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ABSTRACT

Many students are not actively engaged in learning in mathematics classrooms. The purpose of this study was to develop understandings about student engagement with the mathematics curriculum and its influence on student engagement. The research was conducted in two seventh-grade classes taught by the same teacher, who used direct instruction. The social interactions of the students (n=53) and their teacher within the mathematics class were observed, and interviews with the students were conducted. When problem solving, working in groups, and working with manipulatives, students expressed positive attitudes about mathematics, were more likely to be engaged, and showed internal motivation to do well. When performing drill and practice, memorization and rote learning tasks, and computation out of context, students were most often bored with learning, complied minimally with teacher direction, and felt low levels of engagement. Included in the section on implications for teaching is the recommendation that teachers move away from lecturing and move toward activities that motivate their students. The appendix lists 20 student interview questions. Contains 36 references. (MKR)

What Mathematics Students Can Teach Us About Educational Engagement: Lessons from the Middle School

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Introduction

When I was a child, the orderliness of arithmetic procedures appealed to me. The rules made sense to me and mathematics seemed useful. Math wasn't as exciting to me as it was satisfying. I learned to align my columns, carry when adding, borrow when subtracting. I got pleasure from turning in neat papers. However, as a college mathematics student, I found that mathematics was really much more than the sensible rules and neat papers. The more mathematics classes I took, the more creative and intuitive mathematics became for me. It was a "different" way of thinking. I began to enjoy mathematics even more than I had liked arithmetic. Mathematics had become challenging; no longer was it just manipulations of numbers and variables.

As a teacher, I learned that many students did not feel the love and wonder for math that I felt. For too many of my students, there was not an appreciation of the orderliness in arithmetic. They did not see rules as understandable, creative ways to arrive at correct answers. Instead, many students saw the rules as something to be memorized that made no sense. After I had given what I thought were clear explanations, some students still did not know how to proceed. They found mathematics boring. "Why do I have to learn this stuff? I'm never going to need to use it!" they said. Neither they nor I were experiencing satisfaction.

It became more and more clear that the beauty of algebraic reasoning or geometric proving was not a part of students' understanding of the world around them. In general, algebra, geometry, and all that "other math" belonged to me, their teacher, and to the school. How could I help engage them in the learning? I changed my lessons, types of problems, and my teaching style. I began to spend less time showing them how to solve the problems and more time engaging them in problem solving. Both the students and I began experiencing satisfaction. I like to think I began to "inspire" them to learn mathematics. This experience began a process for me that has lead to the purposes for this research: to develop educator's understandings about student engagement with the mathematics curriculum and its influence on student engagement. This presentation describes the results of a naturalistic study concerned with the attitudes and understandings that middle school students have about mathematics.

As a part of my efforts to help teachers develop classroom environments where effective learning takes place, I examined the social interactions of middle school students and their teacher within the mathematics classroom. I interviewed students themselves asking them what types of mathematical activities they most preferred and what types of mathematics they like best. Specifically, this study addresses the question: Under what circumstances are students inner directed to engage in learning mathematics?

Wehlage, Rutter, Smith, Lesko, and Fernandez (1990) in their research on students' engagement say that "engagement is the result of interaction between students, teachers, and the curriculum." The authors explain that promoting engagement requires attention to student characteristics, the tasks students are asked to perform. the school environment in which the work takes place, and the external environment that influences the students. Ross, Bondy, & Kyle (1993) say that if students are to be deeply engaged, teachers must look closely at their own practices.

What can teachers do to help students become motivated to learn mathematics? What happens when students are highly motivated? Wehlage et al. state that if children are motivated, they become engaged with the curriculum, listen to instruction, and attempt to understand. Holmes (1990) states that "Motivation fuels mathematical learning." Children with learning goals are engaged in comprehending and accepting the challenge of learning and persist in the presence of difficulties. *The Standards* (NCTM, 1989) suggest that to help students engage in learning mathematics, teachers should help them find pleasure in learning, stress the value of doing mathematics, and make lessons meaningful and challenging.

