The Voice of Absent Designers

Students' Strategies when Solving Mathematical Problems Using Educational Software

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English abstract

This empirical case study explores how the design of educational software co-determines students' reasoning when solving mathematical problems. The results indicate that the students' awareness of the design process behind the software became a resource for them when solving the task. The student's actions were guided by their understanding of the intentions of the designers, i.e. by listening to the 'voice' of the absent designers.

Keywords: Word problems, problem solving, educational software, framing.

Introduction

This case study takes as its point of departure students' work on solving word problems in mathematics, using digital technology. By studying the actions of students when unpacking tasks, it aims to show what is significant in their process of understanding what the tasks entail.

Being a student implies playing a specific role with regard to using prior understanding of how to act and how to make sense of (how to frame) the task situation. This means that the learning tasks students face in school are never decontextualized, because students invoke their prior experience of making sense of school tasks when they face new ones (Mercer, 1992). We know from previous research that students use a variety of knowledge about schooling as a practice when solving tasks. Educational tasks are intended to work in certain ways with specific goals, and the focus in this article is on task situations and educational activities in which digital technology is used.

Especially in mathematics, there is a long-standing tradition of research concluding that the institutionalized context implies that students seem to disregard what they know about the world when solving mathematical word problems in school (e.g. Carraher, Carraher, & Schliemann, 1985; Davis, 1989; Lave, 1992; Palm, 2008; Scribner, 1984; Silver, Sharipo & Deutsch, 1993; Säljö & Wyndhamn, 1990, 1988; Verschaffel, Greer, & De Corte, 2000; Wyndhamn & Säljö, 1997). This tradition of research shows that students can become so focused on the formal nature of the tasks that they disregard their everyday experiences when solving problems. This phenomenon is sometimes referred to as *suspension of sense-making* (Verschaffel et al., 2000). For example, when given tasks such as: "If a man runs 100 metres in 17 seconds, how fast will he run a kilometre?", students tend to make a calculation and follow the logic of the mathematical algorithm, ignoring their everyday experience that holds that short-distance runners have a completely different pace than long-distance runners (Verschaffel, De Corte, & Lasure, 1994).

Studies on suspension of sense-making

There are a number of empirical studies and conceptual articles discussing *suspension of sense-making* when students solve mathematical word problems. One kind of typical design for these studies is to give students unsolvable problems together with classical word problems. A majority of the studies show that students tend to make calculations with the numbers given even if the problem as such cannot be solved (e.g. Nesher, 1980; Reusser & Stebler, 1997). Other studies have shown that even if the students were notified that some of the word problems were of a problematic nature, they tend to give answers anyway. In these studies, typically two groups were given tests where the instructions for the target group contained some form of information that some of the problems in the test were not solvable. Then, the target group was compared with the groups without this notification (Greer 1997; Yoshida et al., 1997). However, the groups informed about the tricky nature of some of the word problems showed no significant difference in their results when the groups were compared. Thus, the procedural pattern of how to understand the activity of solving word problems is not easily changed.

In a more recent study (Palm, 2008) traditional word problems were compared with word problems that were especially constructed to be as close to the out-of-school situation as possible. In this experimental study, it was concluded 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, however, it also confirms much of the earlier research showing the strong implication of students' habitual action in educational situations due to their previous experience of school tasks.

The studies described above provide knowledge about the situated nature of reasoning in educational situations. They show that there are ways of understanding the activities that have been institutionalized, where students interpret the tasks in such a way that they neglect their everyday knowledge. Word problems thus have to be understood in relation to various formal aspects and habitual ways of working in educational practices. However, these studies say very little about *how* the students have reasoned and negotiated before they reached their conclusions. For instance, Greiffenhagen (2007) implies that the mundane and practical aspects of delivering and receiving instruction in schools per se have been under-researched. According to Greiffenhagen, the process of un-packing tasks, that is, the process whereby students negotiate about what the task entails, is important to consider in order to understand how they comprehend the task activity. The importance of studying the *process*es behind educational activities where institutionalised aspects become noticeable (such as the phenomenon of *suspension of sense-making* when solving word problems in mathematics) has been emphasised by several scholars (e.g. Krange & Ludvigsen, 2008; Luppinici, 2007; Schliemann, 2002).

With the introduction of digital technologies in educational settings, it is also important to study these processes in computer environments (Säljö, 2004; Teong, 2003). The focus of earlier studies on new technologies in institutional learning environment during the 1970s and 1980s was on large-scale economic and occupational surveys, policy and legal analysis, ect., (e.g. Lievrouw, 2004) but today we also see qualitative micro-scale user studies (e.g. Schneider & Foot, 2004). The claims that have often surrounded the introduction of digital technologies in school have had a tendency to include promising possibilities of 'improved learning' due to more realistic presentations, added motivation, involvement, etc. But educational research on the implementation of digital technology in classrooms presents diverse arguments and it has been hard to prove any clear relationship between academic performance and the use of such technologies (e .g. Garris et al., 2002; Ke, 2008; Vogel et al., 2006). One reason is that several of the findings emanate from studies of arranged situations, experimental environments and short-term interventions that did not study the process and that have been hard to replicate in everyday school practice (e.g. Arnseth & Ludvigsen, 2006; Chang, Sung, & Lin, 2006; Egenfeldt-Nielsen, 2006). This points to the need for further studies of the alleged benefits that surround the implementation of digital technologies, as touted by the industry and the producers of these kinds of tools.

Aim of the study

The study presented here contributes to the discussion begun by earlier research. Its main focus is *how* students reason in the *specific* context of unpacking tasks consisting of word problems using educational software in a setting where digital technology is already used as part of the *ongoing, everyday practice*.

