EXPLORATIONS OF CONSTRUCTIVE PROCESSES IN STUDENT LEARNING

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LIST OF ORIGINAL ARTICLES

This thesis is based on the following original publications, referred to in the text by their Roman numerals, and together with them constitutes the academic dissertation of the author:

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II Lonka, K., Lindblom-Ylänne, S. & Maury, S. (1994) The effect of study strategies on learning from text. *Learning and Instruction, 4*, 253-271.

III Lonka, K. & Ahola, K. (1995) Activating instruction - how to foster study and thinking skills in higher education. *European Journal of Psychology of Education, 10*, 351-368.

IV Lonka, K., Joram, E. & Bryson, M. (1996) Conceptions of learning and knowledge - does training make a difference? *Contemporary Educational Psychology, 21*, 240-260.

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Kirsti Lonka

1. INTRODUCTION

Students' learning in higher education is an extremely complex phenomenon, and a lot remains to be done before we fully understand what goes on in students' minds while they are learning new knowledge and skills. There is an obvious need for understanding the psychological processes that may produce high-level learning outcomes. Since the 1970's, extensive research has been carried out in this area using psychological concepts and methods. However, cognitive psychology and cognitive science have not been sufficiently utilized. Many questions still remain unanswered, concerning the central goal of understanding at the system level how individual minds interact with the learning environment, and what might be the most fruitful way to organize this interaction in order to foster high-quality learning.

Applied cognitive science has much to offer both theoretically and methodologically. For instance, research on expertise, conceptual change, and human-computer interaction will probably contribute more and more significantly into research on higher education. A good example of the applications of cognitive science is the field of medical education and more specifically, problem-based learning (e.g., Albanese & Mitchell, 1993; Chi, Glaser & Farr, 1988; Tal, 1991; Gilhooly, 1990; Schmidt, Norman & Boshuizen, 1990).

If we want to carry out research that would help us substantially improve practices in higher education, we must look at complex situations, and if possible use highly motivated subjects. We need to look at learning in real situations which are, at the same time, reasonably well-controlled. Studies on instructional interventions are valuable, and may provide important theoretical and practical insights (e.g., Brown & Palincsar, 1989). However, rigorous studies are not easy to conduct (Shayer, 1994), and there is always a trade-off: the more naturalistic the settings, the more difficult it is to maintain control over numerous variables. For instance, it may be almost impossible to have control groups that are true controls. In many cases, qualitative and explorative studies might be preferable, where the aim is not to imitate methodology adopted from the natural sciences.

Investigations of spontaneous study strategies have important practical implications because such strategies may have a stronger effect on learning than those experimentally induced (e.g., Kardash & Amlund, 1991). The strategies people use when they study for an exam may be quite different from those adopted in psychological experiments. Well-controlled experimental situations are usually new for the subjects, and normal strategies may fail precisely because the material lacks those redundancies which the usual strategies rely on (van Dijk & Kintsch, 1983). Again, we cannot be sure that the subjects in experimental situations are really trying their best. Therefore, we need to test real learning of real material in real situations (Mayer, 1992).

Ecologically valid research on spontaneous strategies, while important, is methodologically demanding. The first problem is that it is difficult to predict what strategies will emerge in real life. For instance, research on note-taking may prove impossible if the subjects take very few notes spontaneously. Therefore, setting precise hypotheses is not easy and research on spontaneous strategies tends to be exploratory in nature (e.g., Kardash & Amlund, 1991; Wade, Trathen & Schraw, 1990). Further, conclusions cannot be reached merely on the basis of subjects' overt behavior, but also on "the basis of what students think

they are doing. Such "covert cognitive processing" does not necessarily have a consistent relationship with overt strategy behavior.

This mission also calls for a theoretical synthesis between different lines of research. During recent years, it seems that diverse research traditions have come closer to each other. Current themes, emphasizing active, constructivist, situational, and collaborative aspects of learning, are now common to many researchers coming from different traditions (Bruner, 1996). The aim of the present thesis is, ambitiously, to combine different traditions in empirical research on students' construction of knowledge in higher education. The present introduction reviews three different theoretical perspectives:

1) *Students' approaches to learning* starts from the European phenomenographic tradition, looking at qualitative aspects of student learning in higher education. A condensed history of the European tradition is necessary in order to understand the foundations of this view, and the background of the methodology that was applied in this research.

2) The section *Epistemological and conceptual development* briefly introduces general aspects of students' epistemological development during the college years, domain-specific aspects of expertise and conceptual change, and finally a concise account of constructivist conceptions of learning and knowledge. One focus of this study is to investigate more closely, which aspects of epistemologies and conceptions of learning are domain-specific, related to expertise in education or psychology, and which aspects may generalize over different domains.

3) *Cognitive research on learning and study strategies* looks at study tactics, study strategies and their relations to learning processes and outcomes. Metacognition, although theoretically and practically a very important aspect, will be discussed very briefly in the context of self-regulation in learning. However, 1) and 2) address students' metacognitive belief systems, and therefore form an integral part of metacognition (Simons, 1996).

After this, some implications for instruction will be presented. These include the notions of learning-by-writing, process-oriented instruction, and activating instruction. One of the aims of this study is to explore whether it is possible to design practical innovations in order to apply the theoretical notions mentioned above. Here, it is not easy to distinguish between applied and theoretical research. As Anderson (1987) has pointed out, sometimes real-world pedagogical experiments may be the best way to understand human cognitive functioning.

The angles overlap greatly, and a preliminary synthesis of the different perspectives is presented in the end of this introduction. Another level of synthesis will be suggested in the General Discussion, after introducing the five studies which comprise this thesis.

1.1. Students' approaches to learning

A brief history of European research[1]. An important line of research was founded in the 1970's, when Ference Marton and his colleagues, the so-called Gothenburg group, started to look at *qualitative aspects of students' learning in higher education* (Marton & Säljö, 1976; Marton, Hounsell & Entwistle, 1984). At the same time, many other European groups, such as von Wright and his colleagues (e.g., von Wright, Vauras & Reijonen, 1979), started their research on school learning in ecologically valid situations.

Students appeared to differ in how they approached learning tasks, such as studying lengthy texts. Marton (1986) called his methodology *phenomenographic*, emphasizing

[1] For a recent review, see Eklund-Myrskog's (1996) extensive doctoral dissertation on the topic.

students' experience, conceptualization, understanding, and perception of the task in a specific context. He was inspired by humanistic and phenomenological psychology rather than by the cognitive tradition (Vauras, 1991). Marton & Säljö (1976) introduced two qualitatively different approaches to learning: deep and surface level learning. The former refers to paying attention to what is *signified* by the materials to be learned (e.g., author's intention), whereas the latter concentrates more on the *signs* (e.g., the text itself).

Another classification was introduced by Pask (1976), whose subjects were required to reach a deep level of understanding. He looked at the strategies they used in trying to carry out this instruction. He differentiated between holist and serialist strategies of learning, and also described different pathologies of learning. Pask (1976) used the term "learning style" to mean a general tendency to apply a particular strategy.

A somewhat different line of research, often referred to as "quantitative", was strongly influenced by both the Gothenburg group and by Pask (see Entwistle & Ramsden, 1983; Biggs, 1993), and applied concepts adopted from their qualitative studies as well as from research in cognitive psychology. Typical of this tradition were inventories, large samples of students, and multivariate analyses. It should be noted, however, that interviews and qualitative analyses have constantly been used also by these researchers, and they have collaborated with the Gothenburg group (e.g., Marton, Hounsell & Entwistle, 1984). Research in Lancaster was started by Noel Entwistle and his colleagues in the 1970's, and the *Approaches to Studying Inventory* (ASI) was developed (Entwistle and Ramsden, 1983). Around the same time in Australia[2], J.B. Biggs (1979; 1985) developed his own instruments, called the *Learning Process Questionnaire* (LPQ, for secondary students) and the *Study Process Questionnaire* (SPQ, for tertiary students). Biggs and Collis (1982) also developed the so-called SOLO taxonomy in order to evaluate the quality of learning outcomes across different contexts.

The distinction between qualitative and quantitative research may be criticized, especially if the latter is being described as "atheoretical". Biggs (1993) suggests the distinction should rather be made between the *students' approaches to learning (SAL) position*, deriving from qualitative analyses and students' reports of their own study processes, and the *information processing (IP) position*, based on analyses of actual cognitive processing. In the former category, he would include the Gothenburg group, ASI and SPQ, and in the latter, study strategy research (e.g., Weinstein & Mayer, 1986). In this review, the section *Cognitive research on learning and study strategies* reflects the IP position, although the line is not easy to draw any more.

What do inventories of learning tell? A great number of scales in different inventories were developed[3] , but Marton and Säljö's (1976) original distinction between surface and deep *approaches* remained a central construct in several studies (Biggs, 1985; 1993; Eklund-Myrskog, 1996; Entwistle & Entwistle, 1992; Entwistle & Ramsden, 1983; Marton, Hounsell & Entwistle, 1984; van Rossum & Schenk, 1984; Ryan, 1984; Säljö, 1979; Thomas & Bain, 1984; Vermunt & van Rijswijk, 1988; Vauras, 1991).

In general, the surface approach refers to an intention that is extrinsic to the real purpose of the task, aiming at investing minimal time and effort to meet requirements, whereas the deep approach is based on "interest in the subject matter of the task; the strategy to maximize understanding" (Biggs, 1993, p. 6). A third important approach was also

[2] Although Australian, J.B. Biggs seems to relate himself to the European tradition. Entwistle & Ramsden (1983) used both Australian and British students in their studies.

[3] These also include various affective and motivational subscales, which are not discussed this summary.

identified by several researchers, called the achieving (or strategic) approach, defined as "ego-enhancement that comes out of visibly achieving, and in particular through high grades" (Biggs, 1993, p. 7).

The deep and surface approaches are different from the achieving one, because the first two describe ways in which students engage in the actual content of the task, whereas achieving refers to the ways students organize their studying (Biggs, 1985). The deep approach may be considered the only "natural" approach, while the surface and achieving approaches are more likely to be created by institutional demands (Biggs, 1993). Although students with an achieving approach will seek high grades by any means, whether surface or deep approach, there is empirical evidence suggesting that it is more useful to combine achieving with the deep approach rather than with the surface one, when it comes to success in various domains (Entwistle & Ramsden, 1983; Lonka, Lindblom-Ylänne & Maury, 1993).

When *approaches*, measured by different scales, are examined by using multivariate statistical methods such as factor analyses, the factors consequently formed are often referred to as *orientations* (Ramsden, 1988) or sometimes *styles* (Vermunt & van Rijswijk, 1988), although styles are typically thought to be more stable and unchangeable than orientations (Ramsden, 1988; Kirby, 1988; Biggs, 1993). If a student has a tendency to use the deep approach across various situations, this is an indication of a meaning orientation, whereas a preference in favor of the surface approach may be labeled as a reproducing orientation. Those high in achieving and strategic studying, aiming at success, are typical examples of achievement orientation.

Individual combinations of approaches or orientations may be called *orchestrations*. Individual students may have various mixtures; if these are mutually incompatible they are called "disintegrated" orchestrations. Meyer (1991, p. 297) defines the concept of study orchestration as "the contextualised study approach adopted by individual students or groups of students". This concept recognizes three important aspects of student learning: the existence of qualitative individual differences in the manner in which students approach and engage in learning tasks, the influence of context on such engagement, and differing conceptions of learning among individual students. Meyer, Parsons and Dunne (1990) emphasize that orchestrations are affected by the qualitative level of perception of the individual towards certain key elements of the learning environment. This fits with Ramsden's (1988) idea of the three related contextual domains which constitute influences on students' deployment of strategies in higher education: the teaching, the assessment, and the curriculum.

Students' ideas of learning. Students' own ideas provide a framework for how they monitor and explain their own and other students' learning. Ramsden (1988, p. 335) points out that "approach to learning begins with one's definition of learning", although other things, such as emotions and cognitive skills, may steer students away from activities aiming at understanding. Roger Säljö (1979), from the Gothenburg group, was one of the pioneers in classifying students' conceptions of learning.

In her doctoral thesis, Eklund-Myrskog (1996) summarized different studies of conceptions of learning from the point of view of the European phenomenographic tradition (e.g., Giorgi, 1986; Marton, Dall'Alba & Beaty, 1993; Säljö, 1979). In many of the studies described, cross-cultural samples were used. In her synthesis, Eklund-Myrskog constructed metalevel categories on the basis of various studies. These categorizations of learning have interesting parallels with constructivist notions of learning, typical of current cognitive learning theory. In the first category, learning was seen as *a quantitative increase in*

knowledge. The emphasis was on adding new facts and information into memory. Knowledge was acquired from external sources and the student played a passive role in the learning process. In the second category, learning was seen as *memorizing*, and the aim was to acquire knowledge from books, and then to be able to reproduce it in the same form. In some of the studies cited (e.g., Säljö, 1979), the third category was found, where learning was seen as *application*. According to this view, students acquire knowledge, principles, and ideas that can be used and applied when necessary. Usefulness was an important part of this conception.

In the fourth category, learning was seen as *a conceptual, qualitative change of meaning*. Learning enabled students to discover perspectives, understand ideas, and develop their own view. In the fifth category, closely related to the fourth, learning was seen as *a constructive activity aimed at understanding* or getting insight into complex wholes. In this category, the active role of the learner was emphasized. There were contextual and cross-cultural differences in defining "understanding" between Western and Asian subjects: the former often saw understanding as taking place quite suddenly, whereas the latter saw it developing gradually. Further, Pratt (1992) showed that in Chinese culture, respect for authorities is often more essential than individual knowledge construction. In the sixth category, learning was seen as *an interpretative process aiming at better understanding of reality*, to see something in a different way. Eklund-Myrskog (1996, p. 39) described this as "a sort of paradigmatic shift taking place in the view of the learner". The view changed with the reconstruction and development of the previous ways of thinking. In this category, there was an aspect of development, because a qualitative change took place. In some of the studies (e.g., Marton, Dall'Alba & Beaty, 1993) a seventh category was found that further expanded the previous ones. According to this conception of learning, it involved *a personal change.* This added an existential layer to learning, when the learner changed as a person as a result of the learning process.

1.2. Epistemological and conceptual development

Besides approaches to learning and ideas of learning, another aspect that may have relevance to study practices in higher education is students' general conceptions of *knowledge*, that is, their epistemologies. Research on epistemological development has its roots in North America. Perry (1970) was a pioneer in the field, carrying out qualitative research on students' beliefs; he described the epistemological development of a college student as moving from a primitive dualist conception of knowledge towards a more relativistic conception. In the beginning of their studies, students saw knowledge as an unorganized set of discrete and absolute truths (dualist orientation), but this conception gradually transformed into seeing knowledge as an array of interpreted and integrated positions (relativistic orientation). In his original work, Perry (1970) separated nine qualitatively different levels of epistemological development from primitive dualist toward integrated thought.

A simple version of Perry's (1968) model was applied by Ryan (1984), who proposed that a dualist would assess his or her reading comprehension in terms of the number of propositions retrieved from memory after reading a text passage (knowledge standards). In contrast, he assumed that a relativist ought to assess reading comprehension in terms of the degree to which clear and coherent relationships can be established among propositions in a text passage (comprehension standards). Ryan's (1984) data suggested that dualists more often reported knowledge standards, whereas students classified as relativists more often

reported comprehension standards. Students reporting the use of comprehension criteria earned better grades in a psychology course, regardless of their experience or aptitude. Ryan (1984) concluded that these epistemological standards may be related to one's text processing efforts.

Simply drawing a line between dualist and relativist may be criticized because, paradoxically, it resembles a dualist dichotomy. Also, researchers such as Glenberg and Epstein (1987) found the dualism scale to account for little of the variance, and therefore did not think it was useful. Schommer (1990; 1993) started her program of epistemological research as an attempt to resolve the conflicting results of research based on Ryan's scale. Her judgment was that Ryan thought epistemological beliefs to be unidimensional. Schommer (1993) found it more plausible that personal epistemology is a system of more or less independent dimensions, and suggested that an individual could be sophisticated in some beliefs, but not in others.

Schommer (1990) constructed a questionnaire to assess several epistemological dimensions, and identified four factors which reflect dualist ideas: (1) *innate ability*, where students believed the ability to learn is determined at birth, (2) *quick learning*, that is, learning occurs fast or not at all, (3) *simple knowledge*, referring to the belief that knowledge is best described as isolated facts, and (4) *certain knowledge*, the idea that knowledge is unchanging. Students who filled in the epistemology questionnaire were, several weeks later, asked to read a passage as if they were preparing for a test (half in social sciences, half in physics). The concluding paragraph was missing in each passage, and the students were asked to write it. After this, they rated their confidence and completed a test on the topic. It appeared that belief in quick learning resulted in oversimplified conclusions, poor performance, and overconfidence. In general, performance could be predicted from epistemological scores. The four-factor structure was replicated in several independent studies. It appeared that the less students believed in simple knowledge, the more meaningful study strategies they reported, and the better was their performance on a mastery test. Family background also had an influence on epistemologies: for instance, the more education students' parents had and the more encouragement they gave for independent decision-making, the less likely students were to believe in simple knowledge. Schommer (1993) concluded that first, there are some differences in epistemological beliefs between students entering different college systems; second, family life is an important contributor to epistemological predispositions; and third, epistemological beliefs in the early years of college tend to be general rather than domain specific.

In the present dissertation, a design resembling Ryan's (1984) study will be applied to a sample of Finnish medical and psychology students. Accordingly, an uncomplicated division between 'dualists' and 'relativists' will be used. With the help of this distinction, we can examine whether dualism is likely to be a domain-specific phenomenon. Further, the unexplored relations are examined among approaches to studying, conceptions of learning, and epistemologies.

On the nature of expertise in ill-structured domains. Besides general epistemological development, studies in higher education involve the gradual process of developing domain-specific competence. Research on expertise shows that amassing a large amount of factual knowledge, while important, is not a sufficient condition for the acquisition of expertise in any area (Bereiter & Scardamalia, 1993; Chi, Glaser & Farr, 1988). Instead, it is necessary for students to construct qualitative models that are essential for a deep structural understanding of their own field. These conceptions are based on domain-specific declarative knowledge, but in addition to single facts, they consist of concepts, propositions and theories

(Champagne, Klopfer & Gunstone, 1985). The structural organization of the domain-specific knowledge base essentially differentiates between novices and experts, and cognitive development requires the reorganization of domain-specific knowledge structures (Chi, Feltovich & Glaser, 1981; West & Pines, 1985). Typical of skillful expert performance is the gradual proceduralization of declarative knowledge, that is, transforming "knowing that" into "knowing how" (Anderson, 1982).

The most frequently researched topics in the study of expertise appear to be well-defined in nature; for example, chess and physics have been widely studied (Chi, Feltovich & Glaser, 1981; Carey, 1985,1986; Chi, Glaser & Farr, 1988). Within these domains, the problems to be solved have known solutions, or at least there is a reasonable consensus within the respective expert communities about what constitutes an acceptable solution. In contrast, the more open-ended domains, like psychology, have not been so extensively studied. Within these domains there are few coherent, commonly accepted theories, and universal agreement may never be possible (Voss & Post, 1988; Kuhn, 1970; Staats, 1983). Perhaps because of this, only few researchers have turned their attention to complex and ill-defined domains such as social studies (Voss, Greene, Post & Penner, 1983), agriculture (Voss & Post, 1988), medicine (Mandl, Gruber & Renkl, 1996), and writing (Bereiter and Scardamalia, 1987). A somewhat distinct, widely researched area of complex and ill-defined expertise is that of social cognition (e.g., Cantor & Kihlström, 1987), which is quite beyond the scope of the present study.

Although it is easier to identify a correct solution in well-defined domains than in open-ended domains, the distinction between them is often fuzzy. For example, problem solving in new areas of well-defined domains sometimes resembles problem solving in open-ended domains (Voss & Post, 1988). This is because differences in performance seem more determined by how well the phenomena in question are understood, and the nature of the problem studied, than by inherent differences in the domains themselves. For example, physics problems may seem quite open-ended when unsolved questions of quantum physics are being explored, and writing tasks may appear well-defined when authors are writing on a topic on which they have written many times before.

Interestingly, expert development is not always linear, in the sense that sometimes novices may surpass experts. For example, Adelson (1984) showed that experts were sometimes less able than novices to apply their programming knowledge in some concrete settings, even if they understood the tasks better at the abstract level than did the novices. In clinical diagnosing tasks (either psychological or medical), those who are considered experts are not always better than novices. For instance, medical experts do not always remember essential facts better than medical students, and they do not show a strong forward direction of reasoning (Gilhooly, 1990; Holyoak, 1991). Also, complex problem solving, like writing, may be more stressful for experts than for beginners (Scardamalia & Bereiter, 1991). Nonlinear development may be particularly typical of open-ended and complex domains (Scardamalia & Bereiter, 1991; Gilhooly, 1990). Typical of expert development is *progressive problem solving*, where an individual is constantly working at the upper limits of current knowledge and skills (Bereiter & Scardamalia, 1993).

There are aspects of psychology, especially in educational psychology or in the cognitive learning theory, that make it an appealing target for the study of expertise. Educational psychology has features of both well-defined and open-ended domains: even though few would agree upon a unified, commonly accepted theory (Staats, 1983), there are widely accepted methodologies, and certain shared norms. Another feature of the domain of psychology that makes it particularly interesting for the study of expertise is that studying different epistemologies or approaches to learning has some relevance for how people learn

or apply their knowledge. For instance, *expert learning* refers to how people approach challenging problems (Bereiter & Scardamalia, 1993): an expertlike student engages in knowledge-building activity, focusing on the concepts that the tasks may teach, rather than on simply carrying out tasks as "a job to do".

In other domains, too, it has been pointed out that conceptual knowledge contributes to reasoning processes (Kuhn, Amsel & O' Louhghlin, 1988; Schauble, Glaser, Raghavan and Reiner, 1991). Finally, as suggested earlier, most laypeople have folk theories about many of the central concepts in psychology such as learning and memory (Sternberg, 1985; Vaughan, 1985). It is therefore possible to examine how these conceptions change with training in psychology, and whether people have general epistemologies which develop independently of this training.

Research on expertise in knowledge-rich domains is closely related to research on conceptual change. The novice/expert shift involves psychological resistance and a gradual restructuring of the novice's belief system (Nissani, 1989): people tend to maintain their original beliefs, if there are no good grounds for abandoning them. Individuals construct certain entrenched beliefs which are based on their everyday experience and, depending on the domain, the knowledge acquisition process requires a revision of some of those beliefs and their replacement with a new explanatory structure (Vosniadou, 1991). The present research looks at developing expertise in complex and ill-structured domains: medicine and psychology. It is not only domain-specific knowledge that is of interest here, but the focus is on the question: what is expert learning in higher education? Mainly paper-and-pencil tasks will be used, and therefore it is not possible to focus on the procedural aspects of expertise.

On the nature of conceptual change. In many studies, students' implicit theories and misconceptions about different scientific phenomena have been made explicit, and these have been compared to aspects of the scientific theories that the students are required to understand (Carey, 1985,1986; Champagne, Klopfer & Gunstone, 1982; Johnson & Wellman, 1982; West & Pines, 1985; Chi, 1992). Researchers have also documented how pre-scientific (mis)conceptions transform into scientific notions (Reiner, Chi & Resnick, 1988).