Over the past decade, several reports have recommended a de-emphasis on the arithmetic paper-and-pencil algorithms and an increased emphasis on more creative aspects of mathematics, such as problem solving (National Council of Teacher of Mathematics. 1980; Commission on Standards for School Mathematics, 1989). Researchers on constructivist learning in mathematics (Carpenter & Fennema. 1989; Yackel. Cobb, Wood, Wheatley, & Merkel, 1989) view instruction in mathematics as a social interaction process. Yackel et al. say that when children are given opportunities to talk about their mathematical understanding. occasions for learning mathematics are natural. Students develop mathematical concepts as they engage in mathematical activity. Teachers with this view provide children with activities that are likely to engage the students. This instructional approach is based on the view that mathematics is a creative human activity and that social interaction in the classroom plays a crucial role as children learn mathematics (Yackel et al., 1990). Children learn a lot more about mathematics and develop beliefs that mathematics is a valuable and meaningful activity (Cobb, Yackel, & Wood, 1989; Lampert, 1991).

As a part of our efforts to help teachers develop classroom environments where effective learning takes place, researchers need to examine the social interactions that take place within the mathematics classroom. We don't know enough about what motivates students to want to learn mathematics. Therefore, in this study I wanted to examine students' experiences with mathematics and ask them how these experiences motivated their engagement

Qualitative research methods were chosen because this type of research could more clearly describe the classroom environment and the effects this environment had on students' engagement. Because this research focused on the nature of the students' understandings about mathematics and their perception of mathematics instruction, it has implications for teachers and teacher educators who are sensitive to students' ways of thinking. It is hoped that these findings will better prepare us to provide suitable learning experiences.

Method

This study was designed to examine the engagement of above average middle school students by observing and interviewing them throughout a four-month period. By focusing on the classroom contexts in which mathematics occurred, I investigated the types of classroom experiences that engaged students more in the learning. As Figure 1 shows, I sought to describe and understand how the students' beliefs, attitudes, actions, and motivations related to the types of mathematics problems they were involved in solving, their task behavior, and ultimately, to their levels of engagement. Because the majority of our students are enrolled in public schools, I chose this context for my research.

CONDITIONS OF LEARNING

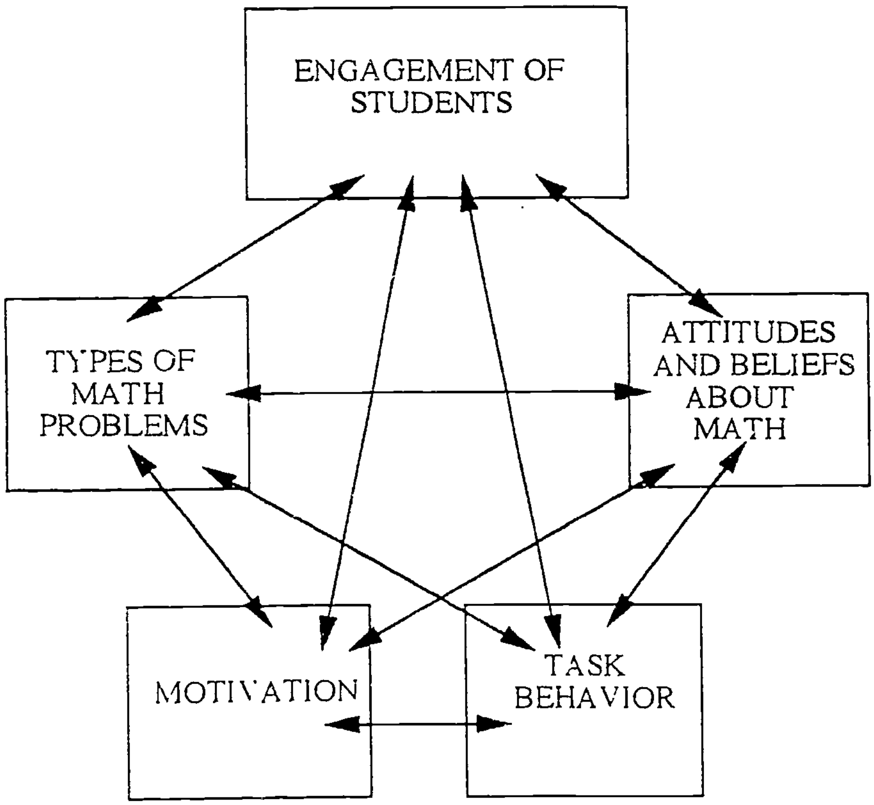

Figure 1. Conditions of learning that engage students.

Participants and Setting

The research was conducted in two seventh-grade classes that were taught by the same teacher, Mrs. Giles [1]. One class was high-average general mathematics, the other was pre-algebra. These classes were selected because students in both classes would be involved in learning more than beginning

1 The teacher's name and all students' names are pseudonyms.

algebraic concepts. The teacher's instructional approach would be considered direct instruction. She took a strong leadership role and used a particular sequence of events during each lesson: daily review, a lesson or demonstration by the teacher, supervised practice, and independent practice. The teacher actively taught and monitored learning in the class. This direct instructional approach is discussed in detail in Good, Grouws, and Ebmeier (1983). The students had opportunities throughout the class period to interact with the teacher and other students. The teacher also was comfortable having an observer in the classroom.

The study was done in a public middle school in a large suburb of a southeastern city. The sixteen-year-old school was in a middle-class neighborhood. The student body included 1200 students, of whom 4% were black. The classroom was overcrowded with desks, cabinets, shelves, and students. An overhead in front of the room was used by the teacher, and occasionally by the students, to work mathematics problems during whole-group instruction. There were 27 students in the high-average general mathematics class and 26 students in the pre-algebra class. Of these 53 students, there were 34 girls and 20 boys. Two students were black, four were Oriental, and the remainder were white (see chart on next page). About half of the students in the pre-algebra class were in the gifted program.

Student Population

Gender		
	Girls	33
	Boys	20
	Total	53
Race		
	White	47
	Black	4
	Oriental	2
	Total	53

Although the students spent much of the class period workin~ at their seats, they were able to cooperate in solving assigned problems, homework or classwork. Before students were assigned seatwork, the previous night's homework was discussed orally with the teacher working most of the problems on the overhead. Sometimes the students also worked problems on the overhead or chalkboard. The students always had questions to ask about problems they may have found difficult. Math instruction centered around the textbook, with the students working mostly on computations and isolated skills. At the end of every section were "word problems." These word problems caused the most difficulty for the students. The students were able to use calculators on most of the work. Some lessons were taught using manipulatives. There were some cooperative problem-solving activities. A quiz was always given at the beginning of class. This quiz always contained problems that had been discussed previously. Mrs. Giles spent a great deal of time discussing the relevance and practical uses of whatever word problems the students were working. She encouraged the students to talk about their examples of "real life" uses of the topics.

Data Collection

The students' attitudes and interactions were explored using Spradley's model (1980) for ethnographic research. I began the study by collecting data during participant observation. I examined the students actions before class, during the whole group oral portion of the lesson, and during seatwork. I looked for patterns of behavior in the characteristics of types of instruction and mathematics lessons. I wanted to describe and explain the contexts for learning in which students were more likely to be engaged. After the first two months of classroom observations, I began two months of interviewing students. These interviews were both formal and informal. They were based on protocols that had been developed and transcribed from the observations.

During the observations, written notes were taken by the observer to record verbal and nonverbal communication as well as the writing on chalkboards and overhead projectors. Interviews were audiotaped. The audiotapes and written notes were used to prepare detailed typed protocols of the observations and interviews. These data were supplemented by collected tests, homework, and written comments of students after activities. I observed the students' behavior, their use of mathematics materials, and I listened to what they said about their activities. I wanted to hear particular speech messages about either mathematics or about the tasks the students were doing. I tried to record my data using the direct language of the students. Examples of speech messages included: Bill says, "I hate math," when the teacher hands out a worksheet for class work; Bob says, "I forget how to do arithmetic since we've been doing geometry"; Paul says, "Do we *have* to take algebra?" and Kim says, "Do we have to work them out *that* way?"

Although the early observations were directed toward a description of the classroom environment, most of the observations were focused on the students' interactions during mathematics work or teacher instruction. I observed 35 hours of classroom activity. These observations led to 67 pages of typed field-note protocols. These observations served as a background to begin my interviews. I wanted to conduct formal interviews to confirm some of my analyses and to help establish a pattern of meaning in the social interaction of the students in these two mathematics classes.

I informally interviewed the principal and teacher. Ten formal interviews were conducted and tape-recorded with the students. Although core questions provided a framework for the formal interviews, the conversation often led to additional questions that were precipitated by the students' answers. These interviews lead to 65 transcribed pages.

The last type of data that I collected were artifacts of the targeted 10 students - quizzes, tests, and completed mathematics assignments. I looked at these documents for information on difficulty of material, grades of students, completion of work, and solution strategies.

The use of several methods of data collection served to increase the validity and reliability of my study. Triangulation enhanced the credibility of my results. By combining participant observation, interviewing, and analysis of documentation, I was able to overcome the narrow focus of just one method.

Data Analysis

From the beginning of my observations, I began to analyze the data (typed records of specific verbatim behaviors). This analysis helped to direct further my observations. I formulated new questions throughout the observations searching for recurring patterns that would explain the students' attitudes and interactions during math class.

When I first began the observations, I asked questions of my data, "Who are the students in the classroom?" "How do students respond when they don't understand?" "When are the students on-task?" "Do students let the teacher know when they don't understand?" "What are students' ways to get help?" In searching for these answers through observations, I was able to narrow the scope of my research to study a pattern that was forming around student engagement. What types of mathematical activities engaged the students? Are students' attitudes and actions influenced by the types of mathematics problems that they are studying? I decided to investigate these areas through interviews with the students. I asked questions like the following: "What kinds of math problems do you like?" "What is your favorite day that you remember in a math class?" "What kinds of problems do you find boring?" "What happens to help you to perform well on a test?" "How do you begin to understand?"

The findings from these questions are presented in the next section are presented as responses to the research question posed: *Under what circumstances are students inner directed to engage in learning mathematics?*

Findings: Student Engagement and the Curriculum

"Educational engagement" refers to the psychological investment required to comprehend and master knowledge and skills explicitly taught in school (Wehlage, Ritter, Smith, Lesko, and Fernandez, 1989). Wehlage and his colleagues describe levels of engagement: 1) students can simply do what they are asked, or 2) they can demonstrate real interest in and commitment to school tasks.

As with most qualitative research designs, it is impossible to present all the data: field notes from observations, field notes from interviews, and students' work and other feedback. Thus, my response to each question is reported using specific descriptions within the framework of interpretive comments. A single pattern emerged that formed around the concept of the engagement of students.

The clearest picture to emerge from the data was the nature of curricular activities likely to foster high versus low engagement. The patterns of engagement became clear when viewed from the perspective of the curriculum.

Students revealed similar attitudes about mathematics in the types of mathematics problems or activities that they preferred. In analyzing students' responses to the types of preferred problems, three main mathematics activities stood out. First, several students felt challenged and engaged when solving open-ended word problems or questions that dealt with contexts that were relevant to them. Second, some students expressed a clear preference for problem solving when working in groups. And third, students enjoyed actually "doing'" the activities with manipulatives, particularly when doing geometry problems.

Students who talked about geometry and measurement made statements like:

> Joy: Geometry is more interesting because it isn't just a bunch of numbers or letters that you have to figure. When you look at the answer, it makes sense. It helps to spice things up. [Joy wants to be an interior designer.]

> John: I like to work in groups when we're measuring. Everyone can figure out the answer together. I like when [the teacher] lets you spend time talking about the problem together.
>
> Researcher: What if the problems are difficult?
>
> John: They were hard, but, you know, teamwork.

One student explained her notion of when mathematics was relevant. When asked her opinions about word problems , she said:

> Fay: I think when you study algebra word problems, like n=?, it doesn't make sense unless you talk about percents or something in real life. It's a challenge when we're like more in depth.

Several students talked in terms of action, actually *doing* the mathematics. They really liked working with manipulatives or visual aids while studying almost any mathematical concept.

> Donna: I wish we could do more activities with things [manipulatives]. Teachers could make it more interesting. It's great when we get to work the problems on the overhead, instead of sitting and watching Mrs. Giles all of the time. I wish we could do it a lot more.

> Carl: I like it when we have a challenge like something new. It's more interesting when we are involved with doing something like working with the centimeter cubes [a type of manipulative]. It's no fun to just sit and listen.

Mark presented the clearest explanation of what it was like when students were highly engaged and had "tasted" success in a math class.

> Mark: It's just like I picked it up really quick. It made me feel good, like I can really do it. I know I'm not going to have any more trouble with it. I've succeeded. I can get ready for the next topic.

Given their preferences about the activities and problems, how did students respond to these types of problems in the classroom? The following episode occurred during a lesson about earning interest on money (I = PRT), a topic that many students find boring. (It must be noted that these students are from middle to high socio-economic families.) These students readily began giving "real life" examples of times when interest would be earned on money. This lesson provoked much engagement.

The following excerpt illustrated that the students begin spontaneously interacting without much input from the teacher when presented with problems that they can readily connect with reality. When the teacher asked the students when interest was earned on money, the students begin to answer her question and to ask their own questions. This involvement indicates that they are beginning to make the connections between the discussion and meaning in their own lives. (Note particularly Jess's part in the dialog).

Teacher: Today we are talking about simple interest. Nothing really gets simple interest, but to begin the topic. we will use simple interest. When would you get interest on money?

Kathy: IRA's and bank accounts.

Mike: CDs.

Juan: Checking accounts.

Jess: Is the rate the same as the yield?

Teacher: What do you think, Jess?

Jess: I think so. And whether you are getting interest or paying interest, it's the same way.

Teacher: When you invest money, what do you need to look for?

Jess: Whether rate of interest is fixed or not. (He was waving his hand trying to get attention. He seemed to have an urgent need to respond)

Kathy: High interest rates.

Jess: The time you can keep your money

Clay: Jess, are you going to be a banker?

Jess: Well, I have been keeping track of my money in my bank account. (Students were jumping in out of the discussion to get a turn to answer the teacher's questions.)

Almost all of the students were highly engaged in this lesson. The topic seemed to be a popular one. A few students made up their own word problems when asked for some examples. They demonstrated real interest and commitment to the mathematical tasks, exhibited on-task behavior, displayed good attitudes about mathematics, and showed an internal motivation to do well. Over the course of the study the types of problems that seemed to direct high engagement were geometry, cooperative activities, problem solving with manipulatives, and measurement.

In contrast, during the interviews when students were given the opportunity to talk about the types of mathematics problems that they did not like, they mentioned problems that required less thinking and emphasized procedures. Problems they disliked fell into two groups. First, all students discussed their dissatisfaction when reviewing over and over problems that they already knew. *Long* division was mentioned as an example by two-thirds of the interviewed students. Second, students expressed dissatisfaction with "just watching" the teacher work problems. Two students explained why they disliked these drill-and-rote problems:

> Sarah: It's boring when you go over things that you already know. It's boring to sit there and talk about numbers when you've learned something already a long time ago. When you've just learned how, it's fun right after that. Then after awhile it gets boring, especially dividing.

Mike: I don't like dividing. When we are dividing, I dread going to class. We have been doing it a long time and it's boring. I usually goof off. I'd rather learn how to do new things. Just looking at numbers, like adding and subtracting really is a pain. We do them every year.

However, these students seemed comfortable about their ability to do addition, subtraction, multiplication, and division. Their grades showed that they had mastered the skills even though they may not have enjoyed learning them.

Several of the students had difficulty feeling motivated when the teacher worked examples and homework problems. Explanations of what it was like were given by two students:

Beverly: I don't like it when she pulls out that overhead and works problems the whole period. I like it better when we get our work for the day, instead of just going over the homework.

Charlie: She just writes so much. We just watch up there. You are just sitting there. There's nothing to do but watch.

Researcher: Do you learn anything when she does tnat?

Charlie: Sometimes, but not very much. Sometimes I just don't pay attention.

The students' behavior during a lesson on simplifying fractions typified lessons with low engagement. There was frequent inattention and off-task behavior. The teacher had to constantly remind the students to pay attention. The following incident from the classroom observations is an example:

Mrs. Giles was using the overhead in the front of the room. The class was working on the order of operations in simplifying fractions. Examples of some problems were:

1. $\frac{4(3)}{2}$ 2. $\frac{12/3(4)}{4}$ 3. $\frac{9(2)}{16}$

Teacher: Which rule do you use first on number 2?

(No answers)

Teacher: Do all multiplications and divisions proceed from left to right?

(Mike, Brian, and Tim are talking.)

Teacher asks Eric: What do you do next in the problem after 3 X 4?

(Eric has been leafing through his book. He can't answer.)

Teacher asks Bob: 8/2

Teacher: Incorrect. (Then she explains the entire problem.)

Teacher: Let's look at number 3. Just because we have parentheses, some people have misconception the () always mean to multiply. For example, look at 98 - (36 + 15). In this problem there is a group, no multiplication. Sue, What is 36 + 15?

(Paul, who sits all alone, is up. He goes over to talk to Mike.)

Teacher: Sit down, Paul.

(Doug is turned around in his seat. Mark is banging his pencil against his desk.)

