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ABSTRACT

The purpose of this exploratory research was to examine two middle school mathematics teachers' views of the nature of mathematics and their perceptions about the purpose of education as it translates into planning for instruction and teaching. In addition, students in one seventh grade mathematics class of each teacher were surveyed about their perceptions/beliefs about mathematics. Change in the students' perceptions/beliefs and mathematics achievement over the course of one year were considered. Data collected, including results from teacher and student questionnaires and student achievement tests, are summarized in the main body of the text. Results indicate that viewing mathematics mainly as a tool for solving application problems is a less powerful guide to teaching than viewing mathematics as a problem-solving process, at least with regard to student success in the area of beliefs and achievement. Implications for inservice teacher education programs are discussed. Contains 23 references. (Author/MKR)

# Middle School Mathematics Teachers' Views of Mathematics and Mathematics Education, Their Planning and Classroom Instruction, and Student Beliefs and Achievement

by

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A paper presented at the annual meeting of the American Educational Research Association, Atlanta, April 1993.

# Middle School Mathematics Teachers' Views of Mathematics and Mathematics Education, Their Planning and Classroom Instruction, and Student Beliefs and Achievement

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Abstract

The purpose of this exploratory research was to examine two middle school mathematics teachers' views of the nature of mathematics and their perceptions about the purpose of education as it translates into planning for instruction and teaching. In addition, students in one seventh grade mathematics class of each teacher were surveyed about their perceptions/beliefs about mathematics. Change in the students' perceptions/beliefs over the course of one year in each teachers class are considered. Achievement is also reported.

A case study approach was used to explore these issues. Data collection from teachers included two semi-structured interviews at the beginning and end of the research year, questionnaires, lesson plans, journals, class visits, and video tapes of lessons. Students completed belief questionnaires and achievement tests at the beginning and end of the school year.

The crux of the matter resides in the conjecture that if teachers' beliefs guide them to provide interesting and relevant problems using modern technological tools in their mathematics classes, these efforts support student beliefs about the usefulness of mathematics. This technique, however, is not sufficient for promoting student beliefs about mathematics as problem solving and subsequent ability to participate successfully in problem solving environments, both in applications settings and more general problem solving tasks. Teachers, particularly experienced teachers who are well respected as "successful, traditional" teachers, tend to remain at the center of mathematical activity in classrooms. This position inhibits potential student progress both in the area of beliefs about the nature mathematics as a life-long communication and learning tool in all of the following environments: application, inductive and deductive reasoning, and problem solving achievement. On the other hand, teachers who provide an opportunity to explore, work in small groups, and emphasize understanding are more successful at promoting those outcomes.

The purpose of this research is to examine middle school mathematics teachers' views of the nature of mathematics and their perceptions about the purpose of education as it translates into their mathematics classes. Next, teachers' planning for instruction and teaching are explored in light of these perceptions and beliefs. In addition, students in one seventh grade mathematics class of each teacher were surveyed about their perceptions/beliefs about mathematics. Change in the students' perceptions/beliefs over the course of one year in each teachers class are considered. Achievement is also reported.

Teachers' perceptions or beliefs are becoming recognized as powerful determinants of teacher behavior (Conroy, 1987). Particularly, teachers' beliefs about mathematics as an organized body of knowledge, as a way to describe the world, or as a creative art (Ernest, 1991; Scheding, 1981) help teachers decide not only what to teach but how to teach (Schmidt & Kennedy, 1991). Such differences can be found in mathematics classes where teachers view procedural ability as more important than understanding underlying concepts (Skemp, 1987; Thompson, 1984). Also, changing the focus of mathematics teaching from a fixed body of content to processes that are relative such as conjecturing, generalizing, and problem solving requires the adaptability of the mathematics teacher to different situations and changing societal needs (Lerman, 1987; National Council of Mathematics, 1989).

In addition, teachers have formulated philosophies of education that explain what teachers and students do in classes (Hollingsworth, 1989). Mathematics teacher's views about the nature of mathematics and their perceptions about the purpose of education are possible important factors in their curricular decisions and their instructional planning (Kagan, 1992). Highly skilled and motivated teachers and teacher educators who communicate the nature of mathematics and the purpose for studying the subject are key to improving mathematics programs. While these views and perceptions are not sufficient in themselves to change teaching practice, they are

certainly necessary if the desired change in planning and instruction is different from common classroom practice.

Thus, teachers' beliefs about the subject they teach and their beliefs about the purpose of education may influence what they choose to emphasize in instruction and how they choose to organize and then teach the material. For example, making mathematics relevant and meaningful to students will assist teachers in making decisions about whether to include applications and activities that lead to student understanding (Borko, Eisenhart, Underhill, Brown, Jones, & Agard, 1991).

