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ABSTRACT

The goal of this longitudinal study was to conceptualize the belief structures of preservice teachers with regard to technology. Concerns included what beliefs were held, how those beliefs were held, and to what extent those beliefs influenced the teachers' use of technology. Two preservice teachers were followed through four quarters of a secondary mathematics education sequence. Analysis of their beliefs suggests that prerequisite mathematical knowledge and the role of the teacher played a major part in the structure of their beliefs toward technology. (Author/MKR)

Teaching with Technology: Two Preservice Teachers' Beliefs

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TEACHING WITH TECHNOLOGY: TWO PRESERVICE TEACHERS' BELIEFS[1]

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The goal of this longitudinal study was to conceptualize the belief structures of preservice teachers with regard to technology. We were concerned with what beliefs were held, how those beliefs were held, and to what extent those beliefs influenced the teacher's use of technology. We followed two preservice teachers through four quarters of a secondary mathematics education sequence. We analyzed their beliefs and found that prerequisite mathematical knowledge and the role of the teacher played a major part in the structure of their beliefs toward technology. We plan to continue working with these teachers as they move into their first year of teaching to see if these belief structures change.

Much research has highlighted the importance of beliefs of preservice mathematics teachers and the way beliefs affect the teaching of mathematics (Cooney, 1994; Thompson, 1992). In terms of the use of technology, we need to be aware that the purposes for which the computers are used, the software used, the ratio of students to computers, the location of the computers, available time, and the curriculum are all likely to influence these beliefs (Kaput, 1992; Schofield & Verban, 1988). Our longitudinal study investigated the beliefs that preservice secondary mathematics teachers held toward technology and its use in the secondary mathematics classroom. Accordingly, we focused on the following questions:

- What beliefs did the preservice teachers hold about the use of technology?
- How are the preservice teachers' beliefs about technology structured?
- How did their beliefs seem to promote or impede their use of technology?

We plan to continue working with these teachers into their first year of teaching.

One way of conceptualizing belief structures is through the work of Green (1971). Green's theory on beliefs allowed us to consider not only what beliefs teachers held, but also the way in which those beliefs were structured. We were concerned with many dimensions of the belief structure. How the beliefs were held could be discussed through the use of quasi-logically held primary and derivative beliefs. The strength at which the beliefs were held could be considered through the use of psychologically central and peripheral beliefs. The reasons for

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holding these beliefs could be determined by considering whether the beliefs were held evidentially or nonevidentially.

Primary beliefs form the basis for derivative beliefs. There is a quasi-logical relation between primary and derivative beliefs, though there may be no empirical basis for the primary belief itself. In the absence of empirical evidence, the primary belief may be based on proclamations from authority. For example, if a person held a primary belief that he would use technology in his teaching, perhaps only because the NCTM Standards promote this, then a derivative belief would be that he would be willing to use graphing calculators, though the commitment to use such calculators may be questionable. Psychologically central beliefs are those which are held very strongly. These beliefs are less open to rational criticism or change compared to psychologically peripheral beliefs which are more open to examination and possible change. Evidentially held beliefs are those that are held with regard to evidence. They are beliefs that may change in light of further evidence. Nonevidentially held beliefs cannot be changed by the introduction of evidence. They are those beliefs which when challenged cause a person to respond, "Don't bother me with facts, I have made up my mind" (Green, 1971, p. 48).

Methods

Over the course of a four quarter sequence in secondary mathematics education we studied the beliefs of Christine and Liz, two of 15 participants in the Research and Development Initiatives Applied to Teacher Education (RADIATE) project. The four quarter sequence consisted of two courses in mathematics education, student teaching, and a post student teaching seminar. All 15 of the participants were followed, but for the purpose of this study we chose to focus on Christine and Liz. They were chosen because of their willingness to share their thoughts and ideas.

Data for this study consisted of an initial survey that involved mathematical tasks and questions about the teaching and learning of mathematics; three interviews during the first quarter, two interviews during the second quarter, one formal observation and interview during student teaching, and three interviews, one of which was a card sort interview, during the post student teaching seminar (all of the interviews ranged from 45 to 90 minutes); four exams administered during the first two quarters; weekly journals in which the participants were asked to respond to questions related to course activities; and observations of their work on campus as well as their field experiences.

Analysis of Beliefs

Through experiences in the mathematics education courses both Christine and Liz were exposed to situations where graphing calculators and computers were used regularly as investigative tools. These experiences involved the use of technology as an integrated approach to learning mathematics. During the first mathematics education course the students were able to spend time in a computer lab.

One activity involved the use of Algebra Xpresser, a graphing program. Liz explained,

> We graphed $y = x^3$, then we graphed $y = ax^3$. Then we compared the graphs. It took a lot of time, but it helped me to see the effects of each part of the function. (Journal, 5/12/94)

The second mathematics education course was taught in an enhanced classroom which contained 17 Power Macintosh computers. During the course of the activities the students could turn their chairs so they would be at a computer. It was a powerful situation especially when the students could move between using technology and using a paper and pencil. We hoped that we were creating an atmosphere where technology was a tool to be used in an interactive process of learning mathematics.

As we began to analyze the beliefs of Christine and Liz, it was clear that as they became proficient in and confident toward their use of technology, they were forming similar beliefs. One of these beliefs was that their success with technology resulted from the fact that they already knew the mathematics involved in the activity. Thus it was their mathematical knowledge that helped them understand the use of technology, hence the technology was simply "icing on the cake." Both Christine and Liz held this belief as primary in the sense that it drove other beliefs, and further, this belief was psychologically peripheral. It was also evidentially held and was open to rational criticism and possibly change in light of new evidence. For example, during a unit on transformational geometry, Liz had an experience which provided an opportunity for her to examine her belief.

> Throughout the week, I learned to use my available materials (computers, MIRAs, paper, etc.) and try to visualize the transformations of a figure... I never knew that formulas stood behind each of these transformations. I think it helped to first work on the computer and experience the transformations, and then discover how the computer followed our commands. (Journal, 11/4/94)

Her belief that success with technology comes after the mathematical knowledge was acquired was peripheral and amenable to change. She was willing to consider a new belief which was contradictory to her primary belief. Though this episode challenged her belief, the evidence was not significant enough to cause her belief to change. Perhaps more such challenging episodes would promote a change.

Both Christine and Liz extended this primary belief of a prerequisite mathematical knowledge to many derivative beliefs. One of these derivative beliefs was that once the mathematical knowledge, "paper and pencil skill", as they both called it, was obtained, then and only then could technology be used for further mathematical investigation. The graphing calculator or computer could be used, as Liz explains, to "speed up the busy work" so the teacher "can get to the real gut of the lesson" (Interview, 5/24/94). Christine added, so, if let's say I had an algebra 3 trig class, and I knew that they had learned or were supposed to have gotten something and we reviewed, then we could go on into the computer looking at graphs and trig functions and things like that. (Interview, 5/17/94)

Christine extended this belief about a prerequisite knowledge of mathematics to include other derivative beliefs. For example, she held a belief that technology is to be used only in the upper level classes.

> If you have a class that has number one a problem with getting it on paper...you might run into some problems...If I was trying to teach functions [in an algebra 3 or trigonometry class] I would love to have a computer in my classroom. But if I was teaching general math and...I was teaching basic skills and what you're going to need to graduate...I would probably do things that were outside...[like] balancing a checkbook. (Interview, 5/17/95)

Liz extended this belief of a prerequisite knowledge of mathematics to derivative beliefs which were different from those of Christine. Liz was concerned with her students using the calculator or computer as a crutch.

> [I would use] computers maybe once every two weeks...I don't think I would rely on it and I don't think I would want the kids to rely on it because...I would want them to understand it. (Interview, 5/24/94)

Later she stated that the students:

> Trust the calculator way more than their confidence...cause they haven't been taught it [mathematics] without the calculator. (Interview, 5/30/95)

In addition to sharing the primary belief of prerequisite mathematical knowledge, both Christine and Liz shared a belief that they would use technology in their teaching. This belief tended toward psychologically central. It was a derivative belief which was based on their primary beliefs of teaching. Throughout their field experience it became apparent that this belief had an entirely different meaning for each of them.

Christine saw technology as an alternative method of teaching. This stemmed from Christine's primary and psychologically central belief that she wanted to reach every student and, in order to do this, alternative methods of teaching needed to be used.

> It [technology] is a different way to teach. It's a different way that a student might understand something. Somebody might not get it looking at it on the overhead. . .but if they were put in

> front of a computer maybe they'd have a whole lot to say. (Card Sort Interview, 5/30/95)

Christine's field experience in the second mathematics education course offered an opportunity to use technology with an algebra 3 class that was currently working on the law of sines. At first she chose not to use technology.

> I felt like we had so much we needed to cover that any structured use of technology would be a hindrance. (Journal, 11/11/94)

Once she was "coerced to use something" she realized that:

> Not only were our students given an opportunity through us, but they also benefited from the exploration of right triangles on GSP. (Journal, 11/11/94)

With such positive experiences such as this, it seemed that Christine would use technology in her student teaching.

Her student teaching took place in a small city high school with a traditional teacher who, in Christine's words,

> Doesn't have a clue about technology, but she's really excited about using it. (Interview, 11/29/94)

Christine had possession of a powerbook and an overhead projection panel, but she rarely used them. Most of her classes were introductory geometry with the exception of one algebra 2 class. On the surface it seemed as though her belief in using technology was in conflict with the fact that she did not use technology in her student teaching. In fact, a deeper analysis revealed that her beliefs were not in conflict. She believed technology to be an alternative method of teaching, so she replaced it with other alternative methods such as group work, manipulatives, and peer teaching.

Christine also believed that using technology in her classroom would give students much needed skills since "our world is becoming more of a technological focus in general" (Card Sort Interview, 5/30/95). It is interesting to note that this belief was contradictory to her belief that technology was to be used only in the upper level classes. One might wonder, if our world is becoming technological and it is important to teach these skills, then why should we only use technology in the upper level courses? For Christine, the answer to this question may be rooted in the belief she held about a prerequisite mathematical knowledge. Perhaps the lower level students have not yet acquired that knowledge and therefore using technology would not be worthwhile.

Liz, on the other hand, was primarily concerned with using technology as a demonstrative tool. Liz's primary belief was that the role of the teacher was that of an authority figure. She believed that her students should be exploring mathematics with technology, but at the same time she saw her role as controlling the direction and substance of the activity. Her teaching was basically teacher-centered in nature. She was not ready to give up or even share the authority in the classroom.

Liz's student teaching took place in a large suburban high school with a teacher who was well versed in computers and computer software. The classroom itself had only one computer with a television monitor but there was a lab directly across the hallway that contained 15 Macintosh and 15 IBM computers. Also, the students were familiar with the TI graphing calculators since there was a classroom set that was available daily. Throughout her student teaching Liz constantly used technology in a very structured, demonstrative way. When she was encouraged by her cooperating teacher to let the students explore on their own, she was frustrated. She wanted to be the one to give them guidance. Nevertheless, she heeded the advice of her cooperating teacher, even if reluctantly. At the end of the lesson she felt that it had been unsuccessful and next time she would be sure to give the students more direction (Interview, 4/20/95). In another student teaching episode, a student who was absent the previous day was asking about the assignment. Liz responded, "It's real easy, the calculator will do it all for you." Liz then handed a piece of paper to the student and stated, that "[the handout] is to tell you all that you need to put in the calculator" (Student Teaching Observation, 2/23/95). It was a summary sheet of all the keystrokes. It is interesting to note that even though Liz had access to computers and graphing calculators on a daily basis, she used them only after the students had learned the mathematics and even then she would tell the students what they needed to be doing. On a positive note, she did use them!

Conclusion

Green's (1971) theory on beliefs has given us a framework to examine the belief structures of these preservice teachers. Analyzing their belief structures has helped us to determine how and when these teachers would use technology in their classrooms. For example, Christine's belief that she would only use technology in the upper level classes was derived from the primary belief that success in technology resulted from a prerequisite knowledge of mathematics. In order to challenge Christine's belief that technology was to be used only in the upper level classes, we could challenge her belief of a prerequisite mathematical knowledge. Since this belief was peripheral, it would be open to examination. This in turn may cause her to examine her belief of technology in the upper level classes. With Liz, her belief that she needed to provide direction in the use of technology was derived from two primary beliefs-success in technology resulted from a prerequisite knowledge of mathematics and the role of the teacher is one of authority. To challenge Liz's belief that she needed to provide direction, it might be beneficial to challenge her belief that success in technology resulted from a prerequisite knowledge of mathematics. Her belief that the teacher's role is one of authority is centrally held and is therefore less open to rational criticism than her belief of a prerequisite mathematics.

Awareness of these preservice teacher's belief structures has given us insight into possible changes in our preservice secondary mathematics education program. As teacher educators, we need to be aware of our preservice teacher's beliefs and we need to offer opportunities to challenge those beliefs. We intend to continue following both Christine and Liz into their first year of teaching to determine if their present belief structures about technology change and if so, what caused the change. Through continuation with the RADIATE project and others like it, we hope to continue to gain an understanding of the beliefs of preservice teachers as they continue through the mathematics education program and into their first year of teaching.

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