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ABSTRACT

A pilot study focused on differences between novice and expert teachers, including the structure of teachers' thought processes and knowledge and teaching behavior during lessons. Study data were collected from seven secondary school mathematics teachers (three experts and four novices) through clinical interviews and lesson observation. Interview questions dealt with teachers thoughts towards: (1) general objectives for education; (2) goals for subject matter teaching; (3) interactive thoughts and decisions; and (4) lesson planning and evaluation of learning outcomes. The lesson observation portion of the study focused on: (1) structure of lessons and use of questions; (2) type of questions; (3) scaffolds; and (4) type of scaffolds. Comparison indicated that experts' pedagogical knowledge included higher level conceptions, principles, and generalizations than that of novices. Expertise showed up in teachers' abilities to make correct interpretations about different students and act accordingly in instructional interventions. (CB)

Teachers' Conceptions of Teaching and Teaching Behavior: Some Differences between Expert and Novice Teachers

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Introduction

The most recent paradigm in the study of teaching, 'expert-novice' paradigm, seems to offer one possible framework to examine teachers' professional development. The goal of expert-novice studies has been to find out differences between beginning and qualified professionals and to reveal the interval stages in the development of expertise. If the progress of the development is known education might be designed to promote the acquisition of expertise.

Such information might also be useful for teacher education. We need to know what kinds of effects teacher education has on the conceptions and behavior of novice teachers, and how the conceptions and behavior develop during the first few years of teaching. Recent developments in cognitive science and especially in instructional psychology have shown that teachers' cognitive processes and their knowledge of the subject matter and pedagogy may have a crucial role in determining their teaching behavior and the achievements of their students.

The purpose of this paper is to describe the results of a pilot study focusing on differences between expert and novice teachers. We are interested in the following questions: 1) the structure of teachers' thought processes and knowledge, and 2) teaching behavior during ordinary lessons. Special attention will be paid to conceptions of interaction and actual interaction between the teacher and students. Both of the areas of subquestions are closely related to each other.

The theoretical framework of the study is based on the research of teacher cognition and studies of expertise. Both areas will be briefly reviewed.

Teacher cognitions

Teacher cognition studies have their roots in the development of cognitive research in the late 50's and early 60's (e.g. Newell & Simon 1956; Bruner, Goodnow & Austin 1956; Chomsky 1957; Miller, Galanter & Pribram 1960). The present efforts concentrate mainly on three areas : studies of judgement and policy, studies of problem solving, and studies of decision making (Shulman 1986a). The conceptions of teachers have also been studied intensively. We only refer to the extensive review of studies concerning teachers' conceptions made by Clark and Peterson (1986).

Teacher knowledge represents an area which is new and covered only in the most recent studies on teaching and teacher cognition. It has become obvious that the teacher's knowledge base is closely related his/her teaching behavior and as a result the need for a coherent theoretical framework in this field has become evident. (see e.g. Shulman 1986b.)

Expert - novice studies in teaching

Effective and less effective teachers have been studied a lot within the process-product paradigm. The goal of such studies was to find out what kinds of characteristics are typical for effective teachers. Examples of the results of the studies can be found in most textbooks on teaching. Effectiveness of teaching was usually defined using students' scores on an achievement test. In more recent studies of expertise the focus is not on the characteristics of effective teachers, but on the cognitions of the subjects.

The nature of expertise has become a research topic after psychologists started to study problem-solving processes which required the use of a large knowledge base. Several studies have been made about expertise in such fields as chess, radiology, physics, reading, social sciences etc... Experts and novices have been found to differ from each other in many respects.

What seems to be a crucial difference between experts and novices is the structure of their knowledge bases. It is these knowledge base differences that are important, for instance, to problem-solving ability. The relation between the knowledge base and problem-solving seems to be mediated by the quality of the representation of the problem. This means that experts have much better representations or models of the problem and can base their solutions on such models. The representation of the problem is constructed on the basis of the domain-related knowledge and its organization. The nature of this organization seems to determine the quality, completeness and coherence of the internal representation, which in turn determines the efficiency of further thinking (Glaser 1985).