Sue: 51.

Teacher: What do you do next, Kathy? (Kathy is drawing on her paper.)

Kathy: 36 + 15.

Teacher: We've already done that......(She later goes on to explain how this problem relates to number 3.)

During this lesson it is obvious that the students are not engaged in the learning. Even though these students were in the above average beginning algebra class, they were working on fractions in a rote-and-drill format.

When students were engaged at low levels, they were "goofing off," talking instead of listening, laying heads down on their desks, laughing with neighbors, playing with items on their desks, and scribbling on the chalkboard. When asked about their attitudes toward these types of problems, the statements included " It's boring," " I have better things to do," "I hate math," and "Ugh."

Although the two episodes that I've presented suggest possible explanations for the high and low levels of engagement, I must caution against over generalization. This discussion suggests explanations, although all possible alternatives cannot be identified. Instruction is too complex and varied to be captured by a few examples. However, episodes do indicate potential links between engagement of students and instruction. There was no clear indication about whether attitude created on-task behavior or the converse. Did internal motivation change attitudes and direct behavior, or did the type of problems change the internal motivation? I concluded through my data analysis that the high levels of student involvement cycled among the variables of types of problems, attitudes, motivation, and behavior (Figure 2--next page).

Interviews and observations provided evidence that students in this classroom had different attitudes about the mathematics curriculum. As can be seen from the examples of data, the analysis revealed that a formidable component of engagement for these students was the type of mathematics problems that they were involved in doing. When problem solving in groups and working with manipulatives, students had positive attitudes about mathematics. When performing drill and practice, memorization and rote, and computation out-

