Preservice Teachers' Reaction to their final Constructivist Mathematics Class:

A Case Study.

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Abstract

Many teacher educators model constructivist pedagogy to preservice teachers in the mathematics classes they take. Preservice teachers however, are not necessarily comfortable being a part of such a class. The following qualitative case study examined the expectations and reactions of a group of preservice teachers who were taking their final content mathematics course. Survey results sorted by content analysis indicated students were expecting (1) a methods class, (2) the instructor to teach them mathematics by telling, and (3) the instructor to take an authoritative role in the classroom. Student reactions are reported as direct quotes. The author's purpose in conducting this study is to stimulate dialogue among teacher educators surrounding these common reactions.

The current reform movement within mathematics education was motivated, in many ways, by the publication of *A Nation at Risk* (National Commission on Excellence in Education) in 1983, warning that standards were being lowered in public schools. Statements like the following shocked the general public.

> If only to keep and improve on the slim competitive edge we still retain in world markets, we must dedicate ourselves to the reform of our educational system for the benefit of all--old and young alike, affluent and poor, majority and minority. Learning is the indispensable investment required for success in the "information age" we are entering. (NCEE, 1983, p. 112)

Many Americans began to ponder the nation's declining standardized test scores, especially internationally given exams which compared American students with students from various countries (Stevenson & Stigler, 1992).

Drawing from other countries' successes and applying learning theory research, many educators hope to change how mathematics is taught in the United States. Traditionally, student learning has been viewed as a process of training students to perform specific skills (Draper, 2002). Mathematical knowledge is usually hierarchical, fixed, sequential, and as Grant (1998) puts it, "a collection of rules and routines and facts and procedures" (p. 29). The student's responsibility is to arrive at the correct answer, and the teacher's role is to tell the student exactly how to arrive at that answer. Teaching under this model is generally predictable: teachers introduce a concept through lecture, select several representative examples to show students, and then have students try similar problems during class, while the teacher circulates about the classroom helping students with difficulties (Stigler & Hiebert, 1997). A traditional view of learning and instruction is a comfortable, predictable, and longstanding tradition among teachers, students, parents, and educational institutions. Yet these "habits" of the U.S. educational system are often associated with a host of student learning problems. Frequently, students pass through more than 15 years of formal schooling successfully and still have deep misconceptions of the most fundamental of mathematical operations (Ma, 1999; Confrey, 1990; Clement, 1982). Learners who do well in mathematics classes often have difficulty transferring that knowledge to other contexts outside of school (Cobb, Perlwitz, & Underwood-Gregg, 1998). Additionally, students often see mathematics as an altogether boring endeavor, with little insight into the order, richness, and beauty of the subject.

Reformers are looking to the learning theory of constructivism as the much needed shift from the traditional approach to classroom teaching. Different aspects of constructivism are utilized by educators. Two of particular importance are personal knowledge construction and social knowledge construction.

Personal constructivism holds that an individual must construct their own knowledge. This knowledge construction is accomplished through the meaningful experiences they themselves undergo (Confrey, 1990). Students are seen as individuals who have their own conceptual framework, built up over time, varying according to their experiences and surroundings. Changing the internal framework of mathematical concepts within a student is a complex task, which can not be met by direct (traditional) instruction alone (Clement, 1982). Student conceptions can and do change as their sphere of experiences expands and new knowledge and procedures are encountered; yet it is up to the student to change their beliefs, opinions, and conceptual understandings. An individual, a student in a mathematics class, must see (through meaningful experiences) that their current understanding of a mathematical idea needs to be altered or replaced. If this self-reflection occurs, a change can be made by the student in which they exchange their previous mathematical views for ones which are new or improved (Glasersfeld, 1995).

Social constructivism expands on this idea of individuals constructing knowledge by highlighting the importance of social interaction in the learning process. Vygotsky (1978) argues that children find meaning within a social context first, before internalizing the meaning in such a way as to be able to transfer the meaning to other contexts.

A constructivist instructor is one who uses teaching methods which help students develop, reflect on, evaluate, and modify their own internal conceptual frameworks. The goal of such a teacher is to promote mathematical ideas within students which are believed to be true, integrable across disciplines, seen as useful, and able to be justified and defended before others. Confrey (1990) describes a constructivist teacher as one who makes decisions, creates environments and selects assignments which cause students to be in charge of their own learning. They increase chances for students to reflect on and change their own conceptual frameworks. They negotiate possible problem solutions with students. They try to understand each student's current conceptual framework, what they are thinking and why, and alter instruction accordingly. Other traits seen in constructivist teachers are listed in Driskol's (2004) chapter on constructivism as: creating environments where students are allowed to engage in actions and activity; fostering student-to-student interaction in and out of the classroom; and bring out several solutions and representations of the same problem.

The reform movement occurring within mathematics education is particularly noticeable in preservice teacher education programs that prepare future elementary teachers (Ambrose, 2004; Cakiroglu, 2000; National Council of Teachers of Mathematics, 2000). The goal of many departments of education is to model constructivist-based teaching methods to preservice teachers in the content mathematics classes they take during their undergraduate program (Carpenter, Fennema, & Franke, 1996; Kamii & Warrington, 1999; Shapson & Smith, 1999). Chicoine (2004) comments on the situation this way:

> If our future teachers are not going to teach as they were taught by many of their own primary and secondary teachers, teacher education courses must not only present the bodies of knowledge needed by future teachers to assume responsible positions as professionals, they must also consistently model the kinds of pedagogical practices that are conducive to active, in-depth learning. (p. 245, abstract)

Preservice teacher classrooms with collaboration environments, student presentations, and learning with a conceptual rather than procedural emphasis, abound in the research literature (e.g., Johnston, 2003; Lubinski & Otto, 2004; Porath & Jordan, 2004). But how do preservice teachers respond to a constructivist-based mathematics course in which they are students?

The Preservice Teacher

Preservice elementary teachers are a very homogenous group in terms of race, gender, and socioeconomic status, and have extremely similar views about the nature and teaching of mathematics (Brousseau & Freeman, 1988; Paine, 1989). According to a 1998 survey of 483 preservice teachers at the University of Washington, Oshkosh, large numbers of students held the belief that mathematics was primarily about memorizing a set of procedures and rules known to be true because the teacher or textbook said so (Seaman, Szydlik, Szydlik, & Beam, 2005). In fact, "preservice elementary teachers are often teacher-dependent, passive learners who rely on memorization, facts and procedures instead of their own independent thought" (Ball, 1990a, 1996, as summarized by Alsup, 2005, p. 4). It's not surprising then that they view teaching mathematics as telling and showing students rules and procedures. They see themselves "in front of their students, erect, lecturing, and managing materials and students sitting in desks" (Thomas & Pederson, 2003, p. 6).

Thomas and Pederson (2003) argue that early memories, such as memories of elementary school, have a large impact on what preservice teachers believe about the nature of mathematics and its teaching. Thus, many beginning teachers have the intention, either consciously or unconsciously, to continue the legacy of teaching and learning they experienced in elementary school decades ago, which in most cases was not constructivist in nature (Battista, 1999). The research literature suggests that early beliefs about how to teach are very resistive to change (Cooney, 2003). In fact, these same preconceived beliefs can remain virtually unchanged over time, experience, and education training (Pajares, 1992). Many authors have examined this recalcitrance and have offered strategies for teacher educators to use within math and science courses designed for preservice teachers (Bryan, Abell, & Anderson, 1996; Clark, 1988; Goodman, 1988; Thomas & Pedersen, 2003; Ullrich, 1999).

In addition, preservice elementary teachers are notoriously anxious and fearful in mathematical settings (Ball, 1990a, 1990b; McDiamrmid, 1990). The majority have had negative experiences with mathematics all their lives (Bobis & Cusworkth, 1994; Carroll, 1995; Swars, 2005). These experiences have caused many to endure mathematics instead of enjoying it. They see their role in the classroom as protecting children from rigorous mathematical activities where students might experience failure (Gellert, 2000; Weinstein, 1989). They consistently express the view that mathematics is necessary and important, a kind of necessary evil, which they must lead their students through by playing games and using fun activities to make the mathematics more bearable (Gellurt).

Teacher Educators and Preservice Teachers

When a teacher educator well versed in current learning theory and reform teaching strategies takes the helm of a preservice teacher content mathematics course, there are bound to be reactions from students. Due to the lack of success many students have had in their mathematical past, which at least is partial due to the traditional way they've been taught mathematics (Clement, 1982; Ma, 1999), it seems students would gladly accept a new paradigm for their mathematics education (Alsup, 2005). And in many instances, this is the case (e.g., Johnston, 2003; Lubinski & Otto, 2004; Spielman, 2004). Nevertheless, teacher educators often find substantial subsets of their class completely resistive to change in how they are taught mathematics (Foss & Kleinsasser, 1996; Schuck, 1995).

In addition to this resistance, there is often a general feeling among preservice teachers that they already know the mathematics they will be teaching (Ebby, 2000; McDiarmid, 1990) and what they really need now is a methods course, not a content mathematics course. They would like to focus on *how to teach* mathematics to specific grade levels.

The Study

In order to better understand the phenomenon of preservice teachers taking reformed mathematics classes, I decided to examine the expectations and reactions of a group of preservice elementary teachers I was teaching. The course I was teaching was the third and final mathematics course required of these students. At this particular university, future elementary teachers major in elementary education, with an area of emphasis, or what might be called a "minor." These minors can be in Spanish, history, mathematics, biology, gender studies, etc. Every preservice elementary teacher must take a sequence of three content mathematics courses: Number and Operations; Probability and Statistics; and, Geometry. The only exception is for those seeking a minor in mathematics. These students take Calculus I and Discrete Mathematics in place of the first two courses in the sequence, but must still take Geometry. These courses are taught by various faculty and teaching assistants, who are encouraged through department meetings to teach in a way consistent with the reform movement within mathematics education.

The textbooks used in all three courses are considered to be reform oriented, and virtually all the instructors of these courses teach non-traditionally. This can be seen from weekly meetings in which the instructors from all sections meet and share teaching ideas, beliefs and strategies as well as from informal classroom observations. The third and final course, Geometry, is structured to be extremely constructivist in nature, much more so than the first and second mathematics courses these students take. Much of this is due to the textbook used in the course: *Geometric Structures: An Inquiry-Based Textbook for Prospective Elementary Teachers* (Aichele & Wolfe, 2005). The text consists of worksheets, group activities, and projects within a 3-ring notebook which students can complete directly, remove from the binder, and submit for grading. The philosophy of the textbook authors is discussed at length in the preamble, and is radically informed by current reform trends within mathematics education: group work is emphasized; different solution paths are allowed and encouraged; assignments are structured to have students explore and discover concepts as opposed to being told directly; no answers are contained at the end, nor is their a glossary of terms; and hands on activities (origami, paper folding, cut-out shapes, etc) are a major focus. The texts in the Number and Operations and Probability and Statistics classes are reformed, but still maintain many traditional features: problem sets at the end of the chapters, subsections dividing different well labeled concepts, answers to problems, worked out examples and boxed theorems, etc. My teaching philosophy as instructor of this course was similar to the other instructors teaching the same class at the university, all of us having been trained in a week-long seminar by the textbook authors. In particular, I maintained that students learn best when they construct their own knowledge, individually and in groups, and that knowing mathematics includes having the ability to communicate it clearly to others in a way that makes sense to the people within the classroom community. I did not espouse the view that mathematical knowledge can simply be passed on by the teacher to students via direct instruction (e.g. lecturing or modeling examples). I therefore attempted to create a classroom environment were students were always engaged in activities, and handled student questions by having group members explain answers to struggling students. Also, students frequently presented or discussed their findings with the entire class.

Students were informed at the beginning of class verbally and in writing concerning the constructivist nature of the course. I communicated the beliefs I had about student learning and teaching mathematics at the beginning of the semester and at midterm.

I felt this course would yield interesting data for two reasons. First, it was the third reformed mathematics course and so student reactions from all three of their mathematics courses might be expressed. Secondly, this third course was more extreme in its demands on students to learn within a non-traditional classroom environment, and so their reactions might be more pronounced in this course than in the previous two. Student feedback was collected via mid-term and end of semester evaluations. I felt this study was worthwhile because it sheds light on a group of students who are nearly finished with their undergraduate degrees and a “step away from teaching.” Additionally, much of the data gives unfiltered student reactions to constructivism and non-traditional classrooms. It is hoped that this study will generate discussion among educational professionals surrounding preservice mathematics courses, especially in situations where teachers and students have differing views of teaching and learning.

Participants and Setting

Participants

Sixty-one preservice teachers participated in the following study. Over 75% of these students were juniors and seniors. Fifty-nine were female, two were male. Nearly all the participants appeared to be between 23-30 years of age and Caucasian. Only one student was minoring in mathematics as an area of emphasis.

In the middle of the semester these students were asked about their interest and enthusiasm for the course on a scale of 1 (low) to 10 (high). The mean was 5.5. When asked about their interest in teaching mathematics in general, the mean score was 7. Their opinion of their mathematical ability in basic geometry had a mean score of just over 7.

Data Collection and Analysis

Data were collected using two surveys. The first was at mid-semester and consisted of six questions. The first four questions were answerable on a 1-10 point scale, with ten being the highest: 1. My interest and enthusiasm in this class is ___? 2. The amount of time I spend outside of class on homework is ___? 3. My interest in teaching mathematics is ____? 4. My opinion of my mathematical ability in basic geometry is ___? The last two questions were open-ended: 5. Do you feel this class is helping to prepare you to teach in your future classroom? 6. Can you list some ways the class, instructor, curriculum, etc. could be changed or modified to increase your learning of mathematics?

The second survey was administered at the end of the semester and consisted of five questions. The first three were answerable on a scale of 1-5. The last two questions were open-ended: 1. This course increased my knowledge in the subject area. 2. The instructor promoted an atmosphere in class that was conducive to learning. 3. Overall, I rate the instructor? 4. Please comment on the teaching effectiveness of the instructor in this class. Be as specific as possible. 5. Are there any additional comments that you would like to make regarding any aspects of this class or this instructor? (for example about the text, classroom, strengths or weaknesses of the course, tests, in-class materials, on-line materials, projects or activities).

Twenty responses were collected from the mid-term survey and 46 responses from the survey at the end of the semester. The data which pertained to the research question was sorted into themes using the constant-comparative method (Strauss & Corbin, 1990).

I did this case study to produce a detailed description of the phenomenon of student reaction within their final reformed mathematics course. To produce the "thick description" of this phenomenon called for by Gall, Gall, and Borg (2003, p. 439), I wanted to re-create the meanings and intentions of the participants in context. Thus, I have reported large blocks of direct quotes. I chose to do this quite deliberately. As Patton (2002) notes, one of the strengths of qualitative research is in how it can bring data alive, making it meaningful to the reader. I felt that students' reactions in their own words would have greater impact than if I were to overly summarize or paraphrase their responses.

Results

The data were sorted into three main themes in terms of student expectations and reactions: (1) They expected the class to be a methods course, where they learned specifics about lesson plans and were instructed on how to teach to specific grade levels (2) They expected the instructor of the class to teach them mathematics by telling them the answers and telling them what steps to take, and reacted negatively when this did not occur, and (3) They expected the instructor to take an authoritative role in the classroom, and were uncomfortable and unsettled when they didn't see the instructor take on this role.

Reaction 1: *"We aren't actually being taught how to teach."*

There was a general expectation among the preservice teachers that this content mathematics course was supposed to be a methods class, or that it should be a methods course. They often felt that simply learning mathematics was a waste of time and effort, and was not going to prepare them to be a better teacher. Some students felt that doing lesson plan assignments or creating activities and projects would help them become better prepared to teach in their future classrooms. The following are several student comments.

"We aren't actually being taught how to teach. We are doing the work, but I don't know if I am any more prepared to teach because of it. I don't think we are getting enough input on how to teach it."

"I feel like the class spends a lot of time trying to figure out the geometry on its own. I think it would be more productive to learn (be taught) a concept and spend some time looking at how to best teach it; what common misconceptions are and the like."

"I feel like the concepts are easy enough to learn, I would like more on methods of teaching mathematics to students."

"This class is more based on concepts, worksheets, and busywork, which will not aid my skills for teaching mathematics. I have learned a few ideas for projects…"

"I feel like this class is only helping me re-learn material. It shows little on how to teach it to children. I think it would be beneficial to have more lesson plan activities to help with the actual teaching of topics. Also to point out specific teaching strategies, we as future teachers, could use."

"This class is kind of preparing me to teach. Yes in that we do things like creating lesson plans and create an activities portfolio. No in that what we do most days is go over homework using formulas and things that children won't know or understand."

Reaction 2: *"We need more knowledge from the professor before we are expected to do assignments on our own."*

A majority of students wanted the instructor to teach them mathematics by telling them what to do and what the answers were. Since the structure of the class was for students to construct their own knowledge of geometry individually and in groups, it's understandable that many students were dismayed that the instructor and textbook would never give away answers, nor lecture ahead of time to prepare them for the concepts they might encounter in an assignment. It's interesting to notice that some students realized that this was because of the structure of the class, while others seemed to think the instructor didn't know the answers, or was unable to explain them because he didn't know how to articulate himself.

Students also tended to focus on answers and procedures. This fits with their view that mathematics is a one-to-one correspondence between a problem and an answer, the answer being found in the textbook or in the instructor's words (Ebby, 2000).

"He didn't really teach anything. We never knew if we got the answers right, because he wouldn't tell us. He would not explain how to solve problems."

"This instructor never answered a question, which made it difficult for us to constructively learn. He may have been knowledgeable about the subject but didn't know how to explain it very well."

"The teacher did not (underlined) teach. I'm so mad that I am paying for this class and have learned nothing (underlined). The instructor never instructed us in anything. He was unable to answer student questions."

"I think he would have been more effective if he knew the answers. Sometimes it seemed as though he was just as confused as I was on some problems."

"I think the instructor tried to be fair, but the class is designed so that he is not really supposed to 'teach.' This course was the problem to me, not the teacher. Although I did learn a lot, it is of my own accord. I think that the course should teach (triple underline) and aid us, not force us to attempt to figure everything out for ourselves."

"I don't believe there was more than 10 minutes of instruction from him. Any questions that we asked were answered with another question, such as 'How would you do that' or
'Can someone else explain.' The worksheets were only busywork with no instruction to go with it. I would suggest that any student needing to take this class find another teacher to take it from, at all costs."

"I believe there was very (double underlined) little (double underlined) teaching in this class. When you asked him a question most times he could not answer them. He had other students answer questions. I do not feel he has enough knowledge of math to teach this course."

"I felt that I had to teach myself the subject matter and felt very unsure about it. I thought the text for this course was horrible. I would have rather worked out of a textbook that gave examples, had a glossary and index, and explained the subject matter."

"It was very ineffective for the instructor to pretend not to know answers and to treat everyone's ideas as equally good because it often made the correct answer ambiguous. It's ineffective to not answer questions directly."

"I was very unimpressed with this course. We received almost no instruction. My group and I taught each other so I do not even know if the knowledge I acquired is correct."

"I think he did a poor job answering questions. He did not know the subject area well enough to explain. He would always say, 'What do you think?' He never would answer our questions on the correct way to solve, and in math there is always a right or wrong answer."

Reaction 3: *"I feel that the students have more control than the professor sometimes."*

Many preservice teachers felt something was amiss in the course because the instructor was not authoritative. Students yearned for more teacher-led learning. A handful of students interpreted the instructor's passive role in the classroom as a lack of confidence. Others saw it as negligence, or a weak personal presence.

"It would help the class atmosphere a lot if he was more confident and firm. The class structure was frustrating because it is so open ended. There comes a point when the students need the expertise of the instructor to arrive at the next level of ability."

"The professor is extremely kind and I admire that, however I would prefer that he took better control."

"Personally I feel that the students have more control than the professor sometimes. I think the professor is too lenient."

"I felt that I was left to fend for myself with questions or concerns. He seemed to place all of his responsibilities on students."

"I thought that this class was basically self-taught and if it wasn't for my group members several of my questions would have never been answered."

"I believe the professor was trying. However his teaching skills need some work. He is helpful on an individual basis but did not address the entire class or command our respect. Group work is great, but we can't learn everything from our group members. We need a teacher, not a room monitor."

"It would be nice if our instructor was more assertive about correct/incorrect answers."

"Go over all homework problems so we know we have the right answer. It seems as though sometimes the instructor is learning along with the class which I don't like. It would be helpful if he was more confident in his teachings."

"He acted like he did not know the material as well as I would like my teacher to know what they're talking about. Often times it seemed that when I would ask a question, he would respond by saying 'I don't know. What do you think?'"

Discussion

Many preservice teachers in this study had major issues with the structure and teaching methods implemented within their third and final mathematics course. After exploring the responses of my students to the course, it seems evident that they do not understand or simply do not agree with reformed-style teaching and learning. As many of these students will be teachers in a matter of months, it seems that another group of teachers will leave the university bent on teaching their students as they were taught, thus perpetuating the teacher-student-teacher cycle of the past 100 years. It appears that direct instruction, with the focus on procedure instead of understanding, has won the day again. This is quite discouraging to me as a teacher educator.

I believe my results lead back to the observation by Pajares (1982) that changing beliefs is "nearly impossible" (p. 323) and that if teachers are going to be won over to a reform-based philosophy of learning mathematics, it must be in small degrees. Perhaps the extremity of the reform strategies implemented in this class were just too much for these students.

I believe that the crucial time for these students to be exposed to constructivist classrooms is in the early years of their K-12 careers, not in college. By the time these students are in college, especially in their third and fourth year, several things are arrayed against any preservice teacher instructor: (a.) Students have already passed several K-12 and college mathematics classes and have developed a pattern for thinking about content mathematics courses. (b.) In the case of my participants, they were not interested or enthusiastic about *learning* the subject matter (mean 5.5), but were more interested in *teaching* (mean 7.0). This suggests that these teacher's minds are on methods, not on content. (c.) The students in my class had a high opinion of their ability in geometry at mid-semester (mean 7.0). Could it be that they are not interested in teaching geometry because they feel they already know enough geometry to make it through their teaching careers? As one of my participants commented, "Having us doing the same activities [as elementary aged children would do], which for me are very easy and thus somewhat dull, feels like busywork that I'm not learning anything from."

Another item of interest was contained in two student responses. Both students believed that they didn't need to learn geometry because in the grade level(s) they were going to teach, the students were not required to learn geometric concepts. This suggests greater effort needs to be made in explaining to preservice teachers the concept of "longitudinal coherence" (Ma, 1999, p. 214). That is, that teachers in earlier grades know what students will learn in later grades, and visa versa.

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