The principle questions are:

How do students reason and act in activities when they try to unpack mathematical word problems in the context of educational software?

How do they frame the activity of unpacking word problems presented by educational software?

Are there specific ways of framing that could be considered fruitful in their effort to unpack the tasks?

Theoretical perspective: A socio-cultural perspective and the framing concept

The theoretical basis of the present study consists of theories within the socio-cultural-historical perspective (Lave & Wenger, 1991; Säljö, 2000; Vygotsky, 1934/1962, 1939/1978; Wells, 1999; Wertsch, 1998) and the frame theory that originated with 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*. Both research traditions also share the same analytical focus, which is on the processes of interaction between individuals and other people and between physical and technological systems. In both the sociocultural tradition and Goffman's perspective on social interaction, 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 a 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). In order to see how people learn, these perspectives take into consideration the institutionalised aspects of educational activities and how new technologies shape the nature of different practices (Lave & Wenger, 1991; Säljö, 2000; Wertsch, 1998; Wells, 1999). To understand activities it is vital to see how participants in a specific activity *frame* events, actions and utterances in order to gain a temporarily definition of the situation (Goffman, 1974/1986). How we define a situation becomes an invaluable resource for understanding and interpreting our activities and in guiding our further actions.

A study that illustrates the point made by Goffman, (1974/1986) that activities are always framed, is Manuilenko's (1975) classical research on the length of time that children, aged 4 to 7, were able to stand motionless. The children were given different conditions for their activity; just standing still, a role-play/game or a competition. The results from this study showed that depending on how the activity was framed, that is, what the children considered they were doing as they stood motionless, was of great importance. Our previous experience and our expectations guide us in how we understand activities, and how we frame activities is then consequential for the nature of our engagement.

Manuilenko's (1975) study illustrates that the presuppositions and the expectations of the participants are important factors when framing activities. Studying a school context with these assumptions implies an awareness of the fact that particular ways of contextualizing messages are functional in institutionalised practices (Säljö, 2000). Educational settings are created for certain purposes and the tasks are designed with specific learning aims. In the present study, we have studied students' interaction in learning activities where educational software is implemented in a pre-existing activity that is designed in accordance with pedagogical goals.

In line with Goffman's (1974/1986) classical formulation of the concept, framing is understood as a process where people define the situations they are in, and act in accordance with their understanding of the specific practice that is connected to each situation. This definition of a situation is, however, most of the time something that we do more or less instinctively with no strategy involved.

> *Presumably, a "definition of the situation" is almost always to be found, but those who are in the situation ordinarily do not create this definition, even though their society often can be said to do so; ordinarily, all they do is to assess correctly what the situation ought to be for them and they act accordingly. (Goffman, 1974/1986, p. 1)*

Furthermore, although in most situations many different things happen simultaneously, this is generally not a problem for participants. However, when the definition of a situation is unclear and there is uncertainty as to how the activity could be understood, the actors often struggle to eliminate the ambiguity in order to recreate social order. The participants then try to clarify their own intentions and understandings in relation to the other participants. This is described as an activity of *clearing the frame*, an interaction pattern where the participants struggle in order to establish a mutual ground for their understanding.

> *When an individual finds himself in doubt or in error about what it is that is going on, a correct reading is usually soon established. In some cases he himself will sharply orient to an examination of the setting so as to pick up information that will settle matters. (Goffman, 1974/1986, p. 338)*

Clearing a frame is the description used here when the participants try to figure out what the problem is and what actions could be relevant when solving the problem. The excerpts are chosen with the aim of illustrating not only the importance of *frame clearing* when collaboratively unpacking tasks, but also *how* this is done and with what means the students reach a common understanding of how to continue their activity. Goffman points out that the ambiguity of the situation needs to be settled so the work can continue and that this is done by actively examining the context, in this case, the educational software.

> *The information that clears a frame can stem from various sources. In the face of ambiguities or incongruities, the puzzled or suspicious individual himself will sharply orient to his surround and maintain vigilance until matters become clear, sometimes making open requests for facts in order to settle the issue. (Goffman, 1974/1986, p. 339)*

The software, the setting and the participants

The definition of educational software used in this study is software that 1) is produced for schools and primarily intended for learning a specific subject, 2) has a relationship with an educational textbook, and 3) is the bearer of educational content. The specific educational software that the students use here is called the *VETA*[1] *Learning Game* and is an interactive web-based multimedia program in mathematics. *VETA Learning Games* is produced for upper secondary school level pupils (16 to 18), but it is also used in adult education. The students work with problem-based assignments in a story-based game context. In the software, the information is presented both in text and through spoken language, and there are different options for the students to get further help in the form of theory sections and various kinds of help buttons. The software also includes a variety of sounds, still or animated graphics and film segments. The learning games consist of a number of modules. A module in mathematics can for example be geometry. A module consists of assignments, theory sections, tasks, teacher's manual sections, and other design elements such as various help buttons. The story-based assignments consist of one or more tasks in which the students help different characters to solve problems. However, there are few connections between the game parts, i.e. the story-based assignments and the learning parts. The game components mainly function as a reward for educational activities having been completed. 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 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. All the games produced by the software company follow the guidelines, the curricula, the syllabi and the grading criteria set by the Swedish Board of Education.

