1990). Med utgångspunkt i interaktionsanalys (Jordan & Henderson, 1995) har fokus i analyserna varit på vad eleverna säger, vad de gör och vad som sker på skärmen. Interaktionsanalys definieras som en metod för empiriska studier av hur människor interagerar med varandra och med objekten i sin omgivning. Med rötter i bland annat etnografin är grundantagandet att kunskap och handling är sociala och situerade i en specifik kontext. För att förstå en aktivitet kan den analyseras på en samspelsnivå där man studerar vad deltagarna i aktiviteten orienterar sig emot (Goodwin, 2003). Idén om turtagning och hur ett yttrande tas emot och förstås har varit grundläggande i analysförfarandet (Sacks, Schegloff & Jeffersson, 1974; Schegloff, Jefferson & Sacks, 1977). Genom att analysera hur eleverna förstår varandras tidigare utsagor och handlingar och hur de svarar mot dessa har det varit möjligt att tematisera hur de ramar in yttranden, handlingar och skeenden i aktiviteten.

Transkriptionen av videosekvenserna har gjorts med hjälp av ett kolumnsystem som utgått från Suchmans (1987) fyrakolumners

[37] Empirin till de tre delstudierna kommer från de 10 videofilmer från elevers arbete med den matematiska delen av det digitala läromedlet.

[38] Lärcenter finns i de flesta kommuner och är en del av gymnasieskolan. Alla elever som läser på ett Lärcenter har en individuell studieplan och ofta ett flexibelt studieupplägg, till exempel genom att en del av undervisningen sker på distans

transkriptioner, vilka diskuterats och vidarebearbetats av Jordan & Henderson (1995) och ytterligare utvecklats av Linderoth (2004). Denna transkriptionsmodell stödjer idén om att interaktion bygger på turtagning och responser samt möjliggör dessutom att parallellt beskriva deltagarnas yttranden, handlingar och skeenden på skärmen.

Sammanfattning av delstudierna

Fokus i analyserna har varit på situationer när eleverna som arbetar med det digitala läromedlet har stött på någon slags svårighet i sin problemlösningsprocess och aktiviteten har avstannat. Det kan exempelvis handla om situationer då eleverna fått 'fel' på sina svar och de inte vet vad som är fel: om det är ett beräkningsfel, om de förstått uppgiften felaktigt eller om det har att göra med funktionaliteten i det digitala läromedlet. I studier inom detta fält studeras ofta situationer där det sker ett uppehåll i interaktionen och deltagarna visar någon form av osäkerhet i hur de skall gå vidare. I engelskspråklig litteratur kallas det för studier av situationer som innehåller någon form av "break-downs". Genom att granska dessa situationer är det möjligt att få syn på aspekter i elevers lärandeaktivitet som annars inte är synliga. Excerpterna i de tre studierna har valts ut eftersom de visar vanligt förekommande interaktionsmönster som framträder just när eleverna upplever svårigheter att lösa uppgifterna.

Studie I[39] diskuterar situationer där eleverna är osäkra på hur de skall rama in responsen från det digitala läromedlet. Osäkerheten visar sig när de har löst ett matematiskt läsetal och fått responsen av det digitala läromedlet att svaret är 'fel'. I denna typ av situationer vet inte alltid eleverna hur de skall förstå vad som är fel; har de själva räknat fel, använt fel räknesätt, förstått uppgiften felaktigt eller ligger felet i det digitala läromedlet. Resultatet från studie I visar att eleverna återkommande är osäkra på hur de skall rama in aktiviteten, och i långa stunder handlar deras samtal inte om det matematiska innehållet utan om olika funktionaliteter och designkvaliteter i det digitala läromedlet.