DIMENSIONS OF ENGAGEMENT OF STUDENTS

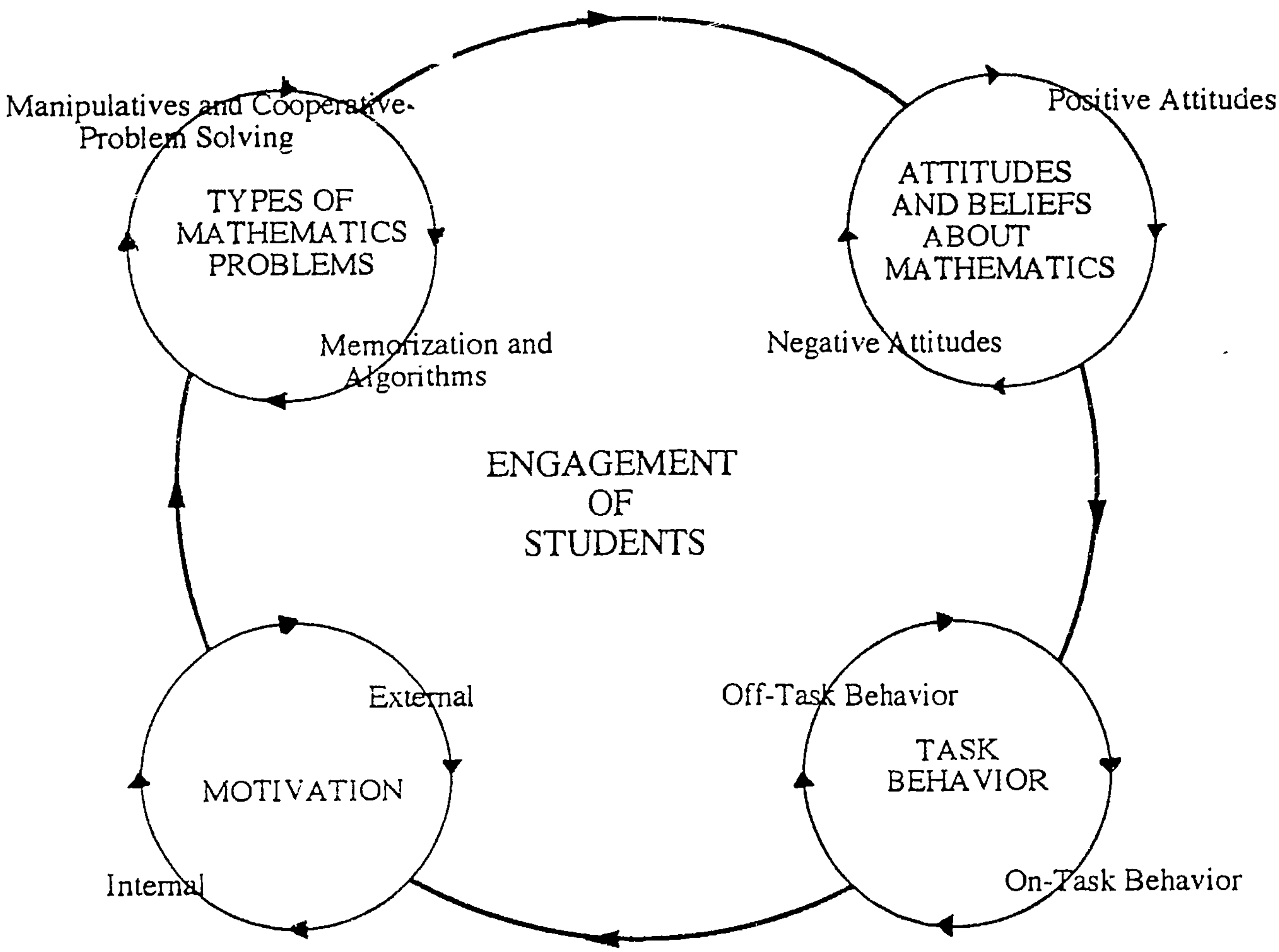

Figure 2. Dimensions of the variables of the engagement of students.

of-context, students were most often bored with learning and felt low levels of engagement. Many favorite types of mathematics problems were shared by the students, and many students named the same disliked problems. That is, the types of problems had an impact on the students' attitudes and reactions during class.

Summary

The purpose of this study was to help educators understand better student engagement with the mathematics curriculum and its influence on student engagement. I specifically wanted to investigate under what circumstances students are inner directed and how teachers might foster engagement with academic content. First, the data collected suggest that students' levels of engagement and success were apparent for the same students during different types of activity structures. Not surprisingly, students were more likely to succeed when they were engaged with the curriculum.

Second, patterns of low engagement suggested that certain types of instructional activities were more likely to result in engagement by students. When executing drill and practice, memorization and rote learning tasks, and computations, students were least likely to be engaged. During these tasks, students were likely to comply minimally with teacher direction, exhibit off-task behavior, and display poor attitudes about mathematics. In contrast, when students worked with open-ended word problems, participated cooperatively in groups to solve problems or worked with manipulative materials, they were more likely to be engaged. During these activities, students demonstrated interest and commitment to tasks, expressed positive attitudes about mathematics, and showed internal motivation to do well.

Educational engagement occurs on a continuum, but it is always a prerequisite to learning (Wehlage, 1990). High levels of engagement are demonstrated when students answer questions, discuss issues, write papers, complete homework, and perform tasks at school.

Implications for Teaching

Ross, Bondy, and Kyle (1993) discuss impediments to student engagement. A major factor is some teachers' narrow conception of learning. In school, students learn tasks that often have little to do with the real world, such as math computation taken out of the context of problems relevant to the students' lives. While in the real world people often work together to solve problems, in school solving mathematics problems is almost always an individual activity (Tobias, 1981). If students make no connection between their learning and their own lives, they will often not value the learning (Ross et al., 1993). The result is that routine, irrelevant curricular tasks tend to bore the students. Because the content of the school curriculum is seen as irrelevant by students, many students stop asking questions and become disengaged from school.

Additionally, this study confirms research indicating that students are not passive recipients of teacher instruction but are active interpreters of the classroom environment (Weinstein, 1983). Teachers need to become sensitive to the students' messages regarding the conditions of learning. The comments of the students studied reinforce the recommendations in the NCTM *Curriculum and Evaluation Standards* (1989). Mathematics teaching should emphasize topics like measurement and geometry, that have a logical connection with the real world. Lampert (1991) states that open-ended problems concerning real world situations provoke teacher-student discussion and communicate to students what is important in doing mathematics. Holmes (1985) says that open-ended questions challenge students to explore and become engaged in generating their own new questions. We learn mathematics particularly well when we are actively engaged in creating the problems and solution strategies (Moses, Bjork, and Goldenburg, 1990). When problems relate to the students' real world of people, action, and things, learning algorithms can be engaging for students (Williams, 1988).

