DOCUMENT RESUME

ED 407 229	SE 059 947

AUTHOR	Shane, Ruth
TITLE	Examining the Second Grade Mathematics Classroom from a Social-Constructivist Perspective: The Interrelationship of Teaching, Learning, Learning To Teach and Teaching To Learn.
PUB DATE	Mar 97
NOTE	15p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 24-28, 1997).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Case Studies; *Classroom Environment; Concept Formation; *Constructivism (Learning); *Educational Strategies; Foreign Countries; Grade 2; Higher Education; *Knowledge Base for Teaching; Learning Strategies; Mathematics Instruction; *Preservice Teacher Education; Primary Education
IDENTIFIERS	Israel

ABSTRACT

This study is an attempt to document the connection between the way children construct mathematics in the second grade and the way student teachers construct their knowledge base. The study examines how student teachers integrate their formal and informal knowledge of mathematics and mathematics pedagogy with the reality of the second grade classroom. Preservice teachers (N=4) taught in a classroom where mathematics instruction was conventional and in a classroom where mathematics was taught from a constructivist perspective. The research study includes a qualitative documentation and analysis of the instructional approach, the children's mathematical understandings, and the student teachers' knowledge. The results of this case study address the issue of how student teachers in two different mathematical environments construct their knowledge about key questions related to the nature of mathematics and what it means to teach mathematics in school. (DDR)

Examining the Second Grade Mathematics Classroom from a Social-Constructivist Perspective: The Interrelationship of Teaching, Learning, Learning to Teach and Teaching to Learn

by
Ruth Shane

Examining the second grade mathematics classroom from a social-constructivist perspective: the interrelationship of teaching, learning, learning to teach and teaching to learn

AERA Convention, 1997; Chicago, Illinois

Ruth Shane
Ben Gurion University of the Negev
Kaye College of Education
Beersheva, Israel

Ruth Shane
3 Neot Hakikar
Beersheva, Israel
e-mail: shane@bgumail.bgu.ac.il

In this research, the classroom community is viewed from a social-constructivist perspective where the instructional approach affects both how the children learn mathematics and how the student teachers learn for teaching mathematics.The classroom teaching experiment is used to look closely at the nature of that community of learners (Cobb,et al, 1991; Hiebert & Wearne, 1993).

Introduction

The student teaching practicum is a significant feature of elementary pre-service teacher education. Mathematics educators often suspect that this practicum serves to reinforce the narrower, computation-oriented, approach to mathematics and doesn't contribute to those reform efforts which put more emphasis on problem-solving and higher-order thinking strategies. This research was an attempt to document the connection between the way children were constructing mathematics in the second grade and the way the student teachers were constructing their knowledge base. It looks at how student teachers integrate their formal and informal knowledge of mathematics and mathematics pedagogy with the reality of the second grade classroom. This research report is based on the author's doctoral dissertation (Shane, 1996). It was supported by the Research Committee of Mahon Mofet, the Israel Ministry of Education and Culture, in 1995 and by the Research Committee of the Kaye College of Education in 1994-95 and 1995-96.

The research reported here was conducted in Beersheva, Israel, in 1994-95. Two student teachers were assigned to two second grade classrooms in one school where the mentoring teachers agreed to teach mathematics from a constructivist perspective. Their approach was significantly different from the conventional classroom. Emphasis was on problem-solving, encouraging children's personal thinking strategies, and building the formal mathematics on the children's intuitive knowledge. Two student teachers from the same pre-service program (third year, early childhood majors), were assigned to two second grade classrooms in a different school where the mathematics instruction was conventional.

The research program included a qualitative documentation and analysis of the instructional approach, the children's mathematical understandings, and the student teachers' knowledge. This research report focuses on the student teachers' knowledge. The results of this case study address the issue of how student teachers in two different mathematical environments construct their knowledge about the key questions: What is mathematics all about? What does it mean to teach mathematics in school?

Background for the Problem
The reform movement in mathematics education

There is general agreement among math educators in this age of hand calculators and accessible, sophisticated computer power, that computational skills are not the main goal of the elementary school mathematics curriculum. Children have to develop a way of thinking compatible with higher order mathematical processes so that technology becomes their tool and not their substitute. Redefining the goals of the elementary mathematics program was therefore the major task on the reform agenda of the 1980's. The National Council of Teachers of Mathematics in the United States published the *Curriculum and Evaluation Standards* (1989) as a comprehensive statement of the rationale and description of a new vision of the contents of school mathematics, K-12.

What characterizes the goals of this reform agenda? The points made in the *Standards* (1989) include:

> Increased emphasis on number sense, problem-solving strategies, relationships-concepts-reasoning
> Decreased emphasis on complex paper-and-pencil computations, isolated treatment of facts
> Increased emphasis on communication, cooperative work, justification of thinking
> Decreased emphasis on rote practice, one answer and one method, teaching by telling
> (pp.20-21)

These *Standards* provided the basis for the instructional approach in the "classroom teaching experiment." The research focused on how the children built their knowledge of mathematics in such a setting and what the student teachers learned about teaching mathematics.