[39] I)

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I studie II [40] är dessa resultat fördjupade och analysen visar att eleverna i situationer där de är osäkra på vad de gjort för fel, skiftar mellan att etablera ramverk som av Goffman (1974/1986, s. 22) kallas *social frameworks* och *natural frameworks*. När *social frameworks* temporärt är etablerade innebär det att deltagarna uppfattar aktiviteten som något som är avhängigt deras förförståelse, kunskap, vilja etc. det vill säga, de är själva ansvariga för att lösa det matematiska problemet. När å andra sidan *natural frameworks* tillfälligt etableras, ramas det som sker i aktiviteten in som något som bara händer, och som ligger utanför deras möjlighet att påverka, till exempel något som har med funktionaliteten och den digitala designen att göra. Resultatet av studie II visar att vid upprepade tillfällen etablerar eleverna temporärt *natural frameworks*, vilket från ett pedagogiskt perspektiv innebär att eleverna lägger problemet i den digitala teknologin och inte diskuterar det matematiska innehållet.

Studie III[41] utgår ifrån elevers 'uppackande' av de matematiska uppgifterna i det digitala läromedlet, det vill säga deras förhandling om vad uppgifterna går ut på. Dessa situationer är intressanta ur ett analytiskt perspektiv, eftersom de säger mycket om hur elever förstår aktiviteten. Resultatet av studie III visar att när eleverna har svårigheter med att definiera aktiviteten, strävar de ofta efter att reducera osäkerheten genom att återskapa arbetsordningen. Eleverna försöker då tydliggöra sin egen förståelse i relation till de andra deltagarna. Goffman (1974/1986, ss. 338) beskriver denna aktivitet som *clearing the frame*, det vill säga ett interaktivt mönster där deltagarna strävar efter att skapa en gemensam grund för sin förståelse. Studie III pekar på att i aktiviteten av *clearing the frame* spelar det digitala läromedlet en framträdande roll. Resultatet visar att, i elevernas strävan efter en gemensam förståelse av vad uppgiften går ut på blir de hjälpta av att försöka ta designerns perspektiv. Således visar eleverna ett slags perspektivtagande i form av att diskutera och försöka tolka logiken i det digitala läromedlets design, för att förstå vad uppgiften går ut på så att arbetet kan fortgå.

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Diskussion och avslutande kommentarer

Flera olika teman har behandlats i denna avhandling. En övergripande ambition har varit att studera vad det betyder för eleverna i en skolpraktik att digital teknik används och vad som blir definitionen av denna aktivitet. De empiriska slutsatserna från de tre studierna beskriver specifika fenomen som tillsammans med kunskap från tidigare forskning syftar till att avmystifiera och konkretisera vad som ofta diskuteras på ett abstrakt plan.

Resultaten från de tre studierna

Resultaten visar att eleverna i stor utsträckning ramar in yttranden, handlingar och händelser i relation till skolpraktiken, men studierna visar också att elevernas samtal och handlingar inte bara handlar om det matematiska innehållet utan om olika funktionaliteter och designkvaliteter hos den digitala teknologin. Det digitala läromedlet inbjuder till vissa typer av aktiviteter, till exempel iterativa överslagsberäkningar som inte nödvändigtvis har att göra med problemlösning av uppgiften ifråga. En rimlig förklaring till detta är att det inte kostar speciellt mycket i termer av tid och kraft att skriva in nya siffror och göra nya beräkningar upprepade gånger. En annan förklaring är att responsen från det digitala läromedlet är neutral, det vill säga å ena sidan tålmodig å andra sidan inte anpassad till de speciella förutsättningarna och individuella behov hos elever, något som kan sägas vara ett grundläggande värde hos lärare. Detta är beaktansvärt i förhållande till påståenden om att digital teknologi mer eller mindre är självinstruerande. Det empiriska resultatet visar att avsaknaden av samspelet för med sig osäkerhet och flertydighet i aktiviteten, vilket innebär att eleverna inte betraktar sig själva som ansvariga för svårigheterna, utan förlägger problemet i olika funktionaliteter i den digitala designen. Eleverna går då miste om möjligheten att lära sig ett visst innehåll, men ges också möjlighet att gå vidare med nästa uppgift utan ett ifrågasättande av sin egen förmåga att lösa den matematiska uppgiften.

