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The use of language in understanding subject matter

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Abstract. Empirical results show that frequently the meaning of expressions used by students in expressing their understanding of subject matter does not correspond to the meaning of those expressions in the subject matter theory that the students are expected to learn. There is also often a lack of identity of meaning between the same students' use of the same expression from one use of the expression to another, in very similar contexts. The context gives a specific meaning to any expression. This variation in context and meaning is very central to the phenomena of teaching and learning. In educational research there is a need to differentiate between specific meanings expressed in conceptualizing subject matter, on the one hand, and concepts and meanings seen as parts of cognitive systems and social languages, on the other. The contextual character of the use of language is crucial to the understanding of teaching and learning and needs to be more carefully considered. The article is a discussion of the problem of varying meanings of language expressions in relation to major traditions of research, focusing on meanings and concepts within the field of learning and teaching.

Key words: Language; thought; understanding; learning; studies; science education; phenomenography;

Introduction

The aim of the present article is to present theoretical thinking developed in relation to empirical research about the function of language use in students' development of knowledge. The development of the phenomenographic tradition of research that forms the background to our approach has been presented by Marton (1981), Marton et al (1984), Marton & Booth (1997) and Marton & Tsui (2004). The general theoretical foundations have been presented by Svensson (1997). The phenomenographic tradition is characterized by its focus on the relation between the subject and his/her world in terms of conceptions of, or ways of experiencing parts of the world. Ways of experiencing or conceptions of parts of the world are fundamental to the development of individual knowledge, and the phenomenon focused here is the role and function of language in this development. The theorizing presented in this article is a further development of phenomenographic research in line with some previous investigations. Svensson (1978) exemplified how the same conception was expressed in very different words, while very different conceptions were expressed in rather similar words, and

argued for the importance of studying the relation between the use of expressions and the conception as a unit of thought. Anderberg (1999, 2000, 2003) and Anderberg et al. (personal communication) later made more extensive and thorough studies of the use of words in expressing conceptions, as well as the change in use of words and/or conception when they were reflected on in a special dialogue setting. These studies were made using an *intentional-expressive* approach to the study of language use, focusing on the relation between the expressions used and the speaker's intended meaning.

In the intentional expressive approach, the meanings of expressions used in a dialogue are seen as dependent on the speaker's intention, and not assumed to be equal to predefined meanings in a social language or to general concepts in a cognitive system (Anderberg et al., personal communication). The intentional-expressive approach acknowledges the dependence of the expressed meaning on the intentional context and underlines the need to clarify the meaning of individual expressions through a process of interpretation in relation to the intentional context of the speaker. It is not assumed that the researcher has access to the speaker's total intention, but that the meaning of individual expressions may be understood through their relation to a more extensive expression of intentional meaning as interpreted by the researcher.

This article is more specifically based on a research project with the title *The interplay between language and thought in understanding problems from a student perspective* focusing on the contextual character of meanings of language units used by students. This interdisciplinary project was financed by the Swedish Research Council, and carried out in the period 2002 to 2005 (Anderberg et al. 2005; Johansson et al. 2006). The disciplines represented in the project by the authors of this paper were Education, Philosophy and Physics. A summary of the results was presented at a symposium with the same title at the AERA (American Educational Research Association) Annual Meeting, San Francisco, April 8-12, 2006 (Svensson 2006). The project formed part of a research programme on "Language use and individual learning" at the Department of Education, Lund University.

Based on the authors' previous research and experience, a shared theoretical and methodological approach to empirical research on students' use of language in understanding subject matter was developed in relation to the field of science education, more specifically in relation to university engineering students' understanding of cases of physical motion. In this article, theoretical implications of the findings are discussed, and compared to findings and theorizing in cognitive and socio-cultural traditions of research. While comparing our findings to research in the cognitive and socio-cultural traditions, we are not in any way doing justice to those broad groups of theories. We do not discuss the great variation that exists within both groups of theories, but simply focus on some of the main characteristics and tendencies within those groups, including some similarities between them. Although this summary treatment may seem overly simplified, we argue that the characteristics and tendencies focused on in this article are both fundamental and critical. The aim is not to present an exhaustive description of those traditions and theories, but rather to critically examine some fundamental assumptions about the nature of thinking, language use and learning. Such assumptions are adhered to in various ways but still share certain common features.

The problem is discussed specifically using teaching and learning of mechanics as an example. This example represents a continuation of an earlier phenomenographic project within the field of teaching and learning mechanics (Johansson et al. 1985; Svensson 1989). The choice of this field is seen as strategic in that it is well developed as a field of research

into teaching and learning, and that it contains some helpful characteristics of language use. Mechanics as a theoretical discipline has a well-developed theoretical language, with rather distinct meanings of terms. At the same time, there is a large overlap of these terms with words and expressions used in ordinary language. Additionally, the phenomena dealt with are commonly experienced everyday phenomena, which are understood and talked about in many different ways depending on context.

In theorizing about students' development of knowledge, that is, the conceptualization of parts of the world (in our example, cases of physical motion) the view of language appears to be of crucial importance. The view adopted of language as a social entity is intimately related to how individual use of language is seen. If we use the student's personal development of knowledge as a starting point to investigate actual use of language in learning, the dominant views of language turn out to be problematic. We find that in both cognitive and socio-cultural theories about thinking, communication and learning, there is a strong tendency to look upon language as vocabulary and/or as a system of expressions (Johansson et al. 2006). Furthermore, we find that such conceptions of languages as vocabularies and/or systems of expressions are not only insufficient, but also problematic as a basis for describing the actual *use of language*. On the basis of our empirical findings, we argue for the need to take an *agent perspective* on the function of language use (Anderberg, et al., personal communication), where the use of language in developing knowledge of the world is seen as a matter of making the world intelligible. We further argue, also on the basis of our findings, for a *contextual view* on learning, starting from the agent perspective. Conceptualizations of parts of the world talked about have to be considered as the most immediate context of language use in development of knowledge, together with a broader individual and socio-cultural context (including social languages), situated within an even broader total context.