Many researchers think that naive or pre-scientific conceptions in the natural sciences are parts of theory-like constructions (McCloskey, Caramazza & Green, 1980; Reiner et al., 1988). These misconceptions, as they mostly are, are very robust and well-documented (Chi, 1992). For example, McCloskey et al. (1980) have shown that the notions of force and motion are typically conceptualized as entities which can be possessed, transferred, and dissipated, such that there must be agents for the causes and control of motion, as well as agents for the supply of force. Thus, force is seen — by children and naive subjects — as an impetus-like substance, and as a property of material objects (which resembles the pre-Galilean view). Analogical misconceptions of heat, light, and electricity have shown to be common. What is more, they seem to be very consistent 1) across studies, 2) across concepts, 3) across ages, 4) across educational levels, and 5) across historical periods, students' naive conceptions resembling those of medieval scientists (Chi, 1992). Indeed, McCloskey et al. (1980) were among the first researchers to suggest that, in natural sciences, there are common features in laypeople's and medieval scientists' conceptions. A similar parallel was later drawn more explicitly by Carey (1986) between the progression of scientific understanding in the child and the progression of scientific understanding in the history of science.

Many researchers also believe that the development of scientific thinking implies a development from less coherent toward more coherent theories or explanations (Thagard,

1989; Chi, 1992). There is, however, an alternative contrasting view that the naive conceptions are not theories at all, but merely untidy, unscientific collections of meanings (Solomon, 1983) or disjointed, piecemeal and fragmented conceptions, phenomenological primitives (DiSessa, 1988; Hammer, 1996). A widely debated issue is whether or not students' naive beliefs are theory-like, and what kind of changes are required to modify naive theory into a scientific theory (Chi, 1992).

Starting from the presumption that misconceptions are theory-like constructions, Carey (1986) distinguishes between strong and weak restructuring in conceptual change, based on Kuhn's (1970) characterization of paradigms and paradigm shifts in the history of science. The weaker sense of restructuring entails new relations among concepts and the addition of new, previously absent concepts. Restructuring in the strong sense, similar to Kuhn's (1970) paradigm shift, entails changes in the core concepts (and their interrelations) of the theory as well, so that the core concepts of the new theory are not directly translatable into those of the old theory. For instance, light as photons (quantum-mechanical entities) is not translatable into Newton's *Optics*, which taught that light was material corpuscles (Kuhn, 1970, p. 12). A *core concept* thus refers to one which mediates the way students think about different phenomena in a given field (Carey, 1986).

Chi (1992) reformulated the idea of radical restructuring as what she calls “radical conceptual change”. She defines conceptual change as “a form of learning in which existing concepts change their meanings” (p.129). This change can occur either within or between existing knowledge structures or categories. When the shift occurs between two ontologically distinct categories (such as from matter to an event), then the change is radical, whereas non-radical conceptual change occurs within an ontological category. She claims that radical conceptual change is difficult and not common in everyday life, because it is not often the case that we encounter phenomena in which our existing preconceptions have to be revised in terms of their ontological status.

Research in different domains indicates that informal knowledge may be highly resistant to change, despite exposure to relevant instruction (e.g., Clement, 1982; Tversky & Kahneman, 1971). For example, Clement (1982) found that, after two semesters of college physics, only 30% of students in an engineering class could correctly answer a coin-tossing problem requiring the comprehension of gravitational forces. It appeared that these otherwise highly successful students had a belief about impetus that conflicted with their formal knowledge of Newton's Laws.

It has been questioned whether it is possible to change naive theories into scientific theories, for instance, by means of instruction. The problem that needs to be explained is how a new organization of concepts is achieved and how new and increasingly complex cognitive procedures are constructed by learners — particularly when learners must grasp concepts and procedures more complex than those they already have available for application (Bereiter, 1985). Engeström (1987) presents this as a metatheoretical problem: How can a structure generate a structure more complex than itself? This problem is called the *learning paradox* (Pascual-Leone, 1980). Bereiter (1985) found it especially severe when the kinds of learning in question are those that lead to understanding the core conceptions of a discipline or mastering more powerful intellectual tools. However, the paradox disappears if we do not look at knowledge as a set of objects, such as propositions, rules, and so on, but view mental representations in more dynamic terms (Bereiter & Scardamalia, 1993): knowledge-building activity may help an expert learner to overcome the learning paradox.

In instructional settings, conceptual change may take place to various degrees. Vosniadou (1994) differentiates between *enrichment*, referring to simple addition of new information into an existing theory, and *revision*, which is required when the information to

be learned is inconsistent with existing beliefs. She also contrasts specific theories and framework theories, the latter including basic ontological presuppositions about how things "are". Revising a specific theory is easier than revising a framework theory. Further, when beliefs concerning a specific theory are constrained by a framework theory, conceptual change may be difficult to achieve. Vosniadou (1991) argues the importance of fostering domain-specific conceptual restructuring. She emphasizes the need to provide instruction which is based on a thorough understanding of students' previous knowledge, the need to make students aware of their mental models and entrenched beliefs, create opportunities for students to enrich their knowledge beyond phenomenal experience, and provide clear explanations of phenomena so that students can understand how to revise their existing knowledge structures. However, Vosniadou (1994) points out that failures in learning may take place because of inconsistencies, when conflicting pieces of information are simply added to existing knowledge structures. Further, inert knowledge is produced when inconsistent information is stored in a separate microstructure and is used only on certain occasions, for instance, only at school. Finally, misconceptions are produced when students try to reconcile inconsistent pieces of information in order to produce a synthetic mental model, which involves a fusion between scientific and common sense theories.

It is also possible that activating previous misconceptions may profoundly confuse the learner. Chi (1992) suggests that instruction in a domain such as physics must be especially difficult, because students do not have the same experiential understanding of energy as they have of material substances, and a radical conceptual change requires some knowledge of the new domain into which concepts must be shifted. She proposes that this difficulty might be overcome by teaching the correct scientific theory independently, without bridging it to naive understanding, since it may be more confusing than clarifying to bridge from conceptions that belong to a different ontological category. Chi (1992) provides evidence which shows how naive and scientific theories can and do co-exist in the mind of expert physicists. She claims, on the basis of cognitive research, that people are capable of maintaining two separate conceptions — they may apply their common-sense notions in everyday settings and scientific theories in their laboratories.

The latest approaches to teaching science (Hammer, 1996) have started to question whether the misconceptions perspective is truly necessary, because it reflects the scientist's position rather than the students', and further, it is doubtful whether student reasoning is as consistent as this perspective implies. DiSessa's (1988) phenomenological primitives (p-prims) refer to basic primitive conceptions, which are more abstract and fundamental than misconceptions. In this sense, p-prims resemble Vosniadou's (1994) framework theories. Hammer (1996) concludes that the differentiation between misconceptions and p-prims has theoretical relevance, but the implications for instruction do not radically change on the basis of which approach is preferred. It may be suggested that conceptual change has different layers, some being more general, others being quite specific. Changes in core concepts, framework theories or p-prims may not take place easily, nor do shifts between ontological categories. However, students may be more likely to revise those specific aspects of their conceptions which are not related to their general and fundamental belief systems.

In physics, then, conceptual change takes place within and across ontological categories. Even if epistemological commitments have been shown to guide students' notions of different physics phenomena (Reiner et al., 1988), physics mostly deals with ontology, while the psychology of learning is closely related to epistemologies (Ryan, 1984; Strike & Posner, 1985). If there is such a thing as restructuring in the domain of psychology, it is probably epistemological in nature: the idea that the origin of knowledge is not outside human beings, but rather, knowledge is a human construction. It is possible that

epistemological changes — analogical to ontological changes in physics — take place in psychology students during the development of expertise. On the other hand, this may also have to do with students' ontological beliefs concerning the nature of "how things are": the so-called "flat ontology" implies that one's view of reality emerges directly from sensory data, without the need for any intervening cognitive mechanism (Prawat & Floden, 1994).

The following section looks at core conceptions in educational psychology, namely, constructivist conceptions of learning. The ontological and epistemological presuppositions that lie behind them may be described as framework theories. Although conceptual change is theoretically important from the point of view of the present study, the methodology will not lend itself to testing profound assumptions of conceptual change. However, the core concepts in educational psychology will be empirically explored.

Constructivist conceptions of learning and knowledge. The following citation nicely sums up the central assumption in the current cognitive theory of learning[4], which also seems typical of researchers in the tradition of students' approaches to learning:

> These days we do not believe that individuals come into the world with their "cognitive data banks" already prestocked with empirical knowledge, or with pre-embedded epistemological criteria or methodological rules. Nor do we believe that most of our knowledge is acquired, readyformed, by some sort of direct perception or absorption. Undoubtedly humans are born with *some* cognitive or epistemological equipment or potentialities ... , but by and large human knowledge, and the criteria and methods we use in our inquiries, are all *constructed.* Furthermore, the bodies of knowledge available to the growing learner are themselves human constructs (Phillips, 1996, 5).

Definitions of learning provide a window for looking at epistemologies, because they implicitly include conceptions of the origin of knowledge. Therefore, conceptions of learning and knowledge are very hard to separate from each other. During the past two decades, a constructivist approach to learning and knowledge has become dominant in educational psychology, and especially in research in science education (e.g., Champagne, Klopfer & Gunstone, 1982) and text comprehension (e.g., Chan, Burtis, Scardamalia & Bereiter, 1992). Learning is viewed as an active, constructive process rather than a passive, reproductive process (Glaser & Bassok, 1989; Bereiter, 1985; Gardner, 1985; Neisser, 1976; Peterson, Fennema, Carpenter, & Loef, 1989; Resnick, 1984; Shuell, 1985, 1990). This approach draws on Piaget's (1954; 1972) notions of intelligence, learning and cognitive development, Bartlett's (1932) conceptions of reconstructive memory, and Ausubel's (1968) assimilation theory (see Novak, 1992). In the cognitive theory of learning, three core conceptions may be identified.

The first concept, *constructivity*, is the idea that knowledge and cognitive strategies are constructed by the learner, and that learning involves qualitative restructuring and modification of schemata, rather than just the accumulation of new information in memory (e.g., Bartlett, 1932; Bruer, 1993; Glaser & Bassok, 1989; Piaget, 1972; Resnick, 1989).

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[4] Recently, there has been a debate among educational psychologists about the notion of `constructivism' (Marton & Neuman, 1989; Shuell, 1985; Niiniluoto, 1991). This debate centers around the nature of knowledge in the philosophical sense, that is, whether we can speak of "absolute" knowledge independent of human construction. However, the philosophical question of the origin of knowledge is not addressed in this study. Rather, 'constructivity' has been approached from a psychological perspective: whether the cognitive processes of learning and memory may be assumed to be constructive in nature, and further, whether people's conceptions of learning and knowledge reflect constructivist views.

The second concept, *active epistemology*, is closely related to constructivity, but refers specifically to beliefs about the learner's role in the learning process. At one end of a continuum, students are portrayed as active, intentional individuals who are primarily responsible for their own learning (Bereiter & Scardamalia, 1989; Shuell, 1990); at the other end, they are portrayed as objects who passively receive what is taught by a teacher, considered responsible for their learning.

Mental representation[5] is the third core concept. In cognitive learning theory, performance on problem-solving tasks and students' explanations of such tasks are most often accounted for by the nature of their mental representations and also by their prior knowledge (e.g., Piaget, 1972; Gardner, 1985; Giere, 1988). The manner in which knowledge is represented is thought to determine understanding and to influence problem solving (Glaser & Bassok, 1989; Chi, Glaser & Farr, 1988).

One of the central questions of the present research is the interplay between students' conceptions and their strategic behavior (e.g., Butler & Winne, 1995; Bromme & Tillema, 1995). In the development of expertise, knowledge and beliefs are assumed to gradually proceduralize and become integrated with the executive control of action (Anderson, 1982; Bereiter & Scardamalia, 1993; Simons, 1996). Is it possible, for instance, that those students whose conceptions are constructivist in nature use different study strategies from those who see learning as simple intake of knowledge?

Further, it is of interest to document the effects of formal training on these beliefs. It cannot be assumed that students' intuitive beliefs will change as a consequence of formal instruction. It is, therefore, an open question as to whether formal teacher education or studies in psychology will have an impact on students' intuitive conceptions of learning. This question is of particular relevance to the training of teachers, because we might wish to develop instruction specifically directed at changing beliefs about learning if we find that these conceptions remain relatively untouched by formal instruction. However, the question also has wider relevance for the relation between training and conceptions of learning in general. The present research will address the coherence between subjects' beliefs and the applications they suggest.

1.3. Cognitive research on learning and study strategies

A categorization of study and learning strategies. Students belief systems thus provide a framework for their strategic behavior. The question arises how to categorize qualitatively different study strategies in order to look at coherence between beliefs and strategies. One of the most often cited categorizations, by Weinstein and Mayer (1986), differentiates among rehearsal, elaborative, organizational, metacognitive and affective strategies. Each strategy may be used for either simple or complex tasks, the latter being more relevant from the point of view of the present research. *Rehearsal strategies* involve repetition aiming at literal reproduction. In complex tasks, these can involve, for instance, copying or underlining information. *Elaborative strategies* are used when knowledge is attached to some meaningful context or some sort of symbolic construction is developed, for example, by creating analogies, summarizing, or using prior knowledge. *Organizational strategies* are

[5] Even connectionist models of the microstructure of cognition (Rumelhart, McClelland and the PDP Research Group, 1986) somewhat go along with the construct of mental representation (Smolensky, 1988). As Fodor and Pylyshyn (1988, p.8) put it: "Connectionist modeling is consistently Representationalist in practice". However, this question is everything but simple, and this debate is beyond the scope of this paper.

used to translate information into another form that will make it easier to understand, for example, by outlining, grouping, creating a conceptual diagram, or by creating a hierarchy. Rehearsal strategies differ from elaboration and organizational strategies, since the latter require more active and deep-level processing by the learner than is required in rote learning. *Metacognitive strategies* include comprehension monitoring strategies such as checking for failures, like using self-questioning to check understanding. *Affective strategies* mainly aim at being alert and relaxed in order to help overcome test anxiety, or to maintain a positive atmosphere to facilitate learning.

How can this classification be related to students' ideas and conceptions? In Ryan's (1984) study, dualists more often assessed their learning on the basis of knowledge standards, whereas relativists more often reported comprehension standards. Because rehearsal strategies aim at reproduction of facts, students who express a dualist epistemology may be more likely to prefer rehearsal strategies than do students categorized as relativists. In that case, study strategies aiming at comprehension, such as elaborative or organizational strategies, would be more likely to be related to relativist notions and comprehension criteria. The relation between epistemologies and strategies may prove important in understanding complex learning in higher education.

Study strategies, study tactics, and approaches to learning. Is it legitimate to talk about a "strategy" where a specific studying behavior, such as underlining, is in concerned? The terminology in the field of study strategy research is somewhat diversified, and therefore requires clarification. Van Dijk and Kintsch (1983, p. 65) define the concept of *strategy* as *a global instruction for each necessary choice to be made along the way to realizing some goal*. Therefore, strategies make it possible to solve complex problems given the time and resources available. On this basis, Vauras (1991, p. 25) defines a strategy as *a learned goal-directed, intentional, and controlled way of acting.* She further elaborates that the impact of a strategy is most often relative, and no strategy is effective on all occasions.

Thus, a *study strategy* usually refers to a conscious and purposeful composition of study behaviors. A strategy is often considered as a deliberate action, a selection of one alternative over another (see Derry & Murphy, 1986; Wade & Trathen, 1989; Wade, Trathen & Schraw, 1990). A *study tactic*, on the other hand, is a more unintentional, specific study habit or a study technique, such as underlining, note-taking, summarizing, etc. A technique or a tactic only becomes a strategy when students have metacognitive knowledge about how to use it.

However, this discrimination between strategies and tactics is somewhat problematic. Biggs (1985, p. 199) points out that "strategies often appear to be used with little or no metacognitive involvement on the part of the students; they appear rather to be functioning in the same way as techniques or tactics". Biggs (1993) points out that although a strategy implies a complex fusion of intention and purpose, the word "strategy" is often imported from cognitive psychology, when what is really meant is a tactic or a procedure for handling a set of tasks. Vauras (1991) herself found that secondary students' assessments of their own activities were rather conflicting in relation to their strategy use, and that it was difficult for them to consciously evaluate and describe their studying.

The surface approach to learning, often accompanied by rehearsal strategies (Entwistle & Ramsden, 1983), may be described as an unconscious gut-reaction to the task (Biggs, 1985). Only the deep approach to learning, related to elaboration and to the search for meaning, may be described as task-focused or natural, whereas achieving and surface approaches are more institutional creations (Biggs, 1993). On this basis, rehearsal strategies may not be strategies at all.

The conceptual problems described above lead to the conclusion that *only deep-level transformation of knowledge is usually guided by metacognitive activity*. It is not possible to talk about intentional and goal-directed action, when students are not aware that there are alternative options to surface-level processing and rehearsal strategies. Rather than make a distinction between strategies and tactics, we should distinguish between qualitatively different ways of learning. A systemic approach (Biggs, 1993) should be adopted, where student learning is seen to take place in a context that affects both the nature of learning and its outcomes.

Finally, Mayer (1988, p. 11) simply does not acknowledge the distinction described above: "Learning strategies can be defined as behaviors of a learner that are intended to influence how the learner processes information. Examples include underlining of key ideas in a passage, outlining the ideas in a lecture, or trying to put some newly learned information into one's own words." Instead of dividing between "strategies" and "tactics", another solution would be to categorize study strategies hierarchically on the basis of generality as (1) specific strategies, e.g., underlining or concept mapping, which in turn reflect (2) more general categories, such as rehearsal or organizational strategies. At the most general level (3), these may be categorized as reproductive versus transformational or generative strategies.

Self-regulation in learning. This is one aspect of metacognitive strategies, and *regulation activities* aim at controlling student learning at the metacognitive level. Vermunt and van Rijswijk (1988, p. 648) define self-regulated learning as "performing educational activities oneself, taking over educational tasks from teachers, educating oneself". They point out that fully self-regulated learning is less common in higher education than an intermediate form between self-regulation and teacher-regulated learning. Self-regulated students are aware of qualities of their own knowledge, beliefs, motivation, and cognitive processes, and these elements jointly create situated updates of the tasks they are working on (Butler & Winne, 1995).

Processing actions may be controlled either internally or externally, and students may differ in terms of their tendency to express self-regulation, to rely on external regulation, or to lack regulatory skills altogether (Vermunt and van Rijswijk, 1988). The reported degree of self-regulation has been shown to be related to efficient studying in medicine (Lonka, Lindblom-Ylänne & Maury, 1993) and in many other domains (Vermunt and van Rijswijk, 1988).

Self-regulation in learning is most often related to the deep approach, whereas external regulation is more likely to be accompanied by the surface approach (Beishuizen, Stoutjesdijk & van Putten, 1994; Vermunt and van Rijswijk, 1988). Other combinations, especially self-regulation with surface approach, may result in poor learning outcomes (Beishuizen, Stoutjesdijk & van Putten, 1994).

According to Butler and Winne's (1995) synthetic model, students draw on knowledge and beliefs in self-regulated learning to construct an interpretation of a task's properties and requirements. On the basis of this interpretation, they set goals, which are then approached by applying tactics and strategies that generate both mental and behavioral products. They constantly monitor these processes in order to generate internal feedback. If external feedback is provided, it may confirm, add to, or conflict with the learner's interpretation of the task. In all, self-regulated learning takes place in relation to task demands, domain-knowledge, strategic knowledge, and abilities, in an interplay of self-regulated monitoring versus external feedback. Butler and Winne (1995) point out that learners' perceptions of tasks and cues have an effect on their engagement and performance

of tasks, and learners interpret feedback according to their systems of beliefs concerning subject knowledge, learning processes, and the products of learning.

The effect of study strategies on learning from text. There is evidence both for and against the effectiveness of specific strategies in learning from text (e.g., Kiewra, 1988, Kiewra et al., 1991; Wade & Trathen, 1989; Weinstein & Mayer, 1986). This may be due to a behavioral approach in many studies which aims at determining the effects of an observable independent measure on an observable dependent measure in an attempt to find out "how much is learned" (Mayer, 1984). For example, *underlining* sometimes seems helpful; but in many cases it makes no difference at all, or it may even hinder learning (Hartley, Bartlett & Branthwaite, 1980; Grabe & Holm, 1992). It is possible that this strategy may serve diverse cognitive functions on different occasions. In general, nongenerative strategies are known to enhance verbatim recall, but they are not necessarily more effective than simply reading and rereading the material to be learned (Kardash & Amlund, 1991).

Note-taking seems to have various functions, such as encoding and external storage, and different note-taking techniques vary in terms of how much generative effort is included (Kiewra et al., 1991). Obviously, the quality and content of notes has an effect on the learning outcome. Note-taking may be a generative strategy, but may also include mere verbatim copying. *Concept mapping*, which may be thought of as one form of note-taking, refers to a graphic representation of a text. Usually, concept maps (or networks or cognitive maps) have supported the retention of main ideas (Dansereau, 1985; Rawer, Dansereau & Peel, 1991), promoted meaningful learning (Novak & Govern, 1984; Okebukola & Jegede, 1988) or enhanced summarization and problem-solving skills (Abbott & Hughes, 1986; Ruddell & Boyle, 1989). These results indicate that concept mapping may be especially effective in integrating information with previous knowledge (Mayer, 1984).

The nature of the thought processes that mediate between study strategies and learning outcomes is thus not yet fully understood. Moreover, little is known of the strategies that enhance deep-level *learning from text* (Kintsch, 1986), instead of just recalling the facts included. Without a coherent cognitive theory it is not possible to determine how different strategies affect learning.

The notion of transfer-appropriate processing (Morris, Bransford and Franks, 1977) implies that meaningfulness must be defined relative to particular learning goals. On this basis, the same study strategies may not be meaningful in every context, and their effectiveness is relative to the quality of the learning outcomes that are being measured.

Besides the lack of a coherent cognitive theory, the conflicting evidence about the effectiveness of study strategies may be due to the fact that some of the following factors have not been taken into account. First, study strategies have often been examined under conditions where strategy use is not spontaneous, but students are being trained in using a certain strategy (e.g., Dansereau, 1985; Kiewra et al., 1991; Ruddell & Boyle, 1989; Weinstein, Goetz & Alexander, 1988; Weinstein & Mayer, 1986). Second, in many studies, students are provided a concept map or an outline by the instructor (e.g., Mannes and Kintsch, 1987; Rewey, Dansereau & Peel, 1991). There are other studies where students constructed these conceptual aids by themselves (Novak & Govin, 1984; Okebukola & Jegede, 1988; Ruddell & Boyle, 1989). Third, the qualitative aspects of the learning outcome have not usually been taken into account, or the assessment has been based on mere factual recall (e.g., Hartley et al., 1980; Rewey, Dansereau & Peel, 1991). There are studies, however, where a wider range of cognitive demands, such as problem-solving and thesis-proof, have been called for (e.g., Abbot & Hughes, 1986; Kiewra et al., 1991; Mannes & Kintsch, 1987; Marton & Säljö, 1976, 1984; Mayer, 1984; Ruddell & Boyle, 1989). Finally,

it seems that the results may also depend on whether immediate or delayed recall has been measured; and that qualitative effects of study strategies on remembering may only be evident in the long run (Mannes & Kintsch, 1987; Marton & Säljö, 1976, 1984).

