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ABSTRACT

What is the response of students to the reform efforts in mathematics education? A survey taken in September 1994 of 59 eighth grade mathematics students showed that their conceptions of what it means to do mathematics were predominantly traditional in nature. The survey was repeated in the spring, when these students had experienced 9 months of a reform-oriented class. The spring survey showed that students were in many respects more open in their acceptance of alternative activities. The majority of students, however, still felt strongly that "listening to the teacher explain" should be included in a conception of school mathematics. There were also strong negative opinions among a majority of students about writing journals in a mathematics class. (Author)

Students' Beliefs About Doing Mathematics

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Introduction

Students' beliefs about mathematics have been of increasing concern to researchers. Much of the work done has been in studies of the relationship between beliefs and students' ability to solve problems (e.g., Garofalo & Lester, 1985; Schoenfeld, 1988). Studies that have focused particularly on students' beliefs about mathematics include Schoenfeld (1989), Hatfield (1992) and Schram, Wilcox, Lanier and Lappan (1988). The Schoenfeld study, a questionnaire/survey of 230 secondary students, found that students believe that mathematics is mostly memorizing, at the same time that they believe it to be a creative and useful discipline in which they learn to think. Such contradictions are explained as stemming from the distinctions students make between school mathematics and the mathematics done out of school. Hatfield interviewed 26 students from grades 7-12, asking students "What is math?," "What would you change?," and "What do you like most/least?". She found that students held three central beliefs: 1) Math is memorizing formulas and algorithms; 2) Math is difficult to learn but essential in life; and 3) Math is taught in a boring way.

In a review of the past twenty-five years of research reported in the *Journal for Research in Mathematics Education*, McLeod (1994) suggests that more studies are needed that relate affective issues with the improvement of practice in mathematics education. An example would be the Shram et al study that examined the changes that took place in preservice teachers' beliefs about mathematics as they experienced an innovative, conceptually-based course. They found that the course had the effect of moving students toward questioning traditional attitudes and beliefs about mathematics, though students still held to the belief that mathematics is heierarchical from skills to problem solving.

One of the hallmarks of the NCTM standards documents is the vision they portray of active learning. The *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) are based on the assumption that "'knowing' mathematics is 'doing' mathematics" (p.7). The *Professional Standards for Teaching Mathematics* (NCTM, 1991) describe classrooms where the emphasis is on students who are responsible for their own learning, on the communication of mathematical ideas, and where such tools as calculators are readily available. Finally, the *Assessment Standards for School Mathematics* (NCTM, 1995) call for a shift toward multiple methods of assessment, including journals and portfolios. In the present study, I was interested in what students make of such visions. Do students buy into the notion that explaining their thinking in writing, or working in groups, or listening to other students' presentations are really part of what it means to do mathematics *in school*? To investigate this, I asked students to answer a questionnaire that listed a wide range of activities that might take place in a mathematics classroom (including more and less traditional activities), and then I interviewed small groups of those students afterwards.

The other question that guided this study was, how stable are these beliefs? That is, are they likely to change over the course of the school year, particularly if they experience a mathematics class that includes many of the activities in NCTM's vision? For this question I repeated the same questionnaire in the spring with the same students, again using follow-up interviews. Nespor (1987) has described the nature of beliefs as disputable, more inflexible, and less dynamic than knowledge systems. If this is so, I would expect to find quite similar results in the spring as in the fall.

Methods

The study was conducted with two classes of eighth grade Algebra 1 students in a public middle school in the Mid-Atlantic. There were 30 students in one class and 29 in the other. Both classes were taught by the same teacher. The gender breakdown was 39 male, 20 female, and there were 8 nonwhite and 51 white students in the two classes combined.

The questionnaire consisted of 23 activities that might occur in a mathematics classroom, each with a four-point Likert scale of agreement (see Appendix A). The items were constructed from the Standards documents, and from descriptions of "traditional" practice (e.g., Romberg, 1986).

The survey questionnaires were administered to both classes on the third day of school, and then administered again on the last day of class in the spring. Of the 59 students, 48 were present for both administrations, and it was these results that are reported here. Students required approximately 15 minutes to complete the survey each time.