The setting is an upper secondary school and the students taking part in this study all have access to a portable computer. The students who participated in the study are 16–17 years old and they all attended a study programme called "The open program", which involved the students not choosing the social studies programme or natural sciences programme until their second year. The aim of this programme was for the students to be able to try out different techniques and applications, such as different media, in their learning processes. The specific course is the first mathematical course taken at upper secondary school (Mathematics A-course). At the time of video recording they have attended this course for a couple of weeks. The video recordings were made in a room adjacent to the classroom where the students worked with VETA's educational software during their regular classes. The students in the study used this software during their everyday schoolwork, and during the data collection the teachers regularly entered the room and interacted with the students as in a normal lesson. Even though we set up the study, we claim that the activity was very close to the regular math lessons of these students.

During most of the sessions there were three cameras in use. One captured the screen, a second one captured the students from behind in order to document their non-verbal activities (pointing at the screen, etc.), and a third one captured the activities from the front in order to record the students' expressions and to facilitate following the conversation. The films have been synchronized into one film, where the different camera angles are visible at the same time, as is shown in Figure 1. The transcripts are organized in a system of columns to make it possible to document participants' talk and actions as well as the activities on the screen (Linderoth, 2004).

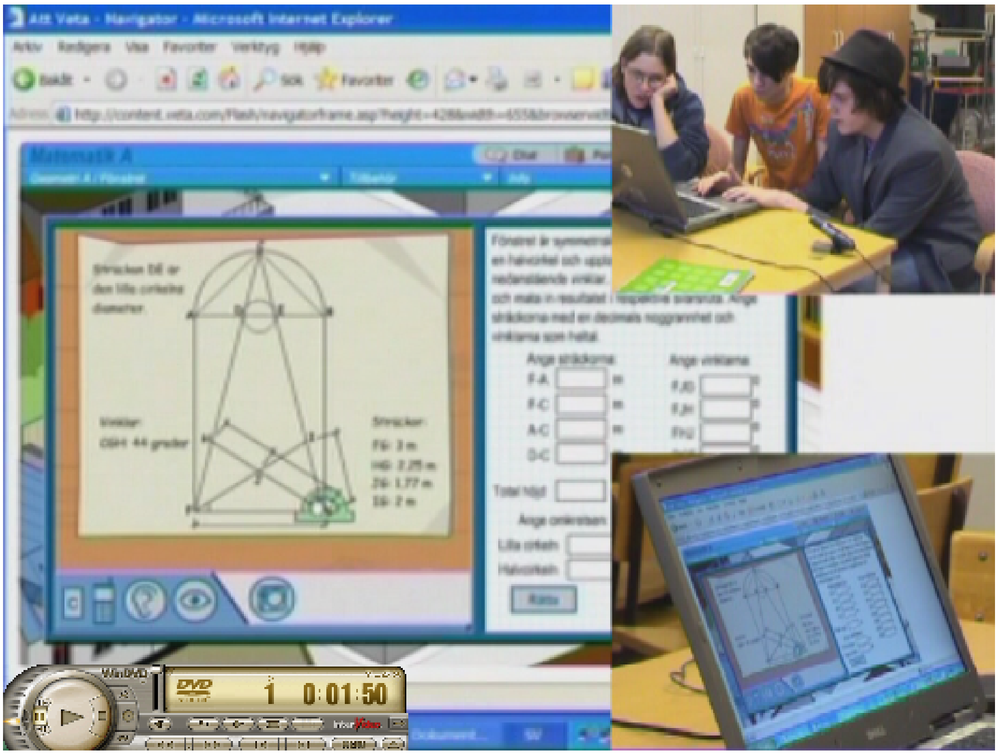

Figure 1. Screenshot illustrating data material

Methodological perspective

The empirical material consists of video documentation of students working in pairs or groups of three. The data are taken from a larger project[2], which contains additional recordings of students using educational software in other subjects and interviews with students, teachers and producers of educational software. In this case study, the focus is on the video recordings. By using *Interaction Analysis* (Jordan & Henderson, 1995), the focus is on how the students interact and communicate with each other and with the tools available in the situation. A basic assumption in this tradition is that knowledge and action are social phenomena, situated in the settings in which they occur. Interaction Analysis is also consistent with Goffman's (1974/1986) 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. The basis of analysis has been the assumption that a utterance get its meaning from how it is taken up that is, how it is responded to by the other participants. This implies that a utterance cannot be analysed in isolation, but must be seen as a response to a prior action, a prior utterance, etc. Interaction Analysis is performed with the use of video data that the researcher transforms into detailed transcripts. Theories of communication and the theoretical concepts derived from Goffman's (1974/1986) ideas about framing are then used as analytical concepts in order to examine what the meanings of participants' utterances and actions are in the analyzed session. 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. The analyses focus on what the participants are doing and what they are saying. 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, than the language per se. It is by scrutinizing how the participants interact, or how they act in accordance with the temporarily definition of the situation, that we as analysts can account for what the activity means to the participants and what kind of framework has temporarily been established.

The students and their parents were informed about the research. It was emphasized that all participation was voluntary. The research followed the ethical code of the Swedish Research Council.

Analysis and Interpretation

In a first mapping of the whole data material, 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. In earlier studies of students' meaning-making and learning related to mathematical word problems in the context of digital technologies (Lantz-Andersson, 2009; Lantz-Andersson, Linderoth, & Säljö, 2009), we have focused on situations where the students experienced some kind of difficulties in the problem solving. The focus here has been on the students' process of understanding the task and their negotiation about what the task entails. The analyses are based on excerpts from the beginning of a lesson, where three students begin an assignment. This case is selected because it is informative and distinct in relation to demonstrating an existing phenomenon that is represented in various ways in the empirical material as a whole. In selecting cases that are typical and representative of the activity, the aim is to illustrate frequently-occurring interaction patterns that appeared in the initial phases of the students' work of unpacking tasks with this educational software. Our special analytical interest has been the situations in which the students try to see the problem from the designers' point of view, that is, they engage in a process of *clearing the frame* (Goffman, 1974/1986, p. 338).