The students were highly engaged when they were working with manipulatives. Manipulatives help students relate problems to the real world. Manipulative materials not only engage the students but can also help students visualize (Hiebert, 1990) Manipulatives can be used to stimulate thinking because they create action that forces thinking. Through exploring concepts and algorithms with concrete material, students develop better understandings and more positive attitudes about mathematics (Hodges, 1983; Martinez, 1987).

Another instructional situation that engaged students was cooperative problem solving. Cooperative learning activities require students to pay attention to others' as well as their own contributions. Davidson (1985) says that cooperative learning provides pleasurable opportunities for groups to study subject matter or complete assignments. Small-group cooperative learning can not only be used to foster engagement with the curriculum, but also to increase effective mathematical communication, problem solving, logical reasoning, and the making of mathematical solutions (Gregory & Morsink, 1984). Students learn by talking, listening, explaining, and thinking with others, as well as by themselves (Davidson, 1990; Lampert, 1991). In cooperative groups, students are actively involved in learning mathematics. They learn to cooperate with others, to improve their social skills, and to communicate in the language of mathematics. Students are not bored in class and like mathematics more than when they are not involved in teacher-centered approaches to instruction. They are engaged at high-levels and are interested in the mathematical activities (Holmes, 1985).

Teachers provide the experiences that exert a powerful influence on students' attitudes about mathematics. It is essential that we examine our classroom procedures and routines to determine what we can do to prevent further negative experiences with mathematics (Battista, 1986). Because of the way that mathematics is often presented in school, we should not be surprised at some students' overwhelming boredom and belief that mathematics is only about getting the correct answers. Think about the following image of mathematics expressed by an intelligent teenager who avoids taking mathematics.

> Math does make me think of a stainless steel wall--hard, cold, smooth, offering no handhold, all it does is glint back at me. Edge up to it, put your nose against, it doesn't give anything back , you can't put a dent in it, it doesn't take your shape, it doesn't' t have any smell, all it does is make you nose cold. I like the shine of it--it does look smart, intelligent in an icy way. But I resent its cold impenetrability, its supercilious glare (Buerk, 1981).

It is not surprising that someone who holds this image of mathematics--as a rigid and authoritarian subject--will avoid engaging in mathematical activities, even if she has the ability. We cannot ignore the fact that almost every day, in most mathematics classes, the teacher introduces a new concept or rule by lecture, applies it in a few simple examples, assigns exercises for practice on homework; then, the next day the teacher goes over these homework exercises and finally verifies that the students understand by giving them a test (Borasi, 1990). Students who experience this type of mathematics instruction become passive learners, focusing on memorization rather than conceptual understanding and can cease achieving (Wehlage et al. 1990).

Goodman (1970) contends that "schools can separate students from real participation in their own education, and ultimate curiosity and learning." But if a student regularly has positive experiences with nonroutine mathematical problem, an attitude of curiosity about problem solving could develop.

Sustaining student engagement in educational tasks is a significant problem (Wehlage, 1990). However, the general conclusions of this study provide some indication that the difficulties can be overcome. A teacher who provides student-centered approaches to mathematics plays a major role. To learn mathematics, students must want to learn and feel good about learning. What counts is that educators become aware of situations that can cause low engagement and work with students in ways that increase engagement levels. Effective mathematics teaching focuses on instruction that promotes students' activity. Teachers need to move away from lecturing and move toward activities which motivate their students. Without motivation, learning is reduced to only a sequence of activities externally imposed by the teacher on the student. When students care about what they are doing to the point that they are actively engaged, their attitudes will keep them learning and seeking to understand.

Appendix A

1. What does the word mathematics mean to you?
2. How is algebra different from arithmetic?
3. Who is the best mathematician in your class? How do you know?
4. Are you good in math? How do you know?
5. Why do people learn math?
6. Why do you think you should be studying math?
7. Why do you think you are studying math?
8. Pick a day in math class you enjoyed most.
9. What are your favorite kinds of problems?
10. What is it like to be in this math class?
11. What are characteristics of good math students?
12. How do you feel when you do well on a test or quiz?
13. How do you feel when you figure out a difficult problem?
14. Who's better in math--girls or boys?
15. Tell me what to look for in a good math student.
16. Tell me what to look for in a good math teacher.
17. How does it feel not to be able to figure out a problem?
18. How does it feel to do poorly on a math test or quiz?
19. What are your least favorite kinds of problems?
20. If you had the power to create your own mathematics program for seventh graders, what would you recommend?

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