After the fall surveys were administered, a colleague and I examined the student responses and chose four students from each class to participate in a group interview. In particular, we chose students who had expressed strong opinions overall, reasoning that these students would be the ones with the most to say. We also tried to put together groups of students with disparate opinions, hoping that discussions would ensue from their disagreements that would shed light on their beliefs. As we interviewed four students at a time, we had their survey results in front of us, with copies for them to look at. We went through the survey items page by page, stopping to discuss any items that had elicited strong or widely disagreeing results. The same procedure was followed for the spring interviews, except that these were done without the assistance of my colleague. Each interview lasted approximately one hour, and Ms. Vance was not present.

During the course of the school year (between the surveys) I observed the classes approximately once a week and kept fieldnotes. The data gathered was part of a larger study on informal assessment practices, done in collaboration with the classroom teacher. Six of the classes were videotaped. In addition, the teacher was interviewed on eight different occasions. Interviews with students and the teacher were transcribed and examined by means of a qualitative software package.

Discussion of Results

Description of the classes

The teacher, Ms. Vance, has twenty years' experience as a mathematics teacher, both at secondary and middle school levels. She characterized herself as having been a traditional teacher until approximately three years ago, when she began to work with a state-wide NSF-funded Teacher Enhancement Project and with the New Standards Project. One of the primary goals of the teacher enhancement project was increasing teachers' pedagogical content knowledge (Shulman, 1986) in mathematics. Ms. Vance became a resource teacher within her school, meaning that she was marked as a leader for the other mathematics teachers in her building. In the New Standards Project, Ms. Vance piloted portfolio materials with the classes I observed. Besides the two Algebra I classes, Ms. Vance also taught a general eighth grade mathematics class and a class in reading.

The pedagogical approach in the Algebra I classes was characterized by an emphasis on conceptual understanding (Hiebert & Carpenter, 1992). Ms. Vance believes that students gain such understanding when they have the opportunity to explore mathematical ideas on their own or in collaboration with a partner, when they communicate those ideas to each other or to her in writing or speech, and when they can experience mathematics in "real" contexts. She rarely used a textbook, but made wide use of materials from a variety of sources, including New Standards and Maths in Context (a contextualized middle grades curriculum).

A typical class day might begin with a whole class game of mental math. Ms. Vance would bring a deck of index cards, on which would be printed something like, "I have 53. Who has that times 2?". When that card was read aloud, the student holding the card with "I have 106. Who has 90 less?" would be expected to read her card aloud. Ms. Vance would pass out the cards, one to a student, and then begin the game with her own card. Play would proceed around the room until the final answer came back to her. One of the students would time the game, and the goal was to get through the cards as quickly as possible. She had cards for operations on whole numbers, integers, fractions and decimals. A typical game would last 4 or 5 minutes.

Ms. Vance would often introduce a new topic, such as linear functions, with a task to do in pairs. An example task had information about two video stores, one that charges a membership fee and has a low rental rate and a second one that has no initial fee but has a higher rental rate. The problem was to figure out which store has the better deal. Students were expected to work together to solve the task, but turn in separate solutions. The worksheet gave some guidance on how to approach the problem (such as making a chart and then a graph), followed by questions that required students to explain why their solution is correct. A task might take two or three days to complete. As the students worked through a task, Ms. Vance circulated around the room, encouraging students to think through the problem. She might interrupt the class for a whole group discussion if she became aware of a widespread misconception or a need for some background information.

The classroom was equipped with a wide assortment of manipulatives and other tools. Boxes of Unifix cubes and other models were available on the shelves, and a set of 30 TI-82 calculators were readily available to the students. Much of the year's curriculum was focused on the use of the graphing calculator, both for data analysis and for exploration of first and second degree functions.