According to Glaser (1985), novices' representations are organized around the literal objects and events given explicitly in a problem statement. Experts' knowledge, on the other hand, seem to be organized around inferences about principles and abstractions that subsume these principles. Experts also seem to categorize problems at a higher theoretical level (physics), e.g. in terms of applicable principles. Experts know better how to apply their knowledge. Their declarative knowledge is tightly bound to conditions and procedures for using it. A novice may have sufficient knowledge about the problem situation, but does not know the conditions of the applicability of this knowledge (Glaser 1985, 5). In addition to the knowledge base differences between experts and novices there may be important differences in self-regulatory or metacognitive capabilities. These abilities include knowing what one knows and does not know, planning ahead what to do, allocating efficiently one's time and attentional resources, and monitoring and editing one's efforts to solve problems. Self-regulatory activities and abilities are probably specific to the knowledge domain of an expert. They may become abstracted strategies after individuals use them in several occasions and fields of knowledge. (Glaser 1985.)

Who is an expert in teaching ?

Leinhardt and Greeno (1986) considered experts those teachers who had best growth scores of students on their class over a 5-year period. A teacher was considered expert if his/her classroom also appeared in the highest 20% in the final achievement. This view of expertise is one possibility, although it also has some limitations. It is applicable if such percentages are available for classes. In Finland, for example, such percentages are not calculated, and different approaches are thus needed. We may assess teachers e.g. by using years of experience, peer and researcher evaluation by colleaques or evaluation by students or using all the above. None of these methods can be considered sufficient for a complete assessment of expertise. In this pilot study several years' experience, high grades from teacher education, and the subject's role as a teacher educator were considered sufficient criteria for expertise.

One difficulty in using student records in the definition of expertise is the interplay between expertise and authority, as shown by Benne (1970). He conceptualizes expert - client situation with an example from medicine. The doctor bases his claim to authority over his patient upon his specialized knowledge, skills, and experience with respect to certain aspects of health and disease. The patient is obedient to the doctor's advice because of the perceived relevance of the doctor's competence to his own need. The field in which the authority operates is jointly delimited by the intersection of the doctor's competence and the patient's need. In educational situations the needs of students are not so clear. The determination of students' needs is largely done by teachers themselves or administrators. Benne's (1970) conclusion is that teachers and students do not establish an authority relation at all. So the teacher must resort to non-authoritative modes of influence in order to get his/her advice and orders listened to and complied with. Examples of these are extrinsic rewards such as grades, threats of failures, etc. The point is that teachers may be successful in using these non-authoritative ways and enhancing student learning independent of the expertise evidenced by the structure of knowledge base. If we use student records as an evidence of expertise, we may confuse the effects of expertise and authority. Expert teachers may appear to be good in using rewards and not so much different in the quality of their knowledge when compared to non-expert teachers. However, this is a question to be considered more profoundly in the future studies.

Leinhardt has made several studies concerning expert and novice teachers. In one of the first she studied experts and novices in an estimation task in which both groups estimated the degree of overlap between the curriculum a child was exposed to and the criterion test used to assess performance (Leinhardt 1983). Both groups were asked to think aloud during the task, and a protocol analysis was carried out to reveal the differences. Both groups were about equal in their abilities to assess students' performance on the criterion task, but the experts had a better understanding of how and why they made the specific assessment.

In another study Leinhardt and Smith (1985) studied expert teachers' subject matter knowledge in mathematics (fractions). From the protocols semantic nets were developed to describe each teacher's knowledge of the field. A comparison of the networks revealed wide disparities in the knowledge of expert teachers. Some teachers seemed to display relatively rich conceptual knowledge of the fractions, while others relied upon precise knowledge of algorithms.

In a recent study Leinhardt and Greeno examined experts' and novices' activities during the lesson using activity structures (routines) and planning nets as their framework (Leinhardt & Greeno 1986). Teaching was considered as a complex skill which requires the construction of plans and the making of online decisions. The environment for the task of teaching is usually relatively ill-defined. The goals are not specified accurately and the environment changes often in an unpredictable way, which complicates the teacher's actions and planning. Leinhardt and Greeno hypothesize that skill in teaching rests on two systems of knowledge: lesson structure and subject matter. The first is the knowledge required to conduct a lesson and the second includes the knowledge of the content to be taught.

The results of empirical study by Leinhardt and Greeno showed that expert teachers constructed their mathematics lessons (4. grade) around a core of activities. This core seemed to move from total teacher control to independent student work. Teachers seemed to use different teaching methods, e.g. presentation, review, drill, tutoring, and testing, irregularly. The presentations and shared presentations (presentation including some interaction with students) of expert teachers were relatively short. Guided practice was used more frequently by experts than novices. Experts' routines during those sessions were also more efficient. Novices used typically presentation and often jumped from presentation directly to practice. A major difference between experts and novices was found in the experts' use of routines. The experts had a large collection of routines which they used flexibly and with little explanation or monitoring. The use of routines made experts able to shift the order and form of lesson segments in a flexible way. The novices had only few routines in their behavior which was characterized by the fact that novices constantly changed the form in how they performed different activities.

Leinhardt and Greeno's study (1986) represents new directions in educational research in at least two ways. First, it has made explicit hypothesizes about the structure of the teacher's knowledge base and showed how the knowledge base and actual behavior may be related. Second, the results of the study seem to show that experts and novices differ from each other at the level of knowledge base structure and actions, and that those differences may be crucial for the development of expertise.

To summarize the discussion we may conclude that expertise seems to be related to the structure and quality of the teacher's knowledge base. In this knowledge base both factual (declarative) and skill (procedural) knowledge are represented. In the development of expertise the knowledge becomes hierarchically organized so that the search of large knowledge units becomes fast and accurate. The integration of declarative and procedural knowledge increases so that the perception and pattern recognition of typical teaching situations are connected to appropriate behavioral procedures in the situation. However, we need more specific results on the differences between experts and novices to map the development of expertise in teaching.

Method

Subjects

The subjects (n=7) were mathematics school teachers, who taught 7th through 12th grade students. All of the subjects were volunteers. There were both men (5) and women (2).

Three of the subject were considered experts and the remaining were novices, who were finishing their one year teacher training. One of the novices had two years experience as a school teacher. All of the experts were tenured teachers who had 5 to 15 years experience in the teacher training school of the university.

Procedure

The data in the study were collected using clinical interviews and observations during lessons. Each subject was interviewed about his or her conceptions and 3 to 4 lessons were observed and recorded. A *questionnaire* for the interviews was developed for measuring teachers' pedagogical theories and conceptions. In the interview the topics were fixed, but the subjects were allowed to talk freely about them. The interviewer did not specify what they should tell but he did, however, try to probe more specific responses after the initial answers.

The interview covered following topics: a) the teacher's goals and objectives for education in general and in their own subject matter, b) the teacher's conceptions about interaction in the class and conceptions of his/her own behavior in interactional situations, and c) the teacher's planning processes before and during the teaching. The interview took about an hour and it was recorded for later analysis. The recorded interviews were transcribed and the conclusions were drawn from the analysis of transcribed interviews.

The classroom observations were done by a research assistant who recorded all the lessons and transcribed them afterwards. The observations were carried out during the last two months of the school year (April – May). In the analysis of the observed lessons attention was paid to the interaction between the teacher and his/her students. The analysis was based on the calculation of quantitative data, such as the number of questions presented etc. Qualitative analysis was also needed e.g. when classifying forms of the teacher's 'scaffolds'. These classifications were made by two independent judges, who afterwards compared their results and discussed incongruous cases.

Interview results

The purpose of the interview was to study the structure of teachers' thoughts and their conceptions about pedagogical topics. Expert teachers seemed to give longer, more exact and detailed answers to almost every topic. They also related their answers more often to concrete experiences and gave examples which showed that they mostly think educational goals from the perspective of their own subject matter.

In the following the experts' and novices' interview results are summarized and expressed in condensed form to make them more comprehensible.

A. *General objectives for education*

Experts

- emphasized development of understanding and thinking as goals for education; also learning to learn was mentioned as an important goal for school education,
- the goals and aims of education were discussed separately for each grade level (e.g. grades 1–6, grades 7–9, and high school 1–3),
- the goals of instruction were usually more connected to actual learning outcomes to be found in students, (e.g. "teacher's duty is to offer stimuli/give basic facts to help students to develop positive attitudes toward themselves")

Novices

- expressed the general goals of education with rather abstract concepts like socialization, development of personality, etc.
- did not relate goals to concrete examples, situations, or separately to different grade levels,
- had difficulties in reasoning how their goals would appear at the level of learning outcomes in students,
- expressed instrumental goals for education (success in life, provide good living for students)

Experts seemed to relate educational goals to specific student outcomes. This may be taken as an evidence that abstract and high-level knowledge structures and specific, practical knowledge structures, such as learning outcomes, have connections to each other in the expert's knowledge representation. The experts' representation of educational goals may be more specific in other respects, too. It may include, e.g. different kind of goals for each school level. Novices did not relate high-level educational goals and practical learning outcomes in the interview.

B. *Goals for subject matter teaching*

In this topic area subjects were asked to specify what kind of goals they regard as most important in their own subject matter.

Experts

- emphasized the learning of the structure and internal logic of the subject matter (e. g. to find out the clue of mathematics),
- discussed the question by referring to variation and individual differences in the class and mentioning the practice of setting different objectives for each student.
- seemed to make a difference between long-term goals and short-term objectives in subject matter teaching

Novices

- expressed instructional goals with rather abstract terms like 'understanding' or 'application' of the subject matter,
- discussed the objectives on the level of individual lesson (" it depends on the lesson...")

The differences between experts and novices may be described with a few comments. Experts' knowledge of goals and aims of subject matter teaching seem to be connected with a knowledge of students. Although the same objectives are officially applied to all students in the curriculum, the practice is different. Experts preferred setting individual objectives for each student or student group. The same fact of general goals and specific objectives was found in this topic as before. Experts have a hierarchy of subject matter goals which include at least the overall goal and more specific goals for different grade levels. The most specific level, lesson objectives, as mentioned by novices, but they are supposed to be present in the experts' goal hierarchies, too.

C. Teachers' interactive thoughts and decisions

This area of questions concerned the teacher's interaction with students during the lessons. The aim was to find out what kind of pedagogical principles or theories teachers apply in the interaction during the lessons.

Experts

- emphasized the importance of the analysis of the student's answer and the way of thinking as the basis of further instructional actions,
- expressed the importance of support and empathy, stressing that teachers should not underestimate incorrect answers,

• teacher actions and behavior were analyzed in the context of different student types (instructional actions depend on the type of students in the class)

Novices
• complained the lack of time for interaction during lessons,
• made a difference between how they would like to act and how they really act,

Expert teachers seem to pay more attention to the contents of students' answers, whereas novices concentrate on the control of their own behavior and the management of the lessons. Common feature for both groups is that the same student is not asked more than one question at a time. The reason which the teachers offered for the habit was that asking several questions may disturb the student's concentration, especially if the student does not know the answer to any of the questions.

D. Lesson planning and evaluation of learning outcomes

The question concerned the extent of the teachers' advance planning and evaluation during lessons.

Experts
• emphasized flexibility in the planning and execution of lessons (only general plans are made)
• emphasized the specificity of the lessons plan ("you cannot use same plan in more than one class"),
• regarded contextual and situational factors important when applying the plan during the lesson (e.g. students' emotional feelings and social climate)
• emphasized continuing formative evaluation more than novices as a way of assessing learning outcomes,
• formative evalution focused on the general features of students, such as motivation, social attitudes, co-operation etc.,
• seemed to pay more attention to the evaluation of the learning process than outcomes,
• seemed to be able to take more factors into account than novices during the lesson execution and evaluation,

Novices

- reported having one basic principle which they applied when planning a lesson (e.g. autonomous learning of students)
- found the possibilities for evaluation during the lessons limited,
- seemed to concentrate on the evaluation of students' knowledge level and observation of the behavior of students,

Typical of experts was their willingness for flexibility. Experts seemed to be ready to take students into account when planning and giving a lesson. An important finding was also that experts focus more on the process than outcomes of learning.

Discussion of the interview results

The above interview results suggest that experts' pedagogical knowledge differs in many respects from that of novices' What seems evident is that experts' pedagogical knowledge includes higher level conceptions, principles, and generalizations which are not represented in the same specificity in novices' knowledge. Novices do not seem to have such connections between the high-level structures and specific, practical experiences with students. High-level, abstract knowledge and its connections to lower structures may gradually develop during the first few years of experience. An important part of knowledge structures, which is supposed to develop along experience, is knowledge of students. This knowledge base is also represented in the interview results.

Observation results

The purpose of the study was to describe the direction of developmental changes in teaching expertise. The differences between experts and novices may be looked upon as an evidence of development. The study focused on such differences which might be affected by the development in the teacher knowledge and cognitions.

Question-answer episodes may be considered crucial for effective teaching. Questions are usually made to evaluate learning outcomes, check students' understanding, direct students' thinking or attention, activate and motivate students, etc. Effective teaching requires a good conduct of questioning episodes. During the questioning the teacher has to interpret and analyze students'

answers and react accordingly.
If the student answers incorrectly the teacher has several possibilities to react. He or she can ask another student the same question or continue discussion with the first one. In case the teacher decides to continue the discussion with the same pupil, s/he may give more time to think about the question, give some cues or attempt to help understanding by giving 'scaffolds'. Scaffold is a metaphor which is better known in building constraction. The idea is first used by Wood, Bruner, and Ross (1976) to describe the ideal role of the teacher. The scaffold provides support, it functions as a tool, it extends the range of the worker, it allows the worker to accomplish tasks not otherwise possible. Scaffolds are used selectively to aid the worker where especially needed. (Greenfield 1984, 118.)
In teaching situations scaffolds are also used selectively to enhance and correct student understanding. Scaffolds can be applied typically during the questioning when a student's answer reveals a misunderstanding or lack of a fact or a procedure. The scaffolds are usually interactional which means that the teacher continues checking with new questions whether the student has understood the new description of the fact or procedure.
The report focuses on the number and type of questions and scaffolds, and the number of students' incorrect answers. Also the number of question-answer episodes which consisted at least three questions and student answers were analyzed from the transcribed lessons. The subject matter during the lessons was both algebra and geometry.

The structure of lessons and use of questions

The structure of the lessons was same for both groups, beginning and experienced teachers. First part of a lesson was used for checking homework. Most teachers asked one or more students to write the problems and solutions on the black board. The checking of the black board problems was done together after the teacher had made individual checking from student to student. The next phase of a lesson was presentation of new material and practice. The last minutes were used for giving new homework. The time used for each part did not differ significantly between the groups. The amount of interaction between the teacher and students can be described with several methods. The number of questions is listed in the Table 1.

Table 1: Number of questions during the observed lessons.

	# of questions	# of questions in episodes
Exp1 (4 lessons)	112	42
Exp2 (4 less)	130	121
Exp3 (3 less)	117	77
average/lesson	**32.6**	
Nov1 (3 less)	41	25
Nov2 (3 less)	67	15
Nov3 (2 less)	40	9
Nov4 (3 less)	40	. 16
average/lesson	**17.1**	

The total number of questions during lessons seems to differ between experts and novices. The average amount of questions per lesson is greater for experts. This may suggest that experts use interaction more often than student teachers. The number of questions connected to question episodes (three or more questions) seems also to be greater for experts than novices. This may imply that experts structure the lesson to larger units and perceive the topic as a more integrated entity than novices. These units may have independent goals which are part of the overall goal of the lesson.

The typical feature of expert teachers was to divide the original problem to several, simple, subquestions which were used to define the path into the solution of the whole problem. This method seems to have several positive consequences. First, the activation of the whole class is easier because of the larger number of questions. Second, the method gives more feedback of understanding and learning outcomes to the teacher during the problem-solving process. The evaluation of understanding seems to be an important part of experts' teaching. Third, it makes possible for more students to participate in problem-solving. Additional advantage may be that the possibility of incorrect student answers may decrease because of more simple questions.

The method used by expert teachers shows that experienced teachers perceive the mathematics problems in terms of hierarchies in which goals and subgoals are organized in a specific way. These hierachies are used to form questions to students. The number of questions may imply that the experts' knowledge structure in the problem area is more specific and includes more components than that of novices. These goal hierarchies are formed on the basis of the subject matter knowledge and the knowledge of student learning, i.e. the teacher is able to predict what kind of subgoals different students are able to achieve. It may be possible that experienced teachers form individual goal hierarchies for different students.

Teacher candidates applied different approach. A typical method was to present the original problem as a question to the students. Thus the number of questions was smaller on a typical novice lesson than expert lessons. The lessons were dominated by teacher presentation and teacher talk almost without control of student outcomes. One explanation for this teaching method may be that lesson plans seemed to dominate teacher behavior. Teacher candidates seemed to follow the advance plan prepared for the teacher educator who also observed the lesson.

There may be several other reasons for the smaller number of questions. First, the interaction with students includes unpredictable factors e.g.incorrect answers which would interfere the flow of a lesson. Another reason may be in the quality of the novices' subject matter knowledge or knowledge of the curriculum. Teacher candidates may not know the subject matter area or curriculum as thoroughly as experts. As a result novices are not able to perceive the content area as a large meaningful pattern with goals and subgoals organized into a coherent knowledge structure. The lack of experience with students may also make novices more willing to apply presentation than interaction.

The following table lists the number of episodes for each teacher and the average length (number of questions per episode) of episodes.

Table 2: The number and lenght of question episodes of mathematics teachers.

	f	episode lenght (quest)	range
Exp1 (4less)	7	6.0	3 - 9
Exp2 (4less)	11	11.0	3 - 28
Exp3 (3less)	9	8.6	3 - 19
Nov1 (2less)	4	10.2	3 - 16
Nov2 (3less)	10	6.7	3 - 9
Nov3 (2less)	3	3.0	3 - 3
Nov4 (3less)	6	6.0	3 - 8

A typical mathematics lesson seems to include 2 - 3 questioning episodes in which at least 3 questions are asked. The length of the typical episode is more than 6 questions. Two of the experts had at least one episode which included about 20 or more questions. The number and length of questioning episodes does not seem to differ significantly between experienced and beginning teachers. However, novices show larger differences within the group than experts. Beginning teachers seem to be able to use interaction to direct the speed and flow of their presentation and to control the learning. However, the variation in the group shows that there may be individual differences in the ability of using interaction. These may be due to the differences in the structure of the teacher's mental models of the topic areas.

Type of questions

The questions presented during the observed lessons were classified into two categories. The first category was procedural and causal questions which usually started with the word 'how' or 'why'. Second category was factual (descriptive) questions which required the recall of factual knowledge. Expert teachers presented 23% procedural - causal and 77% factual questions. The respective numbers for the student teachers were 34% and 66%. This result is in accordance with some earlier studies which have found that factual questions are popular among experienced teachers. Factual questions do not require as much teacher intervention as procedural - causal seem to do. (e.g. Gall, 1970.)
The larger number of factual questions for experienced teachers was somewhat surprising. The explanation may be that experienced teachers prefer factual questions, because these are easier and can be used to activate almost every student. Whereas larger and often more complicated procedural - causal questions activate only the small minority of the students (high score group).

Scaffolds

Scaffolds were analyzed by reviewing the transcribed lessons and picking up all the situations in which the teacher reacted in some way to the student's incorrect answer or the failure to get any answer. Those teacher reactions in which the teacher asked another student the same question in the same form were not classified as scaffolds. The number of scaffolds are presented in the Table 3.

Table 3: Number of scaffolds and incorrect answers during lessons

		scaff	incorrect answers
Exp1	(4 less)	23	18
Exp2	(4 less)	37	31
Exp3	(3 less)	15	14
μ/lesson		6.8	5.7
Nov1	(3 less)	10	10
Nov2	(3 less)	13	11
Nov3	(2 less)	4	3
Nov4	(3 less)	9	8
μ/lesson		3.3	2.9

Experts used scaffolds twice as much as novices. This may indicate signifigant differences in the pedagogical knowledge base of the above groups. The number of scaffolds were compared to the number of incorrect student answers during the same lessons. Experts seem to get more incorrect answers from students. This might suggest that experts make more difficult questions to challenge students' thinking and understanding. A more plausible explanation is, however, that experts direct the questions to the students who are supposed to have problems in understanding. Novices more often ask simple questions which students can answer shortly using only a few words. Novices seemed to direct the questions to the most active students in the class. It was rather unusual for the teacher to ask the same student several questions. However, in most of the cases experienced teachers reacted after an incorrect answer to the student who had answered, but directed the next question to someone else. In this way they seemed to maintain the continuation of the lesson and presumably attempted to avoid student frustration due to another incorrect answer.