In the next section, pursuing our aim to present our thoughts on the function of language use in students' development of knowledge, we will start with the general problem of understanding subject matter and how it is dealt with in practice and research. We then compare three main theoretical orientations concerning the use of language in understanding subject matter. In the third section, the use of language is discussed in relation to an agent perspective, and an illustrative example is presented. This discussion is then seen in relation to questions about broader learning contexts in the following section. The final section is a characterization of the view of learning and understanding explicated throughout the article.

Understanding subject matter

In education, a main focus lies on teaching and learning subject matter within different fields of knowledge. Although, to a large extent, teaching and learning is carried out by use of language, the way language is actually used to develop knowledge is very much taken for granted both in practice and in educational research. In research on teaching and learning, use of language is described in different ways as part of describing teaching and learning. However, the central relation between use of language and understanding of subject matter is usually not investigated further. Assumptions concerning the use of language are then implicit, without differentiating between the use of language and understanding of subject matter in the descriptions. At the same time, it is a rather common observation that students may have learned to use terms, expressions and a certain language within a field of knowledge, without having developed a corresponding understanding of the subject matter that the students are expected to have learned.

The starting point in formal education is taken in knowledge that has already been developed, in research or practice. This knowledge is presented through language. However, terms, expressions and language are given varying meanings in understanding objects of knowledge representing subject matter. From the teacher's perspective, it is a central question how to use language adequately in teaching, to support the development of an understanding of the subject matter taught. From the learner's perspective, it is an open and fundamental question how language could be used in learning to understand the subject matter. The varying use of language units and their meanings in understanding objects and phenomena dealt with in teaching and learning has to be managed in any event. In relation to teaching and learning the use of new words, as well as changes of meaning of well-known words, the dynamic and contextual side of language use must be accounted for.

In educational research, problems have to be considered which, in a certain sense, involve a lack of identity between language and understanding of subject matter. This lack of identity has two sides. One side is in relation to language as a *collectively shared system of meanings*. It is frequently the case that the meaning of words and expressions used by students in expressing their understanding of subject matter does not match the meaning of those words and expressions in any collectively shared meaning system, and especially not the meaning system represented by the subject matter and theory the student is expected to learn. The other side of the lack of identity is between the same students' use of the same expressions from one knowledge object to another. This lack of identity depends on the fact that the expressions form part of a bigger expression of meaning of the whole object and situation, and get their meaning as *parts of this whole*. This variation of meaning in use is very central to the phenomena of teaching and learning.

In the two main traditions of research within the field, the cognitive and the socio-cultural tradition, concepts and words tend to be considered, either in the context of individual cognitive systems of concepts and models, or as words in the context of a social language or discourse. "Concepts" are seen as parts of an individual "cognitive system" (Vosniadou, 1994; diSessa 1998), and "words" as parts of a social language or discourse (Lemke 1990; Wertsch 1998). To interpret the specific use of concepts and words in a situation either as directly based on concepts in a cognitive system, or else as words in a social language, both represent a leap of interpretation and a generalization that can lead to false conclusions. The opposite extreme would be to restrict the interpretation and explanation of the use of expressions and concepts to the actual situation they appear in, not assuming any generalization of concepts, but instead that the use of a concept could and should be understood as totally determined by the situation. In our research we have considered both these extreme positions as too limited, and therefore prefer to assume that the use of concepts and words is related both to the specific situation, on the one hand, and to generalized meanings of the concepts and words, on the other, and finally that these contextual and generalized meanings are based on both individual cognition and collective discourses (Johansson et al. 2006).

A third research orientation within this field is phenomenography, from which our research programme has grown. This tradition has focused on students' understanding of objects, phenomena or situations, rather than on specific concepts or words (or other linguistic units) and the use of those. Words and concepts have been seen as used to express conceptions of phenomena, or ways of experiencing them, without focusing on words and concepts. Phenomenographic research has presupposed the use of words and concepts, rather than

focused on this use as something that has to be described. In other words it is seen as sufficiently described by describing a conception. Recent phenomenographic studies have focused on a number of important aspects of learning and teaching, including university teachers' approaches to teaching, and their relationship to conceptions of good teaching (Kember & Kwan 2000); university teachers' understanding of their subject matter and the relationship of this to their experience of teaching and learning (Prosser et al 2005); the opening up of dimensions of variation in subject matter in web-based discussion (Booth & Hultén 2003); and the enhancing of students' understanding of subject matter through focusing on critical variation in subject matter in teaching (Pang & Marton 2005). However, in this and other recent phenomenographic research, the interplay between the use of language and the understanding of subject matter has not been focused in the way it has in our own research.

A field where research into students' understanding of subject matter has been particularly extensive is science education and physics, with many studies of students' understanding. The understanding of classical mechanics, and especially dynamics, has been a specific field favoured by many researchers. In studies about students' understanding of physical motion, as in studies of understanding in other science fields, there has been a tendency to focus on the understanding of central concepts. The limitations of previous studies focusing on concepts have raised fundamental questions about what contexts are relevant for understanding the use and development of concepts, which have not been sufficiently addressed so far. It has been suggested to view the understanding and use of concepts in the context of individual frames of reference or subjective theories (Vosniadou 1994; diSessa; Gillespie & Esterly 2004). Another suggestion has been that students' statements about subject matter should be seen in the context of communication and collective discourses (Lemke, 1990, 2001). The focus is then more on "words" than on "concepts", but no clear distinction is made between the two. These suggestions represent alternative interpretations to results obtained in studies, where students expressed their understanding of, for instance, cases of physical motion, as answers to questions posed. These investigations have meant different foci in relation to data collection, a focus on individual cognitive contexts, and on collective contexts of communication, respectively. The different perspectives have been accompanied by minor adjustments of the studies carried out. However, common to both foci is a lack of differentiation between meanings of expressions given in a social language or a cognitive system, on the one hand, and meanings of expressions as given in situated specific uses, on the other hand.

Three approaches to students' use of language in understanding subject matter

The cognitive and socio-cultural traditions of research are not primarily focused on the phenomenon of learning, but on cognition and socio-cultural relations. However, these traditions include learning as part of cognition and socio-cultural relations, and/or describe learning based on theories about cognition or socio-cultural relations. In our own study, we focus on individual learning, especially the development of individual knowledge. Based on this focus, but also on general assumptions about man, society and culture, our research represents a different approach to the understanding of learning compared to the two dominant traditions.

Our first and most fundamental assumption about learning is that it has a relational character, in other words, that it is something between the learner and his/her surrounding world. Understanding and knowledge as a prerequisite, process and outcome of learning, is also seen as a relation between the individual and the surrounding world. Now, this relation may be conceptualized in different ways. A dualistic view of the relation is common, and also underpins the cognitive traditions. The mind and cognition, on one side, and the “outer world” (that is, “outside” the mind or cognition), on the other, are seen as separate entities, and are considered to be of different kinds. As a consequence, the relation between them is seen in this tradition as “external”, where the “inner” and the “outer” and how they are related to each other must first be clarified, in order to understand this relation. By contrast, our own starting point in understanding knowledge and learning lies in the relation between the individual and his/her world. Thus the relation itself is seen as coming first when it comes to understanding learning and knowledge. And this understanding, in our view, should be based on the observation of the relation between the individual and his/her world.

What is observable are the outer situation and individuals’ activities, responses and expressed intentions in relation to it. In the cognitive traditions, conclusions are drawn on the basis of observed activity, about the existence of cognitive entities more or less identical to observed entities, with an assumption of additional characteristics of stability and generality compared to what is observed. This is a leap of interpretation that is seldom well founded. There are also assumptions concerning how these cognitive entities make up cognitive “systems” that are even less grounded in empirical results. The assumed system character of cognition appears to be an *a priori* assumption, rather than a conclusion based on observation. We do not question the relevance of an interest in cognition, nor the basis for considering the individual as a unit. We do, however, question assumptions and conclusions that are not good interpretations of observable data and that represent over-generalizations that distort rather than improve our understanding of learning and understanding.

Our own relational and non-dualistic view does not mean that we wish to avoid distinctions. In learning and understanding, the “inner” and “outer”, the individual and the surrounding world, are interrelated and this interrelatedness lies at the very core of the phenomena of learning and understanding. Learning and understanding are also manifested in an observable way as individuals’ relations to the world. Although latent intrinsic conditions exist for learning and understanding to take place, both in the character of the individual and the external world, , we believe that these may best be understood through observing the manifest character of the relation. If a more speculative and deductive approach were adopted, the assumptions made should at least not be in apparent contradiction to what can be observed. However, even when starting with learning and understanding as manifest individual-world relations, we do not escape the need to make distinctions and to differentiate between the individual and the world in the context of the whole of that relation, and as parts of it. We also have to consider that there is always a broader context outside any relation we chose to study.

In relation to the socio-cultural traditions, we wish to stress the need for considering the individual within a relational and contextual approach. Individual learning and knowledge are individual phenomena although, in our opinion, they are not phenomena within a cognitive system but rather have the character of *individual-world relations*. To consider those individual relations to the world as *identical* to a social language, or discourse, or “cultural habit”, or any other collective entity, is to our mind a leap of interpretation. The socio-cultural starting point that the individual is born into an already existing socio-cultural situation is of course correct, but the character of “appropriation” so often assumed does not necessarily

follow. The individual is also born into a material/spiritual world that is more than the socio-cultural world, to which the individual has a relation, and which is also the basis for the relation to the socio-cultural world. The most observable condition for an individual's learning and knowledge is that he/she is a living body. Although this bodily existence has socio-cultural and collective meanings that vary, it is in itself a more fundamental condition underlying these meanings. To understand learning and knowledge, we therefore suggest that the individuals' relations to the world should be considered more fully than in terms of socio-cultural contexts, although those certainly are important. We further suggest that this more complete consideration of the individual's relation to the world is important in principle, even when one as here is focusing on rather small parts of the world. This means that when we talk of a "relational view", we are referring primarily to individual-world relations, and not mainly or exclusively to social relations.

Our conceptualization and focus in comparison to the research traditions mentioned above is illustrated below in *Figure 1*.

Figure 1. *The conceptualization and focus of the investigation concerning language use and individual development of knowledge in three traditions of research.*

<u>Cognitive research cultural research</u>	<u>Phenomenography</u>	<u>Socio-</u>
Expression 	Expression	Expression
Concept 	Meaning 1	Meaning 2
Cognitive system 	Conceptual experience	Social language
A cognitive system basis for knowledge of objects and situations and situations	A experiential basis for knowledge of objects and situations	A social language basis for knowledge of objects

In *Figure 1*, the three views are summarized in three columns and four separate horizontal rows. In the first row, we have used the same word for all three approaches: the word 'expression', by which we here mean "words as uttered sounds". This is in line with the arguments we made above for starting with the observable. The "expression" in this sense is the most manifest and observable character of the individual's language relation to a part of the world. So far, we think there is an agreement between the approaches.

The second row section in *Figure 1* also contains just one word for each approach. These words denote what, in each approach, the expressions are considered to express. In line with the arguments above, the phenomenographic view tends to stay close to the manifest relation. In the figure this is called 'Meaning 1'. This is the meaning that can be found based on the immediate context of use of the expression, and which forms part of how a conception of subject matter is expressed. Our focus on the contextual use leads us to argue that this is the first meaning to consider. In the column of the socio-cultural approach, we have instead used the expression 'Meaning 2'. In this approach, meaning in use is considered to be equal to a

language meaning in a social language or discourse, assumed to be the basis for a specific instance of language use. While in the socio-cultural understanding, Meaning 1 is equal to social language Meaning 2, we argue that what we have is Meaning 1, and that the relation of individual contextual instances of language use to language Meaning 2 is uncertain and problematic. Finally, in the column of the cognitive approach, we have put the word 'concept'. The cognitive tradition tends to see meanings as uses and expressions of concepts in a mental system. This implies here that language meanings in use are thought to be equal to cognitive conceptual units.

The third row in the figure denotes the immediate contexts the expressions are understood to be part of according to the three types of conceptualization. In our conception, we again stick close to the relation that is manifested to a part of the world. We see the expressed meaning as part of a conception of a part of the world, manifested through the expression, and as expressing the meaning of a part of the content of this conception. We expect the character of this relation to, experience of, and conception of any given part of the world, to vary considerably, both in stability and generality, depending on the individuals and which parts of the world are focused on. In the cognitive traditions the concepts expressed are rather seen as parts of a cognitive conceptual system, frame of reference or theory, which is assumed to be relatively stable, although changing over longer periods of time, and where the underlying cognitive system is considered to be the basis for the generality of concepts and meanings over situations. Finally, in the socio-cultural traditions, the meanings are seen as parts of social languages and discourses. This implies, first of all, generality across individuals who share this social language, and secondly, stability and generality within individuals.

We can see that the cognitive and socio-cultural approaches put meaning in the context of individual cognitive systems or socio-cultural communicative systems, respectively, while we remain within a somewhat extended individual-world relation as the immediate context. The cognitive and socio-cultural approaches make much more far-going assumptions concerning both generality and stability than we do, and we find that those assumptions are not well founded.

The last row in our comparison concerns the view on learning and knowledge involved in the approaches. In the phenomenographic approach, the focus lies on units of expressed knowledge in relation to objects and situations and the content of this knowledge. This content is in turn seen as part of the individual's relation to this part of the world, in the context of his/her relation to a bigger part of the world.

The cognitive traditions look upon the expressed meanings as knowledge of objects and situations based on "concepts" and forming parts of an "individual conceptual knowledge system". The socio-cultural traditions look upon the expressed meanings as knowledge about parts of the world "appropriated" from existing languages and discourses that provide the tools to know the world. The phenomenographic view is instead based on the assumption that the most immediate context of the use of an expression is the user's relation to the world in using that expression, and that this context has to be more carefully investigated and understood as a basis for understanding cognitive mechanisms and the role of social language. This ultimately means that we need to differentiate between the generalized and stable meanings given in cognitive systems and/or social languages, and the individual contextual meanings that form part of conceptions of parts of the world.

Individuals' use of language seen from an agent perspective

The theme in our recent empirical research has not primarily been students' understanding of physical motion *per se* like in many other studies, but the question of the function of students' use of language in understanding physical motion, as an example of how students' use of language in understanding subject matter can be understood more generally. The individual student has access to a number of alternatives when conceptualizing a situation, and is able to use both different expressions with different meanings, and expressions taken from a variety of contexts of previous experience. We also find that students' use of concepts and words is more or less creative/productive, and that it changes in the course of the process of conceptualizing and expressing their conception of phenomena. For these reasons, we think that it is important to capture the dynamic and changing character of students' use of meanings and expressions within the immediate context of conceptualizing and discussing (or writing about) the particular phenomena focused on in any given instance of use, as a basis for interpretations concerning the wider context, or any specific contexts on which the individual is dependent. A very important characteristic of the approach we have chosen is that rather than aiming at a generalized explanation, the dynamics of each specific situation is focused on, meaning a focus on the function of language use in expressing thought about an object in a particular situation (Anderberg 1999, 2000, 2003; Anderberg et al. 2005; Johansson et al. 2006; Svensson et al. 2006).

The question here is how we may understand the function of language use for learning through the use of language. The immediate context of language use is the activity of the user and we emphasize the agent perspective as fundamental to understanding language use. We will discuss this somewhat further below, showing the importance of the agent perspective to the understanding of the character and role of both cognitive and socio-cultural aspects of language use and the function of language use in learning. First, the example is given of how one student uses the expression 'force' in his description and explanation of hitting a puck and throwing a ball as examples of physical motion. This example is used to give somewhat more of the "agent context" in the case of a particular student, to provide a background to a wider discussion of contexts of learning, and the need to differentiate between language meanings in systems, and meanings as content of conceptions of subject matter.

Force - an illustrative example

The example concerns the use of the expression 'force', which is maybe the word that has been focused most frequently in science education research, and then in terms of the concept of "force". The example has been taken from a dialogue between a university physics teacher and an engineering student at a university of technology. The student had earlier passed a course in mechanics and was at the time of the dialogue studying the second year on a programme for mechanical engineering. The dialogue is about hitting a puck on ice with an ice hockey stick, and throwing a ball into the air (Anderberg et al. 2005; Alvegård & Anderberg 2006). The teacher was not one of the student's own teachers. The student's participation in the dialogue was voluntary and not part of the courses, but the dialogue nevertheless remained within the context of academic studies in mechanics. The student was informed that the aim of the research project was to study the use of language in describing and explaining cases of physical motion. The citations are verbatim translations from Swedish transcripts of the dialogue. After a short introduction the teacher conducting the interview says:

I: *And the first question I put is, think of yourself playing ice hockey. What happens then when you have hit a puck on the ice?*

The immediate answer is:

S: *Yes, everything, from the moment the stick hits and transfers force to the puck, so that it glides and where it ends up then too?*

I: *Yes, what do you think?*

S: *Yes, you hit the puck, and then, yes, you can start further back, but I start there. The puck is hit by the stick and the stick transfers a force to the puck, and then the puck slides away in the same direction in which the force is directed, if it is lying still, if it is not lying still then it will be influenced by a force in the direction that the stick influences it.*

The dialogue continues with the interviewer asking about the meaning of transfer of force, and other expressions used by the student in the rest of the description and explanation of the event with the puck. At the end of this the interviewer asks:

I: *Yes, but, then if we look at, why does it stop in the end? The puck?*

The student answers:

S: *Yes it depends of course on the external influencing forces. These forces influence the puck all the time with the same force, while this force that you have got at the very hitting of the puck or what you should say, is an initial force, a force that only affects on one small occasion, so that force will be used up over time. And through this the friction force, which is the biggest that influences the whole, will in the end be equal in size to those forces, or it will even out those forces at a certain position, but it will never influence the puck so it starts to slide in the direction of the friction.*

After a few more statements the dialogue continues with the interviewer asking:

I: *What happens when you throw a ball at an angle up in the air?*

The student answers:

S: *Yes, oh, oh, it is still the same thing, but I can make it once more. You throw up a ball in the air and thereby it gets a force in the angled direction that you want, (...) it is the same thing with this, that the ball after the moment when you have thrown it away the ball has got a force in a direction, then the ball will be influenced by external forces in every moment, that are equal in size all the time. And in this case it is gravitation and air friction that exist. And it is the same thing there, that when the initial force is consumed, it will only be influenced by the gravitation force, which pulls the ball down to the ground.*

After having discussed the event with the ball at some length, using different expressions, the student says:

S: *The force that the ball has can be divided into a vertical and a horizontal force. The horizontal will last all the time because it is not influenced by anything else than in some cases the air resistance, while the vertical is influenced, or that the ball is influenced vertically by the gravitation force and thereby you will every moment have different force influences on the ball. From having a force directed upwards, you will in the end have a force directed downwards until it hits the ground.*

To get a better understanding of what the student is expressing, larger portions of the dialogue have to be considered, but we think these citations will be enough to clarify our argument and underpin our conclusion. In the dialogue it is quite clear that the student is actively searching for and constituting meaning in describing and explaining the physical events suggested by the interviewer as a topic for discussion and reflection. The student's perspective on and delimitation of what is talked about is revealed in the activity of describing and explaining. The student seems to think that he/she is giving the same explanation and presumably that he/she is using the same meaning of force in describing both the event with the puck and with the ball (*"it is still the same thing"*). The meaning appears to be that force is something that influences the puck and the ball initially through the contact from the stick and the hand. The force is transferred to and contained in the bodies, and is subsequently diminished by mainly friction from the ice in the case of the puck, and gravitation in the case of the ball. This characteristic of the internal relation of the student to the events is revealed through an interpretation of what the student is saying, as well as the conclusion that the student more specifically expresses different relations to the two events (discussed below).

The meaning of 'force' as transferred, contained and diminished could be a candidate for a cognitive or mental unit, according to cognitive theories about thinking and talking as based on "concepts" and mental models. The meaning of the expression 'force' would be a scheme, a concept, a structure or a mental model, which is alternative to the standard concept of "force" in physics, which would also be a cognitive unit in the mental system of the person using that concept. The idea of "units" in a cognitive system implies that these units have a certain stability and generality, and that they are used in the same way in different instances. Ultimately, it is on the basis of this stability and generality that these units and the system they are part of can be considered to "explain" specific instances of thinking and talking. In our example, one might then expect stability and generality across the two cases, the puck and the ball, in the meaning of 'force'.

In the socio-cultural tradition, on the other hand, the meaning of 'force' expressed by the student is seen as part of a social language or discourse, and as a "tool" used by the student. According to this way of thinking, the student has appropriated this tool (the expression 'force' and its meaning described above), through participating in communication using a social language entailing this expression and meaning. The tool is expected to have a high degree of stability and generality across individuals sharing the same social language, as well as across situations and uses by the same individual. But the tool may be more or less well appropriated. However, the use of tools appropriated from social languages are considered the main basis for the use of language expressions.

In the phenomenographic and intentional expressive approach, the use and meaning of the expression 'force' is seen as part of the student's way of approaching the specific situation, of conceptualizing and talking about each physical event. The student's use of the expression is seen as based on the specific character of the situation and the student's previous experiences and capabilities. The use and meaning of the expression 'force' is expected either to be open

to variation across specific situations, or to be relatively stable, depending on the individual and the situations. The individual is expected to make use of possibilities in the situation and rely on cognitive and language resources in ways more and less (in different instances) specific to the situation. The main and first context for understanding the use of the expression and its meaning is considered to be the student's approach to the situation.

The assumptions in the cognitive and socio-cultural traditions that a meaning of an expression in a cognitive system or in a social language is the basis for the use of the expression and its meaning is a leap of interpretation. What we have is the expression and the meaning of the expression as given in the immediate context of the utterance. The meaning of 'force' as it is actually expressed includes certain inconsistencies, which would be difficult to consider as part of a stable unit in a cognitive system or social language. Those inconsistencies invite other, more situation-specific interpretations. One characteristic of the meaning expressed by the student is that the "initial force" becomes a "contained force" through "transfer" in both cases. This, taken alone, might of course be considered an element of the student's individual alternative concept of "force", or a meaning in an existing discourse, which then lacks a distinction between cause and effect in line with the standard theory of physics. However, in the case of the puck, the force remains expressed as a "force in the direction of the motion", whereas in the case of the ball it becomes divided into a vertical and a horizontal part. This cannot be said to be the same concept of force. The student also talks about friction between the puck and the ice in terms of force, but then there is no transfer of force, so "transfer" cannot be counted as a characteristic of a general concept of force. It follows that we either have to talk about different "concepts of force" (or different "tools in discourses about force"), or else reduce what is included in the concept of force more or less to "something acting in a direction".

However, not even the meaning of "acting in a direction" remains constant in the use of this student, since there is a difference between a "hitting force", a throwing force, a "contained" and a "driving" force, which is not quite clear when it comes to the continuous part of the motion, and a "resisting force". If we include the meanings expressed later on by the student concerning the relation between a vertical force and gravitation, we see that the variation in meaning presented by a single student in the course of the same dialogue is even greater. For instance, when talking about the up-going part of the motion of the ball, the student says there is a force that is the sum of the "vertical contained force" and the gravitation. However, when explaining the down-going part of the motion, the same student only talks about a gravitation force. What we end up with is that the expression 'force' has varying specific meanings in different uses by the same person, and that these uses cannot be said to be equal to a general concept or a general language meaning, even if it to some extent includes common characteristics. Those common characteristics are relatively implicit and could just as well be interpreted as a consequence of the student's personal experience and understanding of the physical events, rather than as the application of a concept or a general language meaning. In theories about different "alternative concepts" of force as cognitive units, one usually tends to include more in such units that are considered to be concepts (diSessa & Sherin 1998; Ioannes & Vosniadou 2002). The same assumption about generality is made when the meaning of 'force' is considered to be a part of a language or discourse (Lemke 1990, 2001; Wertsch 1991, 1998). The meaning of the expression then tends to be seen in its use as equal to a language unit, so that no differentiation between the expression and the language unit is made.

The student may have a more or less adequate understanding of the expression 'force' in itself, which we do not know, since we have not asked about the meaning of the expression.

We have only investigated the meaning of 'force' in how it is used to talk about the two physical events in the dialogue. The meanings expressed in these contexts do not have to be consistent with a meaning given when abstractly defining the word/concept. Meanings in different contexts of use do not have to be consistent, nor does the user have to be aware of inconsistencies.

The meaning of 'force' expressed by students has been studied by many science education researchers. An extensive study was presented by Ioannides & Vosniadou (2002), concerning changes in the meaning of force for 105 children, ranging in age from 4 to 15 years. The results presented give the picture that there are a limited number of meanings of force, and that each child has one meaning which gradually changes over the years. DiSessa et al (2004) have extensively discussed Ioannides & Vosniadou's study and results, both in principle and in relation to their own new empirical data. They did not find the coherent meanings of force or the changes in the conceptions of force reported by Ioannides & Vosniadou. On the contrary, they give a picture of fragmentation in the development of the concept of force. On the basis of this fragmentation, they raise questions about the contextuality, specification and relational structure of the concept of force and any concept. Those are very relevant questions, but we suggest they are better understood and answered within a relational view on the use of concepts as parts within conceptualizations of phenomena, and seen from an agent perspective, than considered within a focus on concepts as parts of a conceptual system. Our empirical results show a great variation in the meaning of the word force among much older students, dependent on variation in the specific object focused on, in this case a given physical event or part of it.

It becomes quite apparent that the expressions get their meanings from the immediate context of the student's conception of what is talked about. In a sense, this is the same also in standard theories of physics, which are not presented as a conceptual system or a language, but as a theory about and model of reality, where expressions get their meaning as parts of the theory/model in relation to parts of the world described and explained. Both when it comes to people's ordinary talk about physical events and the character of physical theory, to see talk as based on appropriation of meanings as parts of languages and discourses appears to be inadequate. Is there a social language and discourse that entails the meanings of force being "something continuous and transferred to" the puck and the ball? This is not the discourse of the theory of physics, nor is it an established everyday discourse. The student's way of talking about the cases of the puck and the ball is in fact a rather peculiar kind of discourse seen against the background of studies in mechanics. There is no established collectively shared educational discourse or discourse among the students that includes this meaning as a kind of shared standard meaning that could be appropriated. Nevertheless, we also see that the meanings the term 'force' is used to express by this particular student are not unique or completely idiosyncratic. Similar meanings are expressed by several other students. However, similar meanings do not seem to originate from a common language or discourse collectively used for discussing physical events, but rather from similar personal experiences of physical events.

In our example about the puck and the ball, the context is the description and explanation in the dialogue. Of course, the student has both some cognitive and socio-cultural basis for constituting the meanings expressed. However, this basis seems not to be that those meanings are already clearly given in the form they are used. This means that we have to consider the immediate context of the use of expressions more thoroughly as the context for the meaning of the expressions. This context also forms the basis for making conclusions about whether

already existing concepts or meanings are used, or if the meanings used are more specific to the present context. In this report, we argue against the supposition that the meanings expressed by students are already given as units in an individual cognitive system or a socio-cultural discourse and that these given meanings explain the meanings expressed. This does not exclude that the main context for understanding what students express in one or other instance may be cognitive or socio-cultural.

In aiming at understanding students' development of knowledge, a critical context consists of the phenomena and objects referred to in the talk and conversation. This is the context emphasized in the phenomenographic tradition (Marton & Booth 1997; Svensson 1989). In relation to the educational problem addressed in this paper, that is, language use in development of knowledge, it is quite clear that language meaning has to be considered in relation to and as part of expressing conceptualizations of parts of the world. The meaning of expressions firstly has to be considered within the context of expressing something about some part of the world, and the conception of this part of the world is a context for the specific meanings of the expressions used. The meanings of expressions also have to be interpreted in relation to the context of communicating these meanings to someone. The meanings have to be understood in relation to both a cognitive and a socio-cultural context, but it is not fruitful to assume the meanings to be equal to already given meanings in those contexts. The use of language appears to be more creative than acknowledged in most research and theorizing about teaching and learning. This means that there is need of differentiating between the specific meanings expressed in conceptualizing phenomena, on the one hand, and meanings in social languages and concepts in cognitive systems, on the other hand.

Contexts of developing and expressing understanding

When it comes to understanding the ways individuals develop and express knowledge about parts of the world, we argue that this has to be based on an agent perspective, that is, an understanding of how the individual is active in relation to the world. It is this activity that represents the most immediate context for interpreting the meaning of expressions used by the individual. This is why we emphasize an intentional-expressive view on language use as fundamental to understanding how knowledge is expressed (Anderberg 2000; Anderberg et al. personal communication). When we take this perspective we find, like in the example above of a student talking about two physical events, that the meanings expressed cannot be assumed to be equal to meanings already given in a cognitive system or social language or discourse system.

Contexts of learning, like contexts of expressing and interpreting expressed meaning, are not equal to any pre-existing physical, cognitive and/or socio-cultural context. They have to be delimited in an agent perspective. The understanding and delimitation of language use and learning contexts is a theoretical and methodological problem. The assumptions about the role of cognitive systems and/or discourse systems in thinking and talking about parts of the world includes assumptions about individuals' relation to the world and what the world is in this relation. The assumptions seem to imply a view of the world surrounding individuals that mainly corresponds to individuals' cognitive systems, or to language and discourse systems appropriated by individuals. Since these systems apparently vary and change, there is more to the relation between the individual and the world than captured in this way of thinking. We have exemplified that an agent perspective shows a different kind of relation, but this also

implies that we have a different view of what constitutes the world for an individual in the individual-world relation. The world considered in understanding individuals' language use with respect to learning is the world surrounding the individual. This world is understood in different ways. We will use the word 'environment' to try to clarify some of the differences and our contextual view of the relation between the individual and his/her world.

A contextual way of thinking is of special relevance to our problem and to investigating learning. It does not only refer to a concern with a surrounding, environment or context, but to the conceptualization of relations, in our present case between students and their environments. What is here called contextual thinking is an understanding of relations as *internal*, in difference to external, in line with the distinction made by Bradley (1908) and More (1922). Svensson (1976, 1979 and 1986) has previously used a contextual analytic approach to study university students' learning, an approach also presented by Marton and Svensson (1979) in relation to the field of student learning.

"Environment" has the general meaning of "something surrounding something else", to which it is an environment. There is a fundamental difference in how we consider the relation between the environment, on the one hand, and the entity (entities) it is an environment of, on the other (Svensson & Kjellberg 2001). We may think of a specified environment as something in itself, apart from entities it may be an environment of. This means that the environment will be described in terms of its own characteristics and qualities, independent of, or without explicitly considering, what it is an environment of. In this case, the relation between the entity and the environment is seen as external. Nevertheless, when the relation between something and its environment is mainly treated as an external relation, it still seems to be based on an understanding of the nature of the unit focused on, and what is a relevant environment on the basis of this nature. If the unit is a rock, a tree, an animal or a human being will make a difference in what is thought to be a relevant environment, and in what way it is considered. So even when the relation seems to be dealt with in an external way, this way of considering it still seems to be situated within a more general internal relation between the unit and its environment. That the relation is "internal" means that the meaning of the environment is dependent on the meaning of the unit it is an environment of, and that the meaning of the unit is in turn dependent on the meaning of the environment it is included in, and this is what we here mean by *context*.

The interdependence between the meaning of units and environments is in turn dependent on the perspective of the experiencing person or researcher. Each disciplinary perspective, for instance, gives different delimitations of and internal relations between units and environments. Thus a contextual way of thinking, in the sense of considering internal relations, has a general relevance, but is methodically used to varying extent and in different ways.

Often, when we talk about "environment", we are thinking of the environments of human beings. In the natural sciences, an environment can be thought of as something that physically affects human beings, like for instance, chemicals affect human bodies. Whereas within the psychosocial and cultural areas, we find that the relation between human beings and their environment is mediated through the *activity of human beings*. This is certainly the case when we are talking about learning environments. All human learning is achieved through the activity of human beings. The relation between human beings and their environments can in this case only in a very restricted sense be seen as external. Instead the relation should be seen

as dependent on the human being as an agent and thought of as an internal relation. This means that the environment is considered a “context”, in the sense we are using here.

Achtenhagen (2001) presents criteria for the development of complex teaching-learning environments in a curricular and didactic perspective. Among several aspects discussed, he emphasizes the need to concentrate on the “intension” and “extension” of terms and concepts (p. 371). In addition, we wish to draw attention to the need to see the relation between person and environment as internal, and to concentrate on the variation in meaning of expressions used by teachers and students. Vosniadou et al (2001) present research on designing learning environments to promote *conceptual change*. As in our own research, the relation between the learner and his/her environment is to a large extent implicitly treated as an internal relation. The subject matter dealt with involves, like in most of our own examples, students’ understanding of forces and energy. A result very much in line with our results and line of arguing is the importance of complex questions and explanations. In our analysis, we find that it is important to consider this complexity as a matter of conceptualization of a part of the world, in this case a physical event, and to consider the meaning of expressions and concepts in this context.

Learning environments are generally defined in two ways: as parts of the environment individuals are interacting with in a way leading to learning, or else as environmental possibilities and limitations to activities that may lead to learning. The narrow sense of “learning environment” concerns the environmental parts involved in activities’ meaning, or leading to learning. The broader sense concerns the limitations and possibilities of the environment as representing conditions of possible learning. When talking about learning environment in the narrow sense, we are talking about learning that is realized. In the broad sense, we are instead talking about potential learning that can or could be realized if the learner is able to, and wants to use the possibilities. To talk about learning environment in the broader sense involves making assumptions about the relation between external conditions and learning. What is possible to study empirically is learning environment in the narrow sense, the environment actually involved in learning.

It is problematic, however, to establish what aspects of the environment are involved in learning. In some cases, it is possible to observe a change in some quality of an activity and relate this change to interaction with the environment. The aspects and qualities of the environment that made the change possible and those that facilitated or enforced it, can then be inferred. The change is then a change within the experience and activity of the subject, dependent on the subject’s responding to environmental demands and possibilities. What parts of the environment are involved in learning may be inferred from the learning, the change in activity, which has taken place. However, the learning is also dependent on how these parts/aspects of the environment are interacted with. So, how good this learning environment is will also be dependent on the individuals’ way of interacting with it. The way of interacting with the environment may be inferred from the outcome, but it may also be observed more directly. Thus learning is dependent on the internal relation between the individual and the environment, and the context of learning involves both the experience and activity of the individual and the parts of the world interacted with.

Socio-cultural theories instead emphasize the external socio-cultural environment as the basis for language use and learning. They tend to see this part of the environment as the total context for learning and for understanding learning. They argue that language units, as they are given in social languages and discourses, are appropriated and used as tools by the

individual learner. These tools mediate the individual's relation to the world (Lemke 1990; Wertsch 1991). Considered in relation to empirical results, it appears that this view is oversimplified. We find that the agent has a much more active role in most cases of learning than merely appropriating something that is given in advance. Individuals' expression of meaning represents a creative activity and a development of meaning, only partly based on existing social meanings, and seldom equal to those. The socio-cultural theories are limited to socio-cultural factors, and omit to consider the agent's active role in learning. The interactive contextual character of the internal relation between the individual and his/her world is thus ignored.

In contrast to the socio-cultural theories, cognitive theories emphasize the individual context, but in a limited way. Cognitive theories describe expressions of meaning focusing on the agent, but without using an agent perspective. They instead focus on hypothesized internal systems of concepts, models etc., seen as the individual context of the expressed meaning, while the agent is directed towards the world. It is argued in this report that there is little empirical support for such hypotheses. In difference to socio-cultural orientations, the cognitive theories do not describe the expressed meanings as dependent on social languages and discourses, but on a cognitive system, which is seen as the immediate basis for the expression of meaning (Vosniadou 1994; diSessa & Sherin 1998.) Cognitive theories acknowledge the context of the individual, the agent, more than the socio-cultural theories, but without fully considering the agent's dependence on his/her world. The development of cognitive systems is assumed to be based on individuals' interaction with the world. However, this dependence on the world is seen as much less specific than in the socio-cultural theories, and the main idea is that individuals *construct* their world. In the main constructivist orientation of the cognitive theories, the individual's internal cognitive system is seen as the immediate basis for the expression of meaning, rather than the individual's relation to the world. Thus those theories are limited in their contextual approach with respect to the contexts that are considered, but even more so concerning the internal relation between the individual and the world, a relation which is not explored.

A relational contextual view on learning and understanding

In any research we cannot give an account of the total external environment, nor can we describe the total learning context. The same external situational environment can serve as the environment for different kinds of learning. Furthermore, we are usually interested in the environment in relation to certain kinds of learning rather than others. For this purpose, we have to delimit different learning contexts, including environmental factors related to the particular kind of learning we are considering. In many cases we are interested in learning that has long term consequences within a broad field. To observe those long term consequences would, however, be very demanding for practical reasons. Also, as the relation between present learning and later consequences is not mechanical, such consequences will be dependent upon the learner as a user of what is learned in later situations (environments). Both the readiness and the ability to use what is learned will nevertheless be dependent on certain qualities in what is learned. An interesting question is therefore what qualities of learning will be important in relation to the use of what is learned (including further learning), and if such qualities may be identified already at the time of learning.

Both the cognitive and the socio-cultural theories of learning are based on inherent far-reaching assumptions about transferability. The concepts and models of the cognitive systems

are assumed to be used and developed from one situation and context of use to another. It is the same with the appropriated language tools. However, empirical research does not seem to support assumptions about transfer and application of specific concepts and meanings. Rather, the students' expression of meaning has the character of open and creative action in relation to specific situations. If the activity has this character, the character of learning this activity and through the activity may also be expected to have qualities of being open and creative. Open and creative action is not only based on learning, but always also has the character of learning, as it involves the creation of a unique act on the basis of previous experience and the specific character of the present situation.

What seems most important then are possibilities to relate to varying situations and to varying characteristics of situations. There is both an external and an internal side to these possibilities. What might be possible from an external point of view and may be realized by some persons, might not be possible from an internal point of view for other persons, due to different ways of relating to the situations. Those differences concern values and aims, as well as knowledge and skills in relation to the situations. Thus, we find that creative acting and learning is to a large extent dependent on previous learning. What is most apparent and most often focused on as representing possibilities for creative acting and learning are experiences of specific concrete situational elements, knowledge of facts and specific skills, on the one hand, and knowledge of abstract general concepts and principles, on the other hand. However the creative use of these possibilities in acting in concrete situations is a very crucial aspect of acting and learning, which is mostly not sufficiently considered. Ways of relating the kinds of elements of experience mentioned to each other, both in relation to specific situations and across situations, represent central qualities of creative acting and of learning.

Research frequently starts by using previously defined concepts and categories and/or variables, observing and describing cases studied in terms of those concepts and categories and/or variables. Both the cognitive and the socio-cultural theories represent variants of this approach. In cognitive theories, hypothetical cognitive entities and processes are defined and expected to describe and explain the content of individuals' speech and action. There is room for some variation between individuals and situations, but not necessarily to the extent that is called for on empirical grounds. In socio-cultural theories, languages and discourses are expected to describe and explain the content of individuals' speech. In both kinds of theories, there is little scope for the agent's intentions as a basis for expressing meanings. The intentions are assumed to be limited in their role to the use of existing cognitive or language tools, based in the cognitive system or on a discourse. Empirical findings suggest much greater latitude for the agent's intention, which is why we stress the relevance of an intentional-expressive view on language use as central to understanding learning.

We have chosen an explorative approach. No cognitive or environmental factors in a given form are defined as basis for observation and interpretation. On the contrary, we expect to discover the precise and specific character of factors involved through the investigation. The factors that are found are thus the results of the investigation, rather than being based on initial assumptions, since we feel that there is no good basis at present for making adequate assumptions-definitions. The factors found in an explorative approach will most probably differ from predefined factors. The basis for the relevance is here delimitation in close relation to the specific cases. However delimitations are necessarily made in wider contexts, and some assumptions always are made. In focusing on predefined factors, the context started from is the theoretical understanding of the researcher. In the explorative approach, the starting point of the investigation is also in the theoretical understanding of the researcher, but not in terms

of given factors. The assumptions made are less far-reaching and less specific, and do not include the idea of a determined relation between the individual and the world that can be known beforehand.

Here assumptions are made concerning the general nature of learning, discussed above, and the possibilities of identifying learning factors from different contexts and perspectives. The most immediate context for learning is the activity itself, if we think of learning contexts as what is closest to learning itself and what surrounds it. Here we have used the term 'learning environment' to refer to what lies outside the activity of the individual, but which remains important to the learning involved in the activity. There is an internal relation between the character of the activity and which parts of the environment are involved. The kind of activity, in turn, can be expected to make a difference to what is the learning context and what learning is involved. The specific character of the activity will be dependent on specific qualities of the external environment interacted with. These internal relations and contextual dependencies have to be clarified in revealing the nature of learning.

We have stressed the importance of an agent perspective and an intentional-expressive view of language meaning as fundamental to understanding language use in learning. This is in line with the view that the individual's activity constitutes the most immediate context for understanding the meaning expressed by individuals. This does not mean that we do not consider an external context. We do not agree with a constructivist view seeing the intentions expressed as rather free constructions based mainly on a cognitive system. We think the expressions and intentions constituted by the individual should be seen within the context of responding to the external environment. Both from a behavioural and an existential point of view, we find it necessary to consider the activity of the individual as a response to the external world, and also in terms of responsiveness (Levinas 1981), to more fully recognize the relational character of learning and knowledge. Responding involves more than appropriation of languages and discourses, and is not fully captured by the concepts of "mediation" and "tool", which give a too limited and mechanistic view of how individuals respond to the world and how they learn. We believe learning is part of a more dependent relation to the world than is assumed in cognitive theories, while it constitutes a more open relation to the world than socio-cultural theories suppose.

The strong tendencies to assume meanings expressed by students in a learning situation to be either individually constructed meanings in a cognitive system, or else collectively predefined meanings in a social language, are not well founded. The individual's way of relating to parts of the world seems to be more dynamic, and not as general across situations as previously assumed. The specific agent-world relation has to be considered more carefully. In most research on learning, the meanings expressed by students are explicitly or implicitly seen as meanings in a cognitive system and/or as social language meanings. The contextual character of meanings used in expressing conceptions of subject matter makes it very important to differentiate between social language meaning and units in hypothesized cognitive systems, on the one hand, and content of conceptions of subject matter, on the other, to be able to understand the function of language use in learning and understanding subject matter.

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