The core of the curriculum centered around about 15 major tasks or projects. In one long-term project (done individually) students were instructed to design a cereal box that minimized surface area and maximized volume. Another task was to discover and generalize patterns in the "Twelve Days of Christmas" carol. When students had completed work on a task, class time was spent sharing their solutions with each other, with Ms. Vance facilitating discussion. More formal presentations were sometimes videotaped and then reviewed again with the class. Students were required to keep their work on such tasks and put together a portfolio at the end of the year, writing about why they chose certain tasks or projects for inclusion, and critiquing each others' work. Other assignments in the class were to occasionally write about the mathematics they had learned on a certain topic (such as slope).

Survey

Table 1 shows the results of the survey for the fall and the spring. A response of "1" indicates strong disagreement, and a response of "4" indicates strong agreement.

Insert Table 1 about here

Interviews

The survey results indicate that these students held a range of beliefs about which activities are part of "doing mathematics." A critical part of the data gathering, however, was the four sets of interviews that followed the administration of the survey in each of the two classes in both the fall and the spring. The interviews reveal a number of interesting nuances to the survey results, beginning with the students' overall interpretation of the survey.

Nespor (1987) has described beliefs as residing in *episodic memory*, as opposed to being semantically stored like knowledge. Beliefs and memory are intertwined, to the point that beliefs can influence not only what individuals recall but how they recall it (Pejares, 1992). If this is true, then students' beliefs about doing mathematics arise from their memories of doing mathematics in school, and one cannot separate students' reports of what they've experienced from their affective responses to those experiences. My initial assumption was that students would base their responses on their past experiences in mathematics classes. I learned through the interviews that such was not the case:

> Interviewer 1: So when you answered these questions were you really thinking about last year's experience in math or were you really thinking about the way that you would like math class to be?
>
> Gabe: Pretty much the way that I would like class to be. That's what I based the whole thing on.
>
> Interviewer 1: John, do you think that you based yours on how things were in math class or the way you want them to be?

John: Want to be.

Interviewer 2: Did you answer what you would like it--to mean to do mathematics--did you answer what you like or what you had experienced?

Monica: What I like.

Interviewer 2: What you would want it to be all the time.

Monica: Yes.

Interviewer 1: What about you, Ann? Do you remember whether you answered these questions according to what you prefer, what you would like a math class to be like, or were your answers based on what you had experienced in the past?

Ann: They're kind of both. Some were easier to distinguish that was what I've had in the past than others, so if it was real easy to remember having it in the past, I based it on that. If not, I based it on how I wanted to do math class.

Throughout the interviews, students peppered their responses with emotions, such as "I hate writing," or "I like to speak in front of the class" as justifications for their responses. In many cases, students who had experienced certain activities refused to agree that such an activity could (or should) be part of school mathematics, *if* their experiences had been negative. Figure 1 shows a theorized relationship between experiences, memory, and beliefs.

Insert Figure 1 about here

As students experienced certain activities in school mathematics classes, their memories of those experiences were filtered through their emotional responses to them. These episodic memories formed the foundation for their beliefs about what it means to do mathematics in school.

In the fall students gave the lowest agreement scores to: *Writing journals* (x = 1.98), *Judging other students' work (2.25), Getting an answer quickly (2.52), Using a textbook (2.65), Portfolios (2.67), and Explaining your thinking in writing (2.77).* By the spring, most of these same items had the lowest agreement scores, though some had shown significant changes from fall to spring. *Writing journals (2.1)* was still lowest, while *Judging other students' work (2.69)* showed a significant increase in agreement. *Getting an answer quickly (2.31)* maintained low agreement, but *Using a textbook (2.33)* dropped significantly in agreement. *Portfolios (2.8)* had a significant increase in agreement, as did *Explaining your thinking in writing (3.29).*

Writing journals. Students in the fall did not associate this activity with mathematics class. Some students had done journal writing in English class the previous year, and spoke negatively about that experience. The students had strong opinions about this activity, both positive and negative, mostly related to whether or not they "like to write." Two of the students expressed concern that journals should be kept confidential between student and teacher.

During the year of the study, students told me that they had not kept a journal. However, when I asked them about some journal-like assignments I had observed, they agreed it was the same thing and that they had done such assignments several times. An example was a class where the teacher asked them to "Write down everything you learned today about linear equations." Such assignments were not called journals, nor were they kept in a journal.