En annan resurs som tas i bruk av eleverna när de har svårigheter att förstå uppgiften är att försöka förstå de tankesätt som innefattas i designen av en viss uppgift. Det betyder att vissa designkvaliteter i ett digitalt verktyg medför att vissa sätt att arbeta är mer fruktbara (jmf. Linderoth, 2004). För att kunna deltaga i en specifik praktik är det betydelsefullt för deltagarna att ha en känd struktur (Lund & Rasmussen, 2008). Detta är en nödvändig förutsättning för utbildningskontexter och för att det skall vara möjligt att lösa uppgifter, vilket

blir väldigt tydligt i relation till digital teknologi. Att försöka ta designers perspektiv och därigenom försöka enas om hur en uppgift skall förstås blir en resurs för elevernas fortsatta arbete.

Resultaten från de tre studierna visar att vissa av resurserna som tas i bruk av eleverna när digitala verktyg är en del av lärandeaktiviteten är annorlunda än när digitalteknologi inte används. De långsiktiga konsekvenserna för lärandeaktiviteter genom användandet av digitala verktyg vet vi dock ännu inte så mycket om utan detta är något som bör studeras ytterligare.

Lärandeaktiviteter i skolan i ljuset av ramverksteorins begreppsliga distinktioner

Med hjälp av de begreppsliga distinktionerna i ramverksteorin (Goffman, 1974/1986) har det varit möjligt att tematisera de olika resurser som tas i bruk av elever när de arbetar med att lösa matematiska uppgifter i ett digitalt läromedel. Didaktisk design, digital design och de speciella villkor som teknologin medför innebär särskilda förutsättningar för definitionen av aktiviteten. Analyserna visar att eleverna återkommande är osäkra på hur de skall definiera situationen, men även om det analytiskt kan beskrivas som en osäkerhet i definierandet av aktiviteten så är inramningen av att göra skolarbete inte bruten. Den övergripande definitionen ’att utföra skolarbete’ är således starkare än de förändringar som ett nytt digitalt verktyg för med sig. Att upprätthålla aktiviteten och att definiera situationen i samförstånd visar sig vara överordnat för eleverna. Det är som om de arbetar efter mottot; ’the show must go on’, vilket stämmer väl med Goffmans teori där just upprätthållandet av aktiviteter är centralt för människors samspel. Att komma överens om inramningen av yttranden, handlingar och händelser i aktiviteten och därigenom stödja utvecklingen av aktiviteten är alltså det huvudsakliga för eleverna. Med hjälp av begreppen i ramverksteorin har analyserna visat att eleverna frekvent ägnar sig åt frågor som rör funktionaliteten i teknologin. Vad de samtidigt uppmärksammar av det matematiska innehållet måste i ljuset av denna studie betraktas som en öppen fråga.

Autenticitet och begreppet ‘suspension of sense-making’

En annan fråga som diskuterats är huruvida digital teknologi ger en mer autentisk och realistisk miljö för elever att arbeta i. Frågan om autenticitet har också diskuterats i förhållande till benämnda tal i matematik. Resultatet från denna studie tyder inte på att det blir mer autentiskt för eleverna utan pekar

snarare på det faktum att mediet som presenterar uppgiften har liten betydelse när det handlar om hur elever uppfattar uppgifter. Således finns exempel i resultatbilden på det som i litteraturen kallas för *suspension of sense-making* (Verschaffel et al., 2000) när det gäller elevernas svarsbeteende, vilket innebär att elever löser uppgifter utan att relatera dem till det som refereras till i texten. I detta sammanhang vill jag lyfta det problematiska med begreppet *suspension of sense-making* både från ett teoretiskt perspektiv och i förhållande till det empiriska resultatet från studien, även om det sätt på vilket detta begrepp vanligtvis används i litteraturen inte innebär att man åsyftar att elever helt och hållet reducerar sitt meningsskapande. Perspektivet som tas här innebär att någon total reducering av meningsskapande inte förekommer, utan snarare *ett annat sätt* att skapa mening eller en *variation* av meningsskapande, vilket dock inte alltid är det samma som det avsedda. I en skolkontext ges många olika, både konflikterande och delvis överlappande sätt att skapa mening. Mot bakgrund av min studie kan man då se att det digitala verktyget blir ett medverkande element i elevers meningsskapande och att då reflektera över de olika funktionaliteterna hos det digitala läromedlet kan också ses som *en form av meningsskapande*.

När det gäller diskussionen om att göra skoluppgifter i allmänhet och benämnda tal i matematik i synnerhet mer autentiska som till exempel lyfts fram av Palm (2008), är Lave (1992) av en annan uppfattning, vilket också stöds av denna studies resultat. Istället för att diskutera skoluppgifter utifrån den dualistiska synen som innebär att de antingen är konkreta eller abstrakta, realistiska eller orealistiska (jmf. Alexandersson & Lantz-Andersson, 2008) menar Lave (1992) att diskussionen om skoluppgifter borde handla om hur man skapar aktiviteter som engagerar elever. Skoluppgifter borde också ses som uppgifter med ett värde i sig och inte alltid relateras till huruvida de kan överföras på en tänkt verksamhet utanför skolan.

Retoriska uttalanden och empiriska resultat

De påståenden om vinster som digital teknologi sägs innebära handlar om allt ifrån att lärandet blir bättre, mer flexibelt, mer självgående, att motivationen och engagemanget ökar till organisatoriska fördelar. Trycket på skolan både från politiskt håll och från en IT-positiv marknad kommer också av en önskan om att människor bör vänja sig vid digital teknologi. Eftersom en stor del av den uppväxande generationen redan har tagit olika digitala verktyg i bruk på

sin fritid, är det också en demokratisk fråga att erbjuda möjlighet för alla att lära sig hantera digital teknologi i skolan.

När det gäller påståenden om att digitala verktyg ger ett mer självgående arbetssätt visar resultaten av denna studie snarare att behovet av en stödjande person inte är mindre än i traditionella undervisningssituationer. Eftersom studiens fokus inte varit på lärarnas roll har inte sekvenser där lärarna interagerade med eleverna valts som analysunderlag i artiklarna. Det betyder inte att lärarna var frånvarande under elevernas lärandeaktiviteter, utan vid många tidpunkter hjälpte och interagerade lärarna med eleverna. I detta sammanhang är det viktigt att poängtera att denna studie inte är en komplett redogörelse för elevers arbete med digitala läromedel utan har fokuserat på tillfällen när eleverna upplever någon form av svårighet. Vid dessa tillfällen hade många av problemen förmodligen kunnat lösas genom en aktiv kontakt med läraren. Avsikten med att välja sekvenser när eleverna arbetade utan stöd av lärare är att relatera resultaten till påståenden om att digitala läromedel är mer eller mindre självinstruerande. Det finns dock inget i föreliggande studies resultat, i tidigare forskning eller något i argumentationen som stöder den typen av utsagor. Slutsatsen är då att marknadsföring av sådant slag ger en förenklad bild av lärande och bör ifrågasättas.

Angående andra påståenden om positiva effekter på lärandet har det inte entydigt kunnat bevisas att användningen av digitala verktyg förbättrar lärandet på något linjärt sätt (Arnseth & Ludvigsen, 2006; Cox & Marshall, 2007; Egenfeldt-Nielsen, 2006; Erstad, 2005, 2006; Ke, 2008; Schrum *m.fl.,* 2005). Snarare visar stor del av forskningen att digitala verktyg ställer nya krav på elever och lärare. Påståenden från en IT-positiv marknad om de fördelar som digitala läromedel sägs föra med sig ger således en alltför enkel bild av en komplex aktivitet. De empiriska resultaten från denna studie visar snarare att skolpraktiken inte är lätt att förändra, att elever handlar inom ramen av att vara deltagare i denna praktik och anpassar de verktyg de använder till denna praktik. Inom forskning finns också ett växande fält som handlar om vad den unga generationens erfarenheter av digital teknologi kan komma att innebära för utbildningsväsendet (t.ex. Gee, 2003; Papert, 1980, 1993; Pedró, 2007; Prensky, 2001). Dessa studier pekar bland annat på att ungdomar är skickliga användare av olika digitala verktyg och att deras sätt att lära sig kommer att förändras. En del av dessa argument bygger på föreställningen om att lärande kan liknas vid en okomplicerad

överföringsmetafor (Stahl, 2009). Men att utveckla människors förmåga att läsa, skriva och räkna består inte enbart i att presentera information för dem. Lösningen är då inte att förpacka kunskap i en ny mediaform. Detta lyfts också av Laurillard (2009) som menar att vad som krävs för att *lära sig* inte förändras i så stor utsträckning, oavsett hur mycket hjälpmedlen och teknologin förändras. Det är intressant att notera att föreställningen om 'förbättrat lärande' i förhållande till digital teknologi är så stark, trots att detta inte kunnat bevisas. I stället pekar mycket av den tidigare forskningen åt samma håll som resultaten av denna studie, nämligen att lärandeaktiviteten blir *annorlunda*. Lärandeaktiviteter där digitala verktyg används leder till nya möjligheter och andra problem, förändrade pedagogiska situationer, nya relationer mellan elever och innehållet de skall utveckla kunskap om samt nya didaktiska situationer för lärare.

Implementeringen av digital teknologi i skolan har således inte förändrat lärandepraktiken så som förutsagt av IT-positiva krafter. Utbildning vilar på tusentals år av tradition och om det hade varit så enkelt som att införa nya teknologier för att förändra skolan, skulle detta ha skett för länge sedan (Säljö, 2004). När det gäller tidigare media (exempelvis radio, film, video etc.) hördes liknande uttalanden där man blåste upp förväntningarna och när sedan inte önskvärd effekt uppnåddes framstod hela projektet som ett misslyckande. Ett sätt att tolka detta är att teknikerna inte anpassats till den praktik som ett institutionellt utbildningssystem bygger på. Alla praktiker har en egen logik och ett eget sätt att arbeta på som inte kan underordnas tekniken. Istället måste teknologin integreras på den specifika praktikens villkor. Det är inte fruktbart att gå in på ett sjukhus eller i en verkstad och berätta hur arbetet borde utföras där, lika lite som det låter sig göras i skolan. En verksamhet som skolan bör få avgöra hur den för elever framåt, det vill säga det måste avgöras i ljuset av det uppdrag som praktiken har, nämligen att utveckla kunskaper och färdigheter hos elever. Den långa raden av tekniska uppfinningar har ett stort värde som pedagogiska hjälpmedel men de bör införlivas på de villkor som gäller i olika pedagogiska praktiker (jmf. Greiffenhagen, 2007; Hernwall & Arvola, 2008; Kebritchi & Hirumi, 2008; Laurillard, 2009; Selwyn, 1999; Sutherland *m.fl.,* 2004; Younie, 2006).

Uttalanden från politiskt och kommersiellt håll, innehållande mer eller mindre välgrundade förslag om hur digital teknologi kan användas för att lösa klassiska pedagogiska problem bör lyftas upp och bemötas med forskning. I

detta sammanhang är det viktigt att komma ihåg att digital teknologi inte uppfunnits för att förbättra lärandet och det är också betydelsefullt att framhålla de ekonomiska faktorer som finns införlivade i denna entusiastiska teknologiska övertygelse, som handlar om att göra skolan mer effektiv och rationell. Empiriska resultat, som de som presenteras här, behövs då som motpol till påståenden som innehåller retoriska pedagogiska utsagor som mer eller mindre tillhör en 'edutainment' argumentation där kunskap ses som en vara, som är till salu. Utbildningspraktiker är generellt sett praktiker som är reglerade av olika regler, läroplaner etc. samt som ofta hårt är styrda av ett strikt tidsschema. Om syftet är att förändra dessa till mer flexibla, motiverande och engagerande praktiker, har historien visat att det inte är möjligt att avgöra *hur* det skall göras med ett perspektiv utifrån; det bör istället utföras i relation till och den existerande praktikens villkor. En intressant fråga är på vilka sätt tekniken kan integreras i klassrumsarbete så att eleverna lär sig ett innehåll, men via digital teknologi. I relation till denna studie handlar det om att elever fortfarande lär sig om matematik och problemlösning men vägen in i förståelsen är med hjälp av tekniken. Som resultaten av föreliggande studie visar, är det tveksamt vad elever lär sig om innehållet när interaktionen i stor utsträckning handlar om olika funktionaliteter i det digitala läromedlet. Frågan som måste ställas är då hur digitala teknologier kan integreras i klassrumspraktiker på ett sådant sätt att hänsyn tas till den institutionella ideologin och till praktikens villkor?

9. References

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