In the present research, it is possible to take into account the first three aspects mentioned above. First, the subjects use study strategies spontaneously, and second, they construct all conceptual aids (such as concept maps) themselves. Third, the qualitative aspects of the learning outcomes are taken into account by comparing subjects' success in various essay-writing tasks that pose qualitatively different demands. The approach to discourse processing is *holistic* (e.g., Kintsch, 1986; Mandl & Schnotz, 1987), which means that the comprehension process is assumed to be less dependent on the text and more dependent on the construction of a mental model of the phenomenon described in the text.

Study strategies and mental representations. For the present, then, it is not quite clear what makes different strategies and orientations produce different learning outcomes. One possible way of approaching this problem is from the perspective of cognitive science. Within the cognitive framework, *the active construction of mental representation* is the central mediating activity between the learning process and its outcome (e.g., Gardner, 1985; Giere, 1988; Kintsch & Kintsch, 1996; Mayer, 1984, 1992). As in qualitative research, the quality and richness of mental representation is considered more crucial than the mere quantity of knowledge. The manner in which knowledge is represented is thought to determine understanding and to influence problem solving, and active transformation of knowledge rather than its reproduction is thought to lead to a deep-level mental representation (Bereiter & Scardamalia, 1987; Chi et al., 1988; Glaser & Bassok, 1989; Mannes & Kintsch, 1987).

A holistic, constructively oriented analysis of study strategies, mental representations, and learning outcomes may prove helpful in understanding the process of learning from text. The cognitive approach allows for predictions concerning when aids will be effective and how they should be used (Mayer, 1984). Van Dijk and Kintsch's (1983) model of strategic discourse processing offers conceptual tools for this task, because they set up connections between constructivist activities in encoding and the quality of the learning outcomes. Their theory differentiates between three forms of mental representation that may be constructed while learning from text: 1) *a surface memory* for actual words and phrases, 2) a *textbase*, in which a coherent representation of the text is formed, and 3) a *situation model*, in which the text content is integrated into the comprehender's knowledge system. The textbase reflects the coherent relations between the propositions in the text and their organization, whereas the situation model is a mental representation of the situation described by the text. Textbase and situation model are not independent of each other, but each has its own characteristics. Kintsch (1986) sees a dichotomy between the two forms of representation, such that *remembering or understanding the text* depends on the textbase, whereas *learning from text* depends more on the situation model.

Surface representation may be thought of as related to surface-level processing (Craik and Lockhart, 1972) or to the surface approach (Marton & Säljö, 1976), whereas the textbase and the situation model require more deep-level processing. It seems likely that forming a situation model requires more constructive processing than forming a textbase (Kintsch & Kinstsch, 1996): whereas a coherent representation of a text is sufficient to support its reproduction, situational understanding is the only way to knowledge that will be easily accessed and beneficial later.

However, it should be noted that detailed learning is not necessarily based on surface representation. Paying selective attention to details may be a highly meaningful activity: Morris et al. (1977) pointed out that even aspects of the learned material that look superficial

may be important, relative to the knowledge possessed by the subjects. Again, van Dijk and Kintsch (1983) have shown that the level of the semantic unit in the textbase hierarchy determines the likelihood of its recall, and main themes or central ideas are thus easier to learn than subordinate details. In a recent study, noting information appeared to have little effect on the recall of that information, once effects due to the importance of the information were statistically removed (Wade & Trathen, 1989). Previous research also shows that recalling a detail is best enhanced with the help of a meaningful framework or by elaboration (Craik & Lockhart, 1972; Marton & Säljö, 1976). A solid textbase offers a frame for recalling meaningful details (van Dijk & Kintsch, 1983), whereas integrating information with prior knowledge may serve to hinder the retention of facts, since the details are changed by the learner (Mayer, 1984).

Mannes and Kintsch (1987) have provided empirical evidence suggesting that different test-taking performances depend on the different kinds of memory representations. In their experiment, students studied an outline providing relevant background knowledge before reading an experimental text. This outline was organized either consistently or inconsistently in relation to the propositional structure of the text. Consistent-outline students performed better than the inconsistent-outline students on cued-recall and recognition tests; they wrote summaries more closely following textual order, and they produced a smaller number of intrusions from the outline material. However, the inconsistent-outline condition did not lead to poorer performance overall. Students in this condition showed superior performance on inference verification tasks as well as on difficult, creative problem-solving tests that required deeper understanding of the material. Mannes and Kintsch's (1987) study was conducted experimentally, and strategy use was thus not spontaneous. The present research will examine whether analogical results can also be obtained in more natural settings.

1.4. Implications for instruction

Cognitive science offers a way of looking at instruction as fostering expertise in students (e.g., Chi, Glaser & Farr, 1988; Ericsson & Smith, 1991). Development of expertise includes qualitative changes in the knowledge base so that novices' conceptions gradually shift from those resembling laypeople towards those resembling experts. In this process, not only declarative knowledge is important, but procedures and thinking skills interact with the changes in the knowledge base.

In all studying, the development of communication skills, such as reading and writing, is important. For instance, Applebee and Langer (1983) emphasize the effect of writing on thinking. Bereiter and Scardamalia (1987; Scardamalia and Bereiter, 1991) call “literate expertise” the academic study skills connected with expertise in various domains. They described two approaches to reading and writing: knowledge telling vs. knowledge transforming. The former refers to an activity that minimizes the cognitive load, whereas the latter engages the learner in effortful and reflective, dialectic processes. Knowledge transforming may have a cumulative effect on learning, because it requires learners to expand their knowledge and work at the upper limits of their cognitive capacity.

Process-oriented instruction. Applebee (1986) has conceptualized process-oriented instruction in the following way: “In process-oriented approaches, the students' goals drive the instructional activity, the teacher stands in the role of collaborator rather than evaluator, and the outcomes are better thought of as procedural rather than declarative knowledge” (p.

107-108). Applebee and Langer (1983) base process-oriented instruction on Vygotsky's (1962; 1978) idea of the social construction of cognitive activity. *The zone of proximal development* is a central concept here, referring to the distance between actual developmental level in independent problem solving, and potential development as determined through problem solving in collaboration with more capable peers (Vygotsky, 1978, p. 86). Applebee and Langer (1983) use the term "instructional scaffolding", adopted from Wood, Bruner and Ross (1976), as a way of describing essential aspects of instruction that are often missing in traditional approaches. They see learning as a process of gradual internalization of procedures available to the learner from the social and cultural context in which the learning takes place. New skills are learned by engaging collaboratively in tasks that would be too difficult to do alone but that can be completed in interaction with the teacher or peers. The role of the teacher is to provide the necessary support (scaffolding) to allow the tasks to be completed, and in the process to provide the learner with an understanding of the problem and of the strategies available for its solution.

The aims of process-oriented instruction have also been presented by Vermunt (1989; 1995). He presents four general principles: 1) Situated teaching of thinking skills so that knowledge and skills are presented within a domain-specific context, 2) cognitive apprenticeship and scaffolding, including a gradual shift in the task division from teacher/peers to student, 3) presenting the content in a way that takes into account prior knowledge and preconceptions, and 4) constructing instructional procedures that are tailored according to both students' skills and the domain. Also, he presents a scheme of four phases of learning guided by the four principles. In the first phase, the thinking strategies and conceptions are diagnosed, instruction is adapted to the learning styles, and constructive frictions are created. In the second phase, activities are taught that students do not master, by gradually withdrawing external support. In the third phase, durability and generalization are practiced. The fourth phase is evaluative, aiming at diagnosing to what extent thinking skills and conceptions have been improved.

Learning by writing. Coursework essays occupy a central place in higher education in many countries. Essay-writing is most often intended to enhance learning. However, essay-writing also serves as a tool of assessment (Hounsell, 1984; McGovern & Hogshead, 1990). In many cases, the latter role seems to dominate in such a way that it may direct students toward a surface orientation. As a result, many students concentrate on performance rather than on learning from writing.

In writing instruction, process-oriented approaches have gradually become quite popular (Applebee, 1986). Since the 1970's and 1980's, research has emphasized the thinking strategies underlying the writing process (e.g., Flower & Hayes, 1981; Bereiter & Scardamalia, 1987). Process-oriented writing instruction has been designed to help students think through and organize their ideas before writing, and also to revise, reflect and rethink during their writing (Healy, 1981). According to Applebee (1986), typical learning-by-writing activities include brainstorming, journal writing, free writing, small-group activities, and emphasis on multiple drafts. He suggests that "properly implemented process approaches are more effective in fostering good writing and breadth of form, and also encouraging more reasoned and disciplined thinking about the topics themselves" (Applebee, 1986, p. 97).

In the teaching of psychology, learning-by-writing activities have been applied in many colleges and universities (e.g., McGovern & Hogshead, 1990; Hettich, 1990). Boice's (1993) review of so-called writing blocks gives support to the importance of process-oriented and activating instruction in academic writing. Boice (1993) concentrates on the

problem of why the tacit knowledge of writing fluency has generally been left untaught. One reason for this is that tacit knowledge is, by definition, hard to teach and difficult to find in written and substantive form. Indeed, the academic environment seems to be far from optimal when it comes to instructional scaffolding.

Activating instruction. Activating instruction is an instructional innovation designed by the author. It is a theoretical synthesis based on Vygotsky's (1962, 1978) ideas, research on applied cognitive science (Bereiter & Scardamalia, 1987; Carey, 1986; Chi, Glaser & Farr, 1988), and models of process-oriented instruction (Applebee & Langer, 1983; Applebee, 1986; Vermunt, 1989). The main idea is to approach university teaching as fostering expertise in students, and to help develop functional mental models of the materials to be learned.

Activating instruction views the act of writing as an aid to students' learning, a tool to be used in acquiring mastery over new information, and a means of revealing present understanding of a given subject (Healy, 1981). The process of writing is supported with the help of peer groups. Learning-by-writing exercises are based on the idea that not just any writing fosters study and thinking skills: exercises that are aimed at enhancing knowledge transforming (Bereiter & Scardamalia, 1987) are the means that may best help development, when carried out in meaningful social interaction. Activating instruction is based on three general principles that can be derived from the points presented above:

1) *Diagnosing and activating*. It is important to diagnose the quality and level of students' (mis)conceptions in the beginning of instruction. The same exercises that make diagnosing possible, like focused free-writing, also help students to activate their previous knowledge. This process of diagnosing must have an effect on how the course will proceed: if some ideas, for instance, seem self-evident to the students, there is no sense in emphasizing them during instruction. Likewise, concepts and theories which appear difficult and counter-intuitive demand special attention.

2) *Fostering the learning process and reflective thinking.* It is essential to make students' strategies and knowledge open to discussion and reflection during the course. The idea of instructional scaffolding may be applied, for example, by using learning logs (or journals), small group discussions and some special forms of focused free-writing.

3) *Giving feedback and challenging misconceptions.* It is important that students get feedback from both their peers and from the teacher. This feedback should not concentrate only on behavior, but on the development of students' thinking. Therefore, the initial conceptions (diagnosed in the beginning) should be taken into account in assessment. After the course is over, it is important to make clear what has been the basis of evaluation and how the student might enhance study habits and approaches in order to make the performance better in the future.

Vermunt (1989) distinguishes between external and shared control in instruction, the former referring to instruction where teachers take over the controlling processes, whereas the latter gives more room for students' self-regulation. He finds shared control more typical of activating and process-oriented instruction, which provides tools for supporting students' self-regulation skills.

1.5. The goals of the present study

Cognitive research seeks to look at the actual processing of information, rather than students' orientations and intentions. However, distinctions between students' approaches to

learning, epistemological development, and cognitive strategies are sometimes hard to make. For example, one of the six main areas of Entwistle and Ramsden's (1983) research program was an *exploration of the cognitive skills, cognitive styles, and personality characteristics underlying different approaches to studying.* Also, they sometimes found some problematic overlap in their scales: "The 'elaborative processing' scale is truly a measure of process — every item describes a process, while 'deep processing' contains an unfortunate mixture of process and outcome" (Entwistle & Ramsden, 1983, p. 95).

To synthesize the traditions described above, analyses of students' learning in different domains show that conceptions of learning, approaches to learning and levels of processing may be roughly divided into two categories: *surface-level reproduction* (or memorizing) versus *deep-level transformation* (or construction) of knowledge, the latter being associated with qualitatively better learning (Bereiter & Scardamalia, 1987; Eklund-Myrskog, 1996; Entwistle & Entwistle, 1992; Entwistle & Ramsden, 1983; Marton & Säljö, 1976; Marton, Hounsell & Entwistle, 1984; van Rossum & Schenk, 1984; Ryan, 1984; Säljö, 1979; Thomas & Bain, 1984; Vermunt & van Rijswijk, 1988; Vauras, 1991).

Instead of being a problem, the interplay between approaches and strategies may be the key for the understanding of student learning. For instance, Kirby & Pedwell (1991) showed that distinct text summarization conditions affected learning in different ways, depending on the students' approach: text-absent summarization facilitated deeper processing for those students who normally adopted a deep approach (especially in the case of a difficult text), whereas the text-present condition brought out surface processing in those who were prone to it. Biggs (1988) presented two case studies on essay writing, indicating that a surface approach was related to focusing on a word-sentence level and a knowledge-telling type of strategy, whereas a deep approach was related to a deep-reflective approach to writing (resembling knowledge transforming).

We can also look at these complex interactions at the metalevel (Biggs, 1988; 1993; Butler & Winne, 1995.) Table 1 shows theoretically assumed relations between approaches and ways of processing information. At this point, they are presented as a dichotomy, which naturally oversimplifies the picture. Although the five studies which constitute this thesis deviate in methodology, the common theme is to differentiation between processes, predispositions, and conceptions that are assumed to lead either to superficial or deep-level learning. The empirical studies explore the type of processing and content of essay-type answers in relation to exam-success (I), the relation between spontaneously used study strategies and qualitatively different outcomes of learning (II), the applicability of constructivist notions in instructional innovations (III), conceptions of learning in relation to expertise (IV), and the interplay between conceptions of learning, epistemologies, and study strategies (V).

All the domains concerned are ill-structured in nature, namely, philosophy, psychology and medicine. The first two studies are based on cognitive research on learning and study strategies. They look at knowledge construction in two highly demanding situations, where we can assume that subjects are truly trying their best: the secondary school matriculation examination (I) and the entrance examination for medical school (II). It was assumed that active knowledge transformation during learning would lead to a flexible and rich mental representation of the materials to be learned, which, in turn, would facilitate writing essay-type answers. However, active knowledge transformation and elaboration during the writing process may also compensate for a lack of transformation during the learning process: the subjects may try to "write around their ignorance" (Scardamalia & Bereiter, 1991). Probably the worst outcomes would result from both a surface approach to

reading plus knowledge-telling during writing, because then constructive activity would be minimal in both phases.

Table 1.
Different aspects of studying.

Processes, predispositions, and conceptions that may lead to:	
a) Superficial learning	b) Deep-level learning
APPROACH (Entwistle & Ramsden, 1983; Marton & Säljö, 1976)	
Surface	Deep
ORIENTATION (Ramsden, 1988; Kirby, 1988; Biggs, 1993).	
Reproducing	Meaning
STUDY AND LEARNING STRATEGIES (Weinstein & Mayer, 1986; Bereiter & Scardamalia, 1987; Entwistle & Entwistle, 1992; Thomas & Bain,1984; Vauras, 1991)	
Rehearsal	Elaborative, Organizational
Knowledge telling	Knowledge transforming
Reproduction	Transformation
SELF-REGULATION (Butler & Winne, 1995 Vermunt & van Rijswijk, 1988)	
Teacher-regulated learning	Self-regulated learning
EPISTEMOLOGICAL STANDARDS (Ryan, 1984)	
Knowledge criteria	Comprehension or Application criteria
CONCEPTIONS OF LEARNING AND EPISTEMOLOGIES (Bereiter & Scardamalia, 1989; Lonka, Joram & Bryson, 1994; Perry, 1968; Vermunt & van Rijswijk, 1988)	
Non-intentional	Intentional
Passive Epistemology	Active Epistemology
Dualist	Relativist
Intake of knowledge	Construction of knowledge

In *Study I*, the relation between knowledge base and type of processing will examined by analyzing students' essay-type answers about psychology in the national secondary school matriculation examination. Is, for example, experiential knowledge treated differently from school knowledge? In this study, it is not possible to infer what kind of processes may have produced the outcomes of learning. However, it is possible to see whether students handle their knowledge differently in theoretical and applied tasks, and what kind of knowledge construction is rewarded in the Finnish matriculation examination. In *Study II*, the relation between spontaneously applied study strategies and knowledge construction will be looked at in a highly motivating real-life situation, namely, an entrance exam for medical school. The tasks are designed to call for deep-level text comprehension of a philosophical text. The idea is to test the assumption that different kinds of study activities have an effect on the quality of mental representation, and therefore on performance in different kinds of essay-type tasks. It is hypothesized that generative study strategies enhance the formation of a situational model, whereas less generative strategies may lead to a more text-based representation.

Study III is an intervention study. It explores the applicability of constructivist ideas in developing instructional procedures in higher education. A case study on a psychology department is presented, where teachers are trained to apply activating instruction, and students' progress is then followed for a six-year period. The intervention is general in nature, and the measures are quite global. However, a longitudinal follow-up study will provide information about the relation between the instructional procedures and students' academic progress.

The last two studies explore epistemologies and conceptions of learning, and more specifically, the impact of training on them. Both studies investigate whether conceptions of learning and knowledge are domain-specific, and examine the relevance of students' theoretical ideas to their applications or study behaviors. However, theories and applications are measured by using paper-and-pencil tasks, and thus it is not possible to look at actual real-life performance:

Study IV investigates whether experts in educational psychology are different from novices or laypeople. Are experts' conceptions more coherent with their applications than those of novices? Also, what happens to students' conceptions of learning during their first six-week introduction in educational psychology? *Study V* probes medical and psychology students' approaches to learning, conceptions of learning and epistemologies, as related to the preferred study strategies expressed by the students. Are constructivist notions of learning more typical in medicine or in psychology? How are conceptions and strategies interrelated? When we look at first-year and fifth-year students in these two domains (by using a cross-sectional methodology), what kinds of differences can we find across fields and phases of studying?

2. STUDY I

Even though global grading of examination essays is considered an easy task by teachers, they find it difficult to state their criteria with precision. There are some qualities in every answer that reflect the way information is understood and used. But how can these be defined exactly?

Norton and Hartley (1986) found a strong correlation between the length of an examination essay and the mark obtained. The question may be raised, what does this correlation indicate. Are there a greater number of relevant topics or facts treated in long essays? Or is the subject being treated in a special way? For instance, more elaboration might be used. However, elaboration may occur more easily when students know the content area well (Bereiter & Scardamalia, 1987). That is, the quality of the content and the quantity of facts presented may interact with each other.

The present study looks at the content base of students' essays, the way they process this knowledge, and also *the interaction of these two*. For this purpose, a twofold classification scheme was used. The length of the essays was taken into account to compare the effects on the length of the content base and the way information is handled. It was assumed that elaboration would take more space in the text than would reproducing facts. This assumption was based on approaching elaboration as enriching information with additional associations (e.g., Anderson, 1985). It was assumed that the number of words used would reflect these associations, and also, the number of facts presented. It was also interesting to see, how knowledge would be handled in two separate sets of data: would an application task call for different treatment than a theoretical question?

2.1. Method

Samples. Two samples of short essay answers of Finnish high school graduate candidates in the examination of Modern Subjects were selected (the normal age of graduating is 19). These essays[6] treated psychology and they were picked out randomly from schools all over Finland. There were 350 essays from the year 1983 (Theoretical Task) and 350 essays from the year 1985 (Applied Task). These samples were chosen because the titles of the essays resembled each other: "Why do people forget?" (Theoretical) and "Why do we forget in school work?" (Applied).

Procedures. The essays were analyzed using a special classification system. In this system the unit analyzed was called "*a thought*", defined as *a unit which is coherent in its contents and which can be expressed with one or more sentences.* Usually, though not necessarily, different thoughts were separated as paragraphs. Each thought was classified separately.

The classification scheme was the following:

[6] The essay answers in this study were relatively short, approximately 200 words. They ought to be called "essay-type answers" and not "essays". But the latter term is also used here for practical reasons.

1. *Single-aspect school knowledge* included information which had been acquired from books, lectures, and psychological publications.
2. *Illustrated school knowledge* was enriched by illustrations, such as describing psychological experiments.
3. *Multi-aspect school knowledge* was found when different aspects of knowledge, such as different points of view, were connected to each other within one thought.
4. *Pseudoknowledge* meant that the writer pretended or thought to know something which was not known: a misunderstanding or a false statement.
5. *General knowledge* covered knowledge outside psychology, such as history or technology.
6. *Experiential knowledge* was based on the writer's personal experiences and observations.

In the case of combination of two different knowledge bases within a thought, the thought was classified as belonging to these two classes at the same time. In addition to the six basic classes there were 13 possible combinations.

The type of processing required by the different thoughts was classified independently of their content as reproductive or elaborative. Reproduction meant that a fact was stated as it was presented in the source. Elaboration occurred when the writer presented reasons for or drew conclusions from the facts mentioned. The system was developed after all the essays had been read once. During the second reading every thought in the essays was placed in some class. The procedure involved (1) separating each thought as a unit, (2) determining its knowledge base and the type of processing, (3) indicating its length by number of words.

2.2. Results

The most common knowledge base in both samples was "single-aspect school knowledge", whereas "pseudoknowledge" or "general knowledge" were very rare. More school knowledge was used in Theoretical than in Applied Task. In Applied Task, the school knowledge was considerably more often combined with experiential knowledge and it was also more often elaborated. The distributions of thoughts differed significantly between Theoretical Task and Applied Task (χ^2 (7) = 342,8, $p < 0.001$).

School knowledge was less liable to elaboration than were other classes of knowledge base. Especially, when single-aspect school knowledge was used, it was usually reproduced as shown in the books. In the Theoretical Task, elaboration occurred in 41 % of the thoughts, whereas in the Applied Task, 54 % of the thoughts were elaborated. Elaborated thoughts were approximately 10 words longer than reproduced ones. This difference was statistically significant in the two independent samples and across all essays (t (3170) = 11.6, $p < 0.001$).

Table 2 shows the correlations between some qualities of the essays and the grade obtained. The most important determinants of success appeared to be length, the number of

thoughts and the amount of school knowledge in an essay. Type of processing was not decisive. The two samples differed in certain respects: students had to use elaboration and also other than school knowledge in order to get good marks in the Applied Task. But in answering the Theoretical Task, only the use of school knowledge was of importance; the use of other knowledge was more of a hindrance than a help.

Table 2.
Correlations between the Grade Obtained and Qualities of an Essay. Theoretical Task (N = 350) and Applied Task (N=350).

	Grade	
	Theoretical Task	Applied Task
Length in words	.60**	.69**
Number of thoughts	.48**	.58**
Number of elaborated thoughts	.21*	.41**
Number of reproductive thoughts	.33*	.30*
Amount of school knowledge	.59**	.65**
Amount of general/exp. knowledge	-.27**	.29**
Amount of pseudoknowledge	-.30**	-.19*

* $p < 0.01$ ** $p < 0.001$

Of different types of school knowledge, multi-aspect knowledge correlated significantly with grades while other kind of school knowledge appeared to be less useful (in Theoretical Task, $r = .21$, $p < 0.01$; in Applied Task, $r = .18$, $p < 0.01$).