THEORETICAL BACKGROUND

The theoretical background presents the relevant research literature from four areas:

- On knowing mathematics
- Learning mathematics in the classroom
- Teacher knowledge
- Learning to teach mathematics

On knowing mathematics

A study which examines the construction of knowledge in the math classroom is necessarily premised on a conception of what it means to know mathematics. In the last fifteen years researchers have been looking at the interconnectedness of the different modes of mathematical "knowing."

Ball (1990) defines mathematical knowledge in the following manner:

Substantive knowledge - understanding mathematical topics, procedures, and the connections between them (what is usually considered subject-matter knowledge)

Syntactical knowledge - knowledge about the nature and discourse of mathematics: what counts as a solution? as a proof? what ideas are arbitrary and what are logical?

Hiebert & Lefevre(1986) define the terms, "procedural" and "conceptual" knowledge as two potentially complementary goals. Procedural knowledge includes the standard algorithms, rules and procedures, for solving problems; conceptual knowledge is rich in the connections which give meaning and power to mathematical concepts. Ginsburg & Allardice (1984) make a distinction between informal knowledge of mathematics which children acquire outside of school and the formal knowledge of mathematics which is taught in school. They recommend using the intuitive knowledge as a cognitive scaffold for building the formal knowledge.

In this research, knowledge of mathematics is interpreted from these theoretical perspectives. The results examine evidence of the construction of substantive and syntactic knowledge, procedural and conceptual knowledge, and the interplay of informal and formal knowledge.

Learning mathematics: A social-constructivist approach

The nature of mathematical knowledge is integrally bound to the theory of how knowledge is learned. Piaget's constructivist theory has been the significant paradigm for theories of learning mathematics in the last ten years. Constructivism puts the emphasis on the individual's learning as a growing organism, assimilating and accommodating experiences which interact with his personal maturation. Increasing attention to Vygotsky's sociocultural theory of learning has begun to impact the community of mathematics education. For Vygotsky, learning takes place in a social context through interaction with peers and adults with particular importance played by language. The emphasis for Vygotsky is on being enculturated into the mathematical community. Cobb (1994) analyzes the two views and finds them complementary.

The research group of Cobb, Wood, Yackel, et al, (1991), developed a classroom teaching experiment in second grade to examine the learning of mathematics from this social constructivist perspective. Their research focused on creating a classroom environment which would allow for the examination of small-group interaction, communication, and cooperative problem-solving. Their research results document the negotiation of shared-meaning as well as the individual construction of knowledge through problem-solving activities. It is this social constructivist theory of the children learning mathematics and the student teachers learning about teaching mathematics which informs this research.

Teacher knowledge

In order to collect and interpret data on student teachers constructing a knowledge base for teaching mathematics, there must be an understanding of what is an appropriate knowledge base for teaching mathematics. Knowledge for teaching mathematics was traditionally seen as the combination of subject-matter knowledge and general pedagogic knowledge. Shulman (1986) posited the third dimension of that knowledge base: pedagogical content knowledge. He explains that general generic knowledge about teaching is not sufficient without the particular repertoire of understandings, representations, examples, and insight into the specific subject matter.

Where do teachers develop their knowledge for teaching? Several researchers have cited the classroom as one of the significant arenas which stimulate the development of teacher knowledge. Given the recent interest in the teacher as reflective practitioner, naturally the classroom provides the stimulus for reflection-in-action and reflection-on-action. Fennema, Carpenter, et al, (1996) present evidence from long-term research data where teachers learn about teaching mathematics from their teaching. Cobb et al(1991) present the same view:

> The view we are advancing proposes that teachers' learning is an ongoing, long-term process and that their classroom experiences are a crucial source of pedagogical problems whose resolution involves the reorganization of their knowledge and beliefs about learning and teaching....(p.8)

The research design was intrinsically related to this view, that knowledge is being constructed by the student teacher from teaching in the mathematics classroom. The issue was to relate the nature of that knowledge to the particular instructional approach. Does an instructional approach which by definition encourages more reflection by the children on their mathematical activity also promote more reflection by the student teachers on the mathematics and the mathematics pedagogy?

Learning to teach mathematics: the role of the practicum

In mathematics education very little research has been done to closely examine the field-based experience and its influence on preparing teachers for teaching mathematics. Eisenhart, et al (1993) documents the tensions around the field placement of student teachers who are educated for a reform agenda but whose mentoring teachers focus almost exclusively on procedural knowledge. They conclude:

> Changes are not likely to occur without more concerted and systematic efforts to organize contexts for learning to teach so that they consistently stress the priorities envisioned by the reform movement. (p. 39).

The intention of this research was to create and study an alternative classroom environment for learning mathematics - one which should provide differently for the construction of knowledge both by the children and by the student teachers.

METHODOLOGY

The methodology was qualitative-descriptive, a case-study of four second-grade mathematics classrooms in Beersheva. In two classrooms in one school the instruction in mathematics was based on a problem-centered, "alternative" approach to exploring the mathematics. In the other two classrooms in a neighboring school, the instruction was based on the conventional textbook. The four mentoring teachers were all experienced primary teachers (the mentoring teacher is not a subject in this research).