## Method

### Participants and setting

Four teachers in a summer staff development project of 21 middle school mathematics teachers at a university in the northwest participated in this research project. The fifteen month staff development project was designed to assist teachers in implementing the spirit of the National Council of Mathematics Teachers' Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) and Professional Standards for Teaching Mathematics (1991). These four teachers were chosen because they had all graduated with mathematics/mathematics education degrees, were certified to teach grades five through twelve, and had at least ten years of experience. The teachers represent the geographic regions of the state and also represent urban, small city, and rural settings.

### Data Collection and Analysis

This study was exploratory in nature so a case study design was used. An open-ended investigation of teachers' subject matter definitions and beliefs about the purpose of education was conducted. Data from the sources listed below were analyzed to identify common themes and patterns, using a constant comparative approach (Bogden & Biklen, 1992).

### Instrumentation

Teacher questionnaires. Teachers completed questionnaires during the first and second summer of the program. They gave explanations about their definitions of mathematics that included the topics/themes/strands that make up mathematics and the topics they taught in their seventh grade classes. They also indicated their views about the main purposes of public school education.

Teacher interviews. A one-hour interview was conducted at the end of the first summer and again during the second summer. The purpose of the first interview was for participants to discuss the goals for teaching seventh grade mathematics that they had set for the coming school year and to share the scope and sequence developed during the summer designed to meet these goals. In the second interview teachers gave explanations for their definitions of mathematics. In addition teachers articulated their views about the general purpose for education and a more particular purpose for studying mathematics in middle school. They were also asked to describe what they had done in their mathematics classes to help reach "ideal" views and what factors keep them from reaching their "ideal" views.

Teaching plans. Middle school mathematics teachers made a year-long curriculum plan for their seventh grade classes during the first summer of the project. During the next school year the teachers made mini-lesson plans detailing how they would translate their curriculum plans into action. The lesson plans included the topic of the lesson, the classroom organization planned for the various sections of the lesson (what the teacher was doing and what the students were doing), manipulative and technology use, and purpose of various activities (eg. motivation, developing understanding, practice). A portfolio of materials other than text materials used to teach this class was also collected. Teachers also kept a weekly journal.

Teacher video tapes and class visits. Teachers made between zero and five video tapes (five were requested) of their seventh grade mathematics class. In

addition two visits, one in the fall and one in the winter, were made to the target seventh grade class for each participating teacher in the study.

Student questionnaires. Student demographic data, perceptions/beliefs toward mathematics, favorite classes, and future uses for mathematics were collected through a questionnaire during the fall and again in the spring of the research year. The perception/ belief items were adapted from a questionnaire developed by Schoenfeld (1989). Reliability on the attitude/belief portion of the questionnaire was established at .84, using Cronbach alpha.

Student achievement. Student achievement was measured using a researcher-developed instrument . The Curriculum Standards and the state Comprehensive Curriculum Goals served as guidelines for preparing the 60-point test containing three sections:

1. Computation skills. The first section (20 points) measured seventh grade content concerned with computational skill. This section included problems on (a) numerical operations using decimals, fractions, percents, and integers; (b) order of operations, finding the value of an expression, and exponents; and (c) estimation.

2. Application problems. The second section (20 points) measured the student's ability to interpret and solve application word problems. This section included application problems using (a) fractions, decimals, percents, and integers; (b) proportional reasoning; and (c) geometry and measurement.

3. Problem solving. The third section (20 points) measured problem solving skill. This section included (a) an open-ended problem (designing an experiment based on collecting, organizing, and interpreting data), (b) a geometry pattern exploration problem (making a table, stating a rule and writing an equation, and graphing the results), and (c) an interpretation, explanation, and evaluation of a typical student's incorrect solution to a particular problem situation.

## Results and Discussion

First, two teachers cases representing the different belief systems held by the middle school mathematics teachers in this study are presented. Secondly, themes and patterns that arose from the data of the teachers are discussed.

### Case Study A--Mr. Roberts.

Mr. Roberts has a masters degree and 23 years of teaching experience. His principal writes of him, "Because of his dedication to mathematics teaching, his stature with other teachers in our district, and his ability to stay with a task to its completion, Mr. Roberts would make an outstanding participant in your project."

Mr. Roberts teaches seventh grade math and computers. He has a large room next door to the computer lab and has access to both rooms. He has a classroom set of scientific calculators which are used extensively. He is committed to using manipulatives and is in the process of building a classroom resource of manipulatives (eg. dice, spinners, cm. cubes, rulers, cards, graph paper). He states, "I gather them as I find a need." He used models and manipulatives in his lessons to lead students to an understanding of underlying concepts. For example, folding fraction models were used to teach ideas around equivalent fractions. He was introduced to the Curriculum Standards during the first year of summer school and was pleased to see that some these goals matched his personal beliefs.

### Beliefs about mathematics.

Mr. Roberts views mathematics mainly as a tool to solve applications problems. At the beginning of the program, Mr. Roberts writes the following definition of mathematics: "The tool one uses to solve number related problems. Basic skills, problem solving, mental math, estimating are the topics that make up mathematics. Basic skills is the foundation, the other skills are the structure that one uses to solve

number related problems. One is successful in mathematics if they are able to take these topics and incorporate them with available materials to solve problems."

At the end of the summer he writes, "the discipline that connects and allows us to understand many areas of life that effect us." He then draws a diagram (see Figure 1) in wheel shape with math at the middle and the spokes are problem solving, science, music, art, economics.

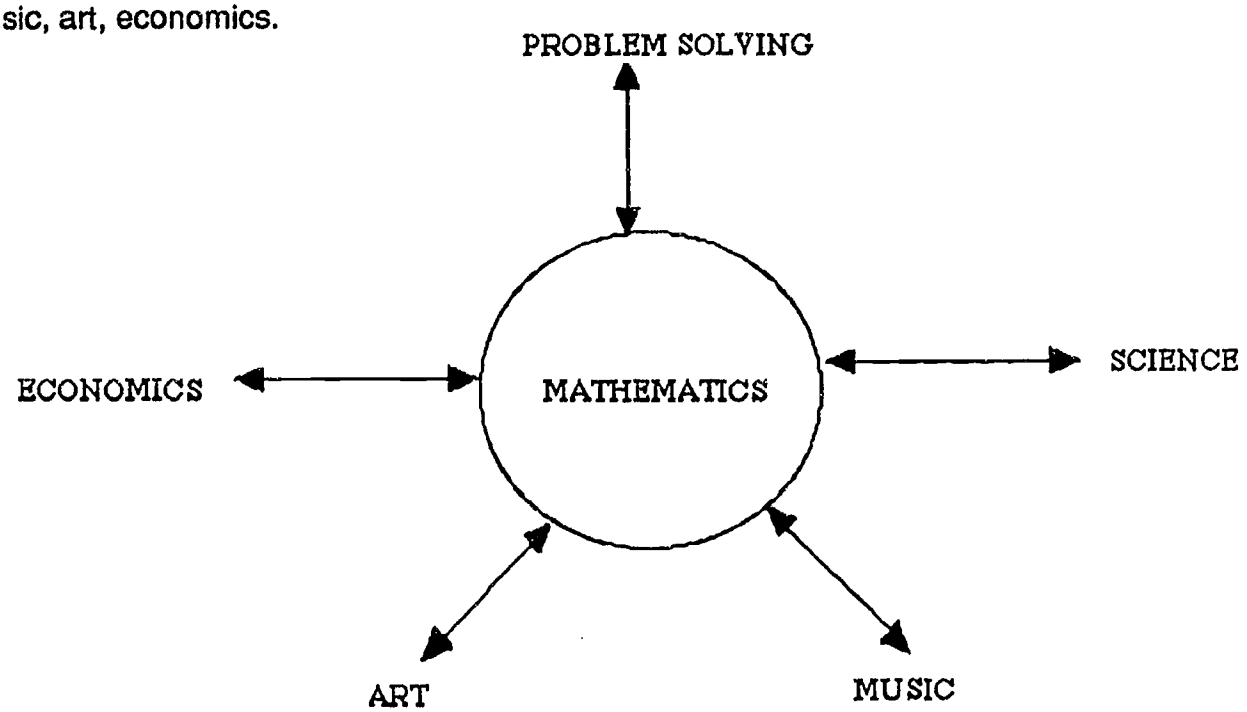


FIGURE 1. MR. ROBERTS' VIEW OF MATHEMATICS.

Following the program he says, "mathematics is a universal language that explains and describes why anything works, language of the planets, cars, series of equations."

Weeks spent on each mathematics topic during the school year

| | 1990 | 1991 |
|---|---|---|
| Probability | 1 | 2 |
| Statistics | .5 | 3 |
| Geometry | 3 | 3 |
| Measurement | 3 | 3 |
| Algebra | 3 | 5 |
| Problem Solving | 5 | 9 |
| Numbers/Computation | 9 | 6 |
| Graphing, patterns relationships | 1 | 5 |
| Other | 2 | |
| Testing | 2.5 | |

He says in his application to the program, "I am frustrated with the math curriculum as taught in our schools now as it doesn't emphasize new and exciting math, but instead emphasizes competence based arithmetic skills...The crisis in our curriculum is now. We should not have to wait another adoption cycle until we can solve our problems. We as teachers need to learn how to teach a relevant curriculum, one that is exciting and gets the kids involved, a curriculum that teaches the kids to think, to be able to successfully handle problem solving situations, and one that utilizes the new technology. I was discouraged as I reviewed textbook after textbook that offered nothing new over our previous adoption. The only books that offered a different and exciting approach to math were from the Chicago Math Project." During the school year Mr. Roberts completed the first seven chapters of Transition Mathematics and intended to complete the book the next year. He organized each week with "regular lessons" from the book on the first four days, and had an application or computer activity on Fridays. For example, on one Friday he had the

class do an activity on codes, "a great activity for data gathering, graphing, and computer analysis. A (names his school's city) historical fact was written in code. The students were to decode the historical fact."