The structure of the essays indicated that there were some differences in using experiential knowledge in the two samples. Table 3 shows that this was also connected with the grade obtained in different kinds of tasks. In the Theoretical Task the grade correlated with school knowledge presented alone (either reproduced or elaborated), whereas in the Application Task the combination of experiential and school knowledge was appreciated. It should be noted that experiential knowledge in the latter sample helped only if it was elaborated. Otherwise its correlation with the grade was negative.

Table 3.

Correlations Between Grade Obtained and Number of Thoughts Containing School Knowledge Alone or Connected with Experiential Knowledge.

	Grade			
	Theoretical Task		Applied Task	
	Reproduced	Elaborated	Reproduced	Elaborated
School knowledge alone	.25**	.28**	.12	.10
School knowledge and experiential knowledge together	-.13	-.15*	-.15*	.25**

* $p < 0.01$ ** $p < 0.001$

2.3. Discussion

The contents of the two samples differed considerably. Although the titles referred to the same general topic, memory, the differences changed the orientation of the writer. School knowledge dominated the content in both samples. But the role of experiential knowledge proved to be decisive regarding the amount of elaboration: if the school knowledge was connected with personal experience and observations, elaboration occurred more easily. The theoretical question did not seem to provide enough prompts for elaboration. If this finding can be generalized across other topics, it can thus be seen that school knowledge is treated differently from the other sources of information. As soon as one is able to connect theoretical knowledge with something familiar and well internalized, elaboration occurs naturally and the manner of treatment changes. Pure school knowledge is often just reproduced as presented in the books.

Elaborated thoughts were systematically longer than reproduced ones in two independent samples. This phenomenon has a natural explanation: obviously more words are needed to give grounds of draw conclusions than simply to reproduce. Nevertheless, the regularity of the phenomenon was striking.

The length of an essay, the number of thoughts in it and the amount of school knowledge seemed to be of importance when determining the grade. The role of experiential knowledge differed between the two samples: writing on the basis of experience was regarded as an advance in an applied answer, while on the contrary, it was not rewarded in a theoretical one.

Elaboration was of importance when linked with appropriate content. If a combination of school knowledge and experience was used, elaboration was valued in an applied task. School knowledge, on the other hand, was rewarded in a theoretical task irrespective of it being reproduced or elaborated. The amount of elaboration determined the length of an answer and length correlated with grade. Still, correlation between the amount of elaboration and the grade was not significant as far as the theoretical task was concerned.

In both samples, the amount of school knowledge appeared more decisive. Multi-aspect school knowledge was most appreciated by the raters.

The aim of this study was twofold. First, a cross-classification scheme was developed, where both the content and the type of processing were taken into account. Secondly, with the help of this method, the features of two samples of short essay-type answers and their connections with the grades obtained were looked at.

This approach proved to be fruitful. It produced important information concerning the writing process. It seems that if a writer directs all cognitive capacity to fact recalling, elaboration will not occur. Is the goal of writing to reproduce facts or is it to arrange the facts in a new way, that is, to think and express oneself originally? In other words, is the knowledge being told or transformed (Bereiter & Scardamalia, 1987)? It seems that the former may be the more common way of producing an examination essay answer. But, while elaboration appears to be rarer than reproduction, it may also be more appreciated by the teachers.

The results show how important it is to react appropriately to titles. Students have to be able to use knowledge in a flexible way, which requires integration of knowledge in their minds. Teachers should pay more attention to the fact that not all students are able to use knowledge in a meaningful way in examinations. Previous research indicates that the best way to practice skills of knowledge construction may be to write about different topics and, at the same time, to practice different kinds of processing (e.g., Langer & Applebee, 1987) Mannes and Kintsch (1987) have shown how different levels of test-taking performance may depend on different forms of memory representation. Study II will explore this assumption more closely by looking at how different study strategies lead to success in qualitatively different essay-type tasks.

3. STUDY II

Recent research on spontaneous study strategies has helped us understand what it means to be an effective learner (Kardash & Amlund, 1991; Pressley et al., 1990; Thornton, Bohlmeyer, Dickson & Kulhavy, 1990; Wade & Trathen, 1989; Wade, Trathen & Schraw, 1990). However, no general agreement exists regarding the advantages of different study strategies. Furthermore, not enough research on spontaneous strategies has been carried out in truly motivating, ecologically valid learning situations.

The purpose of the present study was to obtain information regarding overt study strategies that high-school graduates in Finland spontaneously use while learning from text in a highly demanding and motivating situation, namely, in an examination taken for admission to a medical school. The subjects constructed all conceptual aids (e.g., concept maps) by themselves. Specifically, the intention was to assess qualitative effects of these spontaneous strategies in terms of success in different types of essay-writing tasks designed to measure detailed learning, the ability to form a synthesis of a text, and the ability to review knowledge critically. Three hypotheses were tested, based on van Dijk and Kintsch's (1983) cognitive model of strategic discourse processing. Generally, different spontaneous strategies in learning from text were thought to result in different memory representations and, therefore, in qualitatively different learning outcomes.

Hypothesis 1: Learning a minor detail requires using some specific strategy because the organization of the text does not support its remembering. Again, a central idea may be learned more easily than a detail, regardless of the strategy used. This hypothesis was based on Dijk and Kintsch's (1983) suggestion that a minor proposition in the text hierarchy will be less likely to be recalled than a major proposition (see also Mayer, 1984).

Hypothesis 2: Strategies that maintain a text-based representation of study materials, such as underlining, are related to success in a task which requires a synthesis of the text. This hypothesis was based on the idea that forming a synthesis of the text would require strategies that strengthen internal connections between propositions in the text.

Hypothesis 3: Generative study strategies that enhance forming a situation model of the study materials, such as concept mapping, are related to success in a task which requires critical review of the text. This assumption was based on the idea that concept mapping would require integrating information with previous knowledge.

Previous research shows that note-taking may serve different cognitive functions (Kiewra et al., 1991). Therefore, underlining was chosen to represent a nongenerative strategy that would be most likely to maintain representation organized according to the text (even if this strategy may possibly serve diverse functions, too), and concept mapping was chosen to represent a generative strategy that would most likely enhance situation model. Thus, these two strategies were chosen to examine the second and third hypotheses, representing two opposite extremes of strategy use on two dimensions: nongenerative versus generative, and textbased versus situational.

3.1. Method

Subjects. The participants were the 503 applicants to the Helsinki University Medical Faculty in spring 1988. Most of the applicants were very good students, 70% having an A-level (Laudatur) high school diploma. All of them had to participate in an entrance examination in order to apply for admission to a 6-year study program combining medical school and graduate studies. Out of these subjects, a random sample of 200 subjects was chosen for more detailed study.

Materials and Procedures.

Entrance exam. In addition to other parts of the test which measured factual scientific knowledge, one 3-hour portion of the entrance exam to medical school assessed reading comprehension and essay-writing skills. In this last test, subjects were first asked to read an article written by the Finnish philosopher G. H. von Wright (the last chapter of his book 'Science and Human Reasoning,' published in Finnish). The text was about scientific-technological developments and their consequences for human welfare and the ecological balance of nature. There were 4021 words in the text. The text was loosely organized around 8 themes, numbered by the author. The idea was that subjects would not have time to read the text more than twice. Instead of trying to learn the whole text by heart they had to concentrate on essentials.

During reading, subjects were allowed to make notes either in the text or on an attached blank sheet of paper. At this time, they were not aware of the nature of the tasks they would be presented later. After 90 minutes of reading time, all the materials where collected and subjects were given three essay-type tasks. They were told that they would be credited not only for the content, but also for clear presentation and concentrating on essentials. Here, they had another 90 minutes to complete three different tasks:

In the *Detailed Learning Tasks*, two concepts from the text had to be explained to a reader who had no previous knowledge of philosophy. In the Detailed Learning Task 1, the concept (hereafter, called Concept 1) was the 6th main theme of the text ("the difference between wishes and needs") located in the middle of the text. In the Detailed Learning Task 2, the concept (hereafter, called Concept 2) was a subordinate detail on the last page ("double alienation," referring to humans being first alienated from their environment and then from human nature). Thus, Detailed Learning Tasks were thought to measure both recall and comprehension (i.e., being able to explain) of a central idea and a detail from the text. In the *Synthesis Task*, the title of the article had to be explained. This called for pulling together the essentials of the text. The Synthesis Task was thought to measure the formation of coherent textbase, or a synthesis of the text. In the *Critique Tasks*, subjects were given two paragraphs of the text (called Critique Tasks 1 and 2) which were to be critically reviewed on the basis of the subjects' general knowledge. The Critique Tasks were thought to measure the formation of a situation model, or the ability to go 'beyond' the text. The answers to each task were to be written within a given space in the answer sheet.

A detailed a priori scoring system was applied to the answers by two official raters. The scores for each of the three tasks, varying from 0 to 10, were available to the researchers: In each task, six points were given on the basis of content, and four points on the basis of the

quality of the argument, that is, whether the answer was understandable, logical and coherent.

Questionnaire. All participants had completed a one-page questionnaire about what strategies they had used while trying to learn from the text. They were asked to score 'no' or 'yes' on whether they had underlined important parts, made notes on the text paper, made notes on the separate sheet, drawn maps of the relations between concepts, defined central concepts by their own words, or used a strategy of their own not mentioned in the questionnaire (and if yes, describe that strategy). Also, the subjects were asked to check whether the strategies they used were typical of them, whether they sometimes used them, or whether they had never used them before. The answers of the 503 participants were analyzed.

Analysis of notes and text papers. Text papers and notes of 200 participants were analyzed in terms of underlining, concept mapping, and other notes on the text paper and a (blank) separate sheet. The total number of different kinds of notes was determined (from 1 to 6) as 1) underlining, 2) concept maps, 3) whole sentences on the text paper, 4) whole sentences on the separate sheet, 5) single words or marks on the text paper, and 6) single words or marks on the separate sheet. Each strategy was scored only once. The analysis of notes on the text paper was restricted to three sections of the article: the first page (182 words), the middle page (8th page, 220 words), and the last page (17th page, 173 words). It was determined whether Concept 1 or Concept 2 were underlined, written on the text paper, written on the separate sheet, defined by own words, included in the notes, or included in the concept maps, and also, how many of these strategies were applied for learning each concept.

Statistical procedures. The sample of 200 subjects was divided into three groups on the basis of percentiles. This was done for the total exam scores, and separately for each task. The frequencies of different strategies on the basis of the questionnaire as well as the correlations between scores obtained in different tasks were calculated within the whole group (N = 503). Also, the sample (n = 200) and the rest of the subjects (n = 303) were compared to each other by using a repeated-measures MANOVA design (2 groups of subjects x 5 tasks).

A more detailed analysis of study strategies was carried out in the sample of 200 subjects. The groups Below Average (BA), Average (A) and Above Average (AA) of different tasks were compared by one-way ANOVAs and chi-squares. In the sample, log-linear models were also applied in order to test the second and third hypotheses.

Chi-squares and log-linear models were favored, because in many cases, the distributions were very biased due to the natural settings. In this study, the model fitting was done on the basis of hypotheses, not stepwise. A theoretically constructed model was first screened by looking at the contingency tables, partial and marginal associations and individual parameters (lambdas, lambdas/SE), and residuals (Kennedy, 1988; Tabachnick and Fidell, 1989). After that, model fitting was done by finding a likelihood ratio statistic, G^2 , for a particular model and evaluating its significance.

3.2. Results

Popularity of different strategies: Some descriptive data. Descriptive information of subjects' strategy use was considered important. The first step of the study was to see, what kinds of spontaneous strategies the subjects reported and what appeared in their notes. Most subjects (72%) reported that the strategy they had used was very typical for them. About a

quarter of the subjects (23%) had sometimes used the same strategy, only 2 % had used a strategy in this test that they had never used before, and 2% did not answer this question.

On the basis of notes (n = 200), 91% of the subjects had underlined (59% used different underlining styles such as thick lines and thin lines to organize the text), 73% had written notes on separate sheet, 74% had defined or written concepts or symbols on the text paper (56% used special marks, such as question marks in the marginals), 20% had written whole sentences on the text paper, and 22% had drawn concept maps. The mean number of different strategies used was 3.0 (SD = 1.17).

Study strategies applied and scores obtained.

Total scores. The relationship between total scores and number of strategies was looked on the basis of analysis of notes to be as accurate as possible. Measured by total scores (n = 200), above average subjects used a more diverse set of strategies, the mean of different strategies being 3.27 (SD = 1.09) than did average subjects (M = 3.01, SD = 1.15), and below average subjects used the smallest number of different strategies (M = 2.68, SD = 1.21). Differences between these three groups were statistically significant measured by one-way ANOVA ($F(2,195)=5.90$, $p < .05$). Since the whole test consisted of tasks measuring very different aspects of learning, the interactions between strategies and total scores were not looked at any further.

Detailed recall. The first hypothesis stated that any study strategy aimed at actively manipulating a subordinate detail would enhance its remembering, whereas a central idea would be learned regardless of what strategy was employed. This section aims at verifying the first hypothesis, and it is based on the analysis of notes (n = 200).

In the Detailed Learning Task 1 (demanded explaining a central idea, Concept 1), there were no significant differences among below average, average and above average groups in applying different strategies. The only trend showed that those who had defined the central idea scored slightly better, but this trend was not statistically significant (p = .09).

Those subjects who had either defined Concept 2 (a minor detail), underlined it, or written it down on the separate sheet, obtained a significantly higher score in Detailed Learning Task 2 than the other subjects ($p < 0.001$). Neither writing the concept on the separate sheet nor including it in a concept map made any significant difference.

More selective attention was paid to Concept 1 than to Concept 2: Only 15% of the subjects used more than one strategy for learning Concept 2, whereas 68% used more than one strategy for learning Concept 1. Also, Concept 1 was more often underlined (85% vs. 38%), written down (58% vs. 14%), defined (46% vs. 11%), or included in a concept map (13% vs. 4%) than was Concept 2.

As general strategies, underlining and concept mapping were not related to success in Detailed Learning Task 1. However, there was an interaction between underlining and success in Detailed Learning Task 2. This trend did not quite reach statistical significance ($\chi^2(2) = 5.9$, p= 0.053).

Log-linear models: examining the interactions. In this study, log-linear models were applied in order to simultaneously test our all assumptions about the interactions between study strategies and success in different tasks. Especially, the second and third hypotheses were tested, which suggested that underlining would be related to success in the Synthesis Task, whereas concept mapping would be related to success in the Critique Tasks. Also, it was assumed that the Synthesis Task would measure different aspects of learning from text than the Critique Tasks. Therefore, it was assumed that underlining would interact only with scores obtained from the Synthesis Task and not with concept mapping or with the Critique

Tasks, whereas concept mapping would interact only with scores obtained from the Critique Tasks and not with underlining or the Synthesis Task. Table 4 shows contingency tables that supported the hypothesis. However, the idea was to test the whole combination of interactions at the same time. The models were based on the hypotheses, and stepwise analyses were not applied. Instead, two theoretical models were devised, and their fit with the data was then tested using the sample of 200.

Model 1 tested the assumptions that Synthesis Task (below average, average, above average) interacts with underlining (never/yes), Critique Task 1 (below average, average, above average) interacts with concept mapping (never/yes), and that there are no other interactions among these variables. This model fit well with the data ($G^2(25) = 12.88$, $p = .978$). Model 2 was identical to Model 1, except that Critique Task 2 was included instead of Critique Task 1. This model had an even better fit ($G^2(25) = 11.95$, $p = .987$). In either model, no other partial associations reached significance except those included in the model. Marginal associations provided similar results as the partial ones, and residuals were approximately normally distributed on the basis of plots. Also, without the correction procedure of adding a constant in each cell, both Model 1 ($G^2(25) = 21.56$, $p = .661$) and Model 2 ($G^2(25) = 17.98$, $p = .843$) still fit very well. In sum, there were no major discrepancies between the theoretical models and the data.

Table 4
Success in Different Tasks as a Function of the Use of Concept Mapping and Underlining (n = 200).

	Strategy				
	Underlining			Concept Mapping	
	Not Used	Used		Not Used	Used	
Success	(*n*=18)	(*n*=182)	χ^2	(*n*=155)	(*n*=45)	χ^2
		Detailed Learning Task 1				
Below Average	4	29		29	4	
Average	13	132		109	36	
Above Average	1	21		17	5	
			0.9			2.5
		Detailed Learning Task 2				
Below Average	10	51		47	14	
Average	4	65		55	14	
Above Average	4	66		53	17	
			5.9			0.3
		Synthesis Task				
Below Average	10	45		45	10	
Average	4	88		68	24	
Above Average	4	49		42	11	
			8.2*			1.4
		Critique Task 1				
Below Average	11	71		69	13	
Average	5	78		64	19	
Above Average	2	33		22	13	
			3.3			6.4*
		Critique Task 2				
Below Average	6	62		55	13	
Average	9	85		78	16	
Above Average	3	35		22	16	
			0.1			10.4**

*) $p < 0.05$; **) $p < 0.01$

3.3. Discussion

As our first hypothesis stated, either the position of the concept in the text or its importance directed students' attention, so that learning a minor detail was easier if it was underlined, defined, or written down. Our data also indicated that more strategies were used to learn a central idea than to learn a minor detail. However, the central idea was learned regardless of strategy use. This finding is coherent with the idea that the position of a concept in the propositional hierarchy of the text determines the likelihood of its recall (van Dijk & Kintsch, 1983).

It is possible that the difference between detail and central idea would have been smaller if the task had required only recognition instead of reproduction (Rewey et al., 1991). On the basis of Spiro's (1977) reconstruction hypothesis, it is also possible that those who were successful in the detailed learning tasks, had produced inferences during reading which helped them to optimally estimate whether they needed to pay attention to a concept by using different overt study strategies. Therefore, some good learners possibly judged that they could remember a main theme without underlining or otherwise manipulating it.

Our results give support to the second and third hypotheses that underlining was related to success in a task that required synthesis of the text, whereas concept mapping was related to success in critique tasks. This may be interpreted in line with Mannes and Kintsch's (1987) results, which indicated that memory of text depends on somewhat different mental representations than learning/problem-solving.

The fact that the effect of different strategies interacted with the nature of the task, and that subjects very seldom used a strategy they had never tried before, poses challenges to educators. The conditions for using different strategies should be analyzed more carefully, and students should be made aware that alternatives exist for the most ordinary strategies. The training should focus on conceptual understanding of the effects of different strategies on learning, and not only on overt study strategy behavior. Both van Dijk and Kintsch's (1983) model and Mayer's (1984) model provide conceptual tools for this kind of training, which would enhance students' metacognitive awareness of their learning processes (Weinstein & Mayer, 1986). However, study strategy training is problematic, because mature learners develop their own individual procedures for remembering complex material, and once a study strategy has been composed and proceduralized, it is extremely difficult to change (Thornton et al., 1990). Training might be most effective, if students constantly faced a variety of new learning situations and were motivated to revise their strategies if found insufficient. These learning situations ought to be such where mere reproduction would simply not be reasonable. Study III will explore the possibilities of organizing instructional procedures aiming at such goals, although the intervention is quite general in nature.

4. STUDY III

The main objective of this study was to develop new approaches to instruction at the university level. In addition to new instructional procedures, it was intended to develop a conceptual framework that would help teachers to look at instruction from the student's point of view. This is a case study of development in one psychology department during six years. There are some features of action research, since experience has constantly modified the project. Therefore, the intention is not to present directly generalizable results, but rather, to stimulate theoretical and practical ideas for developing new instructional approaches in higher education.

This paper concentrates on describing the theoretical framework and giving some samples of activating psychology courses. In addition, six-year follow-up data are presented, as well as students' evaluations of different courses, both activating and traditional.

The ill-defined nature and open-endedness of psychology (e.g., Staats, 1983) poses special demands to instruction. Particularly, epistemological development must be fostered to enhance deep processing and theoretical thinking (Marton, Hounsell, & Entwistle, 1984; Perry, 1970; Ryan, 1984). It is possible that traditional instruction does not sufficiently support students' conceptual and epistemological development, which assumably is especially important for psychology students. On the contrary, it is possible that students have difficulties in developing theoretical conceptions, if instruction is strictly teacher-centered and fact-oriented.

The following sections describe how activating instruction may be realized in concrete settings. The evaluation of the outcomes is not a simple mission, and requires innovation also.

4.1. Method

Subjects. In Finland, students participate in an entrance examination in order to apply to a 6-year study program combining undergraduate and graduate studies in psychology. This program gives the legitimate right to act as a professional psychologist.

A total of 114 psychology students took part in the study. They had started their studies in 1982, 1984, and 1986: Course 82 (Traditional), Course 84 (Mixed), and Course 86 (Activated), respectively. Of these students, Course 82 (n = 44) did not participate in activating instruction, Course 84 (n = 33) were introduced the new methods in the middle of their studies, and students from Course 86 (n = 37) started in the redesigned curriculum.

Instructional methods and procedures. The Department of Psychology was used as a "laboratory" for instructional innovations. The structure of the whole curriculum was redesigned in cooperation with the students in 1985. Teachers were trained to apply activating instruction.

The instructional methods were various. They included journal writing and learning logs, different learning-by-writing activities, such as focused free-writing, activating lectures, and a so called Suzuki-method in laboratory courses, where students were challenged with a very difficult research problem in the beginning of their studies. A total of 10 professors and teachers conducted different kinds of activating courses during the Academic Years 1986-1987 and 1987-1988. Later, most of them continued activating instruction as their steady approach to teaching. Two examples for concrete procedures are presented: an activating lecture and a writing-process seminar.

An activating lecture. The central idea of an activating lecture is that the teacher does not view lectures as situations where knowledge is presented by the teacher and acquired by the students. Rather, the control of the learning process is shared (Vermunt, 1989) in a way that students have the right and the responsibility for active participation. In the beginning of the term, a pretest is administrated which aims at diagnosing central conceptions and domain-specific knowledge. Students' learning styles may also be diagnosed. Students are given feedback of their performance and possible misconceptions are being discussed. Also, the information provided by the pretest is used for tailoring the course according to students' needs.

In the beginning of sessions, students are often asked to write about the topic or a central question for 5 minutes. After this, they are asked to read out loud what they have written to a group of 3 to 4 students. The small group then thinks about what they know about the topic and what more they need to know. Finally, each group presents their summaries and questions to the teacher. Afterwards, a lecture or a discussion may take place, or students go to library for more information. This technique, called "stealing", is modified on the basis of Healy (1986). The idea is both to diagnose previous knowledge and to activate the domain in students' minds. The knowledge is not given by the teacher, but instead, constructed by the learners.

In the end of each session, students write learning logs where they discuss what they have learned, what more they would like to know, and what puzzles them about the domain or what is problematic in their own learning. The teacher then reads the logs or at least samples of them. In the beginning of the next session, the logs are discussed and feedback given. Also, the idea is to take logs into account in future instruction and clarify those points that were unclear or hard to understand. The use of learning logs helps the teacher to support the learning process. Also, writing a log helps students to be more reflective on their own learning.