The subject matter in the two excerpts is geometry and the specific task is about measuring and calculating different distances and angles of a window. In the screenshot (Figure 2), the measurement on both sides of the window is shown when the students have measured the possible distances and angles with the virtual instruments below the window (the protractor, etc.). The task is to calculate the distances and angles of the window with the help of the measurements given and to write the answers in the boxes on the right hand side.

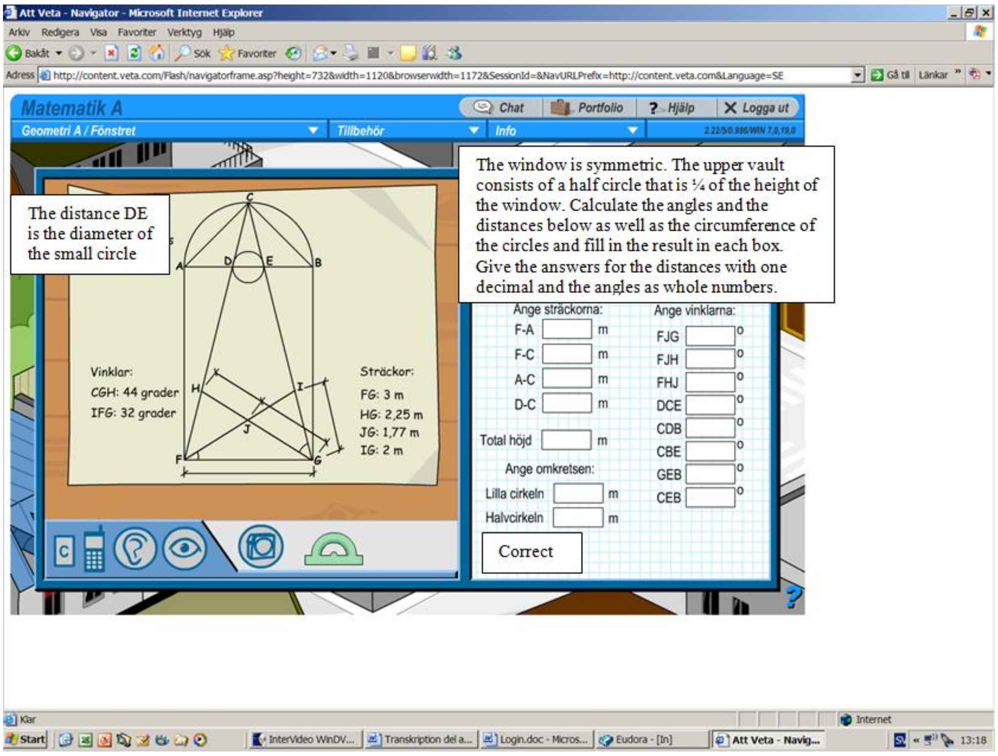

Figure 2. Geometry problem in the software (Authors' translation from Swedish into English in the textboxes above, underneath the textboxes the text is in Swedish.)

In the first excerpt, the students are negotiating in order to understand what the task really entails. When doing this, they start discussing what kind of stuff they need in order to be able to do the rest of the calculations. The students are trying to understand what concepts and methods that could be relevant in this situation. Their negotiations are, hence, 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. That is, they frame their further actions within this understanding of what the task is about and thus they can continue their negotiation. In framing the activity this way, we will argue that the students demonstrate their trust in the fact that the design of the software will support the overall curriculum and the lesson structure

In the second and final excerpt, the students try to reach a common understanding of what specific angles they are supposed to calculate in the problem (see figure 2). Here, our main point is to show how students use their understanding of the designers' rationale, in their *frame-clearing* process. They are, thus, acting in relation to an absent designer, and trying to take this absent person's perspective. This is a form of perspective-taking that is shown to be of importance for their subsequent problem solving.

Framing the activity in order to understand what the task entails

Before Excerpt 1, the students have not yet established a mutual understanding of how to tackle the task. They have made some initial preparations, like measuring the distances and angles, in order to get all the available information. Then, they sit silently for half a minute and read the text of the word problem on the screen. When beginning the interaction shown in the excerpt below, they start the work of trying to understand what this task is about and thus of trying to understand how to frame their subsequent work.

Excerpt 1 from session 10:					
Time	**No.**	**Name**	**Speech**	**Activity in the room**	**Activity on the screen**
02:50	1.	Henrik	well, I think that you have to use some tricky stuff that's up here, which I never really understood		Henrik clicks on *Accessories* (*Tillbehör)* in the menu and then on *Theory* (*Teori)*
02:53	2.	Jacob	what kind of stuff?		Henrik clicks on *Geometry (Geometri)*
02:56	3.	David	if it's something that Henrik didn't get, then it's , it's definitely something that I wouldn't understand		
03:00	4.	Jacob	[laughs]		
03:06	5.	David	sort of angles (laughs)		
03:09	6.	Henrik	I think it was this…		Henrik clicks on *Trigonometry in right-angled triangles.* (as shown in the picture below