The four student teachers were third year students at the K. College of Education, majoring in early childhood education. The two in the alternative classrooms had a minor in math and agreed to participate in a special project. All four were in the same math methods course taught by the researcher for two years.

The "classroom teaching experiment"

The "classroom teaching experiment" is associated with studying children's learning in classes with alternative instructional approaches (Cobb, et al, 1990). In order to study student teachers' knowledge growth in math classrooms with an alternative instructional approach, a classroom teaching experiment was designed and implemented according to the following plan:

- Two second-grade classrooms in the same school would participate.
- The topics in the official State mathematics curriculum would be covered.
- The emphasis in the instruction would be on problem-solving and building on children's intuitive knowledge, with an emphasis on thinking strategies.
- The conventional textbook would not be used; rather a variety of materials would be developed.
- The mentoring teachers and student teachers would participate in a five-day summer workshop, to plan the structure of the math program for the year within the theoretical framework of the project. Specific planning for the first two months of the year would be part of the workshop as well as preparation of classroom materials.
- The mentoring teachers and student teachers would meet every week with the researcher for a 90-minute session to discuss, reflect, and plan. This would be a credit-course for the mentoring teachers and an essential feature of the project.

Data collection

Three aspects of the mathematics classroom are examined, each with its own procedure for data collection and analysis: (1)The Instructional Approach: classroom observations; (2)Children's construction of knowledge: written tests, individual interviews; (3) Student teachers' construction of knowledge: reflective interviews. A summary of the first two aspects is presented followed by a detailed presentation of the third.

The instructional approach: classroom observations

Six mathematics lessons were videotaped in the alternative classrooms and six in the conventional classrooms, between October, 1994, and January, 1995. The videotapes focus on interactions between the student teacher and the class. The videotapes were transcribed and the text was analyzed using qualitative methods (Erickson, 1986).

The first lists of categories were based on the analysis of tasks and discourse in Hiebert & Wearne (1993). The mathematical tasks were identified and classified. The children's responses were analyzed for the length of the response and an interpretation of the nature of the response. The transcriptions were reexamined to locate representative vignettes. The vignettes were organized by sub-theme and the sub-themes clustered by primary themes.

Children's construction of knowledge: Written tests, clinical interviews

At the beginning of the school year a standard, written test was administered to all the children in the four classrooms (p= 140) to establish the relative achievement level of the children on arithmetic items from the first grade curriculum. At the end of the year, a semi-standard, written test of second grade arithmetic material was administered to all the children. This test included items which measure computation skills, conceptual understanding, and problem-solving. The scores on Test II were the basis for choosing a representative one-third of the children from each class for individual interviews. The researcher administered all the interviews, using a written protocol of eight tasks probing conceptual understanding.

Student teachers' construction of knowledge

Reflective interviews were used to uncover the knowledge of the student teachers for teaching mathematics. Lesson-specific interviews were held in most cases immediately after the classroom observations. In addition, a summary interview was held with each student teacher at the end of the school year. All the interviews were recorded on audiotape and subsequently transcribed.

There are eleven lesson-specific interviews with the student teachers, held between October, 1994 and January, 1995. Each was held about an hour after they taught a math lesson, during which the interviewer/researcher had been present. The questions in Chart 1 formed the basis of the interviews. The interviews were semi-structured with the questions providing an entry into the students' thinking. The lesson served as an immediate stimulus for reflection on teaching in the context of an authentic, specific experience.

Chart 1: Lesson-specific interview protocol

1. What were your objectives for today's lesson?
2. To what extent did you feel you succeeded?
3. In what didn't you succeed?
4. What was new in today's lesson?
5. How can you tell what the children know, or don't know?
6. What were the difficult points of this subject?
7. What did you learn about the students? the subject?
8. What surprised you in the course of the lesson?
9. Did any of the children seem to have difficulty with the lesson? how did you help them?
10. Did you make any changes to your plan in the course of the lesson?
11. What did you debate with yourself in planning the lesson?
12. Was this lesson typical of the lessons in the class?
13. Are there children in the class with particular difficulties - new immigrants, handicaps, etc.? (asked in initial interview)
14. Do you always work with the weaker kids?
15. How do you use the 100-Board on the wall? (examples of questions specific to a given lesson)

The concluding interviews were held in June, 1995, and lasted about 50 minutes each. The interview questions (Chart 2) were adapted from the NCRTE research at Michigan State University, on tracking teachers' knowledge growth (Kennedy, Ball, & McDiarmid, 1993).

Chart 2. Summary interview protocol

Name, year of birth, country of birth, family status

1. What did you learn from your field experience this year about teaching mathematics?
2. What did you learn about the mathematics?
3. Can you recount an incident involving weaker students? stronger students?
4. How can you identify when someone has learned the math?
5. What is unique about teaching mathematics compared to other subjects?
6. How were manipulatives used in the class? Which?
7. What about games - were they used? How?
8. How was the blackboard used?
9. Tell about a lesson which was particularly successful.
10. How will you organize your math lessons next year?
11. Did you manage this year to hear, to listen to children's thinking about mathematics?
12. Do you have any questions remaining about teaching math?

