Journal of Computer Assisted Learning (1998) **14**, 120-129

Fostering superficial learning

R. Ramberg & K. Karlgren
Department of Computer and Systems Science, Stockholm University

Abstract Different views of learning and what it means to follow rules are discussed. The activities, the language and context of expertise and knowledge have traditionally often been neglected and underestimated as something ancillary to the real knowledge which lies 'beyond' such surface manifestations. The primacy of 'superficial' aspects are argued for. It is further argued that these should be more emphasised and fully appreciated. The goal of fostering 'superficial' learning is suggested, i.e. an emphasis on practical activities, the use of the language of the domain to be learned and getting familiar with the new culture. A case study is presented and discussed in terms of this theoretical viewpoint.

Keywords: Cognitive science; Instruction; Knowledge; Learning; Rule-following.

Criticisms of traditional approaches to cognition

According to traditional cognitive science, human cognition is described (a) in terms of representations describing a portion of the world, e.g. in terms of propositions, ideas, or mental images or (b) in terms of symbol manipulation (also non-descriptive ones). These representations have been ascribed the role of *explaining* cognitive human action. When observing a subject perform a cognitive task, a researcher has typically 'explained' the subject's behaviour by ascribing a mental representation of some sort to the subject.

Since the end of the 1980s, the traditional cognitivistic view of cognition and learning has been questioned by several theorists. A 'situated' view, sometimes even called a situated 'theory' of cognition, is a term that covers several diverse arguments against the more traditional view of cognition. These arguments often originate from one or more of the following themes (Holm & Karlgren, 1996). Firstly, there is no justification for assumptions that there are general, context-independent cognitive mechanisms and procedures as opposed to viewing action as inherently situation specific. Secondly, that it over-emphasises reflective, intellectual, rational behaviour and neglects instinctive action as well as bodily and emotional aspects. Thirdly, it is too individualistic, because representations are socially

Meeting the Challenge of New Technologies, the PEG'97 Conference, Sofia, June 1997
— a paper based on one selected from the Conference.

Correspondence: Dr. R. Ramberg, Department of Computer and Systems Science, Stockholm University, Electrum 230, 146 40 Kista, Stockholm, Sweden Email: robban@dsv.su.se

constructed and maintained, and human thinking is often supported and influenced by socially constructed artefacts.

Another issue is the problems with mental representations, e.g. how to view the relation between mental representations and action. The traditional view has been criticised for being too mechanistic. Rather than viewing representations as something that determine actions as a controlling system, representations may be viewed as resources for actions (Suchman, 1993). Furthermore, the idea of having a science of mental processes can be questioned in itself (Holm & Karlgren, 1996; Wittgenstein, 1958).

Learning and rule-following

According to traditional theories in cognitive science, learning something, e.g. a rule in arithmetic, *PROLOG* programming or French grammar, consists of acquiring certain rules and representing these mentally in one way or another. The mental representation of what is learned has been viewed as a condition for being able to use the knowledge, to follow the rule, e.g. do some calculation or utter French sentences based on the rule. Once the learner has understood the rule and stored the representation, this representation can be applied more or less context-independently, at least within a domain or to problems that are considered to be 'the same'.

A consequence of this view of knowledge and learning is that the goal of instruction is to support the learner in building an adequate representation of what is to be learned. The aim of instruction is to convey the rule, or its meaning, to learners and support them in constructing a representation of it. The rule, or the representation of it, will then guide future actions.

However, rules and representations may be ascribed a very different role and the relation between representations and actions may be interpreted in different ways.

> "Someone might interpret a NO ENTRY road sign as applying only to motorists, not to cyclists; and someone else might interpret it as applying even to pedestrians. A child might understand the instruction 'Always close the door after you enter the house' as not meaning to keep it closed. A novice in cooking might take the words of a recipe for a cake, 'Add two eggs', as meaning that the whole eggs, including their shells, should be added."
>
> (Malcolm, 1986, p. 158)

However, there is an inclination to say that people learn to follow rules because they are guided by the meaning of the rules. Of course, there are times when rules and recipes do guide behaviour and sometimes they are even learned by heart. A rule can be expressed in various ways, in sentences, formulas or sign-posts which may have differing interpretations.