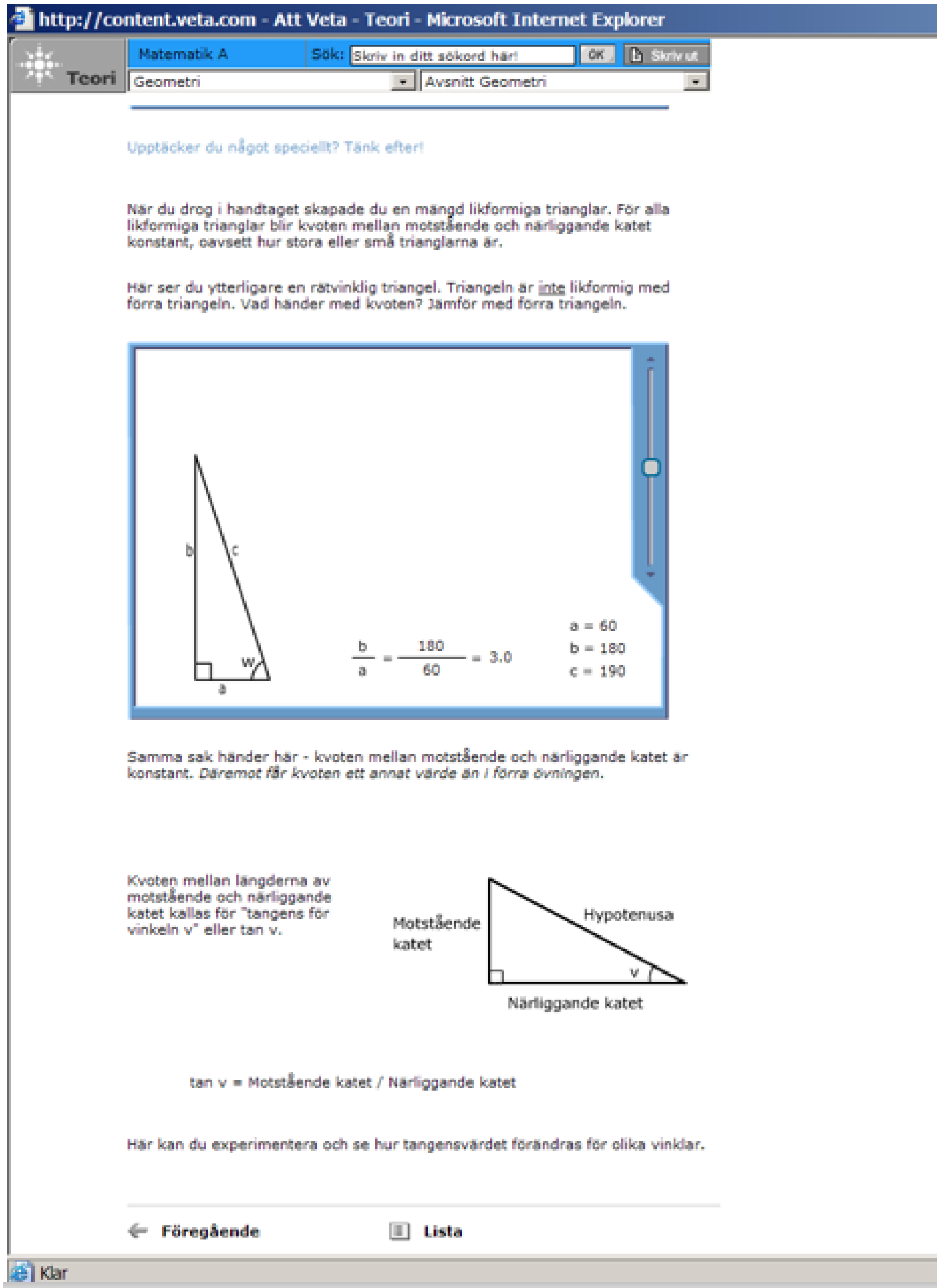

Figure 3. Screenshot from 'The theory section' of the software

Excerpt 2:					
Time	**No.**	**Name**	**Speech**	**Activity in the room**	**Activity on the screen**
03:13	7.	David	[inaudible]…. no… yes that's the one… yes that's the right one… the one I also tried to work out		
03:15	8.	Jacob	[overlapping talk] but what's that?		
03:18	9.	Henrik	it says … it has to be …it has to be, eh, right-angled, so if we find any right-angled		Henrik clicks back to the assignment
03:20	10.	Jacob	but, what, what is it?		
03:21	11.	Henrik	it is, is sort of, how you can calculate … angles and…depending on whether you have a couple of sides and that sort of thing		Henrik clicks back to the theory section and scrolls down the page
03:29	12.	David	you know, it was what we did in the first lesson	David looks at Henrik	
03:31	13.	Henrik	did we?	Henrik looks at David	
03:32	14.	David	we did, didn't we?		
03:34	15.	Jacob	[overlapping talk] but really, that isn't so difficult is it?	Jacob looks up at Henrik	
03:37	16.	David	no, this is something for the B course		
03:41	17.	Henrik	Yes		
03:42	18.	David	he-he		
03:45	19.	Henrik	yes, but that one…then we have one of those also…yes that will be great		Henrik marks the text above the angle (see figure 2) on the page and then clicks back to the assignment.
03:51	20.	Jacob	Mm		
03:52	21.	David	eh [inaudible mumble]		
03:55	22.	Jacob	but which do we know, which [inaudible]?		
03:59	23.	Henrik	but David, for heaven's sake!		David plays with the mouse on the page
04:04	24.	David	[laughter]…but how should we calculate it then, F to A? that can't be so very hard	David points at the screen on the distance F-A	
04:15	25.	Jacob	but we can't use angles there, can we? Or how should that be done?		

In this excerpt the students are searching for information that could be used in order to understand what the task entails. They negotiate which resources and procedures that will lead them towards the solution of the task. When Henrik says; “Well, I think that you have to use some tricky stuff that’s up here, which I never really understood,” (in turn 1), he frames the task as something that is quite challenging.

To be able to continue, Henrik demonstrates a need to know what mathematical formulae, modelling, concepts, etc., are useful for solving this specific problem. He asks about what they “have to use” and states that what he thinks they need to use is something “tricky” that he has not entirely understood . He then opens the *Theory section* and browses to *Trigonometry*. This *Theory section* is based on modules of the course and additional specific content such as *Trigonometry*, which is part of the *Geometry module*. When turning to this page, Henrik states (in turn 6), that he “thinks it was this”, thereby trying to relate the specific problem to the overall content of the software.

These turns express a need to understand where to ‘place’ the problem in order to understand what the relevant means are for solving the task. He searches for a place where the problem at hand fits in relation to the overall course. Our interpretation is that the frame, the taken for granted assumption which is at work here, is that a specific task in the software is always related to a specific part of the overall curriculum. By identifying where a specific task fits in their overall educational plan, the students gain information about which formulas and operations that are relevant to use for solving the problem. This interpretation makes sense according to the response that follows when Henrik clicks on the part that has to do with right angled triangles (in turn 6): David says “That’s the one… yes that’s the right one**…**.” David’s response to the new information coming up on the screen answers the unspoken question: where in the software is the relevant information we need to solve this task? David’s reaction indicates that they now have found where the problems fits.

The text provided in this *theory section* is partially about right-angled triangles and provides the relevant formulae for calculating unknown sides and angles. Henrik responds to this by suggesting, “So if we find any right-angled...” (in turn 9), the word “if” displaying a condition for using this formula. We interpret this as a statement by which Henrik wants to confirm that the problem at hand is related to the specific part of the theory section (and to their overall educational plan). If the relation is there, then they should find right-angled triangles in the task since this is part of what they are supposed to practise. Henrik then moves quite quickly back to the task, but Jacob indicates that he has not grasped what it is about (in turn 10). Henrik then goes back to the theory section and explains his view of how they could use the formula, stating ”It is, is sort of, how you can calculate … angles and… depending on whether you have a couple of sides and that sort of thing,” (in turn 11). He tries to elaborate on the conditions for using this formula, and with this comment he acquires the first resource for making sense of the task. This elaboration is taken as ambiguity by David, who tries to aid Henrik in positioning the task by stating that, “It was what we did the first lesson,” (in turn 12). He further elaborates this positioning when he changes his mind, saying, “No, this is something for the B course,” (in turn 16). As the students are attending course A, their saying that something will come in the next course means that they could postpone their knowledge about this for a while. They are relating the problem at hand to the broader course content and how it fits into the design of the software, and by doing this they bring the institutional expectations to the surface. By understanding what they are supposed to practise here, they also get the necessary knowledge to continue work on solving the task; they have decided that this has to do with right-angled triangles. This excerpt illustrates that it makes sense for the students to relate the specific problem to the overall course content. Once they get an idea of how things fit into the curriculum, they limit their ways of engaging in the activity in order to solve the problem. In this specific case, this is illustrated by them relating the task to trigonometry and then by narrowing it down to theory in the right-angled triangle section.

In turn 25, Jacob expresses uncertainty about the way they have framed the task: "But we can't use angles there, can we?" This could be interpreted as there being a question of whether they have framed the task properly for solving the problem. Expressed in Goffman's (1974/1986) terminology, the work the students are doing consists of *clearing the frame*.

In the next excerpt, the students act in a specific way to make sense of the problem. Once they have decided that they are supposed to solve the task by using formulae for right-angled triangles, the next question that arises is which angles they should calculate. Each point is labelled with a letter, and the angles have a three-letter name such as FJG (see Figure 2). The question is, then, how do they identify which angle they should calculate?

Frame-clearing processes in relation to the absent designers

Excerpt 3 :					
Time	**No.**	**Name**	**Speech**	**Activity in the room**	**Activity on the screen**
05:20	26.	Jacob	but, wait a moment, how should you…what angle it is, then…should we take that angle, then?	Jacob points at the angle in the left corner on the screen (JFG)	
05:27	27.	Henrik	what, which one?	Henrik leans over the screen to get a pad	
05:28	28.	David	what?		
05:29	29.	Henrik	the way I understand it…they draw the angles sort of…F, J, G... then it's that one, if it had been J, F, G it would have been…	Henrik points at the different letters F, J, G on the screen with a pen, and then at the angle next to the letter J to explain that it is the angle in the middle letter that should be calculated	
05:36	30.	Jacob	[overlapping talk] but otherwise, one could have imagined that there, where they've made such a little angle stroke then could it have been that angle they wanted	Jacob points at the angle IFG on the screen	
05:42	31.	Henrik	but that one, but Jacob, we already know that angle	Henrik points with his pen at the angle IFG	
05:44	32.	Jacob	well, well, okay		
05:45	33.	Jacob	ah-ha is it that, that they, ah-ha is it that that it draws	Henrik now points with his finger at the angle IFG on the screen	
05:47	34.	Henrik	hmm		
05:48	35.	Jacob	well, the I get it, yes, but that's obvious, or, yes, sure, it seems like…but…no		
05:52	36.	David	oh yes		
05:53	37.	Jacob	What, then, is F, J, H?	Jacob points with his finger towards the screen at the angles with the letters F, J and H	
05:56	38.	Jacob	is that then…where is F… F, J, H?	Jacob point towards the screen again	
06:00	39.	Henrik	[overlapping talk] F, there is F…J, H…so it's that one	Henrik points with his pen at the angle IFG	
06:02	40.	Jacob	that one, aha, so it's that one, the one in the middle is the one you should calculate?	Jacob points in the air towards the screen	