As in the fall, this item elicited strong negative expressions, such as "I hate them," and "I think they re stupid" (Interviews, 6/8/95).

Judging other students' work. This was an activity that many of the students had had experience with in the past, but they expressed negative attitudes towards it in the fall interviews. The reasons given for their negative feelings were: 1) they don't value their peers' judgments as much as they do the teacher's; 2) such judgments are too subjective; and 3) they don't want to be wrong in front of their peers. One student spoke in favor of having other students' judge his work:

> I think it's helpful to get comments back from other students. The teacher said that she taught it over and over again--she was always grading papers and always doing this, but when the students do it--it just seems better (Interview 9/23/94).

By the spring interviews, these students had just completed evaluations of their classmates' portfolios. Less formal peer evaluations had been a prominent part of their class, usually in the form of class discussions led by the teacher. ML would elicit an oral solution from one student and then ask the whole class to comment on it. This item showed significant increase in agreement in the spring. It was not discussed in the spring interviews, however, because nearly all of the interviewees had given it a score of "3."

Getting an answer quickly. The consensus of both groups in the fall interviews was that this is highly valued in most mathematics classes, but many felt it shouldn't be. Anne, for example, said:

> I think any answer--it doesn't matter how fast you do it or know it--if it takes you under a minute or over a minute it doesn't matter if you get it right and how you do it.

Eric expressed his reason differently:

> If you give an answer quickly, chances are it's probably going to be wrong and not correct.

One student described how she used to hate working under time pressure, but after working with a tutor had gained confidence. However, she said that, if given the choice, she would rather take her time.

In both of the spring interview sessions this item invoked strong opinions, most of them negative. Here are some examples:

> Shakia: Just as long as, you know, you get the answer it doesn't matter to me how fast I get it--as long as I get it.

> Anne: Speed is not important if you understand it.

> John: If you go too fast, you'll get it wrong.

One student tried to take a compromise view:

> Mestafa: If you have to get it fast, get it fast. If you don't, take your time.

One of the few voices for the importance of getting an answer quickly was Gabe:

> If you can rifle off the answer quick and accurately then you would achieve math pretty much.

Using a textbook. Students who had been in this same school the previous year had been taught primarily without a textbook, but all agreed that for most of their schooling the textbook had been the core curriculum. There were opinions on both sides of this issue in the fall. Those in favor of textbooks gave the following reasons: 1) using a textbook requires too much writing, in that students are usualy required to copy down the problems in the book; 2) after copying the problem down, you are usually required to "show your work;" and 3) textbooks are often poorly written. On the other hand, students like to use textbooks as a reference (especially for test preparation), and one student suggested that classroom work out of textbooks almost always means plenty of wait time (i.e., waiting for others to finish an assignment), and that was positive because he could get his other homework done.

Textbooks were not used in this class, except to a very limited degree. There was significant decrease in agreement for this item in the spring. The consensus in the interviews was that they preferred worksheets, primarily because they thought worksheets required less writing than textbooks.

Portfolios. Prior to this class, these students had limited experiences with portfolios in mathematics class. Those who had kept one described it as a "math folder," which was merely a collection of all the work done in mathematics class during that year. The primary reasons for the negative attitudes towards portfolios were organizational, i.e., they disliked having to keep track of so many papers over such a long period of time:

> John: I didn't--I didn't like it because I always have a tendency to lose my work in fact stuff already graded and went over. I don't like keeping it.
>
> Eric: I agree with what he said because I always lose my work and my dog eats it a lot.

This item showed significant movement towards more agreement in the spring. Students had just completed the compiling of their portfolios for the year, which took the place of a final exam. These portfolios were compilations of "best work," and followed the guidelines of the New Standards project. Some students still disliked the process, complaining in the spring interviews about: 1) the difficulty of keeping papers together; 2) that it was "stupid" to be graded twice on work that's already been graded; and 3) that it was hard to remember all about something done a long time ago.