At the end of the school year he also included some application problem projects. Examples of applications problems were checkbooks--where students "write checks, pay bills, make deposits, balance their account, and reconcile their balance with the bank statement". Then the class will, "develop a spreadsheet for balancing a checkbook." A second application example was in having students solve a "Disease Diagnosis Problem--which is a good activity for cooperative learning, data gathering, analyzing data, probability, and using graphs." Examples of his use of technology included seven days during the year using the computer with students completing logo and spreadsheet problems.

He stated that problem solving was included throughout his instruction, but evidence in his lesson plans for using a problem solving approach was small, but limited. For example, " Each groups was given a suit of cards. They were to organize the cards so they could be dealt sequentially with the following rules: Turn the first card over, put the second at the bottom of the deck; turn the third card over, put the fourth at the bottom of the deck, etc. The learning groups who solved the problem were to present their results to the group." From the video five out of seven small groups of students solved the problem using trial and error. Students presented their solutions, but no classroom discourse ensued about different ways of solving the problem or about ways that could solve the problem more generally.

Class organization. From Mr. Roberts questionnaire, he describes his classroom in the following way. However, from his videos, it was evident that the majority of time was spent in large group discussion/independent work with small (5 minutes) in small group activities.

| | 1990 | 1991 |
|---|---|---|
| Large group discussion | 40% | 40% |
| Cooperative small groups | 50% | 30% |
| Independent work | 10% | 30% |
| Other | 0% | 0% |

All of the lessons observed (5 on video tapes, 2 classroom observations) in Mr. Roberts class were teacher led, and the objectives were very clear. Desks were arranged in rows with students facing the front. Students are cooperative, quiet, and follow directions. Evidence of using a variety of activities is plentiful. He includes historical tidbits and application problems throughout his instruction. During one researcher observation day Mr. Roberts started off the day with a mental math problem on percent. Next, he demonstrates his commitment to relevancy and technology. He uses the context of England and France to introduce idea of measure and its human made-ness. He uses learning groups for about 5 minutes of the period and the activity was highly structured and organized.

Beliefs about learning.

Percentage of students that are competent at each skill do not change for Mr. Roberts from the first summer to the second:

| | | |
|---|---|---|
| development/maintenance of concepts/skills | 80% | 80% |
| applications of concepts/skills | 70% | 70% |
| problem solving | 50% | 50% |
| open-ended investigation | 15% | 20% |

Mr. Roberts class emphasizes the teacher in the role of deliverer of knowledge and the student in the role of practicing procedures and then applying particular procedures to solve applications.

An example of part of a class session follows:

Mr. Roberts passes out a sheet of graph paper to each student and says "I am going to give you an example of a real life town's population that doesn't exist anymore." He then leads them through step-by-step drawing a graph of the population of Vanport, emphasizing that the graph needed to be neat. He tells Vanport's story. As the students complete the graph, Mr. Roberts places the data in a spreadsheet in a computer at the front and has the computer draw the graph. Basically, Mr. Roberts tells the students what to do, and they follow directions in a courteous manner, and answer questions when asked.

This particular problem was designed by another teacher in the staff development project as an interpretation and discovery problem. The intent was to have students complete the graph either with paper and pencil or in spreadsheet form in small groups, and then write a story that could describe the graph. Finally, students were to be invited to ask family or friends about the town of Vanport. (Note: Vanport was built around the ship building industry during World War II and was destroyed during a flood shortly thereafter, existing for only a short time.)

This example describes Mr. Roberts beliefs about learning and teaching and how he translates these beliefs into practice. He focuses on applications and interesting problems, but he generally remains the center of classroom discourse and gives students few opportunities to think about the problems and to examine the implications of the problems in a more general sense.

Beliefs about education.

Mr. Roberts believes that the main purposes of education are, "To give a child the foundation to be successful in life. Success in life depends on making choices in careers and education. School should give students the necessary academic background to help in life decisions. School is increasingly finding itself in the role of helping students with social decisions as our society is faced with problems of drugs, aids, breakdown of the family unit and crime."

During the interview at the end of the program, Mr. Roberts says, "Role of education has always been to help the student find their place in society. But the demands are changing, now we are a post-industrial information based society heavily dependent on the new technology. To help students find their role, schools must teach coping skills, thinking skills, socialization skills, skills to find happiness, and skills to become life long learners. The skills are the same as at the turn of the century, but how we approach these skills is quite different."

Mathematics education. "A fundamental to teach to kids, so that they can function in life. Also gives them the ability and flexibility to do anything they want. We must peak their interest and enthusiasm. Lack of mathematics limits options in life. So teachers must try to make math appropriate for these kids.

I have the facilities to implement the ideal in mathematics education. It is up to me to emphasize where it should be. Nothing holds me back but myself and blinders and lack of energy. Without these restraints, nothing prevents me from doing that."