RESULTS

The results are reported in three sections:

1. The features of the instructional approach
2. The children's knowledge of mathematics
3. The student teachers' knowledge for teaching mathematics

A summary of results is presented for sections one and two; the complete results are reported in Shane (1996). Detailed attention is given in this report to section three, on the student teachers' knowledge for teaching mathematics.

1. The features of the instructional approach

The twelve videotaped lessons were scanned to identify instructional tasks assigned by the teacher in the course of the mathematics lesson. In the conventional mathematics lessons 148 tasks were identified and in the alternative lessons, 94 tasks. In the conventional classrooms 11% of the tasks invite more than one solution while in the alternative classroom 31% of the tasks invite more than one solution. In the conventional classrooms the teachers presented a large number of tasks (41%) which were computational in nature, and were presented as operations on numbers without any context. The tasks in the alternative classrooms had a higher-level cognitive component. Fifty percent of the tasks were in the categories of EXPLAIN, requiring an acknowledgment of the thinking which generated the solution.

The transcripts of the same twelve lessons were scanned to identify all the children's responses. In the same number of lessons, the teachers in the conventional classrooms presented over 50% more tasks than the teachers in the alternative classrooms, while the number of children's responses was almost the same. In the conventional classrooms, the children's responses tended to be shorter; 89% of the responses were five words or less compared to 70% in the alternative classrooms. Seventy percent of responses in the conventional classrooms were solutions to one-step computation or recall compared to twenty percent of the responses in the alternative classrooms. Forty-five percent of the responses in the alternative classrooms are explanations or justifications; 3.3% of the responses in the conventional classrooms are in those categories.

A summary of the results can be organized around two issues which highlight the differences in approach between the conventional and alternative classrooms:

What is mathematics about? What does it mean to know/understand mathematics? How does one learn mathematics in school(in the second grade classroom)?

What is mathematics about? What does it mean to know mathematics?

The conventional classroom presents mathematics knowledge as a body of formal procedures, with a given number of individual facts and skills to master, and definitions of concepts to recall. Therefore, a correct answer is a quick response which shows mastery of facts, skills, or definitions. Higher level questions focus on a semantic analysis of the problem or exercise, according to a formal, abstract schema which represents the particular arithmetic operation.

The alternative classroom presents mathematical knowledge as both procedural and conceptual. This knowledge is inherently a building of connections between concepts, so the problems to solve require a synthesis of facts, skills, and strategies. Mathematics knowledge in these classrooms is the ability to use small "bits" to understand new situations. The intuitive knowledge of the student is the starting point for scaffolding the formal knowledge.

How does one learn mathematics in school, in the second grade classroom?

The conventional classroom reflects a rationale for teaching mathematics based on the teacher as source of all knowledge. She explains, demonstrates, and defines all new concepts, algorithms, questions. The nature of the explanation is a presentation of formal mathematical language which derives its validity from the teacher's authority. The alternative classroom reflects a socio-constructivist rationale, where children learn from explaining to each other. The teacher translates their intuitive understandings to formal knowledge; the formal knowledge derives its validity from an intuitive appeal to the children's' number sense. To maximize this appeal, lessons are built around shared-contexts. The subject matter is how the children think about a problem, not just the outcome. This metacognitive component where children share their strategies helps the others learn and strengthens their own understanding. The lesson therefore offers different challenges to the different learners.

Having established this base, that in the alternative and conventional classrooms, the features of the instructional approach for teaching mathematics were significantly different, this has a most significant implication. It is the underpinning for comparing the results on what the children learned and what the student teachers learned, in the conventional and alternative classrooms as two significantly different environments. In the conclusion, there should be a connection between what specifically was different in the nature of the instructional approach in the classrooms and in what was learned.

2. Children's knowledge of mathematics

The results of Test I reflect the relative mathematics achievement level of the four classrooms at the beginning of the year (Complete data for each classroom is in Shane, 1996) .The mean score for the two classrooms in each school were very similar; the mean score in the conventional classrooms (82.8) was significantly higher than in the alternative classrooms (73.8). The results of Test II, administered toward the end of second grade, were different. There is no significant difference between the achievement level of the conventional (67.4) and the alternative classrooms (65.6). The scores for the two conventional classrooms are almost identical, as they were on Test I. while there is more variation in the mean scores of the two alternative classrooms.

The interview included eight tasks, five of which drew heavily on understanding the tens structure of our number system. On four out of the five tasks, the children in both of the alternative classrooms performed more successfully than the children in the conventional classes. Their interview responses were characterized by a "mathematical flexibility" which allowed them to respond to tasks with which they were unfamiliar and to short-cut more complicated computational algorithms.

3. The student teachers' knowledge

The findings on the student teachers' knowledge are presented in two sections:
The lesson-specific interviews with the student teachers, Oct. 30, 1994 - Jan.18, 1995
The concluding interview, June 6-11, 1995

The lesson-specific interviews

The student teachers' knowledge is revealed in their direct responses to questions in the lesson-specific interviews and in their indirect comments which can be organized around certain issues. Examples of both the direct and indirect results are presented here. (Complete results in Shane, 1996).

Question #2. What succeeded in the lesson?

The conventional classrooms

- When I gave them the game to solve the problems, that they all solved them. It's not like one of them just sat and copied the others. I saw that they all were solving and they were all active. Also on the worksheets, they all were active, they all finished, they all did it.

The alternative classrooms

- Most of them understood, they worked on several number sequences and found the patterns without any difficulty. And they went beyond 20. We planned for them to get to 20, and they went further. I saw they got to 50 and even 60.

In the conventional classrooms, success is measured by the general atmosphere of the children being busy. In the alternative classrooms, success is identified in a specific situation where the children showed initiative and mathematical knowledge beyond what the student teacher expected.

Questions #7, #8. What did you learn, what surprised you in today's lesson?

The conventional classrooms

- Lately I notice how each time different children surprise me, children whom I don't expect will do correctly. Children who I expect less from them are the ones who surprise me. So last time Tom, and this time...other children, Jon and David, other weak children surprised me. They knew how to match all three exercises to the schema,...I thought they would be confused or make a mistake...I didn't think they would be totally correct...
- What surprised me, a pleasant surprise, was that almost all the children know
- There's one boy Dani who is usually in the clouds, and when I went over to him,...I saw they he did (the worksheet) and understood...I was surprised that they understood the lesson so well, particularly the word problem. I only started to work on it yesterday ...

The student teachers are teaching lessons for the first time. Their knowledge of what mathematics the children know or don't know develops from experiences in the classroom. Their knowledge of the subject matter is also developed (or not) from classroom experiences. What these student teachers learned was that children are able to recall some of what they have learned and even weak students have certain skills and may enjoy participating. The student teachers' surprise was at the children's giving the correct answer and not making mistakes. There were no surprises on the contents of what they said. There wasn't one example of a child suggesting a strategy for the mathematics that surprised the student teacher.

The alternative classrooms

- Yes, there was a decreasing sequence and we got to zero, but they know, we talked about three dots that you can continue the sequence indefinitely. So one boy said, it could also be "minus" he didn't say minus how many, but it could be minus, there are numbers after the zero. It astounded me because what I thought until now was that children know until zero and that's it. Not beyond that, and here...
- It's interesting how you are sure that they understand, that they know where the 100 is. It's very dominant on the board. Here, not here, there. Because when you turn over the board they are right that if originally the 100 is here when you turn it over it moves to the opposite side. Technically, maybe the idea of turning over the board wasn't such a good idea because it confused them. Maybe I should have taken another board, empty, and it would have been better for them.
- The way they checked, the rough estimate which the children did. I heard them arguing - no, it's more than 70, less than 70. First they add the tens and check, if it's close to 70, to 80. There was so much arithmetic. On their paper, so many exercises they tried...a lot of arithmetic in those riddles.

What surprised the teachers in the alternative classrooms can be organized in three categories:

1) the misconceptions, the different intuitive understandings which children had developed
2) the breadth and versatility of the children's mathematical knowledge beyond the range of the second grade curriculum
3) The computational potential within the concepts they presented

From their "surprise" they have constructed new knowledge for teaching mathematics. They have added to their store of knowledge about the mathematics and about how the children think about the mathematics.

One of the issues which emerged indirectly from the lesson-specific interviews was the consideration of *number sense* in the math classroom.

The conventional classrooms

- Maybe they get confused like we get confused. That they just don't write correctly, but not that they don't know. Not that they don't know that we start from here and then we take from the highest and borrow. It happened to me with 43-39, that I left one ten and forgot that I left it and kept solving. But it's not that they don't know; they know the procedure how to solve it.

The alternative classrooms

- When I gave the exercise with the answer over 100, immediately someone jumped and said "that's more than a hundred." There are children who know how to do the estimation, the mental computation, very well. They know about how it will come out. I think they do it by adding the tens and seeing that it comes out more than ten so they know that it's more than a hundred.
- They have started to use more thinking, they always want to check if it's logical. At the beginning it wasn't like that; it was yes or no. That's it. Today they check you , they check the logic, if it makes sense to them. Then they look at the computation. That's what he did today: it didn't make sense to him so he didn't accept it. He wasn't willing to accept a technical solution, one more, one less.

In the conventional classrooms there was no access cited to "number sense", toward examining the numbers in their mathematical context instead of applying "generic" algorithms. The student teachers themselves did not use examples of such thinking; in fact, they model not-using number sense in the above example. In the alternative classrooms, the student teachers take notice when the children apply "number sense" solution strategies and learn both the strategies and the implications. "Knowing" is used for knowing numbers, the order of the numbers, the value of the numbers, how to estimate. The student teacher notes the child's having connected between number sense and computation, having intuitively established the relationship between the procedural and the conceptual knowledge of mathematics.

A second issue which emerged indirectly from the interviews was the source of *motivation* in the math classroom, as being intrinsic or extrinsic.

The conventional classrooms

- Maybe I should have insisted more that they solve it...if I had left a space on the side, they would have to solve it...it would have forced them to solve the exercise.

The alternative classrooms

- It was amazing. The children already finished the lesson and went into the classroom (from the corridor), and she sat and continued to write the sequence. It was important for her to continue. She got to 70 and something, I don't remember exactly...
- They try to raise the level. They look for that. He knows that it will come out over 100. We know what he thinks. And Martin- for sure. They want harder problems. I see that...
- In retrospect, it's good to give them those matrices to do by themselves. Because some children are bored during math lessons. We raise the level but sometimes not enough for those children. Did you see Ante, he's great in arithmetic, but bored. So he can do what he wants (with the matrices). Or Adi says to me in the last lesson-give me a hard problem. That's funny, but you have to deal with it...We know what they think. They want exercises that are more difficult. I see it.

The student teachers in the conventional classrooms presume that the motivation for doing the mathematical tasks is extrinsic - the teacher assigns/the children carry out. By formulating the task differently from a technical point of view, the children will have to use the strategy which the teacher has chosen. The implied conception of the learner is one who would "cut corners" if the teacher is not watchful. In the alternative classrooms, the student teachers describe their observation that children relate to intrinsic challenges in the tasks and can be motivated by providing tasks which are flexible. Their conception of the child is of a learner looking to "stretch" his knowledge, not content with the minimum.

The data from the lesson-specific interviews sheds light on the student teachers' construction of knowledge in two related domains: how children learn mathematics and how to teach mathematics.

Knowledge of how children learn mathematics

The student teachers in the conventional classrooms describe their lesson planning and lesson maneuvering in terms of general pedagogic principles unconnected to the mathematics. Their stated intention is to keep the students busy writing in their notebooks, interested through games, and under control. They have learned that "weak" children can participate and know the right answer sometimes. They don't mention any particular difficulty inherent in the mathematics, which required a reconsideration of teaching strategy. The student teachers give no examples of "number sense" playing a role in learning mathematics, neither examples of children who demonstrated "number sense" nor of themselves. Motivation for learning mathematics is presented in extrinsic terms and there is no example of a child doing more than the assignment from intrinsic motives.

The student teachers in the alternative classrooms identify points of difficulty in the material which they hadn't expected. They try to connect those difficulties with their teaching strategies (inappropriate model, task, etc.) and suggest alternatives. They give many specific examples of children's thinking strategies. They give many examples of children applying "number sense" in parallel to computational procedures or alone. Describing how children think and talk about the mathematics is the most dominant feature of their interviews.

Knowledge of how to teach mathematics

The student teachers in the conventional classrooms have very little criticism of their own performance, generally accepting how they chose to teach a lesson as the best possible way. There is no questioning of the prototypical difference between the reading lesson and the math lesson. They planned their lessons and delivered them without any particular surprises, which accomplished their goals.

The student teachers in the alternative classrooms explicitly refer to the knowledge with which the children answer questions which they haven't been formally taught. They describe the classroom as a place where the mathematics knowledge is uncovered, discovered, and grows. They present their role as providing a flexible environment in which children of different abilities can find challenges and satisfaction in learning mathematics. They see their role as connecting what the children know intuitively to the formal language of mathematics.

The concluding interviews

The concluding interviews present further evidence of the student teachers' knowledge. Two of the questions are presented here followed by the responses of each of the four student teachers. Students 1 and 3 were in the alternative classrooms; students 2 and 4 in the conventional classrooms.

Question #5. What is unique about teaching mathematics compared to other subjects?

1. I would like to teach other subjects with the same openness, the same atmosphere...
2. In other subjects the kids perform more independently; they are given information and put it together. In math, we break it all down to make it easy, we explain and give examples before they have to think.

3. The experience, the activities - in other subjects they sit and listen passively. In math they try out ideas in all different ways.
4. Math is most interesting for the children

Question #11. Did you manage to listen to the children's ways of thinking in the math lessons you taught?

1. Of course, to hear, to listen, to enjoy. It opened my eyes to things I didn't know so today I relate differently to children and to mathematics. I think differently...
2. No. I gave the lesson but couldn't follow up on it. I had to cover the material, from this page to that. After all, I'm a guest in the classroom.
3. I've said just that so many times
4. I don't know, I don't remember.

The concluding interviews, in full, give a remarkable picture of the differences between the conventional and alternative classrooms. The student teachers in the conventional classroom say they didn't learn from their student teaching anything about how to teach mathematics nor did they hear how the children in their classes think about the mathematical tasks. They didn't learn to use manipulatives or games and didn't learn to provide for the different learners in the class. They couldn't remember any particular expression of the stronger students nor a specific positive interchange with the weaker students. In the lesson which seemed successful based on "number riddles." the student teacher felt she didn't teach anything that day. The image of the math classroom that developed in their minds was one where in contrast to the independent learning mode in reading, the material is divided up into little chunks for the children to digest.

The student teachers in the alternative classrooms describe the frequency and importance of hearing children's thinking, and describe the student teaching experience as a "living" course in math methods. They have learned how to integrate games to advance learning). They have seen weaker pupils learn from stronger ones and developed strategies for sharing children's' ideas. Their image of the math lesson is one where kids are actively engaged in constructing knowledge in contrast to other subjects which are less engaging.

CONCLUSIONS

Four student teachers started their practicum in teaching second grade. Two of the student teachers were in conventional math classrooms, where the math lesson was fairly stereotypical: a few minutes of computational drill, presentation by the teacher at the board of new material, individual practice in the textbook and worksheets for more extensive practice. Two of the student teachers were in classrooms where the math was taught from an alternative, constructivist perspective. Children were presented with problems and asked to offer and explain their personal strategies for solving them. Activities were connected to larger mathematical ideas - a lesson on weighing apples included reading numbers up to 100 on the digital scale, solving word problems of comparison by subtraction, recording data in a table, analyzing the data in a table to make comparisons, discussing the connection between size and weight, estimating relative weight.

In the interviews during the first four months and in the concluding interview at the end of the year, the student teachers in the two settings demonstrated very different knowledge bases for teaching mathematics. The student teachers in the conventional classrooms approached the math lesson with a general-pedagogic approach: explaining, "transmitting" knowledge of symbols and procedures, presenting the mathematics one step at a time (a sort of living text-book), encouraging children's participation with warmth, keeping everyone busy, correcting incorrect responses, maintaining order. The student teachers in the alternative classrooms thought about the mathematics-pedagogy. They learned how children think about certain mathematical ideas, what strategies the children may present, what misconceptions they may have and how they may have developed. They encouraged the children's strategies as the mathematics content of the lesson. They reported that they learned a lot about how children think about mathematical ideas and that they learned a lot about presenting mathematics lessons.

The research results provide the answers to the following questions:

1. **How do different instructional approaches in their field-based experience allow student teachers to use and construct knowledge for teaching mathematics?**

The instructional approach in the mathematics classroom has a significant effect on the knowledge base developed by student teachers. Student teachers in the conventional classrooms applied general-pedagogical knowledge in reflecting on their mathematics teaching. They showed little to no development in knowledge of the mathematics, knowledge of how children think about mathematics or how teachers can generate mathematical activity in the classroom. Student teachers in the alternative classrooms focused on the mathematical issues that arose in the classroom. They showed knowledge of the children's thinking about mathematics, their strategies, and the teaching activity which sparked that learning. Just as the children used their intuitive knowledge as a scaffold for constructing formal mathematical knowledge, the student teachers were able to use their intuitive understanding of the mathematics and the pedagogy to construct their formal knowledge about teaching mathematics.

Student teachers in the conventional classrooms saw their role cut out for them by circumstance. They reviewed with the children the facts and procedures that had been learned the days before or taught the next page in the textbook. The teachers in the alternative classrooms were always weighing different choices about the logical presentation of the material. Richardson (1990) presents the notion of "practice as embedded within theory," as a key concept for integrating educational research into effecting worthwhile change in teachers. In this theory, teachers must have opportunities, like the student teachers in this research, to take responsibility for their classroom decisions, including fundamental issues related to curriculum :

> Taking control of one's justifications involves reflection on practices, that is on activities and their theoretical frameworks, and an ability to articulate them to others in a meaningful way. (p.16)

2. **What are the interrelationships between how the student teachers and students construct knowledge in the second grade mathematics classroom?**

In the conventional classrooms where the emphasis for the children was on simple computation and not on problem solving or conceptual understanding, the children's achievement in those areas was lower. Likewise, the student teachers showed a narrower, lower level, approach to understanding the teaching of mathematics. As they taught the children isolated bits of mathematical facts they also focused on isolated mathematical topics without connecting them. In the alternative classrooms where the children were constructing their knowledge from personal strategies and problem-solving situations, the student teachers were also developing their knowledge of how children think about mathematics. "Thinking about strategies," applying a metacognitive approach to examining how problems were solved, was a mutual task of children and student teachers.

Arcavi and Schoenfeld (1992) articulate this cognitively demanding role of the teacher who is coconstructing knowledge with her students in the mathematics classroom:

> When an instructor's conception of teaching or tutoring shifts from explaining or telling to *facilitating the development of students' knowledge structures or coconstructiong knowledge with the student*, there is a significant shift in the instructor's responsibilities to the student. There is, likewise, a significant increase in the complexity of the decision-making in which he or she must engage to live up to the demands of helping students build complex knowledge structures for themselves. (p. 322)

Further research should be pursued within such cooperative projects between the college of education and the public school. Using the social-constructivist paradigm it should be possible to interpret the development of subject-matter knowledge and pedagogical-content knowledge of pre-service teachers as they reflect-on-action and in-action. When the mathematics classroom becomes a "community of learners", then the practicum will be a significant link for the student teacher between his academic coursework and his on-site professional development.

BIBLIOGRAPHY

Arcavi, A. & Schoenfeld, A. H. (1992). Mathematics tutoring through a constructivist lens: The challenges of sense making. *Journal of Mathematical Behavior, 11*, 321-335.

Ball, D. L. (1990). The mathematical understandings that prospective teachers bring to teacher education. *The Elementary School Journal, 90* (4), 449-466.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical devlopment. *Educational Researcher*, 23 (7), 13-20.

Cobb, P., Wood, T., & Yackel, E. (1990). Classrooms as learning environments for teachers and researchers. In R. Davis, C. Maher, & N. Noddings (Eds). *Constructivist views on the teaching and learning of mathematics* (pp.125-146). Reston, Va: National Council of Teachers of Mathematics.

Cobb, P., Wood, T., Yackel, E., Nicholls, J., Wheatley, G., Trigatti, B., & Perlwitz, M. (1991). Assessment of a problem-centered second-grade mathematics project. *Journal for Research in Mathematics Education, 22* (1), 3-29.

Eisenhart, M., Borko, H., Underhill, R., Brown, C., Jones, D., & Agard, P. (1993). Conceptual knowledge falls through the cracks: complexities of learning to teach mathematics for understanding. *Journal for Research in Mathematics Education, 24* (1) 8-40.

Erickson, F. E. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching, Third edition* (pp. 119-161). New York: Macmillan.

Fennema, E., Carpenter, T. P., Franke, M. L., Levi, L., Jacobs, V. R., & Empson, S. B. (1996) A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education*, 27 (4), 403-434.

Ginsburg, H. P., & Allardice, B. C. (1984). Children's difficulties with school mathematics. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: its development in social context* (pp. 194-219). Cambridge, Mass: Harvard University Press.

Hiebert, J. & Lefevre, P. (1986). Conceptual and procedural knowledge in mathematics: an introductory analysis. In J. Hiebert (Ed.), *Conceptual and procedural knowledge: The case of mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

Hiebert, J., & Wearne, D. (1993). Instructional tasks, classroom discourse, and students' learning in second-grade arithmetic. *American Educational Research Journal, 30*, 393-425.

Kennedy, M., Ball, D., McDiarmid, G. W. (1993). A study package for examining and tracking changes in teachers' knowledge. The National Center for Research on Teacher Education, Michigan State University, East Lansing, Michigan.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Richardson, V. (1990). Significant and worthwhile change in teaching practice. *Educational Researcher, 19* (7), 10-18.

Shane, R. (1996). Constructing knowledge in the mathematics classroom. Unpublished doctoral dissertation. Ben-Gurion University of the Negev, Israel.

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher, 15* (2), 4-14.

AREA 1997

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

SE059947

ERIC

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Examining the second grade mathematics classroom from a social-constructivist perspective

Author(s): Ruth Shane

Corporate Source: Ben Gurion University / Kaye College

Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce the identified document, please CHECK ONE of the following options and sign the release below.

[X] Sample sticker to be affixed to document

Check here
Permitting microfiche (4"x 6" film), paper copy, electronic, and optical media reproduction

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
_____ Sample _____
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Level 1

Sample sticker to be affixed to document [ ]

or here
Permitting reproduction in other than paper copy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY
_____ Sample _____
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Level 2

Sign Here, Please

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Signature: Ruth Shane	Position: Lecturer
Printed Name: Ruth Shane	Organization:
Address: Dept. of Education, Ben Gurion University, Beersheva, ISRAEL	Telephone Number: ( )
	Date: MARCH 24, 1997

OVER

CUA

THE CATHOLIC UNIVERSITY OF AMERICA
Department of Education, O'Boyle Hall
Washington, DC 20064
202 319-5120

February 21, 1997

Dear AERA Presenter,

Congratulations on being a presenter at AERA[1]. The ERIC Clearinghouse on Assessment and Evaluation invites you to contribute to the ERIC database by providing us with a printed copy of your presentation.

Abstracts of papers accepted by ERIC appear in *Resources in Education (RIE)* and are announced to over 5,000 organizations. The inclusion of your work makes it readily available to other researchers, provides a permanent archive, and enhances the quality of *RIE*. Abstracts of your contribution will be accessible through the printed and electronic versions of *RIE*. The paper will be available through the microfiche collections that are housed at libraries around the world and through the ERIC Document Reproduction Service.

We are gathering all the papers from the AERA Conference. We will route your paper to the appropriate clearinghouse. You will be notified if your paper meets ERIC's criteria for inclusion in *RIE*: contribution to education, timeliness, relevance, methodology, effectiveness of presentation, and reproduction quality. You can track our processing of your paper at http://ericae2.educ.cua.edu.

Please sign the Reproduction Release Form on the back of this letter and include it with **two** copies of your paper. The Release Form gives ERIC permission to make and distribute copies of your paper. It does not preclude you from publishing your work. You can drop off the copies of your paper and Reproduction Release Form at the **ERIC booth (523)** or mail to our attention at the address below. Please feel free to copy the form for future or additional submissions.

Mail to:

AERA 1997/ERIC Acquisitions
The Catholic University of America
O'Boyle Hall, Room 210
Washington, DC 20064

This year ERIC/AE is making a **Searchable Conference Program** available on the AERA web page (http://aera.net). Check it out!

Sincerely,

Lawrence M. Rudner, Ph.D.
Director, ERIC/AE

---

[1]If you are an AERA chair or discussant, please save this form for future use.