Type of scaffolds

The scaffolds which teachers applied were divided into four classes. The first one was *repetition* of the original question. The question was repeated using almost the same words as in the first time. The second type of scaffolds was called an *example*. When using this category the teacher tried to make the abstract or difficult question easier by giving a concrete example. The third type of scaffolds may be described as *partition* of a question into several subquestions which were required for the correct answer of the whole question. For instance, after asking a question about the area of an apartment, the teacher might divide the question by asking first the area of one room. In the fourth type of scaffolds a teacher gave *alternatives* for correct answers or guided otherwise the direction of thinking. This was a method in which teachers indirectly showed some of the possible answers. The fourth category was especially used when a teacher supported the original question by offering some answer alternatives. The fifth type of scaffolds was called *additional questions*. These included cases when the teacher after having asked the original question decided to choose another route to the correct solution of the problem. By giving additional questions the teacher directed student attention and thinking with some other concepts or tried to remind students of the concepts or procedures which s/he had learned before. This category was used if the teacher offered concepts which were not present in the original question.
The number of different types of scaffolds are tabulated in the Table 4.

Table 4: Types of scaffolds applied by mathematics experts and novices during the lessons.

	Exp1	Exp2	Exp3	Σ	Nov1	Nov2	Nov3	Nov4	Σ
Repet	8	–	1	**9**	2	4	–	3	**9**
Exam	1	1	–	**2**	1	–	2	–	**3**
Part	4	8	2	**14**	2	3	–	1	**6**
Alt	10	22	9	**41**	4	3	2	3	**12**
Add quest	–	7	3	**10**	1	3	–	2	**6**
Total	23	37	15	76	10	13	4	9	36

The table shows that expert teachers applied more scaffolds during the lessons than novices. The distribution of values show that experts applied mostly scaffolds belonging to the 4th and 5th categories. Novices used scaffolds seldom and about half of them belonged to 4th and 5th category. The numbers seem to show that novices repeat the question more often than experienced teachers (except the first expert). The distribution of different scaffold types seems to show that during the development of expertise the amount of scaffolds increases and teachers learn to use more complex ways of enhancing students' understanding. The analysis did not take instructional outcomes of teachers into account, but the type and number of scaffolds applied may be related to learning outcomes. Further analysis is needed for this issue.

As a hypothesis drawn from the above results it may be supposed that *experienced teachers are better able than novices to take students' answers into account and direct their own teaching behavior accordingly*. The hypothesis was formed from the transcribed lessons which seemed to show that experienced teachers were sensitive to students' answers and were able to change the type of a scaffold if needed. However, there are individual differences within both groups which show that each teacher develops his/her own typical ways of giving scaffolds. For instance, expert 2 used mostly different forms of the 4th category scaffolds, whereas expert 1 seemed to repeat questions in the same form. The pupil answers were taken into account by reacting differently to the pupil answers and using a large variety of slightly different forms of scaffolds. Scaffolds may be supposed to be learned during the experience and stored as a part of teacher's pedagogical knowledge base which enables him/her to direct students' thinking and learning activities.

Discussion

The study focused on differences between experts' and novices' conceptions of pedagogical issues and their teaching behavior. The results found in the study are in accordance with earlier results of the nature of expertise.

Expertise seems to show up in the ability to make correct interpretations about different students and act accordingly in instructional interventions. After the analysis of the situation the teacher has to act properly (make a 'right move'). During the lessons the teacher collects information about the results of the actions to his/her mental model or representation of the situation and plans further actions using the changed mental model. It seems plausible that during the development of expertise the ability to construct more accurate and specific mental models of instructional situations becomes better. This is partly due to the development of the pedagogical knowledge structure. At the same time teachers may become more capable of receiving and storing 'online' information for short-term purposes. The flexibility which experienced teachers show may be due to both the top-down and bottom-up processes which expert teachers may be supposed to carry out more effectively than novices. Experts collect information to the mental model by evaluating students' learning and directing students' attention with questions and scaffolds. These teaching routines or procedures are stored into a hierarchically organized and coherent knowledge base from which they can be accessed without deliberate control.

Although the study was based on a rather small number of subjects the results suggest that continuing efforts in the expertise research will be fruitful for effective teaching and teacher education. The results benefit teacher education by showing the directions in which teachers develop their skills in the process of the acquisition of expertise. However, direct teaching of the skills examined in this study may not be as successful as teachers' own learning through experience and practice.

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