Mr. Roberts' students

Student beliefs about mathematics. Mr. Roberts' students believed very strongly that mathematics was a useful subject, that it was related to other subjects studied in school, that it describes the world in some way, and that it would be useful for them when they were grown-up. They believed that they would need to know more math than they know now both in their regular lives and in jobs in the future. These beliefs were either the same or stronger at the end of the year than at the beginning. In fact, when they were asked an open-ended question about how they would use mathematics in their future, 37% replied "everywhere" and 42% said in "jobs." Surprisingly, only 11% discussed daily lives in their answers and none mentioned college. (42% chose not to reply to the question.)

The next strongest trend of beliefs about mathematics of Mr. Roberts' students included that mathematics was mostly facts and procedures that must be memorized,

that the answers in mathematics are either right or wrong, that students couldn't figure out their own way to solve problems, that the teacher must show you the exact way to solve the problem, that the best way to do well in math is to memorize, and that you have to be taught the right procedure or you can't do anything.

Achievement.

| | Pretest | Posttest |
|---|---|---|
| Computation | 33% | 55% |
| Application | 16% | 26% |
| Problem Solving | 15% | 24% |
| Test Average | 21% | 37% |

Note that students make gains in all areas, though not strong gains.

Discussion of Mr. Roberts

Students beliefs about the usefulness of mathematics reflected Mr. Roberts' own views; that mathematics was a tool for applications. Thus, Mr. Roberts' emphasis on applications and technology bore some fruit. However, Mr. Roberts' students also viewed mathematics as a rigid system that depended on the teacher's explanation and memorization of procedures. Perhaps his insistence on keeping control of the class, using small groups for very small amounts of time, and on telling students very carefully how to set up and solve problems kept students from becoming independent thinkers and problem solvers. One would then expect larger achievement gains for students in the area of computation and applications as compared with problem solving. Students made gains in all areas over the course of the year, but the gains were moderate, at best, in all areas.

Case Study B--Ms. Jenson

Ms. Jenson has an advanced high school mathematics teaching certificate, a masters degree, and 10 years of teaching experience. Her principal writes, " Ms. Jensen is a highly motivated, concerned, and competent math teacher. She has much

to offer a project in terms of her teaching skills, knowledge of recent trends, events, and research in her field. She also possesses a keen understanding of the social, emotional and academic needs of adolescent students."

Ms. Jensen teaches seventh grade math, prealgebra, and algebra. Students have access to a classroom set of calculators, but not to a computer lab. The school lab was in use during the 7th grade mathematics period. She is committed to using manipulatives and has full classroom sets in her room. She writes of her teaching prior to the project year,"Calculators, cooperative team learning, and manipulatives are presently a successful part of my math classroom. I am constantly searching for new ideas and better methodology for relaying math concepts to middle schoolers."

Beliefs about mathematics.

At the beginning of the program, Ms. Jensen writes the following definition of mathematics: "Everything in nature is arranged by order and number. Mathematics explains nature's laws and patterns. Mathematics is a universal language crossing cultural barriers. In addition to explaining nature and functioning as a communication mode, mathematics' purpose is to aid in solving life's problems. Problem solving is a major component of mathematics. Topics which are subsets of problem solving are: estimation, logic, and reasoning, data collection and analysis."

At the end of the summer she draws the following diagram:

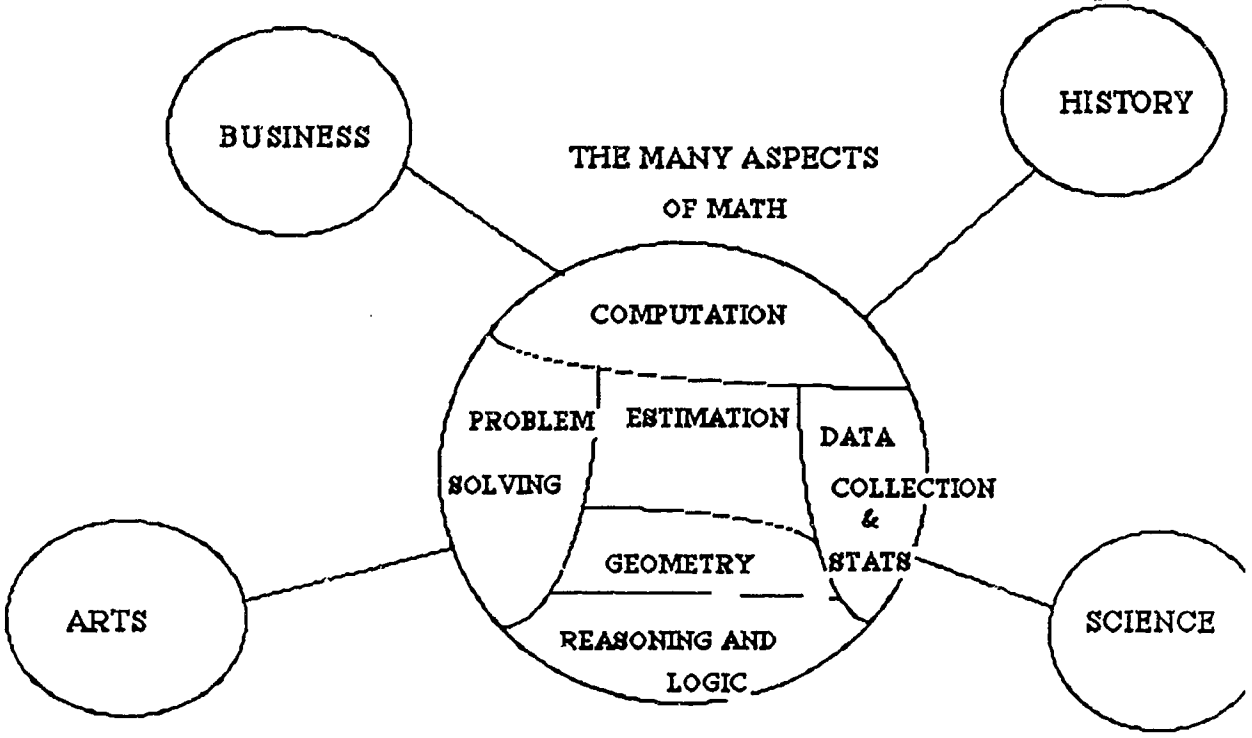


FIGURE 2. MS. JENSON'S VIEW OF MATHEMATICS

Following the program she says, "Mathematics is a combination of logic, problem solving, application. It is the language of science and the universe. It explains nature, music, reasoning. Process and theory is important but the usage of mathematics is the reason for existence which is needed for explanation and communication."

Ms. Jenson's seventh grade course

The first portion of the year was planned around problem solving, number theory, estimation and mental math, and fractions and decimals. Problem solving, mental mathematics, and estimation continued as a strand throughout the year. The second portion of the year focused on spatial visualization, measurement, graphing, and geometry. The third portion of the year included probability, deductive logic, statistics and data collection, fractions and ratio and percent, and graphs. The organization of the course was around central themes. A richness in problem solving

contexts was provided. Ms. Jensen used at least three activities each day. The text was used where appropriate to these central themes.

Weeks spent on each during the school year on particular topics

| | 1990 | 1991 |
|---|---|---|
| Probability | 2 | 2 |
| Statistics | 2 | 4 |
| Geometry | 9 | 8 |
| Measurement | 4 | 3 |
| Algebra | 2 | 2 |
| Problem Solving | 3 | 3 |
| Numbers/Computation | 6 | 4 |
| Graphing, patterns relationships | 5 | 5 |
| Integrated Units (rockets and states and calculators) | 3 | 3 |

She states that the staff development project allowed, "It was so nice to have the year planned with my own personal curriculum sequence."

Class organization. According to Ms. Jensen's lesson plans, she varied classroom routine when the topic called for it. However, she typically had students begin class with a warm-up, followed by large group discussion, small group or paired exploration, and independent practice. In her questionnaires, she characterizes a typical class in the following way:

| | 1990 | 1991 |
|---|---|---|
| Large group discussion | 20% | 20% |
| Cooperative small groups | 30% | 25% |
| Partners, pairs | 30% | 35% |
| Independent work | 20% | 20% |

So, for example, the day might begin with a number puzzler aimed at maintaining a skill, followed in large group with "What's my Number Game" aimed at providing motivation and foreshadowing a coming development. Next these number tricks using variables are discussed in a problem solving vein, with students making conjectures about patterns. Pairs of students explore the "birthday algebra trick." Finally, students work independently on variable equations using calculators.

Beliefs about learning.

Ms. Jensen states, "In the Information Age, emphasis should not be placed merely upon factual knowledge, but rather conceptual understanding and the development of the skills for accessing the information. Learning is best obtained and retained through involvement in meaningful activity." For example, at the beginning of the year, she has students act out the "handshake problem." She states that she wants "kids to have the opportunity for success right from the start...some of the kids are shy and are not used to being up, actively involved, and demonstrating; however, the lesson went well and they seem to enjoy the active learning." By week four she writes, "Considering how low these students are in ability, they are well-behaved and are successful in partners, small groups, and cooperative learning arrangements." At week nine she writes, " For two days, I had students take the book posttest in cooperative groups. I heard math communicated constantly. I feel these two days were very worthwhile. Many of the Standards --resoning, communication, relating etc . . . were addressed through this experience."

Ms. Jensens' class emphasizes the teacher in the role of facilitator. She states in the interview at the end of the school year, "We need to emphasize cooperative learning, the interaction between students with the teacher as facilitator. Teachers create the right environment." For example, during her measurement unit she states, " measurement concepts were best learned through many activities of measurement and weighing". Students favorite activities included " the Big Inch". In a second example she writes, " Students enjoyed arranging other students in order on Tuesday. On Wednesday Base 10 blocks help build conceptual understanding, but the favorite activity is decimal designs using the hundreds grid. (Names a student), who has been absent 60% of the time so far, said how fun these were 3 times." A third example, " The baby growth lesson, Students loved saying how much they weighed (now and at birth, and whether they matched any of the baby growth models presented). Many went home and asked about their growth. Real world math in the classroom." A last example from integers she states, "I used two-colored chips to explain integer mlultiplication. Students drew pictures of chips. I tried to carry students from concrete to pictorial to symolic level." She also has students participate in labs (bicycles and gears), portfolios (responsibility, and writing problems (creation of proportion problems, illustrating, sharing, and solving).

Beliefs about education.

Ms. Jensen believes that the main purposes of education are, "to create lifelong learners, and citizens who will positively function as contributors to society. Public schools also have the responsibility of giving students the skills necessary for job attainment." On another occasion she writes, "My foremost belief concerning education is equity. In a democracy, educational opportunities should be equal for all children within a state. The goal of education is to produce healthy good citizens for the society.. Students need skills for job attainment and the capability for lifelong learning. Lifelong learning ability allows for job retraining and develops a free thinking

responsible democracy. Students should have preparation for successfully functioning in cooperative and competitive situations.

During the interview at the end of the program, Ms. Jensen says, "The purpose of education is to help people to pump up ability. Equity is a big issue. Equal for all. Rather than serving as a filter that some people fall through. (Students should become) lifelong learners who are productive members of society."

Mathematics education. She says, "The purpose for studying math in the middle schools is to develop reasoning, communication, problem solving, knowing the best technology. We need to spark student interest for further math investigation. So much. . . is patterns. Also, complex ideas are the introduction to the future. They need to see math in their world." Additionally she writes, "We need to change courses to a variety of topics, and change the order of the curriculum. Some topics can be taught much earlier. Mathematics can be integrated with other subjects and technology. The threat of standardized testing needs to be taken away, we need alternatives like portfolios."

She describes her ideal mathematics class, "Students must have freedom to take risks. Students are not afraid to risk. There must be an emphasis on different solutions with attention paid to the thought process. Must use cooperation, and a little competition. There need to be activities, labs, technology. We must provide open ended questions with attention paid to different solutions. Students must bring in their own (problems). The environment must be--supportive, warm, positive feedback... laughter, building self esteem."

Ms. Jensens' students

In a writing assignment in October, Ms. Jensons' students write, "To tell the truth, I've never really enjoyed math as much as I do now. You make it exciting, Ms. Jensen, I don't know how you do it--but you do! I had (another teacher) last year, and it was always the same boring thing! Plus, I like the way you have everyone do their

homework." A second student writes, "This year I've learned more about math and I understand it better. I am better at sequences. It's fun when we do little skits or play games like 20 questions to teach us how to do things."

Beliefs about mathematics. Ms. Jensons' students, like Mr. Roberts' students, also believed very strongly that mathematics was a useful subject, and that it would be useful for them when they were grown-up. They believed that they would need to know more math than they know now both in their regular lives and in jobs in the future. The students felt this way at the beginning of the year and did not change their beliefs during the year. Also, when they were asked an open-ended question about how they would use mathematics in their future, 29% replied "everywhere" and 43% said in "jobs." Surprisingly, only 14% discussed daily lives in their answers and none mentioned college. In fact on the questionnaire, her students were lower than neutral about whether or not mathematics described the world in some way and were related to other subjects studied in school at the beginning of the year; and changed their responses to slightly above neutral at the end of the year.

The next strongest trend of beliefs about mathematics of Ms. Jensens' students reflected a problem solving flavor. These included that mathematics was a way of thinking about things, that you could figure out new things by yourself, that common sense rather than math rules helped you solve math problems encountered outside of math class. They disagreed that you would have to be taught the right procedure in order to do anything in a math problem.

Achievement.

| | Pretest | Posttest |
|---|---|---|
| Computation | 42% | 83% |
| Application | 16% | 41% |
| Problem Solving | 18% | 47% |
| Test Average | 25% | 57% |

Note that students make gains in all areas, approximately doubling their scores in all areas.

Summary of Ms. Jensen

The center of mathematics includes estimation, problem solving, logic and reasoning. This center is then applied to problems in a variety of contexts. Ms. Jensen believes the life-long learning is the central theme for teaching and learning, so equity and student success come first with an emphasis on student understanding. Students have opportunities each day to talk and do mathematics in large group and small group settings. Ample opportunity for mathematical thought and application are provided in her mathemtics class.

Discussion: Views of Mathematics and Learning and Effects on Teachers and Students

Viewing mathematics mainly as a tool for solving application problems is a less powerful guide to teaching with regards to both student success both in the area of beliefs and achievement than viewing mathematics as a problem solving process.