06:06	41.	Henrik	yes, that's how I understand it…	Henrik points with his pen at J on the screen	
06:07	42.	Jacob	why do you think it's like that?		
06:08	43.	Henrik	but, it's logical, how should they have drawn it otherwise?		
06:10	44.		[inaudible mumble]		
06:15	45.	Jacob	hm, hm		
06:16	46.	Henrik	Because, I mean, that couldn't that couldn't be…and they couldn't mean that angle, because we already know that angle, since we already know that one…and they can hardly mean that angle since the G is last, can they [irony] **…**do you understand…do you understand how….do you understand what I mean?	Henrik points with his pen on the box were they should write their answers for FJG and then at the angle beside the letter F (IFG, which they have already measured with the interactive instrument). Then he points at the angle beside the letter G (JGH) and then again at the box were they should write their answers for FJG	
06:27	47.	Jacob	[overlapping talk] hm, hm, well, well, yes hm, sure		

In this second and last excerpt, the students negotiate which angle they are supposed to calculate. The angles that are measurable with the virtual instrument are marked with a line (see Figure 2) and the ones that they should calculate are not. The excerpt begins with Jacob questioning which angle they are supposed to calculate in turn 26; "But, wait a moment, how should you… what angle it is, then… should we take that angle, then?" At first, Henrik shows signs of not understanding Jacob's question, since it is obvious to him how the angles are marked, and he replies, "What, which one?" (turn 27). Then he starts to explain (in turn 29) by saying, "The way I understand it..." thus implying a possibility that he is not right. Jacob then points out that "they made a little angle stroke," referring to the half-circle in the corner and stating that this might be the angle asked for. He thus continues Henrik's formulation of a hypothesis in relation to the absent designers. He also talks about "they" and implicitly wants to know what the designers had in mind when they made their design decisions. Henrik then points to the fact (in turn 31), that the angles marked with an angle stroke are the ones that they were able to measure with the virtual protractor below the window, saying, "But Jacob, we already know that angle". The discussion continues in turns 33-42 with Henrik trying to convince Jacob that the middle letter is the designers' choice for describing the angle they are supposed to calculate. In turn 43, Henrik again clearly invokes the designers by saying, "How should they have drawn it otherwise?" Analytically, this remark could be described as a form of perspective taking that forces the participants to place themselves in the role of an absent designer, and from that point of view to ask what choices were made in constructing the software. The implicit question is *what options did the absent designers have in marking the angles*? Henrik concludes that this is the only rational way, saying: "But, it's logical" (in turn 43), meaning that there are no other options and that they can thus rest assured that his hypothesis is correct and go on with their work. Henrik is trying to understand the local logic that the designers have used in the task. They are absent in time and space, but by trying to understand what rationale "they" had when designing the task, the students can gain valuable information about the nature of the task.

The descriptions of the angles are given in the form of three letters (e.g. FJG) where the middle letter indicates the vertex of the angle. Even if this is a standard convention used in mathematics to name angles, this is what the students are concerned about in this context. Since this is a standard convention one would expect secondary students to be familiar with it. One possible explanation for this lack of understanding is that the students have never fully understood the convention and that the digital environment triggered this discussion and probable knowledge. Another possible account is that in a digital environment these standard mathematical conventions do not routinely apply. This is analytically interesting since it could indicate that the students disregard their previous knowledge of mathematical conventions when they move from a traditional paper-and-pencil task into a digital environment. However, Henrik understands the logic of how the angles are indicated. If this has to do with his understanding of conventions or with the fact that he has tried to solve this assignment before is not explicitly shown. Jacob clearly reveals his ignorance of this convention.

The intonation in Jacob's reply, "Hmm, hmm", indicates that he is not completely convinced and is also, analytically speaking, an assertion of his understanding. This makes Henrik continue with a long explanation (in turn 46) of why the middle letter had to be the designers' choice for marking the angles. To underpin his argument, Henrik points to the fact that the angles with the stroke are already known, which excludes them. The last option is that the angles asked for are marked with the last letter, which Henrik refers to in an ironic and rhetorical tone of voice: **"...** and they can hardly mean that angle, since the G is last". He then reinforces his argument by saying, "... can they?" which indicates that Henrik thinks this way of marking the angles could not have been an option for the designers. This last remark is again made in relation to the absent designers, whoever they may be, and indicates the students' thinking. Our interpretation of this is that the students are suggesting that 'they could hardly be so illogical that they would put the letter asked for last'. The students' argument for ruling out this alternative is based on the assumption that the designers are rational; the students expect a design based on reason. Figuring out the expectations that the designers had of the users is here a way of clearing the frame in order to find a way forward and to get on with solving the problem. When Henrik states, "... and they couldn't mean that angle, because we already know that angle," he expresses that it is not likely that the designer would ask for a figure that does not demand any calculation (comp. Säljö & Wyndhamn, 1993).

Discussion of findings and conclusions

In educational settings there are always preconceived assumptions and preconceived ways of framing task situations. In the present study the emphasis has been on how students frame the activity of unpacking mathematical word problems in the context of educational software and on examining if there are ways of framing that could be considered successful.

A designed environment is, in a sense, always designed with some idea of how a user will behave. In the case of educational applications the design will also be based on ideas about how a student should preferably act in order to attain a certain learning objective. This article shows how students actively try to understand these principles when using the designed product. When using the software the students try to understand the designers' ideas about how a student using their program would behave. How did the designers reason about the future users of their product? How did they think these users would behave and act in relation to the software? Our study shows that reasoning about these things i.e. how the designers of a product *imagined* that their future users would act when using the software, is a fruitful strategy for successful interaction with the product.

In this study we have shown how the students process the information in the task and 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 insight (Bergquist, 1990; Greiffenhagen, 2007; Lund & Rasmussen, 2008). The main finding here is that the students are supported in their *frame-clearing* process by their attempts to understand a virtual designers' rationale. They are, thus, acting in relation to a 'constructed absent designer' and try 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. In doing so, they try to position themselves as users from the perspective of this absent designer. They are aware of being part of a system built on pedagogical principles, principles that are built into the software. Somewhere in this system there are people who had ideas about how the students should handle the digital word problem. It is by trying to be receptive to these ideas that the students strive to develop their strategy for handling the problem.

These aspects are more or less linked to the notion of the absent virtual designer and have to do with the fact that the educational software seems to invite a number of meta-activities, – activities where the students relate to what they are expected to do. The students construct an abstract "they", whose intentions and ideas they try to understand. Referring to the educational software as "they" could, in this sense, be said to involve an implicit awareness of the fact that it is constructed, styled, created or designed by someone.

In doing this, the students not only frame the activity by implicitly asking, *what is going on here?* but also via the underlying question: *what do they want us to do?* By trying to understand the aims of these non-present actors, the students get some idea of how the designers regarded potential users. When reaching this understanding, the students may shape their own actions in order to fulfil these aims, thereby taking and playing the role of the designers' *ideal students* (i.e. the students that the designers imagined when designing the software).

Initially, the students get an idea of how to unpack the task when Henrik finds the right-angled triangle section in the theory section. This implies that the students are trying to understand what they are supposed to practise and how this specific task is related to that intention. By having some sort of idea about this kind of educational structure, they can form a vague hypothesis about what sort of resources they can use to solve the task. They relate the task and the specific maths that they think is involved to the specific lesson structure, the overall content of the course and the theory section in the software. By assuming that the theory section supports the users' problem solving, it makes sense to scroll there in search of some concept that might "fit" the problem at hand. The students take it for granted that information about how to solve the task is supported by the software. This way of framing school tasks has to do with their expectations as students and their assumption that there are certain underlying rules in educational settings. One of these assumptions is that every problem presented by the teachers, in textbooks, or by educational software, is solvable and makes sense (Verschaffel et al., 2000, p. 59). In this case, the discovery that the theory section contains information about right-angled triangles becomes the key to unpacking the problem, *clearing the frame* and continuing with the task. Seen as a whole, what the students' interaction and actions have in common is that they are trying to acquire knowledge about the design and setup of the educational situation. This applies to both the overall curriculum and the lesson structure and above all to the internal logic of the software, that is, how problems are sequenced and related to other information.

Our findings add another dimension to the previous knowledge about *suspension of sense-making*. The basic understanding of the concept is that students solve the problems without using their 'out of school' experiences or experiences from other school contexts (like paper and pencil tasks). 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 relate to real word issues. In our view, *disregarding* or *suspending* the references to 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, albeit perhaps not in the intended way. The students make sense of the situation but not as idealised students training for a world outside an educational system. They make sense of the tasks they face as if they were designers, taking a kind of meta-perspective of their ascribed role. Instead of fulfilling this role of idealised students, they analyze what kind of agenda the virtual designers that made the task had in mind by trying to hear their 'voice'. From that position the students can more easily analyse the underlying principle of the task: what they are supposed to practice, what kind of problems they will encounter and what kind of procedures and strategies the designers expect them to use. Thus, this way of framing the activity of unpacking word problems presented by educational software can rather be seen as *another way* of making sense of a task, in a specific situation.

The findings also parallel the cue-seeking phenomenon in educational settings: students deliberately try to figure out what the teachers require (e.g. Marton, Dahlgren, Svensson, & Säljö, 1977). Here we find a similar approach in relation to the educational software. In the digital environment, the design is of great importance since it implies many modals in a non-linear structure, such as text, hypertext, images, representations that are dynamic and possible to manipulate, sound, speech and in this case a frame story. To a large extent, all these modals comprise how the designers want people to act. A question to be asked is, then, whether a necessary competence for students is to not only think about how to solve a task but also to reflect upon the intentions of the non-present designers. As the study indicates, this is a successful way of acting and interacting when solving word problems in a digital environment.

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1 VETA (literally: KNOW) was the largest company developing web-based educational software for upper secondary schools in Scandinavia. A Swedish company, it was established in 2000 and specialised in offering educational solutions in mathematics, physics, language, nursing and healthcare education. Among its owners were Svenska Kommunförbudet, Lernia, Skandia, Svenska kommuntjänstemannaförbundet (SKTF), Metall and Kommunal. VETA closed down its business and website in the autumn of 2008.

2 This project aims to analyse how students' interaction and learning in a computer-based environment are characterized by design qualities in the specific educational software and by occurrences in the practice where the software is used. Accordingly, the emphasis is on studying the everyday use of educational software in existing environments. The empirical material used in this research project consists of video films of students using educational software, working either in pairs or in threes. The basic material includes 16 video films, each lasting about 60 minutes, of 34 students (16 girls and 18 boys) who used educational software in the subjects Mathematics and English as a second language. In addition to the 16 filmed sessions, the research includes 5 taped interviews with teachers of 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 7 observed lessons. The research projects as a whole also include data from a specific learning environment in Sweden called The 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.