Somebody might retort that the meaning of a rule 'guides', instructs, in how to act when confronted with new situations. Consider the example of learning the rule of addition discussed by Malcolm. How is it possible for people to perform an addition of two numbers that they have never been done before, or have seen anybody else perform? Is it because the meaning of the rule 'guides' or instructs how to do the new addition? This would

have to mean, that the rule in some sense contained all the future steps, that is they were already there in the meaning of the rule. How else is it supposed to be of any help? And even if this were true, how would it help: where is it said in which way one is supposed to follow the rule and how to copy the steps taken by it? Maintaining that learning to follow a rule means storing a mental representation of the rule, or the meaning of the rule, leads to serious philosophical problems.

There is philosophical puzzle over how one is able to follow a rule. There is a feeling that the understanding of students must go beyond the given examples and exercises so that they can go on. Extensive discussions on what following a rule consists of are found in Wittgenstein's writings although he does not provide any other explanation as to how a rule is followed, other than that training has been received (Malcolm, 1986).

Instructions and examples are given, and then, at some point, the learner simply goes on, continues, in the same manner. The rule cannot instruct the learner in a definite way since a rule could be interpreted in various ways, and the learner could continue in various ways, but usually does not. Malcolm, following Wittgenstein, has attempted to show that appealing to concepts such as 'the meaning' of a rule, 'intuition', 'similarity' in situations, 'inner voices' etc. do not explain the capability of following rules.

As Malcolm concludes, "[W]e go on, all agreeing, following rules ... in new cases — without guidance. Other than the past training, there is no explanation." According to Wittgenstein, the meaning of a rule is fixed by "our customary way of applying the rule in particular cases." There is a way of acting that is interpreted and called 'following the rule'. Numerous other ways of acting are possible, but these are not interpreted as and called 'following the rule'. An explanation for this agreement in action between people is often asked for (e.g. 'they must share the same mental representation ...'). But it is rather the other way — there is not an agreement because people have absorbed the meaning of the rule. Unless there is agreement in action, a rule would be meaningless. If half of the people act in one way when confronted with a new situation, and the other half in another way, the rule would no longer be a rule.

In what way might these philosophical ideas relate to theories of learning and instruction? Many theorists have emphasised the importance of concrete examples, opportunities to practice one's knowledge in real life, as opposed to teaching abstract knowledge. However, the role of practice and examples is often viewed to be a support to learn the true or deeper meaning, to learn some kind of 'underlying' rule. Taking this view on rule-following and learning, the examples and praxis are not simply support for learning something else. The 'meaning' of a rule cannot be fully abstracted from the praxis without which the rule would become meaningless. The knowledge to be learned is thus not something beyond the concrete examples and the exercises. Crucial for the learner is to get a hang of the praxis. This view of rules and learning is thus one form of the more general criticism directed towards traditional cognitive science for presupposing more or less context independent mental mechanisms, processes,

representations and viewing these as explanations of behaviour that is considered to be 'similar'.

Rational reflection vs. intuition

Learning and expertise do not have to be viewed as primarily based on certain mental representations. Expertise does not only consist of knowing rules of the domain. Getting to know the rules is the first thing a novice does, but much more than learning rules is demanded of an expert. Although knowledge about facts and rules do play a role in expertise, the less explicit aspects are easily overlooked (Brown, 1990). Dreyfus and Dreyfus's (1986) model of learning shows how learning rules may be important in initial phases of learning, but what really characterises expertise involves 'intuition'; knowledge that is not easily made explicit.

Getting used to, and adopting the specific language of a new domain is one important part of learning. This is related to the discussion of the relation between representations and action: representations are traditionally regarded as a determining or controlling mechanism and such a view tends to neglect the importance of action and instinct for a learner to be able to construct representations (Holm & Karlgren, 1996; Malcolm, 1986).