This time, however, there were more positive comments. One student said that it helped her see what she learned over the course of the year (a process that a second student described as "mind boggling"). Another liked the chance to go back and revise previously done work. A final positive comment came from Jessica, who described the advantages she saw in having this year's portfolio with her in next year's mathematics class:

> If you prepare and review and if you take it back and look at it again and you're like "Wow, we did this last year, so I should be able to get it this year," and you look at it and you're like "Okay, I understand it now."

Explaining your thinking in writing. These students claimed that they had not been asked to explain their thinking in writing in mathematics class before this year, but the opinions they expressed about it were divided:

> Gabe: [Writing] is a waste of time. When I get like a test or something I just want to go write down the answers and not have to write down the whole process which takes much more time than if you just do it in your head. I mean it takes much more time if you do it on paper than if you do it in your head.

> Mestafa: I strongly agree with explaining your thinking in writing. I think it's important to be able to show other people how they got their answer--to help other people with their problems. And if people got it different ways then they would help me with--to be able to evaluate the problem differently.

Other students expressed similar views, with more of them agreeing with Gabe's point of view than with Mestafa's. The predominant complaint about writing was the amount of seemingly wasted effort required. Mestafa's more egalitarian opinion is that writing should be done for the good of others.

In my multiple observations and videotapes of these classes, this one item stands out as a theme of Ms. Vance's teaching. In almost every assignment done either in class or out she stressed the importance of explaining one's thinking, either orally or in writing. This item showed a significant increase in agreement by the spring, moving from a predominantly negative view ($X=2.77$) to a predominantly positive one ($X=3.29$).

Gabe, who had felt so negatively about writing out explanations in the fall, did not change his mind about this item in the spring. Many other students described the change in their point of view since the fall. Shakia and Jessica both said that they were simply "used to it now." There were more reasons given for the importance of explaining your thinking in writing. These included: 1) communicating to others how to do it if it's right; 2) showing how you got there if it's wrong; and 3) this activity "puts together writing skills with doing math."

In both the fall and the spring, the item that had the highest agreement score on the survey was *Trying different ways to solve a problem (3.45, 3.35).* Except for the insertion of *Explaining your thinking in writing* into the spring list of highest agreement, the items for fall and spring varied little. *Listening to the teacher explain (3.27, 3.33), Using manipulatives (3.27, 3.25), Using a calculator (3.27, 3.23), Getting the right answer (3.23, 3.10), and Working in groups (3.19, 3.17)* all had strong agreement levels in both fall and spring.

The uniformity in agreement about most of these items was such that they did not become items for discussion in the interviews. The two exceptions were calculators and group work.

Using a calculator. Students described calculators as prevalent in their previous mathematics classes, but there were disagreements in the fall about whether they should be used in school. Reasons for not using calculators had to do with the danger that students won't learn anything if they use one:

> Eric: School's about using your mind, not machinery.

Later he added to this argument that anybody can use a calculator--there's "nothing to learn." Students who disagreed with Eric pointed out that school is also about preparing for a job, and most jobs use calculators.

The classroom had a set of 30 TI-82's hanging on the wall, which ML encouraged students to use for most activities, with the exception of some mental math exercises she often used at the start of class. Students were taught to use the graphing capabilities on the TI-82, and they based their study of linear, quadratic, and exponential functions on such graphs. By the spring there was still strong support for calculators, though a few students still expressed the fear that it "takes the place of math," as one student put it. Among the positive reasons for using calculators were the following: 1) it helps to do complicated calculations; 2) you still have to know how to set up the problem; 3) calculators make it easier to get answers; and 4) they will be important "later in life."

Working in groups. In the fall most of the interviewees agreed that working in groups was an important part of doing mathematics, but one student warned that they shouldn't be used all the time because "some people let others do all the work." Group work was a prevalent organizational scheme in Ms. Vance's classroom. In most cases, work was done in pairs with occasional threesomes. Students in the spring interviews agreed that group skills are a "big part" of "work on the job," but several "despise it" in school because they prefer to work alone. When asked how they would deal with this preference when they enter the job force, the four students in this conversation resolved the dilemma quickly by their confident predictions that they will head for a management position (even president), with the inference being that such positions don't require group skills.