From time to time, the teacher may lecture in a quite traditional way. However, since the students continuously engage in various activities and gradually learn to share their learning process with the others, they are quite likely to participate in discussion. The teacher should not be too rigid. It is not a good idea to plan beforehand a tight schedule for a lecture intended to be activating. Instead, the teacher must be well aware of what are the central points that the students are supposed to understand after the session is over.

The assessment is an essential part of an activating lecture, because students' learning is known to be regulated by expectations regarding the exam (e.g., Vermunt, 1989). Therefore, the exam aims at diagnosing the central domain-specific conceptions and thinking skills. Usually, the exam takes place two weeks before the end of the course. After this, a feedback session is arranged where the exam papers are discussed.

A writing-process seminar. The objectives of writing-process seminars are: to prevent blocks in writing, to support the development of students' writing process, and to enhance their ability to write scientific papers in their own domain. Especially, the seminars are thought to support the future thesis writing.

In the beginning of the term, students are asked to write freely on different topics and read out loud what they have written. Then they are trained to apply gentle feedback strategies on each other's drafts (adopted from Healy, 1986): 1. While one student is reading, the others listen carefully and write down strong points, that is, important and good ideas, and questions (i.e., what they do not understand). 2. After the writer has finished reading, he/she is asked questions and presented strong points. 3. The writer underlines the strong points and writes down the questions. It is important that the students do not start discussion at this point, because the questions are to be answered in the second draft. Also, it is the writer's task to decide which comments are going to be taken into account. Also, students are provided metalevel knowledge on the writing process by presenting them research on different writing strategies (e.g., knowledge telling and knowledge transforming by Bereiter & Scardamalia, 1987). They are given advice in practical matters, such as how to write references. Finally, students are helped in finding a topic to write about. This is done by asking them to write short drafts on topics that they are interested in, and by giving them feedback on how to restrict the topic.

In the middle of the term, students bring the first draft of their essay to the seminar. All participants read the drafts beforehand, and gentle feedback is provided. It is possible to discuss 2-3 drafts during one session. After this, students go on writing the final version. In the end of the term, all students give a conference-like paper presentation. As in real conferences, they bring in the final version of their paper. This is read beforehand by all participants. Also, each student prepares an oral presentation. Each presentation is 15 minutes and after that, a discussion of 15 minutes takes place. Thus, 2-3 presentations are given during one session.

Evaluation of Activating Instruction.

a) Questionnaires. Course 86 (Activated) were sent questionnaires after their first and fourth year of studies. Course 82 (Traditional) and Course 84 (Mixed) were sent questionnaires only after the fourth year. The questionnaires consisted of both structured and open-ended questions, where students were asked to tell about their interests, plans, and study habits and to evaluate the program and instruction in general. The sections of the questionnaire reported in this study consist of the open-ended and structured questions about the strong and weak aspects in the instruction provided by the Department, things that prevented from studying full-time, frequency of voluntary writing related to studies, and evaluating how the Department of Psychology has helped to develop in different subdomains.

b) Archive data. Students' academic progress (as documented by Faculty) was followed in detail from 1986 to 1992 on the basis of records. The success in entrance exam was scored (0-9), as well as points given for admission on the basis of high school diploma (0-9). The study success was scored after one and three years of studying: the mean number of credit points (1-180) and the grade point average (GPA, 1-3). The study success was scored after five years of studying: the grade of master's thesis (1-6), the grade of final exam (1-3), and status, i.e., interrupted (1), undergraduate (2), MA student (3), or graduated (4). Also, the number of activating courses taken was counted.

c) Evaluation forms. Also, anonymous evaluation forms were collected of all students in the end of each individual course. In the beginning of the project (1986-1987), the forms mainly consisted of open-ended questions. The structured evaluation forms were later developed (1989-1992) on the basis of the answers given to the following open-ended questions: What was the central issue in this course? What were the advantages of the instructional method? What were the less favorable sides (disadvantages) of the method? The structured evaluation forms consisted of 54 multiple choice questions grouped on the basis of

the following dimensions: knowledge acquisition, study and thinking skills, scientific and professional methods, interestingness, understanding, the quality of teaching, and external arrangements. The idea of the evaluation forms was not to concentrate on teachers' personality, but instead, students were engouraged to reflect on which aspects of learning were best fostered in the course and to estimate their own contribution to the learning and instruction process.

Data analysis. The data were extensive, and many aspects have also been published in Finnish (Lonka, Ahola & Kuivasniemi, 1988; Lonka & Ahola, 1990). The focus was on students' open-ended evaluations of instructional methods at the department and their academic progress.

On the basis of questionnaires, different groups (year courses) of students were compared to each other by chi-squares. On the basis of evaluation forms, the activating procedures were compared to traditional methods by t-tests. On the basis of academic records, Course 82, Course 84 and Course 86 were compared to each other to see how they had progressed in the program after five years of studying. Archive data was collected of all students. Of those students who continued their studies (n = 91), 78 % returned the questionnaire after four years of studying.

A principal component analysis (3-component VARIMAX-solution) was applied in order to see, which aspects clustered together. Only those students were included who had finished their final exam before 1993 (n = 48). The variables were: number of activating courses taken, the number of positive aspects (of instruction) mentioned, the number of negative aspects mentioned, how often writes voluntarily, GPA and the number of credit points after one year/after three years, entrance exam success, high school diploma, number of obstacles mentioned for full-time studying, the grade of Master's thesis, the grade of final exam, and the status of studying after five years.

4.2. Results

Advantages of activating instruction in comparison to traditional instruction. These results are based on the questionnaires sent to the students after four years of studying, and specifically, based on the answers for the question "What are the positive and negative aspects of instruction at the Department?". In all courses (Course 82, Course 84, Course 86) the mean number was approximately one advantage spontaneously mentioned per each student. There were no significant differences between different year courses in this respect. However, the quality and content of the answers were different across Courses 82, 84 and 86.

Students in traditional curriculum very seldom mentioned the instructional methods as good points, whereas students in mixed and activating curricula mentioned this aspect more often. The differences were statistically significant between Courses 82 and 84 ($\chi^2(1, N = 69) = 7.3$, $p < 0.01$) and between Courses 82 and 86 ($\chi^2(1, N = 69) = 3.8$, $p < 0.05$). Another clear difference between those who had participated in activating instruction and other students was that Course 82 (Traditional) seldom mentioned students' active role, whereas both Courses 84 and 86 mentioned this quite often. Again, Course 82 significantly differed from both Course 84 ($\chi^2(1, N = 69) = 5.3$, $p < 0.05$) and Course 86 ($\chi^2(1, N = 69) = 3.8$, $p < 0.05$). Also, Course 84 (Mixed) mentioned the atmosphere in instructional settings most often as an advantage and, in this respect, differed significantly from Course 82 who did

not mention this at all ($\chi^2(1, N = 69) = 5.3$, $p < 0.05$). Both Courses 82 and 84 mentioned technical quality of teaching as being an advantage, but Course 86 (Activated) did not mention this. In this respect, Course 82 and Course 86 differed significantly ($\chi^2(1, N = 69) = 4.1$, $p < 0.05$).

In sum, when students were asked advantages of instruction at the department, students in activating curriculum paid much less attention to technical quality of teaching and to teacher's personal role than did the other courses. Course 84 and Course 86 mentioned instructional methods and students' active role more often than did students in traditional curriculum. Contents were mentioned more often and the atmosphere was not mentioned at all by the latter. Thus, it seems that students in traditional curriculum tended to concentrate more on content, teachers' person and their technical teaching skills, whereas the students in activating settings concentrated on atmosphere, students' role in the learning process and on the instructional methods.

Development of knowledge and skills. Courses 82, 84 and 86 differed in terms of how they thought they had gained knowledge and skills in the program. Different years' courses were compared by one-way ANOVAs. It must be noted that these differences probably reflect changes in the content of the curriculum, rather than the effect of activating instruction.

Knowledge. Courses 84 (Mixed) and 86 (Activated) more often reported that they had learned a lot of experimental neuropsychology ($F(2, 66) = 3.3$, $p < 0.05$) and new applications ($F(2, 67) = 3.4$, $p < 0.05$) than did Course 82 (Traditional). However, Courses 84 and 86 reported less often that they had learned a lot of developmental psychology ($F(2, 66) = 9.8$, $p < 0.001$) and psychology of personality ($F(2, 67) = 5.3$, $p < 0.01$) than did Course 82.

Skills. Both Courses 84 and 86 felt more often that the program had enhanced their skills both in written communication ($F(2, 67) = 5.7$, $p < 0.01$) and in thesis writing ($F(2, 67) = 3.7$, $p < 0.05$) than did Course 82. Students in Course 86 felt most often that they had developed research skills ($F(2, 66) = 3.1$, $p < 0.05$) compared to Courses 82 and 84.

Evaluation forms. On the basis of evaluation forms, activating instruction differed significantly from traditional teaching methods. In 1986, activating courses and traditional lectures were compared to each other on the basis of open-ended question "What was the central issue in the course?". A total of 96 forms were returned from the activating courses and 164 forms from the traditional lectures. The differences were the following:

1. Only 2.4% of participants in lecture courses mentioned they had learned *study or research methods*, whereas 40% mentioned this on the activating courses ($t(106) = 7.4$, $p < .001$).

2. *Study skills* were more often mentioned on activating courses (24%) than on traditional courses (3%), and the difference was statistically significant ($t(121) = 4.5$, $p < .001$). For instance: "I learned how to write scientific text", "I can express myself better", etc.

3. More students mentioned that their *knowledge had increased* on the subject on traditional courses (62%) than on the activating courses (43%), and this difference was significant ($t(121) = 3.1$, $p < .01$). Students mentioned more aspects like "I got new information about personality", etc.

4. *Understanding* was mentioned more often as a central issue in activating courses than in traditional courses (40% vs. 22%, $t(121) = 2.6$, $p < .01$). Students expressed this by saying, for example, "I learned to look at the textbooks critically", "I understood that there are several points of view".

5. *Interestingness or enthusiasm* was seldom mentioned in any courses, but much more often in activating than in the other courses (9.4% vs. 0.6%, ($t(121) = 2.2$, $p < .05$). Example of this category was: "I became interested in neural level functioning, too".

Students' academic progress. Different courses did not differ in terms of high school grades, which indicates that there were no differences in basic intellectual functioning. However, Course 82 (Traditional) got higher grades from the entrance exam, and the groups differed significantly in this respect ($F(2,103)=42.9$, $p < 0.001$). Course 82 had significantly more credit points than had Courses 84 (Mixed) and 86 (Activated), both after first year ($F(2,85) = 3.5$, $p < 0.05$) and third year of studies ($F(2,85) = 9.1$, $p < 0.001$), and Course 82 also received higher grades ($F(2,84)= 6.2$, $p < 0.01$). However, there were no significant differences in grades after the third year. There were no differences in terms of voluntary writing activities, nor in the number of obstacles for full-time studying. The thesis grades did not differ significantly among different years' courses, although Course 86 got slightly better grades. A statistically significant connection was found between the year course and the grade obtained from the final exam ($F(2,62) = 4.3$, $p < 0.05$), Courses 84 and 86 getting the highest grades.

More students of Course 86 had graduated than those of Courses 82 and 84. Also, students in Course 82 were most likely to remain in basic undergraduate level of studying, whereas Courses 84 and 86 were more likely to have reached the advanced (BA) level. None of the students in Course 86 remained at the basic level in the sixth year of their studying. The distributions of different courses differed significantly from each other ($\chi^2(6, N = 114) = 15.4$, $p < 0.02$).

Aspects related to success in psychology studies. Table 5 shows a summary of three-principal component varimax solution. Principal component 1 (PC1) may be labeled as *high-quality active learning*. On this principal component, variables score high that are related to the grade of Master's Thesis and final exam. The number of activating courses taken loads strongly on this principal component. It is interesting that the numbers of both negative and positive comments on instruction have high loadings on this principal component: it is possible that students who are active and critical give both negative and positive feedback more generously than the others. Principal component 2 (PC2) may be labeled *as efficient school learning*. Variables that are related to success in high school, entrance exam, and during first years of studying have high loadings on PC2. Also, the grade of final exam loads moderately on this principal component. Principal component 3 (PC3) may be called as *pace of studying*. On PC3, only status of studying after five years and the number of third-year credit points load positively, and the number of obstacles for full-time studying loads negatively.

Table 5
All students who had taken their final exam (n= 48). Principal component loadings scales in a 3-principal component solution (Varimax Rotation 1; loadings <.30 omitted).

	Principal components and loadings		
Measures	PC1	PC2	PC3
1. Number of Activating Courses Taken	.73		
2. Number of Negative Comments on Instruction	.62		
3. Number of Positive Comments on Instruction	.62		
4. MA Thesis Grade	.54		
5. Final Exam Grade	.51	.36	
6. 1st Year Credit Points	-.43		
7. Voluntary Writing Activity	.38		
8. 1st Year GPA		.85	
10. 3rd Year GPA		.84	
11. Entrance Exam Success	-.49	.54	
12. 3rd Year Credit Points	-.43	.52	.49
13. High School Success		.46	
14. Status After 5 Years			.89
15. Number of Obstacles for Full-Time Studying			-.66
Eigen value	2.79	2.46	1.88
% explained variance	20.0	17.6	13.4
Cumulative percentage	20.0	37.6	51.0

4.3. Discussion

The follow-up results of this case study must be interpreted with caution. Under the circumstances, there are many uncontrollable variables, and we cannot really say that activating instruction *caused* any changes. For instance, the culture of learning may have changed during the six-year follow-up period. In this kind of setting, it is not possible to have true control groups, when the innovation quite global in nature, including changes in the curriculum as well as in the instructional procedures.

However, it is possible to conclude that different years' courses perceived their learning environment differently. Students in traditional and mixed curriculum appreciated different aspects of instruction after four years of studying than did students in the new curriculum. In general, Courses 82 and 84 appreciated technical quality of teaching. However, students in the traditional curriculum did not see students' role being as active as the others did, criticized the instructional methods that were applied, and did not mention the

atmosphere as an advantage of instruction. Students in the mixed curriculum could be described as having what we called "a honeymoon effect"; they were the most satisfied with the instruction and curriculum, and especially, spontaneously mentioned the atmosphere as an advantage of the instructional environment. This was probably based on the fact that something new and exciting was introduced for them for the first time. Those students who started in the new curriculum could be described as "realistic" in their approach - they took activating instruction for granted, probably because no radical changes took place while they were studying. However, they were significantly more pleased with the instruction than students in the traditional curriculum. Those who did not study in the traditional curriculum found that the program had supported their written expression, research qualifications, and skills needed in thesis writing.

Those who participated in activating instruction studied slower in the beginning of their undergraduate years. The teachers soon realized that students did not get enough credits for the activating courses, which were laboursome in many cases. The same problem has previously been recognized among many others who apply process-oriented instruction (e.g., Hettich, 1990). Our department started to adapt the number of credits according to students' workload in 1987, but this was too late for many students of the mixed curriculum. Their slow studying pace may be partly explained on the basis of this problem.

It is possible that those who participated in activating instruction slowed up their studying pace in the beginning of the studies but enhanced their later studies, because the students had thoroughly proceduralized and internalized some important study skills. Those who survived the first college years with surface strategies, scored lots of credit points in the beginning, but may have found thesis writing and final exam more difficult.

On the basis of questionnaires and evaluation forms, students clearly appreciated activating instruction. They thought it made studying more interesting, fostered understanding, and developed study skills. As in process-oriented instruction in general (Applebee, 1986), the effect of activating instruction was experienced more significant on procedural than on declarative learning.

The results of the principal component analysis suggest that there are two qualitatively different ways of progressing in psychology studies (at least at University of Helsinki), and neither of them is directly related to the status of studying after five years: 1) High-quality active learning, which may be slow in the beginning, but provides qualitatively better results in the long run, and 2) effective school-type learning which is related to success in early phases of studying. The third principal component, associated with pace of studying, appears to be related to neither of the above mentioned. It simply reflects the chance to keep up full-time studying without extra obstacles.

At the moment, the 'effectiveness' of departments and institutions is being inspected intensively around Europe. The most important lesson we can learn of the present small case study is that effects of instructional innovations may emerge after a long period of time. Had we looked at the follow-up data after three years period of time, it would have been very discouraging. However, only after five years could we tell something about the quantitative and qualitative outcomes of the instructional procedures. Complex skills of expertise take a long time to develop - what appears to be 'inefficient' within a short period of time, may be truly effective in the long run!

Study IV will look at how conceptions of learning and knowledge develop in relation to expertise in educational psychology. Although cross-sectional in nature, this study will give some insight on the development in this domain.

5. STUDY IV

People have varying conceptions of learning and knowledge (e.g., King, Kitchener, Davison, Parker, & Wood, 1983; Ryan, 1984; Sternberg, 1985; Vermunt & van Rijswijk, 1988) that play important roles in how they approach learning tasks. Such beliefs are sometimes referred to as an "intuitive psychology" (Carey, 1985), or as an "epistemology" (Strike & Posner, 1985; Ryan, 1984). These beliefs provide a framework for how people understand and explain phenomena such as school learning and intelligent behavior (Sternberg, 1985), which may in turn have consequences for how they behave. It may be possible to identify core concepts of learning common to those trained within a cognitive/constructivist framework, and to compare novices with experts in terms of the form these core concepts take. In the present study, it was examined how students express their core concepts in the psychology of learning in response to several different kinds of questions.

In the first study, the association between students' core concepts and their academic level in educational psychology was examined. Although cross-sectional in nature, it was anticipated that this study would provide insights into the impact of formal instruction on concepts central to the domain of educational psychology, which we then further explored through a short-term longitudinal study (Study B).

The three main core concepts in educational psychology were examined, which a pilot study differentiated among individuals of various levels of expertise: *active epistemology, constructivity, and mental representation.* These conceptions have been adopted from cognitive theories of learning (e.g., Glaser & Bassok, 1989; Bereiter, 1985; Gardner, 1985; Kintsch & Kintsch, 1996; Neisser, 1976; Peterson, Fennema, Carpenter, & Loef, 1989; Resnick, 1984; Shuell, 1985, 1990).

It was also of interest, how the relations between explicit conceptions and the solutions to applied problems might change as a function of formal training. It is well known that students often acquire formal knowledge, but do not spontaneously apply it in situations where it is relevant; this has been called the problem of inert knowledge (Whitehead, 1929). Part of the present assessment was designed to see whether expert students were more likely than novices to provide answers to a problem in ways that were consistent with the core conceptions they expressed on a definition task. Desforges (1995) claims that teachers' knowledge is atheoretical in nature, and that they may be blind to features of their practice which bear significantly on students' learning. Therefore, it was expected that teachers' conceptions of learning would not necessarily be very constructive, although they might suggest reasonably functional solutions for applied problems. The questions asked in this study tapped only participants' beliefs — pertaining to definitions and to an applied problem — as opposed to their behavior. The reported beliefs may be discrepant from behavior. However, it is plausible that belief systems may play an important role in mediating behavior and are therefore worthy of study.

5.1. Study A

Two main questions were examined in Study A: 1) "Will a qualitative difference be observed in students' core concepts of learning, as a function of formal training, ranging from those that resemble the intuitive beliefs held by laypeople, to those that reflect the dominant, constructivist approach in educational psychology?," and 2) "Will expert students' solutions to an applied problem be more consistent with their definitions of learning than those of novices?"

Method

Subjects. A total of 112 participants took part in the study. They consisted of the following groups: 1) Laypeople: 50 Ontario Science Centre visitors who volunteered to participate in response to a sign; 25 had not studied psychology (Laypeople A), and 25 had taken at least one psychology course (Laypeople B); 2) Novices: A group of 23 post-BA students from a major Canadian university, taking their first course in educational psychology in a teacher education program, who volunteered to participate during one of their classes; 3) Teachers: 29 K-12 teachers who had volunteered to take part in a larger research program; 4) Experts: 11 doctoral candidates in educational psychology at a major Canadian university who were asked to participate in the study.

Materials. Participants completed a booklet that consisted of several open-ended questions. The questions were quite general in nature, with the intention of not leading the subjects towards an “acceptable” answer. The idea was to see, whether subjects would spontaneously use constructivist expressions while defining learning.

The first part asked participants to define learning: "Please answer the following questions: a) Give your own, subjective definition of learning; b) Please explain the basis on which you gave your answer to "a"?; c) What else would you like to learn about the topic of `learning'? Please describe below; d) Is there anything about this topic (of learning) that puzzles/confuses you? If yes, please describe below." The second part of the booklet asked participants to apply their definitions of learning to a problem: "What do you think would be the best way to enhance students' ability to learn? Why?". Laypeople were given only Part I of the task booklet consisting of the definition task.

Measures. The age group, sex, and the level of education were scored for each subject. The subjects' *general level of education* was classified on a scale from 0 to 12 from no education (0) to Ph.D. Degree (12). The subjects' *level of education in psychology* was classified on a scale from 0 to 13 from no education (0) to Ph.D. Degree (13).

Responses on *the definition task* were scored on three scales, which were developed on the basis of: a) scales previously developed to measure constructivity in reading (Chan et al., 1992), and b) an analysis of a pilot study carried out with 8 graduate students, and 41 laypeople. Categories on the scales (see Table 6) ranged from traditional to more current constructivist views in educational psychology, described above.

In general, on the *Constructivity* and *Active Epistemology* scales, participants received low scores for responses that suggested they viewed the process of learning or the learner as being passive receptacles of information, and high scores when responses expressed a view of learning or the learner as being active and constructive. The third scale, *Mental Representation,* was designed to tap into the extent to which participants employed terminology suggesting an explicit notion of mental representations.

Each participant was assigned a *confusion score,* according to the following scale: (1) no confusion expressed; (2) some confusion expressed, e.g., "I think learning is not easy to

understand" (no questions posed); (3) some questions posed (1-3), or (4) more than three questions posed or expressions suggesting that the subject was very puzzled.

The *conceptual basis of the application* refers to theoretical basis on which the application was motivated. These responses were scored on the three scales in an identical fashion as those given on the definition task, except that the two middle categories on each scale were combined, and scores thus varied from 1 to 3.

Table 6
Scales Used to Analyze Participants' Responses

Constructivity

1. *Storing existing knowledge*: Learning seen as absorption, intake of knowledge, or simply storing.
2. *Assimilation*: Learning viewed as assimilating new knowledge into a pre-existing framework or interpreting knowledge within an existing framework.
3. *Change or reorganization takes place*: Learning seen as changing thinking or reorganizing knowledge; Learning is an interplay between assimilation and accommodation.
4. *Construction of new knowledge*: Learning seen as changing/reorganizing plus constructing new knowledge, knowledge structures, or new ideas.

Active Epistemology

1. *Learner viewed as object of education*: Learning is absorption of information; To learn is to be taught.
2. *Learner seen as implicitly passive*: Learning is acquisition of information; A change occurs.
3. *Learner seen as implicitly active*: An active verb is used to describe learning, e.g., "learning is using mental abilities"; Learning viewed as problem solving or as a discovery.
4. *Learner emphasized as being active*: Learning explicitly described as an active process.

Mental Representations

1. *No notion of representation*: No representational terminology used.
2. *Folk notion of representation*: Beliefs, thoughts, meanings change when learning occurs.
3. *Notion of representation implicitly applied*: Using a phrase such as "a change in the storehouse"; Idea of representation evident, but cognitive terminology not used.
4. *Notion of representation explicit*: Representational terminology used: "knowledge structures," "schemata," etc.

The forms of instruction suggested were classified as: 1) teacher-centered or formal instruction (lectures, teaching); 2) group work; 3) independent learning (e.g., reading books); 4) external arrangements (e.g.,curriculum arrangements); 5) study skills or learning strategies training; 6) fostering motivation or interest; 7) taking into account individual differences; 8) tutoring or personal interaction (i.e., interacting with a tutor or with peers), and 9) promoting a warm atmosphere. Each category was scored as "not mentioned" (0), "mentioned among other forms of instruction" (1), or "emphasized" (2). This classification was performed independently of the conceptual basis of the application. On these categories, interrater reliabilities varied from 89% to 100%.

Conceptual consistency between subjects' definitions and applications was also examined. This was done by comparing the scores for Constructivity, Active Epistemology and Mental Representation in definitions and conceptual bases of the applications. The answers were scored as *consistent* or *inconsistent* in the following way: if participants received a "3-4" for a scale in the definition task, or a "2-3" for the same scale in conceptual

basis of the application task, their responses were considered to be consistent (2). Otherwise, they were considered to be inconsistent (1).

Results and Discussion

Constructivity. The amount of constructivity in participants' definitions of learning was positively related both to their level of expertise in psychology ($r = .38$, $p < .001$) and to their general level of education ($r = .41$, $p < .001$). Consistent with our predictions, the lowest scores on this scale were obtained by Laypeople A, and the highest scores were obtained by experts (see Table 7). The groups differed significantly from each other on the Constructivity scale ($F(4,107) = 5.54$, $p < .001$). Measured by Tukey's Multiple Range Test ($p < 0.05$), experts and teachers differed significantly from Laypeople A, and experts also differed significantly from Laypeople B.

Those laypeople who had not studied psychology defined learning as a process of passively receiving information from an outside source, for example: "Learning is a source of information that we receive when we are taught we learn and then we can teach others"; "The ability to absorb information." Most Laypeople B, novices, and teachers defined learning as either acquiring knowledge or assimilating knowledge into an existing framework, for example, "[Learning is the] acquisition of skills, knowledge, concepts and attitudes that result in a change in behavior." Among experts, the most common view was that learning is a process of reorganizing knowledge or constructing new knowledge, for example, "Learning is an interactive process whereby structures for interpreting the world are formed and revised on the basis of information from the world."

Active Epistemology. The level of epistemology reflected in the students' definitions of learning was positively related both to their general level of education ($r = .35$, $p < .001$), and to their level of education in psychology ($r = .25$, $p < .01$). When asked to give their own definitions of learning, members of the various subject groups expressed very different views about the learner's role in the process (see Table 7). Again, the groups differed significantly from each other ($F(4,107) = 6.86$, $p < .0001$). Measured by Tukey's Multiple Range Test ($p < .05$), Laypeople A differed significantly from all other groups.

The distribution of responses on the Active Epistemology scale. Laypeople A more often saw the learner as a passive object of education than did the other participants, using expressions like `to be taught,' or `absorption of information.' In the other groups, learning was very often described as an activity similar to problem solving. However, few members of any group explicitly emphasized the learner's active role.

Notions of Mental Representation. Across all six groups of participants, the Mental Representation scale was significantly correlated with the level of general education ($r = .42$, $p < .001$), and with the level of education in psychology ($r = .48$, $p < .001$). Of the three scales, scores on the Mental Representation scale differentiated the most clearly between participants of varying level of expertise in educational psychology, following a predictable pattern of lowest scores obtained by Laypeople A and highest scores obtained by experts (see Table 7). The groups differed significantly from each other ($F(4,107) = 7.78$, $p < .0001$). Measured by Tukey's Multiple Range Test ($p < .05$), experts differed significantly from all other groups. Experts implicitly or explicitly defined learning by using terms suggestive of mental representations, such as "knowledge structures" or "schemata." Few participants in any other group explained learning by using such terminology. On this scale, only the long-term study of psychology was associated with higher scores.

Table 7
Mean Scores and standard deviations (in parentheses) on Constructivity, Active Epistemology, and Mental Representation Scales

Group	Scale		
	Constructivity	Active Epistemology	Mental Representation
Laypeople A	1.20 (0.65)	2.04 (0.79)	1.00 (0.00)
Laypeople B	1.76 (0.92)	2.72 (0.61)	1.44 (0.76)
Novices	1.86 (1.03)	2.95 (0.65)	1.45 (1.91)
Teachers	1.86 (0.78)	2.55 (0.63)	1.55 (0.78)
Experts	2.63 (1.02)	2.90 (0.53)	3.00 (1.09)

Degree of Confusion. Participants were asked whether anything puzzled them about the concept of *learning*, and a confusion score was calculated for each subject. The mean confusion scores across various subject groups differed significantly from each other ($F(4,107) = 10.3$, $p < .001$). The mean score of Laypeople A was 1.0 ($SD = 1.10$), and of Laypeople B, 1.4 ($SD = 1.19$), indicating that laypeople rarely expressed any confusion about learning. The confusion scores of teachers ($M = 2.0$, $SD = 1.08$) and novices ($M = 2.2$, $SD = 1.33$) were slightly higher than those of laypeople. Experts expressed the most confusion ($M = 3.6$, $SD = 1.43$) about the concept of "learning." Thus, the degree of confusion expressed increased with expertise.

The results of the definition task suggest that there is a progressive increase in the expression of constructivity and mental representation as participants' acquire more formal knowledge of educational psychology, however, the concept of an active epistemology appeared not to be as clearly associated with participants' expertise in this domain. This pattern of results suggests that differences in the two core conceptions (constructivity and mental representation) found in our study cannot not be attributed to overall differences in participants' level of intelligence.

The fact that expert participants expressed more confusion and posed a greater number of specific, theoretical questions can be understood as a reflection of their more sophisticated ability to monitor their own comprehension. Chi, Bassok, Reimann and Glaser (1989), showed that successful students more readily expressed failures in comprehension, and raised a greater number of specific inquiries during problem solving, than unsuccessful students. Expertise in psychology appears to be associated with a shift away from questions of a personal nature towards relevant, and theoretical inquiries about learning.

Forms of instruction suggested. When asked what they thought would be the best way to enhance students' ability to learn, novices' responses did not show any clear

patterns whereas experts and teachers emphasized a variety of forms of instruction and techniques for learning, including group work, and study skills. Teachers and experts also emphasized motivation more often than novices. Roughly one-third of teachers and experts saw tutoring as a useful way to enhance learning, whereas only 10% of novices shared this view.

Conceptual basis of the application. The subjects gave reasons and explanations for the applications they suggested. In all groups, students' active role in learning was discussed very often. This aspect was usually discussed in terms of interests, goals, and motivation. There were no statistically significant differences between the three groups of subjects in this respect. Constructivist notions were discussed by almost half of the experts in the application task. These subjects emphasized situations where prior knowledge was taken into account and situations where students would have to reorganize their knowledge or construct new knowledge. On this Constructivity scale, the experts scored highest, and the teachers scored lowest. The difference between subject groups was statistically significant ($F(2,57) = 6.54$, $p < 0.01$).

Notions of representation were seldom discussed in the application task, except by the experts. They explained learning in terms of changes in schemata and mental models, for example, and directed their interventions towards modifying these kinds of knowledge structures. Also on the Mental Representation scale, the experts scored highest and the teachers scored lowest ($F(2,57) = 6.16$, $p < 0.01$).

Consistency Between Definitions and Applications. The groups differed significantly from each other in terms of the consistency between their scores on the Constructivity scale of definitions of learning and their applications ($\chi^2(2) = 19.1$, $p < .01$). Whereas novices seldom (14 %) expressed consistency and teachers never did so (0 %), more than half of the experts (55%) were scored as having conceptual consistency in their definitions and applications. Again, 45 % of the experts, 4 % of novices and none of the teachers expressed consistency on the Mental Representation scale ($\chi^2(2) = 19.9$, $p < .01$).Thus, on the Constructivity and Mental Representation scales, consistency between definitions and conceptual bases for applications increased with expertise. Significant differences were not found between the groups on the consistency of either their scores on the Active Epistemology scale and their applications.

The ability to define psychological concepts in scientific terms did not guarantee that participants would generate solutions to the applied problem that reflected the constructive view expressed in the definition task. Conceptual consistency in participants' definitions of learning and their applications of this concept increased with theoretical expertise, but not with practical expertise. Teachers' applications, however, closely resembled those given by experts, suggesting the development of a sophisticated layer of practical knowledge. Gobbo and Chi (1986) found that with expertise, important changes occur in the structure of the knowledge base, and not only in the amount or type of knowledge. Our results echo this finding in that, for expert participants, different kinds of conceptual knowledge appeared to become better related.

5.2. Study B

The results of Study A indicate that there are differences in core conceptions held by individuals at various levels of formal training in educational psychology. The cross-sectional nature of the design of this study, however, leaves open the possibility that these differences can be accounted for by factors other than formal training (e.g., general intellectual level, age). In order to further address the question of how formal studies in educational psychology affect core concepts in this domain, we conducted a short-term longitudinal study involving students taking a six-week course in educational psychology.

The participants in this study were administered the battery of questions, described above, at the beginning of their course, and these results are described in the report of Study A above (Novice group). We then readministered this battery upon completion of their course. The nature of the design of this study reduces the likelihood that factors other than formal training would account for differences in students' pretest and posttest scores. We report here only results of the definition and application tasks (see Note 1).

Method

Subjects. The participants in this study were the same education students attending a teacher training program who participated in Study A (Novice group). They ranged from 18 to 25 years in age. In addition to our main research question concerning the effects of training on core conceptions in educational psychology, we were also interested in whether students' level of academic skill in educational psychology would play a role in such changes. After administering the posttest in Study B, therefore, participants were divided into below-average students (n = 11) and above-average students (n = 12) on the basis of their final exam grades in the course on educational psychology. The final exam measured the success in answering essay-type answers about basic cognitive and educational psychology, e.g., knowledge about Piaget's theory of cognitive development. Academic skill (below average/above average) was then used as a between subjects variable in the analyses described below.

Procedure. Students completed the battery of questions described earlier (Pretest) once at the beginning and again at the end of a six-week, introductory lecture course in educational psychology (Posttest).

Results and Discussion

Changes in theoretical views. Students' responses were analyzed using the scales developed in Study A. Because the same raters were used, and interrater reliabilities already established, interrater reliability was not recalculated.

Changes in constructivity scores. A repeated-measures MANOVA was carried out on Constructivity scores in order to determine whether participants' conceptions of learning would become more constructive during the course, and whether their level of academic skill had any bearing on such changes. The repeated measures within subjects factor was training (Pretest/Posttest) and the between subjects factor was academic skill in educational psychology as assessed by the final exam (above average/below average).

The effect of training was significant ($F(1,19) = 14.0$, $p < .001$), indicating that, overall, students' definitions of learning showed more evidence of notions of constructivity on the posttest ($M = 3.2$, $SD = 1.44$) than on the pretest ($M = 2.1$, $SD = 1.57$). Students used constructivist terminology more frequently on the posttest than on the pretest, for example: "Learning is a cognitive process whereby the external world is incorporated through assimilation or accommodation into existing schemas."

There was no significant difference between the Constructivity scores of the above average and below-average students ($F(1,19) = .06$, $p = .81$). There was, however, a significant two-way interaction between training and academic skill on Constructivity scores ($F(1,19) = 6.7$, $p < .05$), indicating that training had little effect on above-average students, but that below-average students gained considerably. On the pretest, the mean score of below-average students was only 1.4 ($SD = .82$) whereas the mean score of above-average students was 2.2 ($SD = 1.13$). However, on the posttest, the mean score of below-average students was 3.0 ($SD = .94$), and of above-average students, 2.5 ($SD = .85$). Thus, below-average students doubled their mean Constructivity scores from pre- to posttest whereas above-average students improved only marginally.

Changes in Active Epistemology scores. Analyses identical to those described above were performed on Active Epistemology scores. The effect of training on Active Epistemology scores was not statistically significant ($F(1,19) = 2.61$, $p = .12$). Overall, students scored 2.9 ($SD = .67$) on the pretest and 3.3 ($SD = .64$) on the posttest. There were no significant differences in the Active Epistemology scores as a function of academic skill ($F(1,19) = 3.10$, $p = .09$), nor were there any significant interactions between the two factors. On the pretest, below-average students scored 2.7 ($SD = .65$) on the Active Epistemology scale, and the above average students scored 3.2 ($SD = .63$). On the posttest, below-average students scored 3.2 ($SD = .60$), and above-average students scored 3.4 ($SD = .70$).

Changes in Mental Representation scores. Analyses identical to those described above for Constructivity scores were performed on Mental Representation scores. The effect of training on Mental Representation scores was statistically significant ($F(1,19) = 13.36$, $p < .01$), indicating that at the end of their course, students used more representational terminology in discussing the concept of *learning* than they had at the beginning of their course. Students' posttest scores resembled those of experts in Study A: Their mean score was 1.4 ($DS = .93$) on the pretest and 2.4 ($SD = .94$) on the posttest. There was no significant difference in Mental Representation scores as a function of academic skill ($F(1,19) = .7$, $p = .41$), nor was there a significant interaction between academic skill and training. Thus, below-average and above-average students did not differ in their use of terminology relating to mental representations, and both groups benefited equally from the instruction. On the pretest, both below-average students ($M = 1.3$, $SD = .47$) and above-average students ($M = 1.6$, $SD = 1.26$) made few references to mental representations in their definitions of learning. On the posttest, both below-average ($M = 2.3$, $SD = .90$) and above-average students ($M = 2.5$, $SD = 1.08$) used many more terms in their definitions that suggested a notion of mental representation.

The results of Study B indicate that training in educational psychology led to significant increases in students' notions of constructivity (particularly, for below-average students) and mental representation, whereas students' active epistemology scores remained much the same from pre- to posttest. However, without the inclusion of a control group, strong conclusions about the effects of formal training cannot be drawn on the basis of this study alone.

Changes in Performance on the Applied Problem. In the *conceptual basis of the applications*, a significant change occurred in novices from pretest to posttest on Constructivity scale. The scores on the Constructivity scale in the application task were 1.5 (*SD* = 0.5 *)* and 2.0 (*SD* = 0.7 *)*, respectively, and measured by the paired-samples t-test, the difference from pre- to posttest was statistically significant, $t(20) = 2.49$, $p < .02$. Active Epistemology scores were high both in the pretest (*M* = 2.2, *SD* = .78*)* and in the posttest (*M* = 2.3, *SD* = .64*)*, and no statistically significant improvement took place. On the Mental Representation scale, a slight increase took place from pretest (*M* = 1.4, *SD* = .58*)* to posttest (*M* = 1.7, *SD* = .73*)*, but this change was not statistically significant.

Although students' conceptions of learning had become more constructive at the end of their six-week course, and they also gave constructivist bases for their applications, these changes were not reflected in their approach to the concrete problem they were asked to solve, that is, *the forms of instruction suggested*. The applications were similar in the pre- and posttests, with students emphasizing teacher-centered instruction even more (27 %) than in the pretest (15 %). This difference was not statistically significant.

Discussion. In two studies we found that when asked to define learning, greater training in educational psychology was associated with higher scores on the Constructivity and Mental Representation scales, but not as strongly on the Active Epistemology scale. A considerable amount of formal training (experts) or practical experience (teachers) appears to be necessary for the generation of answers to the applied problem that reflect the current constructivist tone in educational psychology. However, teachers' definitions were less sophisticated theoretically than were their expert-like solutions (see also Desforges, 1995). Only the experts in Study A gave conceptual bases for their applications that were consistent with their definitions of learning.

Each of the studies reported here has limitations: in Study A, the differences in performance we observed among the groups may have been attributable to a factor other than formal training; in Study B, the lack of a control group precludes drawing strong conclusions about the impact of formal training. The pattern of results obtained on both studies was similar, however, and this lends credence to the conclusions that formal training leads to significant changes in notions of constructivity and mental representation, and that a great deal of formal training is necessary to develop strong connections between different kinds of conceptual knowledge in educational psychology.

The questions asked of the participants were quite general in nature, and it is possible, therefore, that subjects interpreted them in different ways. However, we were not interested in their knowledge of what is in their textbook, but rather, their own personal beliefs, theories, and intuitions. Giving a textbook definition (e.g., “a change in an individual caused by experience”) cannot be considered very constructive when asking about people’s subjective definitions of learning, although this answer may be considered as ‘correct’. The present study may be considered exploratory in nature, and further studies are required to confirm the degree to which conceptions of learning are truly domain-specific.

The results of these studies suggest that students undergo changes in several core concepts in educational psychology as a result of formal training. It seems, however, that further studies or practical experiences in this domain are necessary to affect changes in their answers to applied problems.

One pedagogical possibility for affecting such changes is *activating instruction*. In Study III it appeared that the number of activating courses taken was related to success in final exam, calling for application of knowledge (e.g., clinical cases). As in process-oriented instruction in general (Applebee, 1986), the effect was more significant on procedural than

on declarative learning. However, both the intervention and the measures were quite general in nature. More specific research is needed in order to examine whether we can influence the conceptions of learning and their practical applications. The results of the present study suggest that interventions such as activating instruction might be useful to help students in teacher training programs undergo more significant changes in their core conceptions, which may then lead to greater coherence between their beliefs and applications.

Conceptions of learning are somewhat domain-specific, training within cognitive framework being only one possible context. In Study V, it will be looked at what kinds of conceptions of learning are expressed by students in two different domains, namely, medicine and psychology. Further, the subjective definitions of 'learning' are examined in relation to inventories intending to measure epistemologies, approaches to learning, and preferred study strategies.

6. STUDY V

Successful studying in higher education is not only a matter of effort, but is also determined by the *nature* of the study activities. For example, entry-level reading and writing skills have shown to be best predictors of medical students study success (Glaser, Hojat, Veloski, Blacklow, & Goepp, 1992). Students guide their learning and text comprehension by different monitoring procedures. Ryan (1984) showed that there are individual differences in comprehension standards which may influence students' academic performance indirectly by controlling the effectiveness of their reading efforts. This article first describes different epistemologies and conceptions of learning reported by medical and psychology students at different levels of their studies (first-year and fifth-year). Second, it then examines how these conceptions are related to students' comprehension criteria and comprehension testing strategies. The goal of this paper is exploratory with respect to the relationships among different aspects of learning: How do epistemologies, conceptions of learning, and comprehension monitoring standards interact with each other? How domain-specific are these phenomena?

In this study, dualistic epistemology (Ryan, 1984; Perry, 1970) was expected to be closely related to phenomena such as knowledge-oriented epistemological standards (Ryan, 1984), rehearsal strategies (Weinstein & Mayer, 1986), passive and non-constructivist conceptions of learning (Lonka, Joram & Bryson, 1994; V; Vermunt & van Rijswijk, 1988), and to surface approach (Entwistle and Ramsden, 1983). In contrast, relativist epistemology was expected to be related to comprehension-oriented epistemological standards, elaborative study strategies, constructivist conceptions of learning, and to deep approach.

On the basis of earlier studies on Finnish students in medicine (Järvinen, 1985), Finnish medical schools have traditionally been teacher-centered and school-like[7] (Lindblom-Ylänne, Lonka & Maury, 1992), and epistemological development from dualist toward relativist orientation has not been common in Finnish medical students as compared to education in other academic domains (Järvinen, 1985; Viitala, 1991). This does not seem to be typical of Finnish medical education only: For instance, Tooth, Tonge and McManus (1989) found that among a group of entrants to one British medical school, study habits showed declining deep and strategic approaches, and increasing surface (or rote-learning) approaches during studies. On this basis, development from dualist epistemology and externally regulated, surface-oriented learning towards more self-regulated, meaningful, and goal-oriented learning was not expected to be as evident among medical students as among psychology students.

.It was also expected that constructivist conceptions of learning would not be as common among medical students, but instead, would develop in psychology students as they progress in their studies. Thus, it was expected that there would be both domain-specific and domain-general aspects in students' epistemological development. First-year students (i.e., undergraduates) were expected to be likely to express dualism, external regulation, surface approach, and to test their knowledge on the basis of knowledge standards. Fifth year

[7] The situation has changed in 1990's when problem-based learning has been introduced in some Faculties of Medicine. At the University of Helsinki, a parallel track started in 1994.

students were expected to be more likely to express deep approach, self-regulated learning, relativist epistemology, and to test their knowledge by using comprehension standards.

6.1. Method

Subjects. In Finland, those who want to become physicians or psychologists, participate in an entrance examination in order to apply to a 6-year study program. A comparable procedure takes place after secondary school graduation both in psychology and in medicine, approximately at the minimum age of 19. The subjects in this study comprised 175 students who had started their studies in 1988 (fifth-year students called *advanced students)* or in 1992 (first-year students called *novices*), 116 medical students and 59 major psychology students. The psychology students were 33 novices and 26 advanced students. The medical students were 49 novices and 67 advanced students.

Materials. The task booklet consisted of open-ended questions and Likert-type questions. In the open questions, students were first asked to give their own *subjective definitions of learning.* Scales to score the answers were identical to Study IV. Second, subjects were given *a comprehension monitoring probe* (Ryan, 1984) where they were asked to write their responses to the following questions:

"How do you determine (when you have completed a reading assignment or when you are reviewing the material) whether you have understood the material well enough? What specific information do you use to assess the degree to which you have understood the material you have read in a chapter? On what basis would you decide that you need to go over the chapter again or to seek help in figuring it out?".

Each student's response to the comprehension monitoring probe was analyzed to determine the specific comprehension criteria he or she employed. An effort was made to score each response for as many different comprehension criteria as possible in order to capture the full range of each student's comprehension monitoring capabilities. Comprehension monitoring criteria were adopted from Ryan (1984), classified as knowledge criteria or comprehension/application criteria. In addition, each response was analyzed in order to see if Weinstein and Mayer's (1986) study strategies were suggested for assessing comprehension.

Finally, students rated a set of 71 statements concerning learning approach, regulation of learning and conceptions of learning on a five-point scale. The first fourteen statements consisted of three scales adopted from the *Approaches to Studying Inventory* (Entwistle & Ramsden, 1983). The three scales were Deep Approach, Surface Approach, and Achievement Motivation. The scale varied from (1) totally disagree, to (5) totally agree. Twenty-five statements consisted of three regulation-of-learning scales adopted from the *Inventory of Learning Styles* (ILS, Vermunt & van Rijswijk, 1988): Self-regulation, External regulation and Lack of regulation. The scale varied from (1) I seldom or never do this to (5) I (almost) always do this. The remaining 32 statements described five conceptions of learning adopted from as many subscales of the same ILS: Intake of knowledge, Construction of knowledge, Use of knowledge, Stimulating education and Cooperation with fellow students. Embedded in this set of 25 statements were an additional seven items that were used to classify students as dualist or relativist. *Perry's (1968) seven item dualism scale* was adopted from Ryan (1984). The scale varied from (1) I seldom or never do this to (5) I (almost) always do this.

Procedures

Data Collection. The data were collected in 1993. All medical students who started their studies in 1988 were mailed questionnaires, but only 67 (60 %) returned them. Two groups of psychology students were also mailed the questionnaires: to all freshmen, of whom 33 (77 %) returned, and to fifth-year students, of whom 26 (63 %) returned the task booklet. For practical reasons, the first-year medical students were given the task booklet on an anatomy course. Of those first-year students who were present there, 49 (82 %) filled in the task booklet.

Statistical Procedures. Following Ryan's (1984) study, students whose mean score on the Perry's dualism scale was 3.0 or more on a 5-point scale, were classified as "dualists". The students with scores lower than 3 were classified as "relativists". Also, the numbers of both knowledge criteria and comprehension criteria were counted on the basis of open-ended responses to the comprehension monitoring probe. A variable was created that expressed whether subjects reported more knowledge criteria that comprehension criteria ("fact-oriented", score 1), as many knowledge criteria as comprehension criteria ("neutral", score 2), or more comprehension criteria than knowledge criteria ("comprehension-oriented", score 3).

Dualists and relativists were compared in terms of their epistemological standards (i.e., how many different knowledge and comprehension criteria they had applied, and which criteria dominated). Their comprehension criteria were also compared in terms of the study strategies they suggested (rehearsal strategies, elaborative strategies, organizational strategies, metacognitive strategies, or affective strategies).

Correlations were computed and principal component analyses done in order to examine the interactions between study orientations, epistemologies, and conceptions of learning. A four-principal component varimax solution was chosen identically with Vermunt and van Rijswijk (1988). Interactions between study orientations and level/domain of studies were looked at by combining the individual scales according to their varimax rotation principal component structure (using principal component scores for each subject), and then comparing different subject groups on the basis of these principal component scores. A two-way ANOVA (2 x 2) was applied to compare different groups (2 Levels x 2 Domains). A log-linear model was also applied in order to examine the interactions between level of studies, dualism, and the two domains.

6.2. Results

Relationships between different scales. Table 8 shows the principal component loadings of the task booklet scales in a 4-component Varimax solution (explaining 50 % of total variance). This solution was satisfactory both theoretically and statistically, all eigen values exceeding 1 (see Statistical Procedures). The first two principal components resemble those in Vermunt and van Rijswijk's (1988) study, and their names have been adopted accordingly: The first principal component (PC1) is characterized by high loadings on surface approach, dualism, external regulation, lack of regulation, stimulating education, cooperation, and intake of knowledge. This principal component is *called externally regulated and reproduction-directed learning.* The second principal component (PC2) shows high loadings on deep approach, self-regulation, construction of knowledge, and achievement motivation. Negative loadings on surface approach and lack of regulation are also quite strong. This component is called *self-regulated, meaning-directed, and goal-*

Table 8.
Principal component loadings (a 4-component Varimax solution) of scales from approaches to studying inventory (Entwistle & Ramsden 1983), inventory of learning styles (Vermunt & van Rijkswijk 1988), Perry's (1968) seven item dualism scale, epistemological standards (Ryan, 1984), and conceptions of learning and knowledge (Lonka, Joram & Bryson, 1994).

Variable	Principal component				Communality
	PC1	PC2	PC3	PC4	
Learning approach					
Deep approach		81			.66
Surface approach	55	-43			.53
Achievement motivation		43		-45	.46
Regulation of learning					
Self-regulation		79			.65
External regulation	67				.51
Lack of regulation	52	-50			.52
Conceptions of learning					
Intake of knowledge	72				.61
Construction of knowledge			62		.50
Use of knowledge				66	.49
Stimulating education	63				.45
Cooperation	57				.33
Epistemology and Epistemological Standards					
Dualism	45		-48		.48
Knowledge criteria			-43		.27
Comprehension criteria			60		.49
Conceptions of Learning and Knowledge					
Constructivity			65		.45
Representation			45	-58	.47
Active epistemology				62	.55
Percentage of variance	20	13	10	7	

Decimal places and loadings less than 0.30 are omitted.

oriented learning. Characteristic of the third principal component (PC3) are high loadings on constructivity and representation scales (adopted from Lonka et al., 1994), and the number of comprehension criteria reported. On the contrary, knowledge criteria and dualism have negative loadings on this principal component. This component is named *constructive epistemology*, since it reflects more epistemologies and epistemological standards than conceptions of learning. The fourth principal component (PC4) has high loadings on the active epistemology scale and use of knowledge, and negative loadings on representation scale and achievement motivation. The interpretation of this principal component is somewhat problematic. This component may be characterized as *active use of knowledge*, where students who score 'high' are not very competitive and are interested in active professional development, not so much in academic theoretical questions.

Study orientations in different subject groups. To check whether medical and psychology students or students at different level of their studies (first-/fifth-year) differed from each other in their orientation, principal component scores were computed. Four variables were thus formed describing externally regulated and reproduction-directed learning (called PC1), self-regulated, meaning-directed, and goal-oriented learning (PC2), constructivist epistemology (PC3), and active use of knowledge (PC4). Table 9 shows the mean scores on the four principal component score scales of different groups of students.

On the PC1 scale, psychology students scored lower than medical students, and novice medical students scored highest. Measured by two-way ANOVA (2 Domains x 2 Levels), the effect of domain was statistically significant (F(df=1,167) = 5.98, $p < 0.05$), but the effect of level of studying was not (F(df=1,167) = 3.47, $p = 0.064$). There was no interaction between the two effects. On the scale PC2, neither the main effect for level of studies (F(df=1,167) = 2.90, $p = 0.09$) nor the effect for domain was significant (F(df=1,167) = 3.11, $p = 0.08$). The interaction between the two effects did not reach statistical significance (F(df=1,167) = 3.32, $p = 0.07$). The highest PC3 scores were obtained by advanced psychology students, and in general, psychology students scored higher on this scale. Measured by a two-way ANOVA (2 Domains x 2 Levels of Studying), the main effect of domain was statistically significant (F(df=1,167) = 12.39, $p < 0.001$), and so was the main effect of level of studies (F(df=1,167) = 5.42, $p < 0.05$). There was no interaction between the main effects. On the PC4 scale, the highest scores were obtained by advanced medical students, and psychology students scored lower in general. The main effect for domain was significant (F(df=1,167) = 22.06, $p < 0.001$), but the effect for level was not (F(df=1,167) = 3.62, $p = 0.06$). The interaction between the main effects also reached statistical significance (F(df=1,167) = 7.36, $p < 0.01$), indicating that among psychology students the scores declined from novices to advanced students, whereas the scores of medical students increased, respectively.

Table 9.
Component scores of PC1, PC2, PC3, and PC4 by novices and advanced students in two domains. Means/Standard Deviations and F-values.

Domain	Level of Students		Results of ANOVA	
	Advanced	Novices	Source	F
PC1: Externally regulated and reproduction-directed learning				
Medicine	0.00/.93	0.31/.96	Domain	6.0*
Psychology	-0.36/1.09	-0.11/1.01	Level	3.5
Total	-0.10/.99	0.12/1.05	DOM X LEVEL	0.3
PC2: Self-regulated, meaning-directed, and goal-oriented learning				
Medicine	-0.30/.92	0.19/.83	Domain	2.9
Psychology	0.27/1.14	0.17/1.11	Level	3.1
Total	-0.14/1.01	0.18/.96	DOM X LEVEL	3.3
PC3: Constructive Epistemology				
Medicine	-0.08/.89	-0.33/.91	Domain	12.4***
Psychology	0.63/1.14	0.08/1.01	Level	5.4*
Total	0.11/1.01	-0.14/.97	DOM X LEVEL	0.9
PC4: Active Use of Knowledge				
Medicine	0.48/.60	-.09/.81	Domain	22.1***
Psychology	-0.63/1.42	-.39/1.05	Level	3.6
Total	0.18/1.02	-0.22/.93	DOM X LEVEL	7.4**
Numbers of students:			Degrees of freedom:	
Medicine	67	42	Domain	df=1,167
Psychology	25	37	Level	df=1,167
Total	92	79	DOM X LEVEL	df=1,167

Note: * $p < 0.05$, ** $p < 0.01$. *** $p < 0.001$

Dualism and epistemological standards. In all groups of students, there were more relativists than dualists. There were most dualists among novice medical students, and most relativists among advanced psychology students. The distributions among different subject groups differed significantly ($\chi 2(3) = 14.46$, $p < 0.01$). However, there were more advanced students among medical students than among psychology students. All interactions between the three variables (level of studies, domain, and dualism) were looked at the same time by constructing a log-linear model where level of studies and domain interacted, level of studies and dualism interacted, and domain and dualism interacted, and that there are no other interactions among these variables. This model fits well with the data ($G^2(1) = 0.026$, $p = .872$).

Novice medical students scored highest on dualism scores, second highest were the advanced medical students, then novice psychology students, and lowest the advanced psychology students. Measured by two-way ANOVA (2 Domains x 2 Levels of Studying), there was a significant main effect for domain (F(df=1,170) = 17.07, $p < 0.001$), and also for level of studies (F(df=1,170) = 7.20, $p < 0.01$). There was no significant interaction between these two main effects. Relativists were more often comprehension-oriented or neutral than were the dualists. Dualists were more often fact-oriented. In this respect, the distributions of dualists and relativists differed significantly ($\chi^2(2) = 6.97$, $p < 0.05$).

The question of whether there were any differences between dualists and relativists in terms of different study strategies for assessing comprehension (Weinstein and Mayer, 1986) was also addressed. It appeared that relativists more often suggested elaborative strategies (46 %) than did dualists (29 %). This difference was statistically significant ($\chi^2(1) = 4.10$, $p < 0.05$). On the other hand, dualists more often suggested rehearsal strategies (87 %) than did relativists (72 %). This difference was very close to statistical significance ($\chi^2(1) = 3.77$, $p = 0.051$). Another trend was close to statistical significance was relativists suggesting affective strategies more often (28 %) than dualists (13 %), $\chi^2(1) = 3.78$, $p = 0.051$). There were no differences between the two groups in the frequencies of organizational and metacognitive strategies.

6.3. Discussion

This study clearly reflects the so called 'student approaches to learning' (SAL) position, rather than 'information processing' (IP) position (Biggs, 1993; Entwistle & Waterston, 1988): We were not tapping students' on-line processing while doing a task, but asking what they would usually do. We assume that many of the results reflect context-specific phenomena, instead of some general aspects of students' information processing. Mixing Perry's (1968; 1970), Ryan's (1984), and Lonka, Joram & Bryson's (1994) measures in the same study with approaches to learning provided a chance to look at the interactions between different theoretical constructs. However, combining different theoretical approaches is problematic, and this study should be considered exploratory.

The main objective of this study was to explore how different conceptions and epistemologies are interrelated. Scales adopted from different sources were combined to look at interactions between different aspects of students' responses (Entwistle & Ramsden, 1983; Lonka, Joram & Bryson, 1990,1994; Perry, 1968; Ryan, 1984; Vermunt & van Rijswijk, 1988).

Although measures were not quite similar to previous studies, two principal components were found which resemble those reported by Entwistle & Tait (1990) or

Vermunt & van Rijswijk (1988). These two strong principal components reflected *_self-regulated, meaning-directed and goal-oriented* versus *externally regulated and reproduction-oriented learning.* In the present study, however, it was notable that Perry's seven item dualism scale (Perry, 1968; Ryan, 1984) was related to the latter component. Again, Perry's dualism scale was negatively related to the third principal component, called *constructivist epistemology*. On this principal component, comprehension criteria loaded positively and knowledge criteria negatively (these interactions give support to Ryan, 1984). In addition, high loadings of the scales Constructivity and Representation were typical of this principal component. This principal component reflects conceptions of knowledge rather than those of learning. The fourth principal component, labeled as *active use of knowledge*, most probably reflects a professional orientation. It is interesting that the scale Active Epistemology, referring to learner's active role, is not necessarily related to a constructivist epistemology.

In sum, interactions between conceptions of learning and conceptions of knowledge appear theoretically interesting. We can assume that these conceptions affect students' study habits by guiding their reading efforts (Ryan, 1984). Conceptions of knowledge (epistemologies) may not only guide comprehension standards, but also study strategies and orientations. Our results indicate that relativists more often than dualists suggest elaborative study strategies for testing their comprehension.

7. GENERAL DISCUSSION

The five studies investigated studying in higher education from various perspectives. The most important results may be summarized in the following way.

I In the first study, two samples of short essay answers of Finnish high school graduate candidates were examined. Although the titles referred to the same general topic, memory, the differences in them changed the orientation of the writer. The titles of the essays resembled each other: "Why do people forget?" (Theoretical) and "Why do we forget in school work?" (Applied). School knowledge dominated the content in both samples. But the role of experiential knowledge proved to be decisive regarding the amount of elaboration: if the school knowledge was connected with personal experience and observations, elaboration occurred more easily. Pure school knowledge was often just reproduced as presented in the books.

Further, elaborated thoughts were systematically longer than reproduced ones in two independent samples. The length of an essay, the number of thoughts in it and the amount of school knowledge seemed to be of importance when determining the grade. The role of experiential knowledge differed between the two samples: writing on the basis of experience was regarded as an advantage in an applied answer, while on the contrary, it was not rewarded in a theoretical one. Thus, elaboration was of importance when linked with appropriate content. If a combination of school knowledge and experience was used, elaboration was valued in an applied task. School knowledge, on the other hand, was rewarded in a theoretical task irrespective of whether it was reproduced or elaborated. The results showed how important it is to react appropriately to the title and it was concluded that students should be able to use knowledge in a flexible way, which requires the integration of knowledge in their minds.

The study was carried out several years ago, and many things have changed since the data were collected. For instance, the results have had some impact on the reform of Finnish National Matriculation Exam. Now it would be time to see whether we can still obtain analogical results.

II The purpose of the second study was to obtain information regarding overt study strategies that high-school graduates in Finland spontaneously use while learning from text in a highly demanding and motivating situation, namely, in an examination for admission to a medical school. Log-linear models were applied in order to look at many interactions simultaneously, which would not have been possible with simpler analyses.

As the first hypothesis stated, it was either the position of a concept in the text or its importance that directed students' attention, so that learning a minor detail was easier if it was underlined, defined, or written down. However, the central idea was learned regardless of strategy use. Log-linear models gave support to the second and third hypotheses, that underlining was related to success in a task that required synthesis of the text, whereas concept mapping was related to success in critique tasks. This was interpreted in line with Mannes and Kintsch's (1987) results, which indicated that memory of text depends on somewhat different mental representations than learning/problem-solving. The question of mental representation is, however, far from simple, and it will be looked at more carefully in this discussion.

III The third study described a case study of an intervention in a psychology department; the aim of these intervention procedures was to enhance effective study skills. The idea was to stimulate active learning in students by so-called *activating instruction*. A six-year longitudinal study was conducted in order to see what kinds of choices psychology students made and how these choices were connected with their academic progress. On the basis of students' evaluations, the new methods differed significantly from traditional methods. Students associated the development of study skills and understanding more often with activating instruction than with traditional courses. The number of activating courses taken was related to success in final exam and thesis writing. Those who participated in activating instruction studied more slowly during the first three years, but were more successful in the long term. This intervention was global in nature, and it cannot be concluded that activating instruction actually *caused* any changes. The data should not be overinterpreted, but rather considered as a documentary of what may happen when constructivist innovations are introduced at a university department. It must be noted that introducing and applying the new framework *per se* was probably the main contribution of this study.

IV Two studies examined the conceptions of learning held by Canadian subjects at varying levels of expertise in educational psychology. In Study A, the conceptions of participants with varying expertise in educational psychology were compared. Laypeople, novices, teachers, and experts answered open-ended questions, in which they were asked to define *learning* and to give a solution to an applied problem. Results indicated that a constructivist approach to learning was associated with expertise in this domain, as assessed by participants' definitions of learning. However, only experts produced solutions to the applied problem that were consistent with their definitions. Study B examined conception changes that occurred in novice students over a six-week period, as they completed their first course in educational psychology in a teacher training program. The results of Study B were consistent with those of Study A, and supported the idea that formal education in educational psychology has a significant impact on students' expressed conceptions of central concepts in the domain. However, even after a six-week course, students' solutions to an applied problem did not change. The results were discussed in terms of the changes in conceptual knowledge that develop with increasing expertise in psychology. Both studies had methodological limitations, which were already discussed.

V In the last study, the subjects were freshmen and fifth-year students in psychology and medicine who described their modes of studying. Students' approaches to learning, conceptions of learning and epistemologies were looked at, as well as the relations of these to the strategies students preferred. It was found that constructivist conceptions of learning were the most typical of (advanced) psychology students, whereas learning was more often seen as intake of knowledge by the medical students. The highest dualism scores were obtained by the first-year students, especially medical students. In both domains, fifth-year students scored higher on relativism. In general, dualists were more likely to report knowledge criteria to test their understanding than were relativists, and dualists' conceptions of learning were also more passive. An important result was that relativists more often suggested elaborative strategies than did dualists. Thus, epistemologies had some relevance on preferred strategies. Four principal components were identified that reflected qualitatively different approaches to learning and knowledge: *externally regulated reproducing orientation, self-regulated meaning orientation, constructivist epistemology*, and *professional orientation*. Medical students scored higher on variables related to professional orientation and reproducing orientation, whereas psychology students scored higher on scales associated with constructivist epistemology.

In the last two studies, there appeared to be both domain-general and domain-specific aspects in conceptions of learning: an active epistemology developed during academic studies in general, whereas a constructivist epistemology was typical of those having formal training in psychology. However, it is possible that students only started *to talk about learning* differently, since no direct measures of performance were applied.

7.1. Students' approaches to learning

Various methodologies were used to analyze approaches to learning (V), mainly from the students' approaches to learning (SAL) tradition. The results supported the assumption that meaning orientation would be more typical of psychology students than of medical students. The result that was unexpected was that medical students were less meaning-oriented at the end of their studies than at the beginning. Instead, they developed towards a *professional orientation*, where directly useful and applicable knowledge was of most interest. This is quite understandable: at the end of their studies, future physicians are concerned about taking care of their future patients. In a novel study (Lonka & Lindblom-Ylänne, 1996) we found that this phenomenon was related to gender in the psychology student population: male psychology students tended to be less professionally oriented than their female colleagues or medical students. Interestingly, another study (Lonka & Lindblom-Ylänne, 1995) showed that the grade obtained from the psychology Master's thesis was negatively correlated with professional orientation. This supports the assumption that professional orientation is more likely to reflect clinical or practical interest than scientific ambition. In psychology, where professional and practical skills are important, it may be problematic that students are mainly acculturated to a research-oriented apprenticeship (Mandl, Gruber & Renkl, 1996), and a clinical orientation is not rewarded. In medicine, the importance of integrating scientific and professional interests in a meaningful way should be emphasized in pedagogical solutions.

However, it is still not clear what the theoretical construct we labeled "professional orientation" really reflects. It resembles Vermunt's (1996) *application-directed orientation*, defined in his qualitative study, where students were interested in concrete applications and the use of knowledge in vocational settings. Application-directed students could be either externally or self-regulated, depending on their practical interests. The nature of professional orientation will be exmained more closely in future research.

It might have been interesting to analyze our findings not only dimension by dimension, but also on the basis of students' scores on each of the four dimensions together. Lonka & Lindblom-Ylänne (1995) examined the unique ways in which students orchestrate their studying (see Introduction 1.1.), and also the relationship of these different orchestrations with their study success. It appeared that orchestrations where a meaning orientation dominated, the less typical one in medicine, were related to study success in this domain. Especially interesting, and quite unexpected, was the result that constructive epistemology was related to novice students' success in medicine. This makes us think about a mismatch between the perceived environment (i.e., school-like, externally regulated) and the factors that really lie behind successful studying. The results possibly reflect a situation where the learning environment supports maladaptive ways of studying, and where only those few students who manage *not* to adapt accordingly will do well. This assumption requires further investigation, and we intend to look at the situation more thoroughly in the future.

Mixing constructs derived from the IP position with those derived from the SAL tradition may lead to problems of interpretation (Biggs, 1993). We found that, as long as we

were asking the students about what they would do (rather than making assumptions about their actual processing), our results and measures showed conceptual coherence, and also construct validity. For instance, students' suggestions for efficient study strategies were related to their epistemological beliefs, as we expected. Future research will show whether the results are replicable in other sets of data.

7.2. Epistemological and conceptual development

What is the nature of conceptual change in the domain of psychology? Studies IV and V both addressed conceptual development in psychology. Study V suggested that epistemological development towards constructive ideas of learning and knowledge is domain-specific, more typical of psychology students. On the other hand, students' active role was emphasized by all students, especially by advanced medical students. On the dualist epistemology scale, both domain and level of studies appeared important. The general level of dualism was higher among medical students than among psychology students, but in both domains there was a shift towards more relativist views. Because of limitations in methodology, it was not possible to look very deeply into conceptual change.

However, the two studies provided some insight about the possible nature of the epistemic change that takes place during studying, and the relationship between conceptual and applied aspects. It is not quite clear, though, whether we can actually talk about conceptual change in the case of psychology. Kuhn's (1970) definition of a scientific paradigm includes a particular coherent tradition in scientific research, and scientists whose research is based on shared paradigms are committed to the same rules and standards of scientific practice. Kuhn analyses the maturity of different sciences and points out that in mathematics and in astronomy, the first firm paradigms date from prehistory, whereas in parts of biology — like heredity — the first universally accepted paradigms are still quite recent. He doubts whether some parts of social sciences have acquired such paradigms yet at all — but does not specify which parts these might be.

As mentioned above, many researchers have suggested that the conceptions of physics of children and laypeople tend to resemble medieval conceptions (e.g., McCloskey et al., 1980; Carey, 1986). In the case of psychology, it is interesting to notice that it was typical of medieval conceptions (as described by Kemp, 1990) that memory was viewed as a storehouse or a container and that ideas were seen either as innate, divine, or as absorbed from the outside. This view reflects Plato's and Aristotle's writings, combined with medieval Christian scholars' ideas. Eysenck (1984, p. 79), referring mainly to Plato's ideas, calls this kind of view "the spatial metaphor", where the mind is thought to be "a physical space, with memories and ideas as objects contained within that space". Eysenck also points out that the spatial metaphor has shown extraordinary longevity, and that many cognitive psychologists have tended to take it for granted. The spatial metaphor fits well with common-sense intuitions and has been broadly accepted even among experts. It is not surprising that in Study IV, non-professional subjects' definitions of 'learning' echoed the spatial metaphor.

However, the open-ended nature of psychology may raise the question whether we can really talk about conceptual change within this domain. Chi (1992), whose work is influenced by Thomas Kuhn, thinks that the acquisition of the majority of biological concepts, unlike physics concepts, does not require conceptual change at all: 1) misconceptions in biology do not resemble medieval conceptions, 2) they are easily removed by instruction, and 3) they decrease with age and schooling. Whether or not misconceptions are robust, consistent, and theory-like depends on whether an ontological shift is necessary

for their removal. Even though Chi (1992) does *not* imply that conceptual change within an ontological category is simplistic, the question remains: if learning biology does not require radical conceptual change, what about a domain that is much more open-ended — psychology? On the basis of Studies IV and V, laypeople's conceptions somewhat resemble medieval conceptions, but schooling in psychology has some impact on them. However, it may be suggested that something like conceptual change may be needed before students fully grasp constructivist ideas of learning. These ideas appear quite counterintuitive, and further, current educational practices echo quite the opposite interpretation.