Objectivistic and constructivistic views

'Objectivism' is sometimes presented as the view that equates information and knowledge, and views knowledge as something that each individual can come to know in the same way. Constructivists often assume that knowledge cannot be objectively defined and that instead it is individually constructed from what learners do in their experiential worlds. As a consequence, there is no 'target knowledge' that can be pre-specified and transferred to the learner. Although one can objectively specify the syntax of a programming language, knowing a programming language is not possessing this objective knowledge, the knowledge:

> " . . . comes out of actively transforming and interpreting an experiential world involving the use of that programming language. The meaning of the programming language elements can only be built by the learners from the cognitive structures that they manage to assimilate while interpreting their own experiences." (Akhras & Self, 1996)

The key words here should not be 'cognitive structures' or even 'actively interpreting own experiences'. The key word is rather 'use'. Learning the meaning of programming language elements can only be done by practicing to use those elements and taking part in activities in which they are actually employed. Constructivists emphasise individual reflection on knowledge which is a sound reaction against objectivistic and behaviourist approaches, but the meaning of programming language elements or any other concept is so much more than individual conceptions of these. What gives the elements meaning is how they are used in programming activities rather than the individual conceptions programmers have of them.

Learning as gaining membership in a social community
That language is essentially a social activity and that the meaning of words cannot be based on something private has been convincingly argued by Wittgenstein (1958). Many of these, or similar, insights have lately been echoed by several different theorists and often in polemics towards 'traditional cognitive science' (Holm & Karlgren, 1996). The importance of talking science and participating in scientific activities, rather than just hearing science has been emphasised by Pea (1992) who also draws upon arguments put forth by Wittgenstein. During recent years, the traditional theories have been rivalled by those which emphasise that knowledge is socially constructed and that central to learning is gaining membership of social communities (Brown *et al.*, 1989; Lave & Wenger, 1991).

Instruction

Deep understanding versus superficiality
As a reaction against 'instructivism' and the ideas about building tutoring systems that were supposed to be intelligent and keep track of the knowledge of the learner, certain theorists have suggested 'unintelligent tutoring' as the goal for instructional scientists (Kintsch, 1991 in De Corte, 1996). Rather than having a tutor that plans and monitors the learning processes, it is emphasised that these activities should be performed by the learners themselves in order to learn. There is, as De Corte points out, a general trend of shifting from tutoring to coaching with supportive systems that are less structured and less directive (De Corte, 1996; CTGV, 1996).

Pedagogues sometimes talk about the importance of 'deep' understanding and knowledge in learning, i.e. learning the content or the ideas behind concrete examples. However, the value of practice, concrete examples and learning-by-doing is not that learners finally grasp the 'meaning', 'idea', or 'context' lying behind the concrete examples. It is rather that the praxis gives meaning to the concept Therefore exercises are not only a means to finally understand, praxis is the goal for learning. Only when learners have got an idea of how a certain concept is used, may they create an idea about the concept. Even more abstract knowledge, such as mathematical rules, is not an exception to this, since abstract knowledge is like any other knowledge used in concrete situations. An important aim for instruction should be to foster the learning of 'superficial knowledge'. Superficial aspects are those that are viewed as incidental to particular learning environments and that are typically left out of abstractions. They are often treated as ancillary to real knowledge lying beyond the particular cases. However, experienced practitioners often make use of such aspects in their everyday reasoning and these are often overlooked in instruction. As argued in the discussion on rule-following, what is crucial for learning a rule is not acquiring a hidden meaning but becoming familiar with the praxis of applying the rule. More emphasis should be placed on practicing to 'talk' the language of a domain, to take part in its activities, etc. Expertise in a domain consists of more than just acquiring conceptual knowledge in one way or another and an important instructional goal should be to support the

learning of these. Some important characteristics of experts is that they have the ability to recognise what factors in a situation are important and relevant to attend to. They can recognise opportunities, quickly choose adequate strategies, etc. (Dreyfus & Dreyfus, 1986). These kinds of characteristics may be impossible to make explicit or objectively formalised.

How can the overlooked 'superficial', non-conceptual aspects of expertise and learning be attended to? Of course these cannot be pointed to directly or be formalised, and many of these aspects cannot be taught at all. However, environments that help the learner be introduced into the culture and the language games of the domain being learned can be designed. One important aspect here is to provide opportunities to use the concepts in ways similar to those used in authentic situations. One direction to promote the learning of non-conceptual, intuitive knowledge is by providing opportunities for extensive practice on making quick decisions without relying on reflection. The practice gives opportunities to accumulate concrete experiences on which to base quick problem identification and decision making. As an example:

> "Excellent chess players can play at a rate of five to ten seconds a move and even faster without serious degradation of performance. At that speed they must rely almost entirely on intuition and hardly at all on analysis and comparing alternatives." (Dreyfus & Dreyfus, 1986)

Explicit and non-explicit educational goals

Intelligent tutors are more suitable for cases when there is a strong consensus about the knowledge to be taught. If there are strong conventions about the knowledge, e.g. as is the case with geometry, arithmetic, or French grammar, the knowledge can perhaps be more easily made explicit.

The TPLC-system (Training Program for Liquid Chromatography) is a multimedia system for training future sales personnel at a large pharmaceutical company in Sweden. There is thus a clear goal to learn to become a salesperson with specific knowledge about protein purification which is taught in a theoretical part of the system. The expertise involved in being a good salesperson is, however, not only explicit knowledge; a good salesperson has to learn to perceive the relevant aspects of a problem quickly, choose strategies, suggest solutions, etc. This ability may not be possible to make explicit. However, such skills can be practiced partly in learning environments in the system.

Thus, computers can be used to support learning in two ways:

- intelligent programmed tutors can support the learning of explicit, prescriptive knowledge (e.g. about protein purification);
- an interactive learning environment can facilitate learning when there are less well-defined educational goals and where the learner can practice skills that may be difficult to make explicit (such as becoming a salesperson).

In the first case the focus may be on giving feedback, diagnosing the knowledge of the learner and perhaps correcting or 'debugging' this

knowledge while in the second case the learning environments typically have a supporting or facilitating goal.

Case study of a learner-centred system

A study of collaborative problem-solving in a simulation-based learning environment (TPLC-system) was conducted in cooperation with the EC Slater Instituut, Amsterdam. Crucial to sales personnel is to understand the needs of the customer (scientist) so as to be able to sell the equipment for protein purification offered by the company.

There are three video-based simulations of typical sales scenarios in the TPLC environment. In the scenarios, the learner who plays the role of a salesperson is confronted by a customer (scientist) in a laboratory. The scientist describes his/her particular problem (voice) and the task of the learner is then to suggest solutions to the problem. For the learner to be able to do this, he/she will first have to understand the scientist's problem. The learner can then choose from predefined questions to obtain additional information from the scientist. If the learner asks irrelevant questions, he/she receives irritated replies from the scientist. If too many irrelevant questions are asked, the learner gets thrown out of the laboratory. After interacting with the customer and making a suggestion, the learner can watch a video clip of an expert commenting on the scenario. Students of protein purification at a summer school participated as subjects in the study. Subjects (four pairs) sat and interacted with the system and they were encouraged to collaborate and discuss questions relevant to ask as well as possible solutions to the problem.

Preliminary results from the study reveal that all subjects participating in the study considered the simulated scenarios as very valuable. There is however no objective measure since these are subjective experiences but, from the perspective adopted in this paper, these results make sense. In the scenarios, subjects were given an opportunity to practice how to use the specific language in a specific context. After practicing in the sales scenarios, they could listen to recommendations from an expert.

The TPLC system relates to technology-based principles of so-called anchored instruction and a proposed instructional model of cognitive apprenticeship. An anchored instruction model has been developed by the Cognition and Technology group at Vanderbilt (CTGV). The approach is to present complex, realistic contexts that encourage the active construction of knowledge by learners (Gruber *et al.*, 1996). The use of educational technology is central to the anchored instruction approach but, instead of just presenting video-based lectures, technology is used to present stories to be explored as 'anchors' for learning. The CTGV group has formulated seven principles for design most of which relate to characteristics of the TPLC system:

- *The use of video makes the presentation motivating, problems posed can be more complex and interconnected than in a written medium and it is especially helpful for poor readers.* The TPLC scenarios were liked by the subjects but

the expert's comments following the scenarios were considered to be annoying and their pedagogical value can be questioned. A video clip showing an expert reciting his comments does not make use of the possible advantages of the video format; presentation speed cannot be adjusted; the presentation cannot be skimmed in a meaningful way, and it is difficult to search for information. The expert's comments are better presented in other ways, e.g. as a simple text. The argument that using video supports students with poor reading skills is hardly relevant for the group of users for which TPLC is targeted.

- *Presenting problems in a narrative format lets the learner see the purpose of concepts in meaningful contexts.* The sales scenarios in TPLC are designed to be realistic 'stories' and were commented on as fun and engaging by the learners. The video clips with the expert reading his recommendations were commented on as boring and difficult to follow.
- *A generative learning format leaves the end of a story open so that the learner will have to come up with a solution which is motivating and teaches the learners to find and define problems.* In TPLC the sales scenarios are open; the customer presents a problem and the task for the learner is to understand it, search for relevant information by listening, asking questions, and by making a recommendation.
- *Using embedded data design means that all the data needed to solve the problems are in the video but the problems are not explicitly defined and the required information is incidentally presented so that learners learn to search and select information and to define problems.* In TPLC all the necessary information to solve the customer's problems is either incidentally mentioned in the customer's talk or provided by the customer when the learner asks the right questions but well-defined problems are not presented.
- *Presenting complex but manageable problems permits the learner to practice how to solve complex real-life problems.* The TPLC scenarios present complex problems; some learners thought that they were too complex.
- *Presenting pairs of related adventures that tap into similar content allows the learner to learn what is specific about each context and what is generalisable — multiple perspectives on concepts to be learned are provided.* In TPLC there are three scenarios to practice interacting with customers.
- *The stories are used for learning different subject matter and enable learners to detect links across the curriculum.* The CTGV principles are aimed at designing instructional material for school children. The learning goal in TPLC is narrower which is why this principle does not apply to TPLC.

The instructional model of cognitive apprenticeship introduces the learner to a culture by authentic activities and social interaction. A learner should start out from the beginning with authentic tasks which should be corrected and enlarged in the learning process by a teacher or expert. In the TPLC system, the scientist is a counterpart to interact with who indirectly provides the learner with feedback. TPLC provides opportunities to practice using the new terminology by letting the learner actively participate in situations that are typical — albeit simplified and limited — for the work of a salesperson

in the area. The practice in using the terminology in concrete situations makes it possible to build up an understanding of the new concepts. The scenarios give some insight into how a salesperson should act in typical sales situations that would be cumbersome to describe explicitly in text format. The system will be developed to include an experienced salesperson who can coach the learner. The 'coach' will be a 'role model' for the learner and the 'coach' should be able to take over the interaction with the scientist if the learner so wishes. The coach will not analyse faults in the behaviour of the learner or give expert explanations but the learner will be able to observe how the coach handles a situation and solves problems. In this way, the learner can make use of three important aspects of learning: observing, engaging in conversation and active participation.

Concluding remarks

A prerequisite for understanding a concept is that one has some familiarity with how the concept is used. One does not have to practice using each new concept that one learns and sometimes it is possible to teach something by giving instructions alone. A rule or concept can usually be explained in terms of other concepts but any rule or instruction can be (mis-)interpreted in different ways. Formal instructions have the advantage that they may function as a shortcut to learning something general but they presuppose a higher degree of familiarity with the concepts used, or else the instructions will not be understood. Giving concrete examples and simulations etc. on a less general level may sometimes be less efficient in cases when the learner is familiar with the domain, but has other advantages.

Firstly emphasising practice and the use of knowledge at a particular level may provide opportunities for the learner to gain some understanding of the new concepts from seeing or experiencing their use. The praxis thereby serves as a foundation for creating generalisations and abstractions. Secondly, simulations and the practice of interacting in realistic situations may support the learning of non-explicit, intuitive aspects of the culture that the learner is trying to become familiar with. Thus, one factor that may be important when choosing the kind of instructional support is the degree of familiarity the learner is assumed to have with the concepts to be learned.

Recognising the social aspects of learning and meaning negotiation does not have to lead to view the role of computerised learning support systems as exclusively tools for collaboration or conversations. Learning support systems can have many other roles; computer environments can be used individually by learners when collaboration is not possible or desired. This can be achieved by designing scenarios with examples and simulations of typical situations and in following realistic sequences of events, perhaps by following a 'coach'.

In this paper a view of learning has been presented and the importance of superficial aspects for learning have been emphasised. Fostering superficial learning is one important goal for instruction. Participation in the praxis of the domain is a foundation for more abstract knowledge. By being confronted by concrete problems where the learner has to search actively for

relevant information and make decisions in realistic settings, the learner can identify his/her needs for further learning and get a better understanding of the intuitive, non-conceptual aspects of being an expert in the domain Emphasis should be upon practicing how to use central concepts in the language of the domain, practicing the activities of the domain and familiarising oneself with the culture Computer-based environments are one of many tools and resources which can support these goals

References

Akhras, F & Self, J (1996) From the Process of Instruction to the Process of Learning Constructivist Implications for the Design of Intelligent Learning Environments In *Proceedings of the European Conference on Artificial Intelligence in Education (EuroAIED)* (eds P Brna, A Paiva & J Self) **pp. 9-16** Edições Colibra, Lisbon

Anderson, J R (1990) *Cognitive Psychology and its Implications* W H Freeman and Company, New York

Brown, J S , Collins, A & Duguid, P (1989) Debating the situation - A Rejoinder to Palincsar and Wineburg *Educational Researcher*, **18**, 4, 10-12

Brown, J S (1990) Toward a New Epistemology for Learning In *Intelligent Tutoring Systems At the Crossroads of Artificial Intelligence and Education* (eds C Frasson and J Gauthiar) pp 262-287 Ablex, New Jersey

CTGV (The Cognition and Technology Group at Vanderbilt) (1996) Anchored Instruction and Situated Cognition Revisited In *Situated Learning Perspectives* (ed H McLellan) pp 123-154 Educational Technology Publications Inc , Englewood Cliffs

De Corte, E (1996) Learning Theory and Instructional Science In *Learning in Humans and Machines* (eds P Reimann & H Spada) pp 97-108 Pergamon/Elsevier Science, Oxford

Dreyfus, H L & Dreyfus, S E (1986) *Mind over Machine The Power of Human Intuition and Expertise in the Era of the Computer* Basil Blackwell, Oxford

Gruber, H , Law, L-C , Mandl, H & Renkl, A (1996) Situated Learning and Transfer In *Learning in Humans and Machines* (eds P Reimann & H Spada) pp 169-188 Pergamon/Elsevier Science, Oxford

Holm, P & Karlgren, K (1996) Cognitive Science on Trial In *Proceedings of the 19th Information systems Research seminar In Scandinavia (IRIS)* pp 905-923 Gothenburg Studies in Informatics, Report 8 Lokeberg, Sweden

Karlgren, K & Ramberg, R (1996) Language Use & Conceptual Change in Learning In *Proceedings of the European Conference on Artificial Intelligence in Education (EuroAIED)* (eds P Brna, A Paiva & J Self) pp 45-51 Edições Colibri, Lisbon

Lave, J & Wenger, E (1991) *Situated Learning Legitimate Peripheral Participation* Cambridge University Press, Cambridge

Malcolm, N (1986) *Wittgenstein Nothing is Hidden* Basil Blackwell, Cambridge, MA

Pea, R D (1992) Augmenting the Discourse of Learning with Computer Based Learning Environments In *Computer Based Learning Environments and Problem Solving* (eds E De Corte, M C Linn, H Mandl & L Verschaffel) pp 313-343 NATO-ASI series, Springer Verlag, Berlin

Suchman, L A (1993) Response to Vera and Simon s Situated Action A Symbolic Interpretation *Cognitive Science*, **17**, 1, 71-75

Wittgenstein, L (1958) *Philosophical Investigations* Basil Blackwell & Mott, Oxford