All participants in this study listed the one of the main purposes for studying mathematics in middle school was the application of mathematics to students' private lives, future schooling, work opportunities, and the world in general. Positive attitudes, " a real can-do or stick-to-it-tiveness attitude to solving problems", was also emphasized by many of the teachers. Other attitudes about developing personal and social responsibility were featured in some teachers' philosophy.

Another reason for giving mathematics special prominence in the middle school curriculum was to increase logical reasoning and thinking skills, especially at this time when students' developmental stages allow for bridging the gap from concrete to more abstract thinking. Other reasons listed were choosing and using proper mathematics tools, estimation and mental math skills, and decision making. Only one teacher

mentioned the study of mathematics as being part of a "well-rounded" education, knowledge shared by an educated populace of the world."

Planning for instruction

Year long plans were generally organized in one of two ways: (a) topic oriented using the organization of the book (a heavy dose of number and computation followed by geometry, probability and statistics) and (b) topic oriented using a more integrated approach (starting with number theory, geometry, or probability and ending with applications and statistics). A variety of strands (particularly problem solving and technology) were woven throughout the year. Teaching thematic units (simulations, maps, bicycles, M & M's) were used to varying degrees by each of these teachers.

Students views and teachers planning

Students increased ratings on mathematics' describing the world some way, being related to other school subjects, and having lots of ways to solve the same problem were in classes where teachers included activities and applications as explorations of new ideas, as developing problem solving skill, and for developing a positive attitude. These teachers also wrote more of their own materials specifically relevant to the area (small town, rural, city) in which they teach.

Teachers success in meeting their ideals

Teachers felt most successful if the ideals of the staff development program (exemplified in the NCTM Standards documents) and their own ideas were the same at the beginning of the program and if they had been implementing their "evolving" beliefs into classroom practice for several years. These successful teachers were also expert in classroom management skills. Some of the practical applications of beliefs that these teachers used with students were writing in journals, grouping in cooperative or paired learning, using technology and manipulatives,

Teachers having the most difficulty implementing their beliefs fell into two camps: (a) those whose students were discipline problems--"I tried, but the students

wouldn't let me"-- and (b) those who were experienced, traditional teachers and well respected by their school principals but who see the need for new goals for mathematics education. Other impediments in implementing ideal mathematics teaching were: preparation time and lack of collaboration with peers, size of room, availability of technology and materials and money, non-supportive administration and parents, need for lengthened class periods, personal opportunity for growth "I don't think about problems the way I want kids to think about problems."

## Implications

Inservice teacher education programs should provide for discussion of alternative views of mathematics and philosophy of education. Teachers choose from many alternatives, forming a "highly personalized pedagogy...a belief system that constrains the teachers' perception, judgement, and behavior " (Kagan, 1992). So, at a time when the mathematics we are recommended to teach, and the way that we are asked to teach it is different from what most mathematics teachers have experienced themselves; time should be allotted for reading, thought, and discussion within methods courses both at the inservice level, as well as the preservice level, about a broadened perspective of mathematics. These broadened perspectives might emphasize mathematical processes such as problem solving, looking for patterns, generalizing, and reasoning as well as mathematical algorithms such as multiplying fractions or finding the roots of a quadratic equation. These broadened perspectives might also emphasize mathematics as a cooperative human endeavor. The possibility may then exist that teachers will provide a more balanced view of the subject they teach if these teachers are aware of how this may be done and are given the opportunity to practice. Particularly potent are teachers' willingness to steep students in problem solving environments in which they formulate problems and solutions and reflect on solutions themselves. Explicit examples of how this might be accomplished should be provided in both preservice and inservice mathematics and methods

classes with students required to practice implementing plans with a broadened view of mathematics as one of their goals.

Emphasizing understanding basic concepts and problem solving skills in mathematics prior to learning procedures and constructing an abstract system of ideas is relatively new thinking for many teachers. This emphasis alone may be worth the staff development effort.

These teachers, however, felt frustration in their efforts to improve instruction in mathematics classes. They felt frustrated in the face of an overloaded curriculum with little time for teachers or students to think; much less time to include exploration of a wide variety of ideas of which some are student suggested and constructing mathematical concepts and processes from student experience. Other difficulties arose when teachers found skills that they were particularly expert at implementing and well respected for successful implementation in their districts, were skills that they no longer valued as much as other less well developed skills.

The crux of the matter that supports other research efforts and needs to be followed up in future research seems to reside in the conjecture that if teachers provide interesting and relevant problems using modern technological tools supports student beliefs about the usefulness of mathematics. This technique, however, is not sufficient for promoting student beliefs about mathematics as problem solving and subsequent ability to participate successfully in problem solving environments, both in applications settings and more general problem solving tasks. Teachers, particularly teachers who are well respected as "successful, traditional" teachers, must be convinced that remaining at the center of mathematical activity in classrooms detracts from potential student progress both in the area of beliefs about the nature mathematics and in application and problem solving achievement (Franke, Fennema, Carpenter, & Ansell, 1992). The students must "do" the thinking about mathematics and solve the problems themselves, not the teachers.

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