Conclusions

It is the nature of belief systems that they may contain inconsistencies or even logical incoherence. In this study, student beliefs about doing mathematics were sometimes contradictory.

Most of the students believe that doing mathematics in school means trying different ways to solve problems and making educated guesses, but getting the right answer is also critical. Manipulatives and calculators should be available for use. Students may work in groups at times, but not all work should be organized this way. Listening to the teacher explain is one of the most prevalent aspects of a mathematics class. These attitudes prevail even after a year's experience of a mathematics class that emphasized problem solving processes more than correct answers, and in which the teacher emphasized listening to other students and working cooperatively over teacher lectures.

Certain activities evoked strong negative responses from the students. For example, some students have extremely negative views about writing, most of it related to the amount of time and effort required to write. Students who dislike writing *can* be convinced that writing out explanations is a reasonable thing to do in mathematics. Writing in journals, however, is not an activity that belongs in mathematics class, according to these students. Another type of activity that the students responded to negatively is one that features time pressure. Activities whose goal is to get the answer as quickly as possible are, for many of these students, extremely distasteful.

Earlier work on beliefs indicates that the earlier a belief is incorporated into the belief structure, the more difficult it is to alter. Such beliefs subsequently affect perception and strongly influence the processing of new information. This is why newly acquired beliefs are the most vulnerable to change (Pajares, 1992). Indications from this study are that such vulnerability may also be linked to the degree of emotion linked to the belief. Students' beliefs about activities that were more emotionally neutral were relatively easy to change through experience. Students adapted easily to not using a textbook and most students were satisfied to accept alternatives. Likewise, students who began the schoolyear skeptical of whether portfolios belonged in mathematics class came to accept them by the spring. They also changed their minds about judging other students' work and about having conferences with the teacher, neither of which they felt was a part of mathematics class before.

Assessing students' beliefs about doing mathematics is valuable for two reasons. First, students are in the process of formulating the belief structures that will influence the attitudes about school mathematics they hold as adults, whether as parents, teachers, or citizens. Such attitudes could have a powerful influence on the future direction of school mathematics. Second, listening to students' views about doing mathematics can give us important information now about how well the vision of the Standards is being realized.

References

Garofalo, J., & Lester, F. (1985). Metacognition, cognitive monitoring, and matheamtical performance. *Journal for Research in Mathematics Education, 16*, 163-176.

Hatfield, M. (1992). The effect of problem-solving software on students' beliefs about mathematics: A qualitative study. *Computers in the Schools, 8*(4), 21-37.

Hiebert, J. & Carpenter, T. (1992). Learning and teaching with understanding. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning*, pp. 65-100. NY: Macmillan.

McLeod, D. (1994). Research on affeact and mathematics learning in the JRME: 1970 to the present. *Journal for Research in Mathematics Education, 25*(6), 637-647.

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

National Council of Teachers of Mathematics (1991). *Professional standards for teaching mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics (1995). *Assessment standards for school mathematics*. Reston, VA: Author.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*, 317-328.

Pejares, M. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Romberg, T. & Carpenter, T. (1986). Research on teaching and learning mathematics: Two disciplines of scientific inquiry. In M. Wittrock (Ed.), *Handbook of research on teaching*, pp. 850-873. NY: Macmillan.

Schoenfeld, A. (1988). When good teaching leads to bad results: The disasters of "well taught" mathematics classes. *Educational Psychologist, 23*, 145-166.

Schoenfeld, A. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education, 20*(4), 339-355.

Shram, P., Wilcox, S., Lanier, P., & Lappan, G. (1988). *CHanging mathematical conceptions of preservice teachers: A content and pedagogical intervention*. Paper presented at American Educational Research Association, New Orleans.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational*

Researcher, 15(2), 4-14.

