Language Use & Conceptual Change in Learning

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Abstract: In this paper we discuss theories of learning, especially physics, and the implications for instruction and design that these theories put forth. We further discuss assumptions regarding whether cognition is individually or socially based, and the traditional cognitivistic view that infers stored mental representations from observations of behavior. We question views that look upon concepts as things to be stored. In the course of discussing the theories we present a view of learning that focuses on language games and use of language in different activities and contexts. The language of a certain field of science, e.g., Newtonian theory of physics, is viewed as a specialized form of language with specific purposes. A scientifically correct Newtonian description of an idealized situation is a specialized form of speaking that may be counter-intuitive viewed from a common-sense perspective of the world that has entirely different goals. Learning a scientific language game is not viewed as replacing an old and "naive" knowledge structure as much as learning new activities and a new specialized language. In learning, people have to learn how to use a specific language by taking part in the activities in which the language is used, since the meaning of the new concepts are rooted in these activities. Understanding the concepts is thus coupled with participation in the new activities.

We end this paper by presenting results from two studies, one within physics, more precisely within the area of electromagnetic waves, and another focusing upon learning in a hypermedia environment within the domain of protein purification.

1. Introduction

Has recent cognitive science contributed anything new to how instruction should be carried out, and consequently how learning systems should be designed? We believe there are good reasons to question the implications for instruction of the traditional, cognitivistic theories of learning and cognition.

People spontaneously acquire knowledge about the physical world. The knowledge, or beliefs that laymen have of how the world operates based upon their interaction and experience with it, is called "intuitive physics". Several theories have been set forth to account for the transition from this common-sense reasoning about the physical world to a more scientific understanding. These theories differ as to basic assumptions made regarding the nature of human cognition. There is a debate between a more traditional cognitivistic view on cognition and learning and a "situated" view on cognition. A situated view, sometimes even called a situated "theory" of cognition, is a term that covers several diverse arguments against a more traditional view of cognition. These arguments often originate from one or more of the following themes (Holm & Karlgren, 1996): Firstly, the traditional view of the relation between mental representations and actions is considered too mechanistic. Rather than viewing representations as something that determines actions, representations may serve as resources for actions but not as a controlling system (Suchman, 1993). Second, another argument against the traditional view is that it overemphasizes reflective, intellectual, rational behavior and neglects spontaneous, instinctive, improvisatory action as well as bodily and emotional aspects. Third, the traditional view on mental representations has been criticized as being too individualistic and it has been pointed out that representations are socially constructed and maintained and that human thinking is often supported and influenced by socially constructed artefacts. Differences in basic theoretical positions regarding learning naturally have implications for instruction.

A few years ago the dominating view on learning was that it is productive to view the knowledge that novices possesses of, e.g., the area of physics as a theory of roughly the same quality as a scientific theory such as Newtonian theories of the mechanical world. Such views have been called "theory theories", with McCloskey as one of the most prominent figures. An alternative view, held by Andrea diSessa, claims that theory theories are highly misleading. In this view intuitive physics is a fragmented collection of ideas, loosely connected and reinforcing, having none of the commitment or systematicity that one attributes to theories. Both theory theories and diSessa's theory of fragmented knowledge are challenged by theories that emphasize that representations are not something exclusively individual but may be socially shared. Theory does not exist in an individual mind, the robustness of naive explanations comes from that theory is always socially formed and maintained.

We will below give a short description of the above mentioned theories. We will in the context of each theory also describe proposed implications for instruction. The remainder of the paper will describe a view of learning physics focusing on aspects of language use. When studying novices' understandings of a certain domain, the answers that novices give to questions are influenced by social factors in that the meaning of words are determined by their use in
There has been a great deal of research on how novices view certain scientific domains, i.e., what their conceptions of the domain and its concepts are like. Studies on the "structure" of the novice's understanding have been carried out and compared with how expert's understand the same concepts. The aim of some of such studies has been to understand the difference between the novice's and the expert's understanding and to learn how the novice's learning can better be supported. E.g., Chi et al attempt to explain why some conceptual shifts are more difficult than others. Their theory assumes that entities in the world belong to different so called ontological categories, such as Matter or Processes. Chi et al's central point is that the ontological status a certain concept initially has determines the difficulty of learning. If a student's and the expert's (the "correct", scientific) conception are compatible (e.g., both are Matter) conceptual change is easy. If the two conceptions are ontologically distinct, learning is difficult. Chi et al's theory thus ascribes coherence to untutored physics reasoning in that novices' learning of a new concept in a new context, e.g., learning the expert use of the physical terms "force" and "light", is influenced by the novices' categorization of the terms in other contexts, in particular the ("naive") everyday use of the terms. As opposed to diSessa's theory (below), Chi et al's theory assumes the novice understanding of a concept is based on a general ontological categorization rather than just a quite arbitrary conception based on experience ("p-prim").

2.2 Ontological Categories

Implications for Instruction: Ontological Shifts

Learning to think like an expert sometimes means making a profound ontological shift which involves replacing a whole system of thought rather than just the refining the concepts of the novice. It is not possible to refine or develop an ontologically not correctly categorized concept into veridical physics knowledge.

2.3 Knowledge in Pieces

It is today widely agreed that non-experts of physics are not theorists in a scientific sense (Resnick 1993) and there is a debate about how much coherence should be ascribed to untutored physics reasoning. Theory theories are in Andrea diSessa's view highly misleading. Rather than a tightly connected, logically organized structure, people have "knowledge-in-pieces"; loosely connected ideas about the world that can be used to generate explanations in particular situations and in response to particular questions or cues (Resnick 1993). diSessa calls these ideas "p-prim" (short for phenomenological primitives). They can be understood as simple abstractions from common experiences. They are phenomenological in that they are responses to experienced and observed phenomena. They are linked to, cued by, those phenomena rather than being general or abstract. They are primitive in the sense that they generally are self-evident and need no explanation; they simply happen. He exemplifies this by asking why is it that you get more result when you expend more effort, pushing a big rock? He believes that people often have no ready answer, nor do they need one. People have so much experience with things that work like that so that the phenomenon is simply an expected event. There is need for further thinking only when things fail to work in an expected way.

Implications for Instruction: Building a New and Deeper Systematicity

In diSessa's view the transition to scientific understanding involves a major structural change toward systematicity, rather than simply a shift in content. An implication of diSessa's view is that a broader attack needs to be made. Instead of a one-by-one attack on the intuitive knowledge fragments that constitute the only material we have to develop...
scientific knowledge, building a new and deeper systematicity using precisely those same knowledge fragments is a
superior heuristic to the "confrontation" approach. diSessa emphasizes the importance of considering everyday events
since these can be seen to be central in contributing to legitimate scientific understanding. He points out that thinking
about everyday phenomena is invoking the very resources out of which expertise is built.

diSessa further discusses the use of computers in education that are consonant with his theory of knowledge in pieces
(diSessa 1988). diSessa notes that computers are very flexible as a design material and that we soon should see a boom
in materials-based, experiential learning. He further notes that computers will allow us to go beyond the constraints of
conventional materials. He discusses the idea of micro worlds, that is artificial realities, and he presents heuristics to
help guide the design of these. One heuristic is what diSessa calls a "mega-microworld" and is based around the idea
that one single perspective is almost never enough to be able to build a understanding we would call scientific. Proper
contexts expressing all of the correct perspectives should thus be made available to the student. A second heuristic
focuses upon having expectations about what students will learn from various contexts and finding places where
knowledge must be adjusted.

diSessa further notes that computers can have an important role in mediating between formalisms and experience. He
argues that computers can be very helpful in providing students with experiences that meet their intuitive ideas and
beliefs, and develop them toward more integrated and profitable points of view and he presents a few techniques to do
this. Instead of focusing on analytic methods in, e.g., problem solving, which is often perceived by students as finding
the right equation, computers could have a role here in providing qualitative, nonanalytic but still technical help in
solving problems. Another technique is using a computer as a tool in providing opportunities to build simulations of
reality.

2.4 Social Aspects of Learning
The theories described above all have in common that conceptual change is conceived as an event that occurs in the
mind of an individual. Traditionally, when cognitive scientists have described learning and understanding they have
done so in terms of individual representations and symbol manipulation. Such theories have, however, been questioned.
The focus of the study of learning, conceptual shifts and representations can be shifted from the individual to a social
context.

Ueno and Arimoto have argued that learning is not only an event in an individual mind since theory is always socially
rooted and the kind of metacontext implicitly shared leads to a certain way of thinking (Ueno & Arimoto 1993, Ueno
1993). In everyday discourse about moving objects and forces the frame of reference, e.g., that the ground is static, is not
explicitly noted and Ueno argues that this is not only tacitly presupposed by individuals but is socially shared. P-prim
are not just in an individual's mind. He also points out that we usually do not communicate with each other to explain
phenomena but to coordinate our situated actions for collaboration ("Push harder!"). Theory is embedded in a specific
language game in a specific community. In other words, theory is always socially formed and maintained. Representations
are shared socially and the robustness of naive explanations come from a specific social maintenance system rather
than an individual cognitive system. Ueno has shown that students maintain that motion observed from the
ground is real motion, whereas motion observed from another system (e.g., a moving ship) is only an appearance. This
suggests that the ground is implicitly considered to be the given framework for discourse, and that it is static.
Experiments that illustrate the relativity of motion will not falsify this and produce conceptual change if the metacontext
of Newtonian physics is not clarified. Students will interpret the results of experiments within their tacit metacontext.

Implications for Instruction: Expansive Recontextualisation
According to Ueno learning physics is not to abandon the metacontext of everyday discourse but to clarify the contrast
between the metacontexts of everyday discourse and Newtonian physics. Conceptual change should be regarded as a
process involving expansive recontextualization rather than merely the transition from one conceptual structure to
another. Learning Newtonian physics is different from problem solving within a given context. Rather, one has to
expand the problem context to focus a learner's attention on his or her own metacontext (Ueno & Arimoto 1993). E.g.,
when explaining the phenomena of motion and force, Ueno & Arimoto suggest that astronomy will produce an
appropriate context in order to recontextualize motion and force on the ground.

3. The Approach Taken to Learning
Individual or Social Cognition?
It has been argued that "situated cognition" misses some important insights of the past; focusing on social phenomena
may erase the individual – "individuals do – sometimes for extended periods of time – think by themselves" (diSessa
1993b). diSessa has pointed out that, e.g., babies give signs of organized cognition that hardly have social origins and
many of diSessa's subjects gave evidence of personally idiosyncratic views. However, if, e.g., a person is reasoning
about a physics problem of motion and forces, his/her thinking will be influenced by the reasoning in the social
communities that the person is familiar with, i.e., the way the person is used to speak about such matters with other
people. Ueno is obviously right in that theories are embedded in a language game, while diSessa is as right in that
thinking can be an individual activity. However, these claims do not necessarily have to contradict each other.
We believe the debate may have its origin in the kind of examples of reasoning focused on. Ueno concentrates on reasoning about advanced physics problems involving physics terminology. diSessa's interest includes basic beliefs about the physical world such as "pushing an object from rest causes it to move in the direction of the push" (the force as a mover p-prim) – "beliefs" that even a small child cannot do without to get around. The frames of reference (e.g., that the ground is static), do not need to be represented socially and this is not because they are represented by the individual. The assumptions may be part of people's "tacit" assumptions. It's a matter of reinterpreting how to view individual reasoning, it is not a question of denying that people can think on their own, or have personal views. However, the concepts used to reason with and to communicate with are not individually created but originate from socially negotiated language games.

Language is Social
That language is essentially a social activity and that the meaning of words are not based on something private has been convincingly put forth by Wittgenstein in the so called private language argument. Wittgenstein argues that that the meaning of words cannot exclusively be something "mental" or private. His argument, however, does not rule out the possibility that something private exists – he was not a behaviorist – only that the meaning of words are not determined by mental representations.

From a traditional cognitivist view instructions given will be translated into an "internal" language, mental code, or a mental representation of some kind. In our view it is not meaningful to speak of any such "inner" language isolated from a social language. The thinking of an individual is inherently intertwined with the language used in a specific context. But this does not, of course, rule out that people can think on their own. However, words in expressions used in interviewing, giving instructions etc. in studies can strongly influence the reasoning of the subject.

Perhaps all of diSessa's P-prims do not have to be socially rooted. Some of such p-prims may be based on individual experiences, and as noted above, even be created by a child before a language has been developed. However, the meaning of a word is always social. Ueno is right in that explanations and descriptions of p-prims are social, simply because they are expressed in a language. The words and expressions used in interrogating an individual about a physics problem then, may lead the person to think in a certain way. Moreover, when an individual attempts to describe his/her reasoning and beliefs the description will be influenced by the language the individual at present has at hand in the act of actually giving the description.

Mental Representations
According to a traditional view, novices create coherent theories of the world, and further, that the theories are stored in an individual's mind in some form. The existence and the characteristics of "mental representations" are often inferred from the study of linguistic and other behavior. But, does certain behavior or the use of a certain word/expression presuppose that we have a "mental representation" of the concept that the terms stands for? In our view there is no reason to assume that we must have "stored" "representations" of concepts "in" our heads.

Wittgenstein disagreed with 'rationalistic', overly intellectual, explanations of how people develop concepts of causation (Malcolm, 1986). Malcolm exemplifies Wittgenstein's view: suppose a child runs into another child, knocking him down. The latter might react by jumping up and hitting the other one. He would be 'reacting to the cause' of his falling. One could ask: Doesn't the child's response presuppose that he has the concept of causation? According to Malcolm it does not, firstly, because "it is wrong to speak of the concept of causation as if there were an essence of causation, a set of necessary and sufficient conditions, a hidden definition of causation that lies behind the different uses of causal expressions" (Malcolm). As most concepts do not have exact definitions – they are rather held together by "family resemblances" – there is no reason to assume that people should have "stored representations" of any concepts. Secondly, the child's immediate reactions is a foundation for the learning of causal language. Learning the meaning of causal expressions ('He knocked me down', 'He caused me to fall') are rooted in such reactions rather that presupposed by them. It is by linking these to the unlearned reactions, by using them with, or in place of, the instinctive behavior that the child learns causal terms.

The meaning of words are rooted in the activities in which they are used, and rather than the use of the term presupposing the concept or a mental representation of it, the opposite is true. Understanding a concept, and creating mental representations of it, presupposes experience of the different activities which are the foundation for the meaning of the term. In everyday life people do not first learn a concept, and then how to use the word. Rather the other way around, first people take part in activities (physics laboratories, systems development projects etc), and even start using the terms in these language games, and then they may gradually build up a refined understanding of the concept that a specific term stands for.

This does not mean that it is not meaningful to speak about representations, only not in a cognitivist sense. Behavior is not generated from, or determined by representations or programs. But we create representations when we consciously speak, write, think, imagine etc. Representations are not manipulated in a hidden unperceivable way inside our brains (Clancey, 1991). Speaking is not translating an internal code of representations and behavior does not presuppose the use of representations. Every situation is new and demands that we interpret it in some sense, construct a conception of it partly on the basis of former experience, but not by retrieving stored memory structures or by running stored programs.
Language Games

With the dominance of mentalistic/rationalistic theory in the area of conceptual shifts in learning it may be fruitful to introduce the concept of a language game. It was coined by the later Wittgenstein to shed some light on the manifoldness of how languages are used: "Here the term "language-game" is meant to bring into prominence the fact that the speaking of language is part of an activity, or a form of life." (Wittgenstein, 1958, §23). Although he did not introduce the concept to build a theory of language the concept could be enlightening in this area. The concept of a language game can lead thinking about conceptual shifts in the right way where formulations such as "storing separate mental representations" may be misleading.

In a language game linguistic activities, using expressions, are intertwined with non-linguistic activities in such a way that the meaning of the expressions can only be understood through a description of the totality; how the expressions are used in concrete situations and what the role and purpose of the language game are. For instance, the terminology of physics cannot be fully understood without understanding how the terms are used and what role they play in the activities of physics, i.e., laboratory work, the theories of physics etc. Consequently, an expression does not have meaning independent of the way it is used in certain activities. The concept of a language game can give us the right hints about what is central to conceptual shift – changing the way of using, or learning new uses of, words.

Many words that are used in everyday language are also used in specialized fields of, for instance, trade, sports, science etc. However, the role of the words may be entirely different in the different language games. A scientist typically attempts to describe or explain phenomena in the world while that is only one of countless activities that people in everyday life engage in. People can use words that are more or less directly related to physical terms such as mass, weight, friction, resistance, power, force etc without fully understanding these terms in a scientifically correct way and still be successful in coordinating their interaction with others ("Use more force – push harder!", "Keep pulling!" etc). The words simply have a different function in the different language games. In everyday life we do not explain what 'force' and 'resistance' are and how such concepts are related, while that is the kind of activity that physicists may be involved in. For example, as has been pointed out by Donald Norman (Norman 1988), according to Aristotelian thought, moving objects keep moving only if something keeps pushing them. While according to Newtonian physics this is nonsense: a moving object continues to move unless some force is exerted to stop it. Yet anyone who has pushed a heavy box along a street knows that Aristotle was right! If you don't keep pushing, the movement stops. Aristotelian physics is more functional in everyday life since it starts from the real world we live in and not an ideal world without friction and air resistance.

Refined Language Games

With this background, the language(s) of physics, or other languages of other specialized fields, can be viewed as refined, specialized uses of language and everyday language should not be viewed as "less correct" versions of these specialized languages. They have different functions: everyday language is not mainly used to describe and explain phenomena in the world, everyday language is used for a plethora of purposes. Describing and explaining have no special status in everyday language and everyday language can therefore not in general be said to be "less correct" than some specialized language. To sum up this section, before giving a short description from two studies:

• The language game approach is in many ways compatible with the "fragmentation of knowledge" approach discussed by diSessa. Some of this fragmentation can however probably be viewed as resulting from participation in different language games rather than literally retrieving a different p-prim from a cognitive system.

• The language game approach can also be compatible with a weak version of a theory of ontological categories which may be practical models since they mirror a psychological realism. We do not, however, view the categories as "natural" in any strict sense and believe the hierarchies should not be interpreted too literally. The original theory (Keil 1979) seems to presuppose that it is unproblematic to separate ordinary language from metaphorical use of language which is treated as an exception. We do not think that is unproblematic at all. Our language is full of metaphors that are not even looked upon as metaphors because the metaphors have become a part of the language as idiomatic expressions.

• We further think that our approach is compatible with Uenos "situated" view as well. Uenos' shifts of metacontexts can from our perspective be viewed as different language games.

4. Studies

Predicting vs Explaining Familiar and Unfamiliar Polarization Phenomena

As discussed above, the function of everyday language may be very different from a specialized language such as the language of physics. Reasoning done in everyday language may be entirely suited to its purpose while such reasoning viewed from a Newtonian perspective is considered incorrect and "naive". The point of departure taken by the Newtonian theory is more abstract and based on an idealized view of the world and therefore it may even be less functional than our "incorrect" common-sense view. Reasoning about or explaining a phenomenon is strongly governed by the language at hand. Making predictions, on the other hand, is not expected to be as directly governed by language, but rather by experiences of activities and observations. In our study we therefore chose to make a distinction between tasks where subjects were to make predictions given certain preconditions as opposed to tasks where they were to reason about, or explain equivalent phenomena. We chose to study the phenomenon of polarization of electromagnetic waves. An example of this phenomenon occurs when polarizing sunglasses filter sunlight reflected from a water surface.
Most students are capable of making correct predictions about the polarization of light in many everyday situations. However, their knowledge of the mechanisms of polarization is not sufficient for predicting other less-typical situations in which polarization occurs. The subjects have knowledge that covers many common everyday situations but leaving out more unusual cases that can be explained with a scientific theory of physics.

Many subjects know that polaroid-sunglasses extinguish reflections from water or snow. But they over-generalize and falsely believe reflections from a metal surface are also extinguished. They probably do not have as much experience of reflections from metal surfaces and knowledge of it probably is not very relevant in everyday life, while knowledge of the extinction of reflections from water and snow is highly significant for anybody interested in sea life or skiing. The subjects seem to have built up a conception of how polarization works on the basis of everyday experiences and common sense knowledge ("polaroids extinguish reflections"). The idea that the polarization mechanism is located within the sunglasses, seems to be robust in that the subjects are unable to discriminate between situations in which polarization does occur from situations in which it does not. People thus have to learn that within physics the concept of polarization extends to other mechanisms as well, such as the reflection off a water surface.

Most subjects are aware of that when sunlight is reflected in water, part of the light is refracted under the surface of the water, whereas if light is reflected onto a metal surface this does not happen. They are thus aware of the fact that more light is reflected off the metal surface than off the surface of the water. The same subjects, however, supply answers to other questions about the reflection of light that suggest an incompatible belief: when asked to graphically indicate the existence of the different component-directions of light, the majority of subjects (8 out of 11) reported that no change to the light had occurred after the reflection off the water surface. Not until the light had passed through a polaroid lens had a change occurred; at that time only one of the component-directions of light had been lost. In fact, polarization occurs when the light is reflected on the water, resulting in that the reflected light loses one of its component-directions. When reaching the lens, the other component-direction is removed, which explains why reflections off a water surface are (almost completely) extinguished when wearing polaroid-glasses. These observations indicate that many subjects have conflicting conceptions about what happens when light is reflected. On the one hand less light is reflected off the surface of water than off the surface of metal, and on the other hand the subjects do not seem to be aware of that one component-direction is removed (polarized) when reflected on water; they seem to believe that polarization only occurs when light passes through polaroid glasses.

In sum, subjects correctly predict experiences in familiar situations while they incorrectly overgeneralize to less common situations. When asked to explain the phenomena they offer the same explanations to both situations. Giving explanations gives rise to a theorizing on behalf of the subjects. The theorizing involves the usage of everyday conceptions as well as attempts to incorporate and use concepts in a way that is compatible to a scientifically correct language use. These results are in line with the results obtained by Anderson et al. (Anderson et al, 1992) implying that predictive and explanatory knowledge can develop separately and that the former relies on intuitive knowledge in the form of theories or models whereas the latter relies on the reconciliation of the principles in the model and experience-based knowledge, or in some cases only on knowledge from experience. Similarly, Clancey points out that "... there is a difference between solving a problem and articulating a model " (Clancey 1994).

A Study Within the Area of Protein Purification

The second study reported on in this paper was conducted in a hypermedia environment. At Pharmacia LKB Biotech, Uppsala Sweden, a hypermedia system designed for education of sales personnel is being developed. The question asked in this context was if the system reached its educational goals in teaching sales personnel the area of protein purification. Crucial to sales personnel in being able to sell Pharmacia's products is to be able to understand the needs that customers (scientists), within the domain have. The sales representatives sell equipment for protein purification offered by Pharmacia. A typical scenario is a sales representative entering the laboratory of a scientist. The scientist gives a short but detailed description of his/her particular problems and the task of the sales representative is to persuade the scientist to buy the products he/she has to offer since these products will help in solving the particular problem. An interesting aspect of the system particularly relevant to the approach taken in the paper, is that the system contains simulated scenarios. In these scenarios the user enters a scientist's laboratory and finds him-/herself confronted by a scientist with particular problems. The scientist describes his/her problem (voice) in terms of concepts used within the domain. The task of the user is then to suggest solutions to this problem. For the user to be able to do this he/she will first have to understand this scientist's particular problem. The user can then choose between predefined questions to receive further information from the scientist. In case the user asks irrelevant questions, he/she gets irritated replies from the scientist. If too many irrelevant questions are asked, the user gets thrown out of the laboratory ("go sell your stuff somewhere else!"). In both cases, the user is recommended by the system to study those aspects that put him/her in the unpleasant situation of being "insulted", or thrown out of the laboratory.

The results relevant to consider in the context of this paper is that all subjects experienced the simulated scenarios as valuable in a learning context. There is no objective measure as to this claim since we are dealing with subjective experiences. However, if we look upon these results from the perspective taken in the approach taken to learning reported on in the paper, these results immediately make sense. In these scenarios subjects were given an opportunity to practice how to use a specific language in a certain context. Subjects were given immediate feedback as to how they succeeded in using the language since they were either insulted by the scientist as to their lack of knowledge, or simply thrown out of the laboratory. Subjects were further given feedback in terms of what aspects they should study further.
and come to an understanding of to be able to do better the next time. In this sense, subjects were presented with both scientific definitions of concepts and a context in which they were allowed to practice how to use these concepts.

5. Concluding Remarks

As put forth by diSessa, knowledge is fragmented and shows no systematicity one usually assign to theories. In diSessa's view knowledge is piecemeal and consists of so called p-prim's. These p-prim's, according to diSessa, find expression in making predictions or explaining phenomena. We agree to the assumption of the fragmented character of knowledge without assuming that the knowledge structures are stored in the head of an individual. In our view the fragmentation of knowledge originates from that people may base their reasoning on the languages used in different language games and that reasoning is contextual, dependent on various features of the situation. Not only is knowledge fragmented, or used differently in different language games, it is developed through situated use and through constant negotiations with others. A concept is thus always under construction and not a static knowledge structure.

According to the traditional view that assumes that novices have a coherent model or theory of a domain, the goal of instruction is to replace the naive model with a scientifically correct model. Since we question this assumption of coherent models we have a different view of instruction. In our view, using a belittling term such as "naive", or even "incorrect", about common sense reasoning only because it does not correspond to a scientifically acceptable view is naive, and even incorrect. In our view the goal for instruction should be to practice and learn how to reason and use the language in the new activities rather than to change the reasoning of other activities. Thus, building something new as opposed to replacing or debugging something old.

Learning is intimately intertwined with taking part in the new language games and their activities and therefore the learner must practice and exercise participating in these. The explicit conceptualizing and the capability to abstractly generalize over situations is not a precondition for this, but something secondary that develops from experiences of the activities. The term language game denotes something wider than only linguistic behavior, thus this approach to instruction is not restricted to natural language but also applies to the use of diagrams, pictures, mathematical symbols etc in the activities to be learned (Pea, 1992).

The implication for instruction is then not so much to concentrate on the knowledge or model of the expert. More focus should be on the learning of the new area and thus the perspective of the learner. And this is intimately involved with focusing on the language games with their various activities that are to be learned. As Brown et al have pointed out, educators need to understand the students's world and "they also need to understand the culture into which they are inducing the student" (Brown et al, 1989). The non-explicit, non-conceptual aspects of expertise have been overlooked. We must build systems that take language games and "enculturation" into account. An overall goal is to create environments where users are given opportunities to use the concepts in ways similar to how they are used in authentic situations.

6. References


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