In the domain of psychology, epistemological development appears crucial. Overtly challenging students' existing conceptions of learning by showing them data that contradict with their current beliefs may cause *constructive frictions* (Vermunt, 1995) which are necessary in order for students to become willing to change their conceptions. Creating constructive frictions is an integral part of process-oriented learning, the aim of which is to help students become aware of their beliefs, strategies, and self-regulatory skills.

There are aspects of conceptual change that may not be directly domain-specific, even though they arise from strategy use in specific domains. For instance, D. Kuhn (1989) suggests that the heart of scientific thinking is the coordination of theories and evidence, and only a mature scientist is able to a) consciously articulate a theory (s)he accepts, b) see what evidence would contradict it, and c) justify why the coordination of available theories and evidence has led him or her to accept the theory. It is the instruments of scientific thinking that undergo strong restructuring. Further, Kuhn (1989) suggests that strategy changes occur in the context of efforts to acquire knowledge. During this process, students also gain metacognitive knowledge for understanding their strategies, and therefore the development of scientific thinking skills has a strong metacognitive component.

Students' ideas of learning, or their approaches to learning, may be regarded as *metacognitive beliefs* about the nature of intelligent behavior and learning, which may have relevance for their learning goals and processes. Metacognitive knowledge and beliefs form necessary but insufficient conditions for executive control of learning strategies (Simons, 1996). As Study V suggests, therefore, these beliefs affect students' preferences for particular strategies.

Constructivist notions revisited. Because constructivist notions permeate the theoretical ideas behind all five studies, it is time to look at them more carefully. What is actually meant by "constructivist notions" in this study? Constructivism has many faces (Phillips, 1996), and not all are applauded in applied cognitive science, cognitive psychology or educational psychology. It appears that extreme relativism is not appreciated, at least if it leads towards treating the justification of knowledge as being entirely a matter of sociopolitical processes or consensus (Bereiter, 1994; Bruner, 1996; Cobb, 1996). Most researchers adopt a view that represents some form of scientific realism.

From a psychological point of view, the main question is the process by which we "know" something. Is this a process of intaking already existing knowledge, or is all knowledge constructed by the learner? Many psychology textbooks still maintain that simple knowledge is directly perceived and that only complex knowledge requires construction. However, empirical evidence suggests that already basic processes of perception are constructivist in nature (Gardner, 1985; Loftus & Loftus, 1980; Neisser, 1976). The reconstructive processes in human memory are well-documented (e.g., Anderson, 1985; Bartlett, 1932; Chan, Burtis, Scardamalia & Bereiter, 1992; Cofer, 1973; Mannes & Kintsch, 1987; Marton, Dahlgren, Säljö & Svensson, 1977; Rauste-von Wright & von Wright, 1994; Resnick, 1989). In general, empirical research suggests that when asked to

present contents of text, stories, or pictures to be learned in experimental situations, subjects do not simply reproduce information from memory, but rather reconstruct its content, presumably on the basis of their personal mental representations. Research on conceptual change (Carey, 1986; Vosniadou, 1994) has shown how difficult it is for students to learn scientific concepts which are contrary to their everyday beliefs. Thus, the constructivist theory of human learning cannot simply be thought of as an ideological position, but rather as an empirically testable scientific theory of cognitive functioning.

Another question concerns whether or not there is knowledge without human construction. This is a philosophical question, and it is quite beyond the scope of this study. Maybe it is better to address a question one degree more specific, although not much easier: in what degree is the process of knowledge construction socially-shared, situational, and context-specific (Brown, Collins & Duguid, 1989) as opposed to universal, general, and abstract? This question differentiates between situationists and conceptual rationalists (Resnick, 1996): the former emphasize a contextualized and social view of the nature of thinking and learning, whereas the latter claim that there exists a set of biological constraints on learning and cognitive development. Each side appears to maintain coherence by asking questions which support their views. Resnick (1996) asks how these views might saturate each other by providing an account of how individuals learn both universal concepts and the much greater variety of culturally specific knowledge and ways of acting: there are cultural elaborations of conceptions initially founded on biologically prepared structures, and education is clearly part of this cultural elaboration process. Resnick, Bill, and Lesgold (1994) deny the fundamental distinction between competence and performance, and seek to understand cognition, not as something-in-the-head, but rather as forms of cultural practice. They state that shaping dispositions to critical thought is at least as important in developing higher-order cognitive abilities in students as is teaching skills of reasoning and thinking.

Jerome Bruner (1996, p. 61) admirably sums up an epistemological attitude with which most of us could agree:

> In these post-positivist, perhaps "post-modern" times, we recognize all too well that the "known" is neither God-given truth nor, as it were, written irrevocably by the Book of Nature. Knowledge in this dispensation is always putatively revisable. But revisability is not to be confused with free-for-all relativism, the view that since *no* theory is the ultimate truth, *all* theories, like all people, are equal. We surely recognize the distinction between Popper's "World Two" of personally held beliefs, hunches, and opinions and his "World Three" of justified knowledge. But what makes the latter "objective" is not that it constitutes some positivist's free-standing, aboriginal reality, but rather that it has stood up to sustained scrutiny and been tested by the best available evidence. All knowledge has a history.

According to Bruner (1996) it follows from this position that teaching should help children to grasp the distinction between personal knowledge, on the one hand, and what is taken to be known by the culture, on the other. However, it is not enough to grasp this distinction, but one must also understand its basis, as it were, in the history of knowledge. Bruner presents a major challenge by recommending us to incorporate such a perspective in our pedagogy.

Thus, all learning takes place within a cultural and historical context. Smith (1996), for instance, points out that both Vygotsky and Piaget acknowledged the importance of culture in their developmental theories of cognition, although their emphasis was different: Piaget regarded the social element as only one essential element in the growth of knowledge, whereas Vygotsky found it the principal element. Obviously, there are parts of human

thinking which are more general, and those which are more domain- or context-specific. It would be quite impossible to learn anything if no transfer took place from one situation to another, and there is a lot of evidence of transfer across contexts (Anderson, Reder & Simon, 1996). Obviously, there are general skills, but they always emerge in a context: general and contextualized are not mutually exclusive (Perkins & Salomon, 1989).

On the basis of Study V, it seems that there are parallels in both psychology and medical students' epistemic development, but in some important respects, special domains and learning environments engage students in qualitatively different forms of instructional interactions, and therefore shape thinking in diverse ways. Further, different epistemic presuppositions probably have an impact on the development by directing the way students perceive their learning environment. This assumption will be tested in future research.

7.3. Cognitive research on learning and study strategies

The effect of spontaneous strategies on learning from text. The research on study strategies in Study II was based on the idea that spontaneous strategy use has relevance for the construction of mental representation, and therefore on the outcomes of learning. The results showed that underlining helped subjects in the task where a textbase was called for, whereas concept mapping was most effective in the task where a situation model was needed. This indicates that the effect of underlining cannot be merely described as one of rehearsal or rote learning: combined with efforts to understand it can serve organizational functions as well. Further, the effect of concept mapping on learning may be similar to that of inconsistent outlines (i.e., outlines organized inconsistently in relation to the propositional structure of the text), as in Mannes and Kintsch's (1987) study: both break the structure of the text and require information from different places in the text to be combined and actively integrated with previous knowledge. It is possible that mapping or other elaborative strategies enhance the formation of a situation model.

There are, however, some alternative explanations that do not rely on the encoding process only. First, it is possible that the same kind of orientation guides performance during both the encoding phase and essay-writing. That is, those who show a deep approach to a text are more likely to have a deep approach when writing (Bereiter & Scardamalia, 1987; Marton & Säljö, 1976; 1984). The second possibility is based on Spiro's (1977) reconstruction hypothesis, which implies that able learners use reasoning skills during encoding to determine which discourse ideas can later be inferred from prior knowledge. Similar reconstructive processes also inform the exam performance.

The ideas of mental representations, different approaches, and reconstructive processes are not necessarily contradictory notions. They all fit well with research on writing, which shows that there is a close interaction between text representations and writing strategies: the writer's mental representation of a text guides the way of writing about it. Also, having access to a variety of representations at different levels of abstraction makes the writer's planning and problem-solving possible (Bereiter & Scardamalia, 1987). Rich and sophisticated representations are typical of expert writers, whereas novices are forced to work with near-verbatim representations of the text, and often end up with information overload. On the other hand, both reading and writing may include either knowledge-telling or knowledge-transforming type strategies: these two strategies differ in terms of how much active construction and reflection is included in the process (Scardamalia & Bereiter, 1991), the latter being more constructive and typical of expert writers and readers.

A Finnish university entrance examination offered an ecologically valid, well-standardized setting for Study II. It provided a chance to look at the study strategies spontaneously applied by the applicants in a highly demanding situation. It is possible, though, that the situation was exceptional in nature, because the subjects were under enormous stress. The situation also set methodological restrictions: it was not possible to use any other measures but a short questionnaire. Therefore, analyses were mainly off-line observations of study strategy behavior, such as analyses of notes.

It is worth recalling that our experimental text in Study II was about philosophy. It is possible that success in this specific domain requires special study skills or mental representations. It is generally agreed that prior knowledge and its organization contribute to learning from text, and that domain-specific declarative knowledge has an effect on learning (e.g., Resnick, 1984). Our recent studies showed parallel results in the domain of statistics (Lahtinen, Lonka & Lindblom-Ylänne, 1997; Lonka, Lahtinen & Lindblom-Ylänne, 1996): generative strategies were useful in tasks calling for application of knowledge. Lahtinen et al. (1997) showed that not only concept mapping but also other generative strategies such as summarizing were equally useful in this sense. In these studies, it was not possible to specifically control the effect of prior knowledge, owing to practical limitations. However, an ongoing study (Lahtinen & Lonka, in preparation) indicates that both the quality and the quantity of spontaneously constructed notes are related to deep-level text-comprehension after adjusting the effect of previous school knowledge.

It must also be kept in mind that the same study strategy may be used for different purposes. A more qualitative approach might have revealed something about the nature of the thinking processes that mediate between study strategies and learning outcomes. On the basis of the present results, although replicated in two sets of independent data, we can only show that certain strategies are related to success in certain kinds of tasks, as we expected. The nature of the relationship is, at present, based on a theoretical assumption. However, there is evidence that the association is not only statistical, and that the quality of concept maps is related to the quality of knowledge construction in essay-type tasks (Lahtinen & Lonka, 1996).

Moreover, it is worth pointing out that we concentrated only on the encoding function of study strategies, since our subjects were not allowed to review their notes. In an ongoing study (Lahtinen, in preparation; Lahtinen & Lonka, 1996) the differences between two situations will be looked at more closely: half of the subjects had the chance to review their notes whereas the other half were not allowed to do this. Preliminary results suggest that already the metacognitive awareness of the possibility of reviewing the notes somewhat directed spontaneous note construction, and further, that the construction process had an impact on success regardless of the chance to review the notes.

In Study II, we were not able to tell which strategy might prove most helpful in a classroom situation. However, our setting resembled a natural situation common to medical students: they must be able to learn from text under stressful conditions without having time to extensively review their notes.

Process and outcome of learning — mental representation as a mediating concept. In Study I, the type of processing was classified as “reproductive” or “elaborative”. Although not clearly mentioned in the article, this reflects the general differentiation made in the literature between surface-level reproduction versus deep-level transformation of knowledge (II). Von Wright, Vauras and Reijonen (1979) also inferred strategies from the learning outcomes, as was done in Study I, and similarly distinguished between transformation and

reproduction strategies. The problem of mixing process and outcome measures, discussed in some previous studies (e.g., Entwistle and Ramsden, 1983), was avoided in Study I by focusing strictly on the number of elaborative expressions in the essays. The classification system in Study I clearly concerned the outcome of learning, and as a result its reliability was very good.

Study II examined whether students were able to write essay-type answers which called for different kinds of processing, and no direct process measures were used. The relation between process and outcome was theoretically explained by using the concept of mental representation (II), central in cognitive learning theory (IV). Because no on-line measures were available, the inferences had to be made on the basis of overt study behavior and the products of learning. In Study I, only the essay-type answers were available, whereas in Study II it was possible to look at the relation between reading activities and writing outcomes. The most problematic inductive leap took place when the results were interpreted on the basis of cognitive theory. The whole line of argument was implicitly based on the assumption that it would not have been possible to produce certain kinds of cognitive outcomes without high-level cognitive processes. That is, in Study I elaboration could be interpreted as a reflection of deep-level processing. In Study II, it was inferred that it would not have been possible to successfully answer critique tasks without forming a situational representation of the subject matter. The assumption that the critique tasks actually measured the formation of a situation model is somewhat problematic. However, these tasks certainly required going beyond the text itself rather than being fixated with a representation directly derivable from the text.

Without using *mental representation* as a mediator between process and outcome, it would have been quite impossible to predict and interpret the results obtained in Studies I and II. This theoretical concept was also important in Study III, being the aim of the activating instruction intervention, where diagnosing mental models and supporting conceptual change were crucial. In Studies IV and V, mental representation was found to be an important conception, developing specifically during psychology studies, when advanced psychology students tended to apply the concept of mental representation while defining and explaining the concept of learning.

Vauras (1991) assumed that the use of different strategies in formally similar tasks may lead to qualitatively different knowledge representations in memory.[8] Parallel with our results, her studies on text-learning strategies indicated that a deep approach results in more *structured memory representations* than does a surface approach. Also, she found that a deep approach also led to better retrieval, both immediate and delayed. Thus, it seems reasonable to assume that the approaches to learning tasks and the formation of functional mental representations are related to each other.

However, we should not think about mental representations as artifacts "in the head", but rather, metaphorically (Bereiter, 1996). The dynamic and constructive nature of cognitive processing continually updates our thinking, and mental representations may be not only context-specific but also highly situational (Brown, Collins & Duguid, 1989; Schank, 1982). The situational aspects of cognitive processing, on the other hand, do not make the notion of mental representation go away. The purely mentalistic, in-the-head account in cognitive science is nowadays considered *passé* because it is widely recognized that knowledge is constructed in specific social and historical situations (Resnick, Bill & Lesgold,

[8] Von Wright, Vauras & Reijonen (1979) preferred the concept "strategy" over the more general global concept of "approach", because their aim was to understand students' learning activity in a context of information processing (see Vauras, 1991, p. 34).

1994; Resnick, 1996; Salomon, 1993). However, it would be quite impossible to predict and explain the relation between process and outcome in cognitive research without the notion of mental representation.

7.4. Implications for instruction

The importance of conceptions of learning in different domains.. Students' epistemological develop-ment and their conceptions of learning should be taken into account in instruction. On the basis of Study IV, it may be conjectured that when discussing *learning*, laypeople, teachers, and experts in educational psychology may be talking about very different things. Perhaps the general failure to carry out significant reforms in school systems is partially related to this problem: policymakers, parents or students may simply not share the same epistemological views with teachers and researchers who suggest new approaches to learning. There are three special challenges, which Studies III, IV and V address: medical education, the teaching of psychology, and teacher training.

First, dualism and non-constructive epistemologies in *medical students*, observed in Study V, may be obstacles to their academic development. Medical students appear more likely to express professional orientation, where only directly applicable information is appreciated. A dualist epistemology may be especially problematic when problem-based learning (PBL) is introduced to Finnish medical students. Previous research indicates that PBL students are more likely to study for meaning and less likely to study for reproduction (Albanese & Mitchell, 1993). We assume that skills in self-regulation will be important for PBL students. Also, PBL may enhance not only clinical reasoning skills but also general epistemological development. The measures introduced in this study will be used in further comparisons between conventional and PBL students, and their conceptual validity appears promising.

Second, conceptions of learning and knowledge are crucial in the domain of *psychology*, where conceptual change may be epistemological in nature (III, IV, V). Therefore, these aspects are especially important in the teaching of (educational) psychology, where instruction should aim at creating a constructive friction between everyday conceptions and scientific explanations. In the teaching of psychology, and much remains to be done in order to map the major misconceptions which may be hindrances to learning.

Third, *teacher education* is a domain of great importance, when it comes to conceptions of learning and knowledge. For teachers and other professionals who interact with children, such beliefs could have a profound impact on their approaches to teaching and on the decisions they make about interventions directed at children who have learning problems (Desforges, 1995; IV). Teachers vary in their ability to take into account students' understanding of the subject matter (Bromme, 1989; 1993). There is a set of beliefs, which Bruner (1996) refers to as *folk pedagogy,* which are prevalent in the Western educational system. Bruner classifies current theories in terms of two dimensions. The first is the *internalist-externalist* dimension. Externalist theories emphasize what adults can do for children from outside to foster learning, whereas internalist theories focus on what the child can do, what the child thinks s(he) is doing, and how learning can be premised on these intentional states. The second dimension is the *intersubjective-objectivist* dimension, which describes the degree of common understanding assumed to be shared between pedagogical theorists and the children to whom their theories relate. Intersubjectivists tend to create

psychological theories which are as useful for children organizing their learning as they are for adults who work with them.

Applications which may be considered both internalist and intersubjectivist are those where one is concerned with the students' mental activity, and where one is likely to formulate a theory of teaching-and-learning that can be shared with the students in order to facilitate their efforts (Bruner, 1996). An example of such a practice is CSILE (Computer-supported Intentional Learning Environments; Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989; Bereiter & Scardamalia, 1994), where children's inquiries are made overt and where collaborative building of knowledge is the main facilitator of learning. This environment is based on the notion that reflection and metacognition are most likely to develop in meaningful social interaction. Process-oriented instruction and activating instruction share these aims, although the collaborative aspect is not emphasized in quite the same degree. Activating instruction is a pragmatic tool, a framework constantly being reshaped, and therefore collaborative aspects are more and more taken into account in current applications. A special challenge has been to apply these notions in lecture halls where 500-700 students attend at the same time (Lonka & Saarinen, 1996). The final challenge for constructivist pedagogy is thus to design innovations in mass instruction, too. It is not realistic to assume that expensive computer equipment or small-group instruction is always available.

Different modes of thinking as components of integrated thought. Finally, a purely cognitive approach is too narrow in real-life instruction. Experiential learning, in addition to mere reflective thinking, should be provided (Kolb, 1984; Norman, 1993). Study I indicated that students more easily elaborated on experiential knowledge than on school knowledge. Many studies show that the most problematic aspect of transfer is that between classroom and real life (Biggs, 1994): whereas everyday learning is concerned with personally valued content, dealt within its context, school knowledge is mostly declarative, an abstraction of what others have already discovered. School knowledge has the tendency to remain *inert* (Vosniadou, 1994; Whitehead, 1929), that is, students possess knowledge, but tend not to apply it in the necessary circumstances. Study IV indicated that this may be in the case with conceptions of learning as well. Motivational considerations (Lepper, 1988), such as interest (Hidi & Baird, 1986; Krapp, Hidi & Renninger, 1992), may prove to be central in the successful renovation of the educational system. There is empirical evidence suggesting that students' interpretations and attributions of themselves have important implications, for example, for the ways they process text (Mandl & Schnotz, 1987) and for their academic achievement in general (e.g., Salmela-Aro, 1996).

Biggs (1994) reports that successful learning has been noticed when students teach other students, one-to-one interaction occurs (involving scaffolded instruction), formal content is learned in the context of solving actual professional problems (such as problem-based learning), abstract learning is built on lower-level learning, or formally taught knowledge is linked to experiences. He concludes that successful methods for teaching abstract, depersonalized content appear *not* to be those that treat the content in an abstract, depersonalized way.

Certainly, it is possible that many pedagogical innovations fail, because we forget the fact that teachers and students are not only intellectual creatures, but have their emotional lives as well. Bruner (1986) refers to two different modes of thinking: paradigmatic versus narrative. The former refers to scientific, analytical thinking, asking "*What are the true answers?"*, whereas the latter inquires: *"What makes a good story?"*. We do not have to

separate the two in scientific instruction, because a good theory no doubt also provides a convincing story. Further, the folk psychology (Sternberg, 1990; Bruner, 1996) of learning that lies behind our instructional procedures is one form of a story, too. It may become a disposition of learning which is more crucial than the things we are actually trying to teach. That is, our implicit theory of learning expresses itself in our action, and may be contrary to the explicit, official story we think we are telling.

Consequently, what makes a good story of learning in higher education? It is a complex story, rich in details, not a description of a stage-like development. We may be able to state some generalizable trends of development, but domain-specific expertise will be more crucial than age in this evolution (e.g., Pozo & Carretero, 1994). Certain forms of cognitive activities, such as knowledge transforming or knowledge building (Bereiter & Scardamalia, 1987; 1993) or metacognitive activity (Demetriou et al., 1994), may have a cumulative effect on students' development, and therefore may be related to exceptional, non-linear development. All in all, it is hardly plausible that a direct mapping between instructional activities and cognitive outcomes will be found, because the internalization process is transformational in nature (Vaalsiner, 1994): development includes a series of transformations, where the quality of thinking changes. In other words, learning may be initiated by instruction, but mediating variables, especially the quality of students' activities, will determine the outcome. These activities, in turn, are guided by beliefs, strategies, epistemologies, and self-regulatory activities. Externally provided feedback may or may not be taken into account in this process, but we cannot assume a direct causal mechanism between external feedback and mental functioning. The chances of observing linear causality in the emerging of high-level learning are thus quite slim.

Recent notions of *wisdom* as a form of integrated and mature thought (Labouvie-Vief, 1990) provide inspiring challenges for higher education, because this concept goes beyond a cognitive theory of expertise: it combines the paradigmatic and narrative ways of thinking, that is, *logos* and *mythos*. The former refers to mechanical, computational, rationalistic, and deductively certain knowledge, whereas the latter involves more holistic thinking, based on a bond of close identification between the self and the object of thought. Labouvie-Vief (1990) points out that the traditional separation between formal and informal thought is based on a fallacious dualism, which is especially invalid when we talk about the thinking of mature adults who should move towards transformational, dynamic, and dialectical thought. This might be described as "flexible expertise" (Mandl, Gruber & Renkl, 1996) or progressive problem solving (Bereiter & Scardamalia, 1993). A dualist division between the two modes of thinking — whether we name them paradigmatic and narrative, logos and mythos, cognitive and experiential, formal and informal, scientific and artistic, analytic and holistic — is gradually breaking down, and theories of wisdom seek to form a synthesis in which the mind is viewed more integratively as encompassing the two modes as complementary and irreducible poles (Labouvie-Vief, 1990; Schmeck, 1988). If we look at learning as *personal change*, which is a fairly rare conception of learning among university students (Marton, Dall'Alba & Beaty, 1993), it comes close to this idea of wisdom. Would it be possible to teach in such meaningful ways that students would experience personal change or, even more, an increase in their wisdom? The role of university teaching may move towards this idea, and the result may be a holistic view of integrated competence (Hager & Gonczi, 1996), which is conceptualized in terms of scientific and professional knowledge and affective attributes combined with cognitive, interpersonal, and metacognitive skills.

The present thesis approached the question in much narrower terms. However, at the heart of the development of expertise is the active construction of knowledge and ideas. Further, meaningful learning is not only accumulation of knowledge or mere changes in

behavior, but much more: fundamental conceptual changes in students' belief systems and thinking. It is not enough that our students know a lot. This knowledge must have some personal meaning for them, and most importantly, changes in their belief systems should direct their performance and change the way they interact with new information, with each other, and with the world.

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