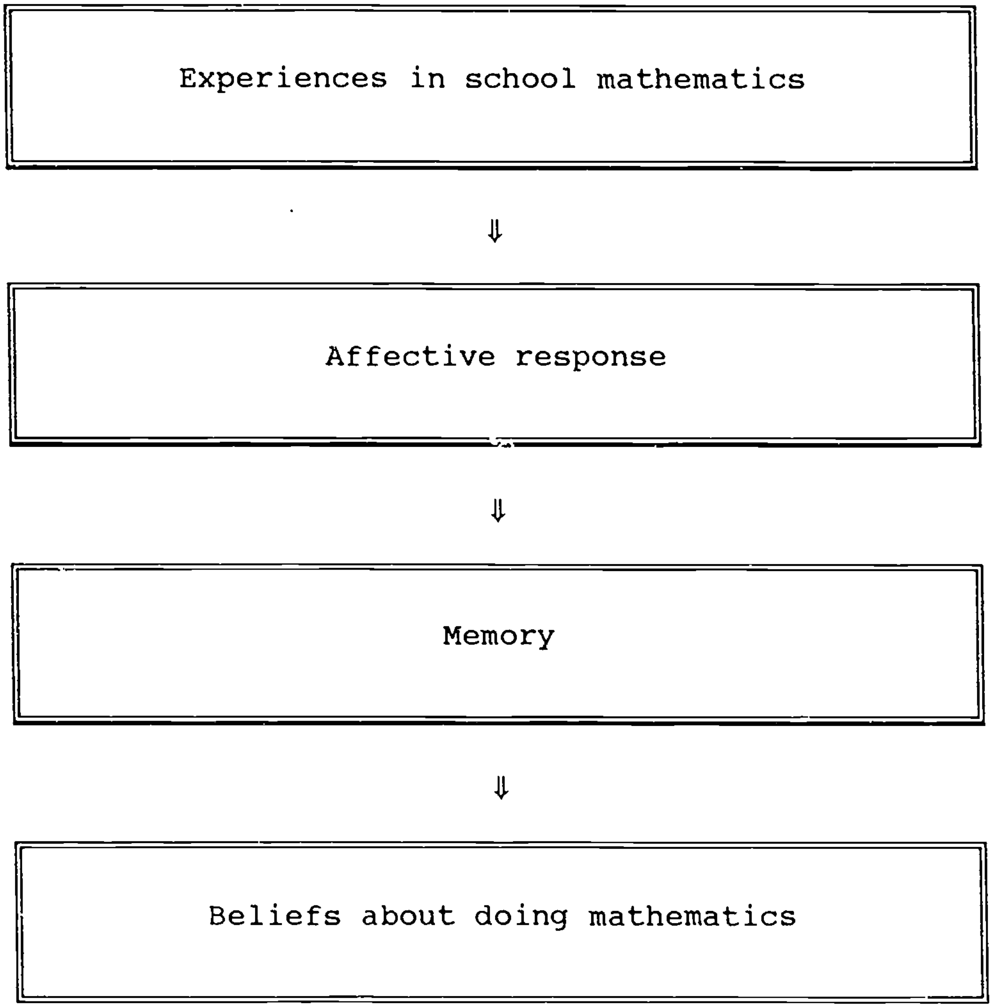

Figure 1. Theorized relationship between experiences, affect, memory, and beliefs.

Table 1

Survey Results, Fall and Spring

Survey item (n=48)	Fall mean	Spring mean
Practicing computational skills	3.04	3.06
Getting the right answer	3.23	3.10
Drill and practice	2.85	2.87
Doing problems on worksheets	3.02	2.88
Memorizing basic facts	3.06	3.06
Getting an answer quickly	2.52	2.31
Using a textbook	2.64	2.33*
Listening to a teacher explain	3.33	3.27
Explaining your thinking orally	2.98	2.83
Working in groups	3.17	3.19
Explaining your thinking in writing	2.77	3.29**
Making an educated guess	3.06	3.19
Testing hypotheses	3.04	3.10
Trying different ways to solve problems	3.48	3.35
Presenting solutions to the class	2.96	2.83
Using manipulatives	3.25	3.27
Using a calculator	3.23	3.27
Listening to other students explain	3.0	3.0
Doing projects	3.04	3.10
Judging other students' work	2.25	2.69*
Writing journals	1.98	2.1
Portfolios	2.67	2.80**
Having a conference with the teacher	2.98	3.08**

*p<.05
**p<.01
1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree