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ABSTRACT

The purpose of this study is to trace the learning, dispositions, and professional development of the first group of preservice secondary mathematics teachers as they make transitions from college freshmen to student teachers to first year teachers. Research questions are addressed as: (1) How participants' knowledge, beliefs, and goals are affected by their experiences in an innovative, reform-based, four-year secondary mathematics teachers preparation program that engages them in a variety of learning communities, then how these cognitions are revealed in their instructional practice as student teachers and as certified classroom teachers; and (2) how participants' behaviors are as undergraduate college students related to their behaviors as certified secondary mathematics teachers and the behaviors they expect from students in their school-level classes. Based on the findings from the study, implications for preservice secondary mathematics teacher preparation programs are proposed in this paper. (KHR)

[From College Freshman to Secondary Mathematics Teachers: Longitudinal Case Studies Based on an Analysis of Knowledge, Beliefs, Goals, and Behaviors]

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From College Freshmen to Secondary Mathematics Teachers: Longitudinal Case Studies based on an Analysis of Knowledge, Beliefs, Goals, and Behaviors[1]

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Jason, an undergraduate preservice secondary mathematics teacher, enters the class and the room lights up. He is bright, outgoing, and friendly to all. During class he makes numerous worthwhile contributions, each one impressing his professors and fellow students. He is not afraid to ask questions and willing to take the risks with innovative and challenging ideas. He is clearly self-confident and socially comfortable.

At the same time, Tammy, also an undergraduate preservice secondary mathematics teacher, enters the room quietly and remains so during class. She takes copious notes, yet rarely if ever raises her hand to make a comment or ask a question. The only time she can be seen talking is when she is working within a group. Several weeks into the first semester Tammy confides in her professors that she doesn't feel she has what it takes to succeed in the program. She is clearly insecure about her abilities in mathematics and somewhat self-conscious about it. Indeed, the concepts come hard to her and she spends extra time with her professors and with her peers trying to catch on. Who can envision the future for Jason and Tammy? What types of mathematics teachers will they become? Can we predict?

Researchers in mathematics teacher education continually question and study the impact of preservice teacher preparation on the future teachers who graduate from their programs (Ensor, 2001; Phillipp et al., 2002; Romagnano et al., 1999; Steele, 2001; Wilcox, Lanier, Schram, & Lappan, 1992). The many internal and external obstacles (e.g., deep-rooted beliefs about teaching, time constraints, expectations of colleagues, need for "control") that may impede novice teachers from implementing reformed-based[3] instructional strategies and techniques to which they subscribe during their preservice preparation appear to surface during the first few years of teaching, causing tensions and discomforts that lead novice teachers to revert to "more familiar and traditional practices" (Wilcox et al., 1992, p. 20).

Furthermore, the influence of various communities (e.g., university teacher education community, internship classroom/mentor community, and classroom community) on developing teachers' knowledge, beliefs, goals, and practice has recently been the subject of study for several researchers (Koc & McGraw, 2003; Van Zoest & Bohl, 2003; Wenger, 1998). How such learning communities support preservice and in-service teachers and contribute to shaping their cognitions and practice has implications for teacher preparation programs.

After observing teaching from a learners' perspective for approximately 14,000 hours (Cicell, 1994), future teachers have informally developed mental models of and beliefs

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[3] Throughout this paper, "reform" refers to the vision of teaching and learning mathematics espoused by the National Council of Teachers of Mathematics (2000).

about teaching that may provide a "fall back" approach of teaching the way they were taught (Goodlad, 1990; Wright & Tuska, 1968). To support reform efforts in mathematics education, offering a "safety net" and preempting events that may lead to a "fall back" approach pose challenges for providers of professional development.

Although many studies have been designed to create changes in the conceptions of preservice and in-service teachers (e.g., Cooney, Shealy & Arvold, 1998; Raymond & Santos, 1995; Schifter & Fosnot, 1993; Steele & Widman, 1997; Wilcox et al., 1992), at the secondary level very few studies have examined whether and how these changes in conceptions have been sustained through the beginning years of teaching. Motivated by a critical shortage of mathematics teachers and the need to have long-term access to changing and building future teachers' beliefs in support of reform efforts, TIME 2000 was designed to immerse participants in a full four years of multiple types of experiences concerning mathematics education, as well as to support them during their first three years of teaching as they function and interact in various learning communities. Having such a sustained involvement with these participants allows for the examination of their evolving knowledge, beliefs, and goals as well as an examination of how their behaviors as students relate to their behaviors as teachers during their student-teaching and first-year teaching experiences.

About the TIME 2000 Program

The goals of the TIME 2000 Program are to recruit high school seniors who do well in mathematics into a secondary teacher preparation program that begins in their freshman year, conceptually integrating mathematics, the psychology of learning and teaching mathematics, and mathematics pedagogy, and prepare them to become reform-minded, highly competent secondary mathematics teachers. Key components of the program that are networked between and among on-campus and off-campus learning communities include coordinating course schedules across and within departments (i.e., mathematics, education), offering topical monthly seminars conducted by participants, faculty, and off-campus guests (e.g., tutoring techniques; mathematics and real estate; mathematics and dance), designing community-building and service activities (e.g., the formation of a tutoring club by the participants to serve the local community through low-cost tutoring in mathematics), team-teaching (e.g., faculty in educational psychology, mathematics, and mathematics education), building professionalism (e.g., participants attend local mathematics teacher conferences), meeting regularly with participants in small discussion groups; co-planning courses (e.g., mathematics, educational psychology, and education faculty); and reviewing student progress (i.e., to offer career guidance and support). The program faculty includes mathematicians, educational psychologists, and mathematics educators. For more information about the program visit <www.qc.edu/time2000>.

Purpose of the Study

The purpose of this study is to trace the learning, dispositions, and professional development of the first group of preservice secondary mathematics teachers as they make transitions from college freshmen to student teachers to first year teachers. We have found that over the four years of their undergraduate study and into their first year of teaching, by having participated in a variety of learning communities, these preservice teachers have shown evidence of changes in their knowledge and beliefs about

mathematics and the learning and teaching of mathematics. Furthermore, we have found interesting relationships between these preservice teachers' behaviors as college students and their behaviors as student teachers and then as teachers.

Research Questions

Two of the research questions addressed are:

- How are participants' knowledge, beliefs, and goals affected by their experiences in an innovative, reform-based, four-year secondary mathematics teacher preparation program that engages them in a variety of learning communities? Then, how are these cognitions revealed in their instructional practice as student teachers and as certified classroom teachers?
- How are participants' behaviors as undergraduate college students related to their behaviors as certified secondary mathematics teachers and the behaviors they expect from students in their school-level classes? Specifically, how are participants' behaviors related across different learning communities?

Theoretical Framework

Couched in the tradition of cognitive psychology (Brown & Borko, 1992), work on examining teaching as problem solving (Artzt & Armour-Thomas, 1998, 2002; Carpenter, 1988) has set forth the role of teachers' overarching cognitions (i.e., knowledge, beliefs, goals), as well as their cognitions before (i.e., planning), during (i.e., monitoring and regulating), and after (i.e., assessing and revising) teaching a lesson. Artzt and Armour-Thomas (1998, 2002) have found that the nature of teachers' instructional practice, that is, the tasks they design, the learning environment they create, and the discourse they orchestrate are directly affected by the nature of their cognitions. Using this metacognitive framework, we propose that teacher development as reflected in instructional practice is shaped by knowledge, beliefs, and goals (Artzt & Armour-Thomas, 1998, 2002; Ball, 1991; Brown & Borko, 1992; Kagan, 1992).

Knowledge encompasses knowledge of subject matter, knowledge of students and learning, as well as pedagogical knowledge (Shulman, 1987). Such knowledge is revealed in various ways—scores on standardized tests, grades in courses, recitation and class presentations, and in the content of lesson plans and the design of instructional activities.

Beliefs encompass beliefs about the discipline to be taught, beliefs about students and learning, and beliefs about oneself as a learner and a teacher (Cooney, Shealy, & Arvold, 1998; Kagan, 1992; Thompson, 1992). Such beliefs are revealed in belief scale inventory results, observable behaviors, and journal entries.

Goals encompass the teacher's goals for student learning. Such goals are revealed during instruction or in planning, and they are developed and modified as the teacher interacts with learners (Simon, 1995).

These three key elements (i.e., knowledge, beliefs, and goals), influenced by preservice and in-service teachers' participation in various learning communities (Van Zoest & Bohl, 2003; Wenger, 1998), provide a foundation for analyzing the behaviors and development of participants as they make the transition from student to teacher. The influence of learning communities on participants' knowledge, beliefs, and goals is depicted in figure 1, as an encircling, all-encompassing entity. Since instructional practice

is conducted within classroom and school communities, the communities continue to affect the ongoing development of knowledge, beliefs, and goals of novice teachers.

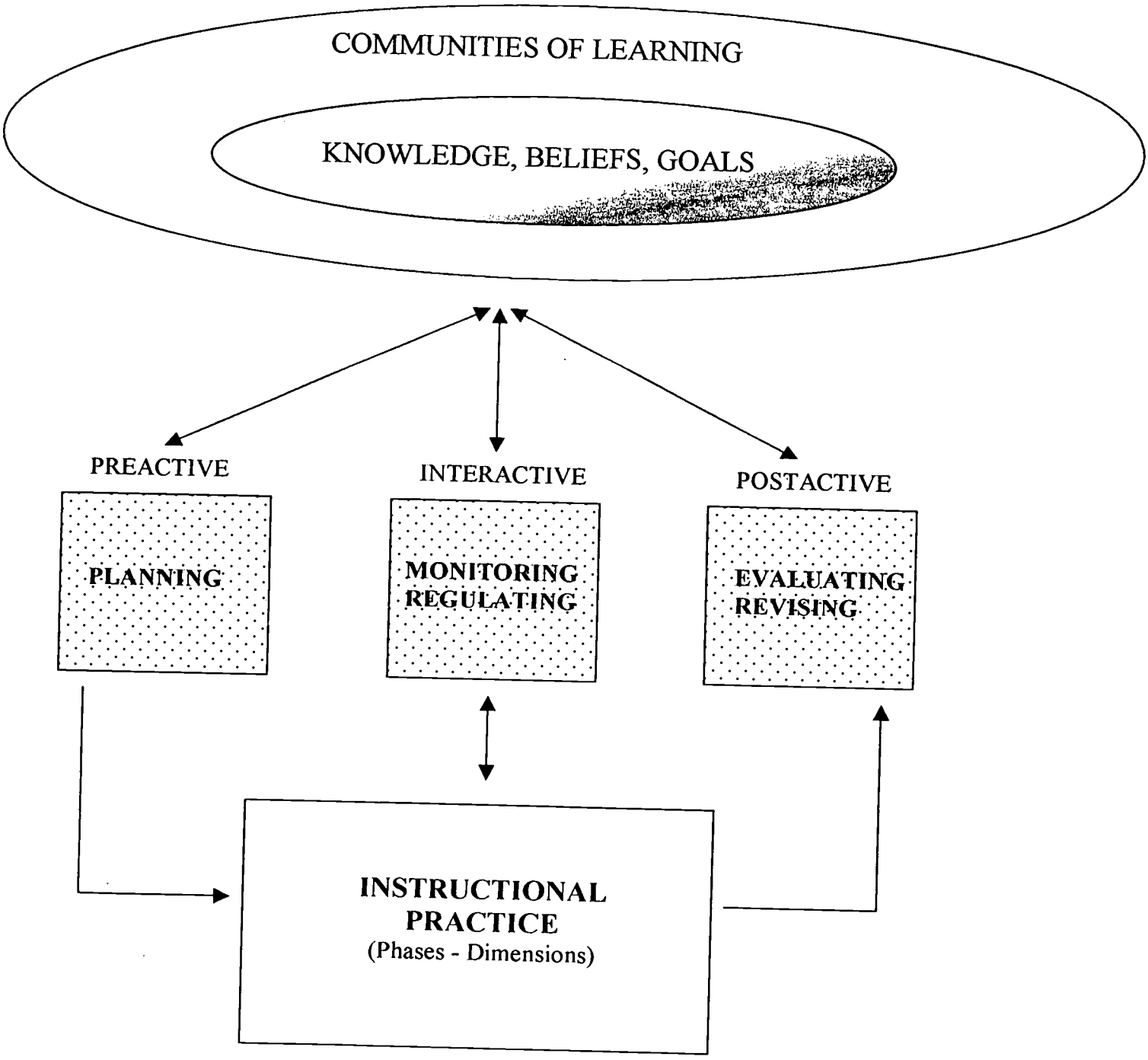

Figure 1: Components of the Model for Teaching
(Adapted from Artzt & Armour-Thomas, 2002)

The Method

Since August 1998, when the first cohort of 33 high school graduates was accepted into the program, an extensive amount of quantitative and qualitative data has been collected to document the development of their knowledge, beliefs and goals. Observational data as well as questionnaires completed by professors were used to measure the behaviors of participants in their college classes. Teaching behaviors were observed, videotaped, and recorded by the authors. A case study research approach was used to access the rich stories that reveal the often strange turns that impacted the development of these participants' beliefs about mathematics, learning, and teaching, and ultimately their teaching behaviors during student teaching and their first year of teaching. Case study research methods (Merriam, 2001) have been employed to examine patterns and themes in longitudinal qualitative data, allowing for the creation of a descriptive and broad view of participants' experiences and developing conceptions regarding mathematics and the learning and teaching of mathematics. Such an approach provides insight into the context and experiences that influence the development of secondary mathematics teachers.

Participants and Context

Of the 33 freshmen who entered the program in 1998, 18 (i.e., 55%) are still in the "pipeline," with 14 of them in full-time teaching positions. An extensive amount of data for eleven of the 18 who have completed the program has been collected. Case studies of Tammy and Jason, pseudonyms of two of the original cohort, are presented to illustrate the contrast among the new teachers. Samples of data related to their knowledge, beliefs, goals, and behaviors are presented in relation to the other participants.

Data Collection

Qualitative data. To increase the validity of the research findings, multiple methods of data collection were used (Lincoln & Guba, 1985; Merriam, 2001). Throughout the program participants were required to write journals a minimum of once each semester documenting their emerging knowledge, beliefs and goals regarding mathematics and the learning and teaching of mathematics. At the completion of each of their four academic years they had to submit a portfolio that included the supporting evidence for their developing conceptions. During their freshman semester, participants were observed during their mathematics and education classes and their behaviors were observed and recorded as well as, videotaped several times. During their lower senior year participants presented mini-lessons that were observed and videotaped accompanied by postlesson reflections and revised lesson plans. During their upper senior year participants were observed four times, two of which were videotaped. These lessons were accompanied by written documents of participants' prelesson thoughts, lesson plans, and postlesson thoughts. As part of these reports participants were required to describe their knowledge of the content, students, and pedagogical strategies, as well as their goals for student learning. The authors wrote evaluations of these documents as well as evaluations of participants' instructional practice and abilities to reflect on the lesson immediately following their instruction. The authors observed each of the participants twice during their first year of teaching. Immediately following the lessons the authors spoke with the participants regarding their ideas about the lesson and their changing conceptions about mathematics, and learning and teaching. Both the lessons and conferences were videotaped. After six months of full-time teaching, participants completed a questionnaire

inquiring about their changing beliefs and their ability to implement reform-based teaching strategies.

To measure participants' behaviors as college students 14 of their college professors (both in education and mathematics) completed questionnaires regarding the frequency and quality of comments they made and questions they asked in class and how prepared and attentive they were.

Quantitative data. To measure knowledge of mathematics, participants' SAT scores in mathematics and their grades in the mathematics courses they took (i.e., four-year Math GPA) were used. To measure their knowledge of school mathematics, participants were given quizzes based on the New York State exams administered in 8th grade, and approximately the 10th and 11th grades. To measure knowledge of ways of learning and teaching mathematics, participants' total GPAs in their education classes were examined as well as their grades after each observation and their overall grades for student teaching. (See Table 1.)

Participants were asked to complete a Mathematics Beliefs Scales questionnaire adapted from Fennema, Carpenter, and Peterson (1987). The participants completed this questionnaire four times: before they began the program, after their first semester senior methods class, after their second semester senior student teaching experience, and after six months of teaching.

Professors in fourteen of their classes (both education and mathematics) recorded their participation, preparation, attendance, and punctuality.

Data Analysis

The qualitative data were systematically recorded, classified, and analyzed to reveal patterns or themes. During this process we were able to ask and answer specific questions related to the data. Two themes were revealed: (1) The level of verbal participation of participants as students in the university teacher education community relates to the type of discourse they create when they student teach in the internship classroom/mentor community or teach as professionals in the classroom community (Van Zoest & Bohl, 2003); and (2) Participants' abilities, work ethic, and interests are manifested in all of their communities of learning, and ultimately, in their teaching behaviors.

The Case Studies

College students exhibit different learning behaviors as students that appear to be related to some of the behaviors they exhibit as student teachers and as teachers. Such teaching behaviors are a reflection of the knowledge, beliefs, and goals they develop throughout the course of their education. Each theme is discussed in general and then examples of Tammy and Jason are presented.

Theme 1: Verbal participation in their college classes is related to the discourse participants create as student teachers and as teachers (i.e., teacher-centered vs. student-centered[4] instruction).

[4] Teacher-centered instruction is didactic and prescriptive, characterized by the teacher disseminating information, usually by lecturing. Student-centered instruction is characterized by the teacher building on

There appears to be a relationship in the level of verbal participation in college classes (e.g., number of questions and comments they make) and the type of discourse participants create when they student teach or teach (e.g., teacher-centered vs. student-centered).

Professors of fourteen of the courses (i.e., 10 mathematics and 4 education courses) completed the Student Learning Behavior Forms at the completion of each of their courses. Interestingly, the behaviors they noted were fairly consistent across time periods and course content. Verbal participation data are ratings of how often participants asked questions or made comments in class. Ratings for questions asked and comments made in class were recorded as "None," "Some," or "Many." In Table 2, participants are listed according to their level of classroom verbal participation as students from low (many instances of "None") to high (many instances of "Many") and ranked according to the degree to which they exhibited a student-centered style of instruction when student teaching and teaching. It is interesting to note how the participants conducted the discourse in their own classes when student teaching and then teaching. That is, participants who tended to be more vocal in class and dominate class discussions as students were more inclined to adapt a teacher-centered style of instruction as student teachers and as teachers. On the other hand, participants who were not as vocal in class appeared to be more inclined to adapt a student-centered style of instruction.

This contrast is most clearly exhibited by Tammy and Jason. According to the rankings of classroom verbal participation, Tammy was rated second lowest and Jason was rated the highest. That is, Jason was clearly the one who asked the most questions and made the most comments in both his mathematics and education classes. Professors of 14 of his classes 9 reported that he asked "many" questions and 7 claimed he made "many" comments. He was never described as asking "no" questions or making "no" comments. Tammy, at the other end of the extreme, reportedly rarely if ever asked questions or made comments in any of her classes. Her professors of 10 out of 14 courses reported that she asked "no" questions. In 7 out of 14 courses they reported that she made "no" comments. She was reported as having made "some" comments in 6 out of 14 classes, and only in 1 class did she ask "many" questions.

During student teaching and teaching, Tammy's and Jason's classes were equally contrasting.

Tammy's Road to Student-centered Teaching

Although Tammy's patterns of verbal behavior were to be very quiet in class she did learn to participate in small groups. However, this behavior developed over time and eventually influenced her beliefs about the role of student discourse in the classroom.

Beliefs about cooperative learning and students' role in the class. In her first autobiography written as a student, Tammy stated that she preferred to work alone:

> I work best individually. (9/98)

In her responses on a belief scale questionnaire given at the same time, Tammy's view of group work was somewhat negative. Out of 12 questions regarding attitude towards group work, on a scale of 1 to 5 where 1 is a negative attitude toward group work,

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students' prior knowledge and interests, and engaging them in dialogue and meaningful activities to strengthen their conceptual understandings.

Tammy averaged 2.58. However, it did not take her long to begin to appreciate the benefits of working in small groups. In her first journal assignment, she demonstrated appreciation of its social value.

> I am glad that we get to work in small groups because it has helped us to get to know one another. (9/98)

A few weeks later, after having worked in groups in her calculus class, she wrote,

> Group work enables us to see that there are numerous ways of analyzing a given problem. (9/98)

By the second semester in her junior year, in her mathematics journal, she wrote,

> I have once again seen the benefits of group work and the importance of having all students actively participating in hands-on class activities. (5/01)

In the first semester of her senior year she wrote,

> I believe that students should feel comfortable participating and being involved in the discourse. (9/01)

In her post-lesson thoughts related to her second observation she wrote,

> I think that it is evident from my lesson that I view the role of students as active participants in their own learning where they are encouraged to propose approaches and solutions to problems by debating the validity of one another's claims. (3/02)

After having taught a more teacher-directed lesson when one of her peers was observing her, she wrote,

> After teaching the lesson, some of my ideas have been reaffirmed about the students' learning of the content. I think that if the students were more actively engaged in the activity they would have been more willing participants. For example, they could have met in groups and agreed upon their answers. By sharing their results, they could have learned about different possible methods for solving the problems. (3/02)

In her post-lesson thoughts related to her third observation during student teaching she wrote,

> I have noticed that students are truly motivated to learn through this discovery and investigative approach to learning. (4/02)

Table 1. Quantitative Data for Participants

	Student-Teaching Grade	Math SAT	Knowledge and Goals Content GPA Math	Prelesson Math	Pedagogy GPA SEYS	Prelesson Pedagogy	Students Prelesson Students	Self-Assessment of Instructional Practice	Post-Active Observation Grade	Beliefs Math Beliefs Questionnaire Preservice
Maximum in category	**1.0**	**800**	**4.00**	**1.00**	**4.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Name										
Tammy	**1.00**	**520**	**3.96**	**1.00**	**4.00**	**1.00**	**1.00**	**0.89**	**1.00**	**0.87**
Lynn	1.00	590	3.86	0.83	4.00	0.88	1.00	0.60	0.98	0.82
Ginny	1.00	500	3.34	0.88	3.97	0.92	0.92	0.75	0.90	0.79
Tonya	1.00	420	2.38	0.58	3.82	0.58	0.67	0.62	0.77	0.83
Edward	1.00	560	2.65	0.92	3.82	0.78	0.96	0.69	0.94	0.78
Linda	0.93	620	3.28	0.67	3.73	0.67	0.58	0.69	0.86	0.81
Jason	**0.93**	**660**	**3.23**	**0.79**	**3.56**	**0.83**	**0.79**	**0.79**	**0.91**	**0.73**
Sarah	0.83	430	2.64	0.67	3.55	0.67	0.75	0.55	0.86	0.86
Erin	0.83	600	3.11	0.58	3.25	0.78	0.75	0.70	0.79	0.81
Sam	0.83	580	3.13	0.63	3.10	0.78	0.83	0.67	0.90	0.74
Martin	0.75	very high *	2.95	0.56	3.35	0.50	0.58	0.61	0.71	0.76

* SAT not available, teacher rating

Table 2. Verbal Participation in College Classes and Teaching Style

Name*	Questions in Class None,Some,Many	Comments in Class None,Some, Many	Rank Order of Student-centered Instruction**
Tonya	9, 4, 0	9, 4, 0	3
Tammy	**9, 4, 1**	**7, 6, 1**	**1**
Sara	8, 6, 0	7, 7, 0	6
Linda	6, 8, 0	8, 6, 0	5
Ginny	5, 8, 0	6, 8, 0	2
Sam	5, 7, 0	4, 8, 0	9
Erin	3, 11, 0	4, 10, 0	4
Edward	2, 11, 1	1, 12, 1	7
Lynn	0, 10, 3	2, 9, 1	8
Martin	0, 7, 7	0, 7, 7	11
Jason	**0, 5, 9**	**0, 7, 7**	**10**

*Pseudonyms

**Determined and agreed upon by authors' independent ratings from classroom observations

(Based on participation in 10 mathematics courses and 4 education courses)

In her final student-teaching post-lesson report for her fourth and last observation, she wrote,

> I think one of the most important beliefs was in the abilities of my students. I viewed their capabilities as limitless, and I was really encouraging them to investigate, explore and discover. They detected amazing patterns, and I was extremely excited to see how eager they were to share their ideas. The lesson clearly demonstrates my perception of the role of students as being active participants in their own learning. (5/02)

In her final evaluation of her own student teaching, Tammy wrote,

> As a mathematics teacher, I...always try to get the students actively involved in developing their understanding. During lessons I often walk around the classroom, and I encourage the students to share their answers and explain things to one another. (5/02)

Responses to the belief scale questionnaire given at the conclusion of student teaching in May 2002, her mean score for group work was 4.5, indicating an extremely positive attitude toward the value of group work for her own learning as well as for the learning of others. Four months after she had been teaching, in December 2002, her mean score for group work was 4.0, still indicating a positive attitude towards group work, although less positive than it had been before she began teaching. In every lesson that Tammy taught for her observations during student teaching and then during teaching, her students were actively engaged in activities and encouraged to participate in either small groups or whole class discussions, thereby indicating that her professed beliefs about active learning were more than just "talk." As a result of her own positive experiences during

the program working with others, she came to value the effects of being actively involved in learning.

In her post-lesson conference two months into her teaching Tammy said,

> I encourage them to talk to one another...I was going to have them work in pairs and they were really going to come to the understanding together...There was going to be a lot of student interaction. (10/02)

Tammy's beliefs about teaching changed dramatically from when she first entered the program to when she completed her student teaching. One indication was in her responses to the belief scale questionnaire. For the first two administrations of the questionnaire when she was a student, Tammy strongly disagreed with the statement: "The teacher should make students figure a problem out for themselves rather than show how to do it." However, at the completion of her student teaching she strongly agreed with the statement. In fact, in her prelesson thoughts for her last observation during student teaching she wrote,

> I want to challenge the students to think for themselves through mathematical reasoning by communicating with one another. (5/02)

Her change in attitude towards the role of the teacher might have been a reflection of the positive experiences she had after rising to the challenge of being an independent learner of mathematics.

Tammy's attitude about the importance of students' role as independent thinkers continued into her beginning months as a teacher. In a post-lesson conference she said,

> I try to encourage everyone to participate and try to get the students to explain themselves. I did not want to just have answers on the blackboard, I wanted them to explain. (10/02)

During student teaching and then teaching, Tammy's classes were student-centered with emphasis placed on participation of all her students. In each of her five student-teaching observations, Tammy was commended for the discourse she conducted during her classes. She consistently communicated with students in a non-judgmental manner. She would listen intently to their comments and then invite the responses of other students. Using long wait times in combination with a non-threatening learning environment, she encouraged all of her students to participate in the class discussion and interact with one another. Furthermore, she was praised for giving all of her students the opportunity to take an active role in developing their own understandings. She designed carefully structured cooperative learning activities that ensured the participation of all of the students. Such behaviors gave positive evidence that the beliefs she expressed regarding pedagogy were more than just lip service. She wrote in her journal,

> Students learn from the active participation of other students—they must listen to one another. (11/98)

So, not only did she place a priority on her own listening skills but her goals for her students were that they become good listeners as well. At the end of student teaching, in her final portfolio, Tammy reiterated her goals to create a classroom in which students are active participants. She wrote,

> As a mathematics teacher, I always try to get the students actively involved in developing their understanding. During lessons I often walk around the classroom, and I encourage the students to share their answers and explain things to one another. (5/02)

Most impressive about Tammy was that she had a multitude of suggestions for how to create student-centered lessons that would capture her students' interests and actively engage them in learning. She gave specific ways that students could do this through the use of technology, real-life applications, manipulatives, projects, writing assignments, and having them work in small groups. Furthermore, her expressed goals for students were that they

> question whether their answers make sense, estimate and justify their reasoning, and use precise mathematical terminology. (5/02)

The two lessons that were observed when she taught as a teacher in a middle school were equally student centered. Again, one of the prominent features of both of her lessons was the discourse. She showed a genuine interest in what the students said and through careful structuring of problems let the students develop the new ideas. Specifically, in one of her lessons concerning the addition of integers, she had students put "warm up" work on the board and had them explain it and field questions from their classmates. She consistently encouraged students to answer one another's questions. She then gave students problems to work on in pairs or small groups using counters. Through their work on these problems the students were required to "formalize general statements." Tammy's skills as a listener were clearly demonstrated in every lesson she taught.

Jason's Road to Student-centered Teaching

Jason's road to student-centered instruction was a bumpier one than Tammy's. His experiences in three learning communities affected Jason's development: his experiences as a learner in Korea, his experiences as a learner in the TIME 2000 Program, and his experiences student teaching in both a high school and a middle school. Throughout the program, Jason grappled with the value of the lecture approach which worked well for him during his elementary schooling in Korea in contrast to a more student-centered approach which he experienced in the program and subsequently agreed would be more "fun" for his students.

Jason's beliefs about cooperative learning and students' role in the class. In his responses on a belief scales questionnaire given right before the program started, out of 12 questions regarding attitudes towards group work on a scale of 1 to 5 where 1 is a negative attitude toward group work, Jason averaged 3.00, which is a somewhat neutral attitude toward group work. None of his journals written as a student prior to student teaching made reference to cooperative learning strategies and their effects on him. However, in the beliefs scales questionnaire given at the completion of student teaching and then four months after he had been teaching full time, his average increased, but not dramatically (3.5 and 3.67, respectively).

While a student in his methods course he wrote,

> I have found that lectures are as important as activities. In school, I never had any kind of activities, only lectures, yet I learned a lot and enjoyed it too, even though

the tasks were hard in the beginning. So for the result, I learned a lot and it worked well. (9/01)

In his prelesson thoughts before his first observation during student teaching, Jason reiterated his lecture approach preference when he wrote,

> Because of the time, I tend to go over many of the questions by myself, so I might explain everything. (2/02)

However, he also incorporated a cooperative learning activity into the lesson because,

> it brings life into the classroom. (2/02)

During the first half of his student teaching, which took place in a high school, he began to develop a close relationship with his students and slowly incorporated more and more student-centered strategies. He wrote,

> As the semester goes by our relationship in [the] classroom is growing and building. They are not afraid of asking questions, not afraid of answering, not afraid of giving wrong answers, and willing to help one another. This relationship helps me to teach. (3/02)

In fact, he was praised for the central role that student discourse played in his lessons. In his own accurate assessment of his discourse he wrote,

> I am open to any kind of answers and do not try to be judgmental. It is still hard to know when to stop the conversation but I have learned in some ways. Students love to talk and make criticisms of their peers, which drives them to work harder. (3/02)

He did, however, acknowledge his difficulties in formulating questions,

> I need to improve on the questioning skills to be more of problem-solving kinds of questions. (3/02)

Unfortunately, during the second half of his student teaching, Jason was placed in a middle school class with extremely unruly and disrespectful students. His beliefs about the value of student-centered approaches drastically diminished. In his prelesson thoughts before his fourth and last formal observation he wrote,

> In terms of pedagogical strategies, instead of what works, I know from experience what does not work. The group work can destroy the whole lesson in no time. I almost have failed to love my students using group work. Group work without cooperation and interest in doing the assignment can result in disaster. Therefore, I will try to reduce the group work. (5/02)

At the end of his senior year Jason's beliefs about the role of the teacher as the provider of information resurfaced explicitly in his written philosophy of teaching:

> Teaching is more of explaining so that the wealth of the knowledge can be passed on and help to expand the greater knowledge. (5/02)

However, at the same time, he professed the advantages of small group work in his end-of-year portfolio:

> Group work is an informal situation where no one gets penalized and their peers can correct them without any embarrassment. They learn a lot from their peers by freely talking to one another by expressing their ideas and drawing conclusions through their talking and discussions. (5/02)

Jason entered his first job as a mathematics teacher with these conflicting beliefs and goals regarding his role as a teacher. While he wanted to

> help and teach students to have an interest and confidence in mathematics (5/02),

he still resorted to the teacher-centered approach to instruction. During his conference after his second observation as a teacher Jason confessed that his student-teaching experience in the middle school had "frightened" him. He was very concerned with "controlling" his students so that he would never be treated so disrespectfully again. In his latest questionnaire written after six months of teaching (2/03), Jason expressed his conflicting goals when he wrote,

> I really want to do more cooperative learning but the obstacle is the classroom management. I have to have firm control of the class. (2/03)

However, he was also dismayed that he had turned into a "lecturer," just what he did not want to be. Although it certainly appeared that his students had great affection for him, his instructional practice did not reveal the student discovery approaches he had learned during his undergraduate program. In his lesson on simplifying radicals, although Jason did allow a few students to go to the board and explain their work, rather than allowing for student discovery, he resorted to telling the students the rules that they would need to do the new problems. In his latest questionnaire written six months into teaching, Jason described his disappointment with how he has conducted student-centered approaches.

> Cooperative learning, I had a hard time achieving the things that I wanted. First, if the class is not disciplined, it gets even harder to control the class and it ends up being a nightmare. Lecturing is the easiest way of teaching yet so boring that I just want to stop teaching. It is boring for both students and a teacher. I cannot and have not lectured the whole period. It is so boring. (2/03)

Happily, Jason's awareness and concern for his developing strategies show promise that within the coming years, as he gains more confidence in his ability to control a class, he will relinquish more and more of his authority as a dispenser of knowledge to his students.

Jason's beliefs about teaching changed from when he first entered the program to when he completed student teaching and into his first six months of teaching One indication was in his responses to the belief scales questionnaire. Before he began the program, Jason was neutral to the statement: "The teacher should make students figure a problem out for themselves rather than show how to do it." After taking the methods course he indicated that he disagreed with the statement. However, after student teaching

and after six months of teaching he indicated that he agreed with the statement. In fact, in his final evaluation at the completion of his student teaching he wrote,

> My perception of teaching mathematics at the beginning of this student-teaching semester was like dreaming for ideal classes. I thought I had all the knowledge but I was far from the realm of experience. I forgot to put students in the equation...The role of the teacher is opposite from performing everything for students. They should create activities where students will be able to discover the theorem with their hands and with their own constructions. This will make students feel that they are part of the subject and they will start to make a connection with mathematics. (5/02)

Unlike Tammy, aside from repeatedly stating his desire to create motivational lessons that used real-life examples and technology, Jason never gave explicit suggestions for how to create student-centered lessons that would actively engage his students in the discovery of new concepts.

Theme #2: Ability, Work Ethic, and Interests Influence Learning and Teaching

College students enter the program differing in ability, work ethic, and interests. These differences permeate what and how they learn within the different learning communities they experience and thus affect their development as teachers. The knowledge, beliefs, and goals they develop from having experienced the program as students and the resulting teaching behaviors they exhibit during student teaching and teaching are a reflection of all of these factors.

Each of the eleven participants entered the program with different abilities and work ethics (see Table 3). They were all mathematics majors and typically took 46 credits in mathematics. As a measure of knowledge of mathematics the grade point averages (GPAs) of the 11 participants in the14 mathematics courses they took were calculated (see Table 1). The GPAs range from 3.031 to 3.975 (out of 4.0). Interestingly, during student teaching, in their post-observation conferences, each of the four participants who had GPAs less than 3.00 were encouraged either to improve the way they represented the mathematical concepts, sequenced the mathematical concepts, or correct faulty mathematical representations for explanations (Observation Reports, 2/02-5/02).

Participants in the program took 24 credits of education (including 6 credits of student teaching). GPAs in their education courses ranged from 3.1 to 4.0 (out of 4.0). The three participants with the highest GPAs also had the highest ratings for their knowledge of pedagogy and knowledge of students as rated in their student-teaching observations (2/02-5/02). See Table 1.

Participants' grades in student teaching are a measure of teaching effectiveness. Of the five participants who received an "A" for student teaching, three also received the highest GPAs in mathematics, education, and in their knowledge of the content, pedagogy, and students. One of the five had the lowest mathematics SAT score of the group and three others had scores in the lower half of the group. One had the fourth highest score. See Table 1.

Table 3. Overview of Participants' Potential, Work Ethic, and Performance

Name	Entering Math Ability: Math SAT score	Work Ethic: Homework Preparation (Always, Sometimes, Never)	Overall College GPA
Tammy	**520**	**10,0, 0**	**3.975**
Ginny	500	7, 2, 0	3.508
Linda	620	6, 4, 0	3.414
Lynn	590	6, 3, 0	3.770
Erin	600	5, 5, 0	3.267
Tonya	420	5, 4,0	3.112
Edward	560	5, 4, 1	3.297
Jason	**660**	**4, 5, 0**	**3.325**
Sara	430	2, 8, 0	3.036
Sam	580	2, 5, 2	3.031
Martin	Not taken	0, 8, 2	3.133

In the TIME 2000 Program a great emphasis is placed on demonstrating the many applications of mathematics and the interrelationships between and among the different branches of mathematics. Supplementing the coursework, guest speakers were invited to give seminars on how mathematics relates to dance, art, real estate, and so on. Such activities expanded the students' communities of learning into the professional domain. Although each of the eleven participants shared these experiences, as with all learning, they each internalized them differently and benefited from them to varying degrees. As in the learning of any subject, prior knowledge and beliefs play a critical role in the level of impact of new exposures.

As indicated in Table 4, each of the eleven participants has different interests. These interests often played out in the work that they did as students in part of their undergraduate program and in the work in which they engaged their own students when student teaching and teaching. Of the nine participants who described outside interests, all of them claimed that they incorporated their interests in their work with students (questionnaire, 2/03). Six of them were able to demonstrate this interest during their undergraduate studies. For example, the participant who loved art always made the most beautiful portfolios and designed aesthetically pleasing worksheets and activities for students during her methods and student-teaching courses. Such interests created other avenues for participants to excel in the program and in their future teaching.

Table 4: Participants' Interests and How Their Interests were Revealed throughout the Program and into Their Student Teaching and Teaching

Name	Interests	Interests shown as students in preservice courses	Interests shown during student teaching and teaching
Tammy	**Theatre, English, Going to NYC, summer institutes-Cyberchase**	**Always evident in lessons and projects, portfolios**	**Real-life problems have these scenarios as backdrops, uses Cyberchase, works in the drama department**
Ginny	No data available		
Linda	Puzzle books	Likes problem solving	Gives extra credit questions on tests from puzzle books
Lynn	No other interests		
Erin	Puzzles	Likes problem solving	Gives extra credit math puzzles to students
Tonya	Art	Portfolios very artistic as well as all projects	Has students incorporate art in mathematics
Edward	Films and movies	Did projects involving video projection for math lesson	Uses films where applicable in lessons
Jason	**Applications, Technology**	**Sought out applications of mathematical topics. Always applied technology in presentations**	**Uses real-life problems in student activities, incorporates computers and PowerPoint Lessons**
Sara	Reading and bike riding	Not demonstrated	Incorporates literature in math class and rates
Sam	Sports	Not demonstrated	Incorporates sports all the time as well as students' interests
Martin	Sports	Not demonstrated	Incorporates sports examples

Tammy: Her Ability and Work Ethic

Tammy is a classic overachiever. Despite the fact that her Mathematics SAT score was the fourth lowest in the group, her GPA in mathematics, in education, and her overall GPA were well above the other 10 participants. During student teaching, participants were evaluated on their knowledge of mathematics as demonstrated in the accuracy of the mathematical content in their lesson plans and the accuracy of how they represented mathematics when teaching. The rating scale ranged from 1 to 3, with 3 being the highest. From four observations, the mean scores ranged from a low of 1.67 to a high of 3.0, Tammy's mean score.

Tammy's cooperating teacher applauded her for her knowledge of mathematics and her ability to represent mathematical concepts accurately using manipulatives and technology. In the lessons for which Tammy was observed during student teaching, her mathematics continued to be represented with accuracy and precision. Geometric drawings were pre-drawn on transparencies and all units were indicated precisely and accurately.

Throughout her college years, Tammy struggled with her own high standards for herself. Many times her anxiety level brought her much distress and discomfort. In every class she took her preparation was well beyond those of her peers. As a freshman she used to explain how she would "rewrite" all of her class notes every day. Every annual portfolio that she created was "A+" quality.

When student teaching, she, herself, recognized her hard work ethic as a positive quality as she described in her final evaluation at the conclusion of her student teaching:

> One of my strengths is that I am an organized person. Another strength is that I am a determined person, who doesn't mind working hard. (5/02)

However, she also worried that her over preparation was sometimes a hindrance for her. After her first observation during student teaching she wrote,

> Despite the fact that the lesson really didn't go as planned, I tried to remain extremely flexible throughout the lesson. This is difficult for me because there is always a part of me that craves order, structure, and control. (2/02)

In both her student teaching and her teaching it was clear that her extraordinary planning was an amazing asset to her instruction. In each one of her student teaching lessons she was praised for her planning and preparation. Not only was this exemplified in the structure and sequencing of the concepts in her lessons and in her questioning and carefully planned variety of instructional strategies, but it was evident in the materials she used. For example, when she used real-life examples, she included updated pictures and materials (e.g., a real menu, a bill from a local restaurant, a real advertisement from the Internet). She also made effective use of technology (TI interactive, graphing calculators). In her evaluation of Tammy, her high school cooperating teacher wrote,

> I have never seen such thorough preparation and lesson plans as was done by [Tammy]. (5/02)

This behavior continued into her teaching when she was observed using more real-life examples and manipulatives (e.g., counter chips) with her own middle school students. Her carefully prepared diagrams that she displayed on the overhead projector and distributed to students were further indications of how meticulous she is when preparing her lessons.

In her latest questionnaire written two months into her teaching, Tammy reported,

> Teaching entails a great deal of work. I couldn't even begin to calculate how much time I put into my work after school hours to prepare for my classes...I need to discover the attractiveness, uniqueness, and beauty in what I am teaching before I profess the concepts' importance to my students' lives. At times, this requires research that I thoroughly enjoy! Regardless of the time demands, once the concepts come alive for me, I

> try to make them come alive for my students. I try to plan ahead, and generally I don't put time constraints upon myself. As long as I see the merit in what I am doing, I keep going on! (2/03)

Tammy's Interests

When Tammy entered the program she said that she had many interests of which mathematics was only one.

> Throughout high school, I never really considered myself a math person. I loved all of the subjects that I studied, but most of all I loved English and history. (06/02)

Her love for history, drama, art, English, and science probably contributes to how she embraces the many applications of mathematics.

Tammy's belief in the interrelatedness of mathematical topics was always apparent during the course of her undergraduate education. In each administration of the belief scales questionnaire, she consistently responded, "Strongly Disagree" to the statement, "Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus, and geometry)." She often wrote about her knowledge and beliefs about mathematics. In her autobiography written as a lower freshman she wrote,

> I am fascinated by how there is more than one way to analyze a problem while still ending up with an accurate solution. (8/98)

In her upper freshman year she wrote in a journal that she was

> ...fascinated by the many applications of Calculus. (3/99)

Tammy's fascination with the applications of mathematics continued throughout her undergraduate years and into her teaching. In her second homework assignment in her methods course she wrote that she was trying to

> develop and organize [her] conceptual understanding of the content of mathematics and its interdisciplinary component as it relates to a variety of other fields such as English, history, and science,

and that she perceived

> mathematics as a subject consisting of a series of connected principles and ideas that can be discovered, constructed, and explored. (9/01)

Mathematical applications became a passion of Tammy as evidenced in her portfolios each year that included multiple examples of how mathematics was related to other disciplines (e.g., the mathematics of square dancing, the mathematics of fashion). These attitudes toward mathematics transferred into goals for her students and goals for her own pedagogy. During her methods course she wrote in her second homework assignment,

> As a teacher my goal is that students learn to appreciate mathematics as an interdisciplinary subject that demands creativity, discovery, flexibility, and understanding by exposing them to its relevance, applicability and self-expressiveness. (9/01)

She also wrote,

> I want to try to convey the idea that there is not one single way to solve mathematics problems, and there are a variety of methods equally acceptable that can be employed. (9/01)

In her prelesson thoughts composed during her student-teaching in the second semester of her senior year, for the lesson that was observed by a peer she wrote,

> I strongly believe in the importance of exposing students to the relevance and meaningfulness of mathematical concepts in their everyday lives. Additionally, I want students to feel comfortable sharing their results and asking questions. Since there are a variety of acceptable ways of solving mathematics problems, I believe that students should be encouraged to explore and express their methods for solving problems. (3/01)

In her final evaluation at the end of her student teaching she wrote,

> I love to do research and make original connections to interdisciplinary ideas and I am hoping that I can incorporate this interest into my classroom teaching in some way. (5/02)

Because of all these interests, when appropriate, Tammy's lessons were replete with interesting real-life applications that captured the interests of her students as was evidenced by her teaching during student teaching and teaching. Some of the applications that provided the context for the tasks she created included: Computing tips in restaurants, modeling quadratic functions through counting high fives, the game of mathematical "Jeopardy," and depositing checks. In each of her lessons during student teaching, Tammy was consistently praised for the meaningfulness of her lessons and the real-life applications she incorporated. She was also praised for giving students the opportunity to explain multiple solution strategies. Real-life applications and multiple solution strategies were characteristics of her teaching.

In her post-lesson conference two months into her teaching Tammy said,

> I want to do all of the things I learned in the program...especially with real-life application stuff. That makes so much of a difference... With every lesson I start out with a real-life example and I really get their enthusiasm. (10/02)

Tammy's hard work ethic, combined with her interests in real-life applications were a powerful combination that contributed to the captivating tasks that she designed for her students.

Jason: Ability and Work Ethic

According to his score on the mathematics section of the SAT exam, Jason had the highest mathematics ability of the 11 participants. However, his rankings on his overall GPA, Math GPA, and Education GPA were 4th, 5th, and 8th, respectively. During student teaching, participants were evaluated on their knowledge of mathematics as demonstrated in the accuracy of the mathematical content in their lesson plans and the accuracy of how

they represented mathematics when teaching. The rating scale ranged from 1 to 3, with 3 being the highest. From four observations, the mean scores ranged from a low of 1.67 to a high of 3.0. Jason's average was 2.3. The low ratings were a result of unclear representation of mathematical concepts and misuse of mathematical language in two of his four observations. Although his mathematical representations were accurate when he was observed teaching, the way he used the calculator for his lesson on simplification of radical expressions confused students and undermined their motivation for learning the content.

Throughout his college years, unlike Tammy, Jason held a part time job, and although his work was quite good, given his intellectual potential, it could have been even better. Note also, that since English is not his native language, writing was a challenge for him. Nevertheless, on his annual portfolios he received grades of "B+," "A-," "A-," and "B+."

As a beginning student in TIME 2000, in a journal entry during freshman year, Jason admitted that he did not do enough studying for his exams. In his final evaluation, Jason admitted that teaching preparation required a great deal of time and that perhaps his side job had interfered with his work in the past. He wrote,

> To improve my future teaching of mathematics I must do lesson planning ahead of time, at least one week in advance. I am even thinking about quitting my long experienced and well-paid part-time job during weekends, so that I could spend time lesson planning. (5/02)

Although during student teaching, Jason's' level of preparation could not be compared with Tammy's (no one's could), it was certainly adequate. His lesson plans were all well structured and designed to capture the interests of his students. The weaknesses that did occur, however, might have been prevented with more planning time. That is, some of the suggestions that were outlined for improving his lessons during student teaching were: use of more hands-on materials and better motivational questions. Despite his deep interest in technology for instruction, none of his observed lessons during student teaching or teaching incorporated its use.

In his latest questionnaire written six months into his teaching, Jason claimed that teaching entailed

> more work than I anticipated. I do not get enough sleep. Sometimes I come home around 8 or 9 PM. (2/03)

Jason's Interests

Throughout his stay in the program, Jason often expressed his interests in mathematical applications. In the freshman year calculus class, against the wishes of his fellow classmates, he was always asking the professor to assign and discuss application problems. He displayed genuine excitement each time that one was presented.

Jason often wrote about his interests in mathematical applications and in technology. In a portfolio he wrote at the end of his junior year, he expressed his beliefs that applications contributed to his learning of mathematics.

> I love applications and activities in the lesson. It helps me to visually understand the concept and remember it longer. And applications make me appreciate the learning more. (5/01)

He transferred his own personal beliefs about how mathematical applications helped him learn to his goals for how he wanted to teach. For his mini-lesson in the methods course, he used a real-life context of a deadly virus for a lesson on locus. His problem statement was:

> This afternoon, government officials have announced that they have found a deadly virus in Flushing. Since this virus is not only deadly, but also very contagious, every living organism within 5 miles is asked to evacuate immediately. Where are the people who must evacuate? (11/02)

At the end of this methods course (12/01) he wrote,

> When I really enjoyed the subject was when the mathematics was in real situations and in applications. (12/01)

In his final portfolio Jason wrote,

> I want to plan my lessons to be connected to nature. The applications of mathematics are infinite and they show and explain what students are learning and what they are learning has meaning and use around us. (5/02)

Jason's interest in technology was evident throughout his undergraduate studies. He was always the one with the laptop computer, the digital camera, and other electronic devices. He was the local technological problem solver. In his junior year he chose to do a presentation using the Calculator Based Laboratory for a mathematics class. At the end of the methods course he wrote,

> I really want to bring technology into the classroom. (12/01)

In his final portfolio he wrote,

> I want to use the graphing calculator and the View Scan. Also, I want to use the motion detectors and so many other applications to the calculators will surely bring intense attention. If there is a computer lab, I want to use Geometer's Sketchpad and other software that will help the students understand. (5/02)

Although, when he was observed student teaching and teaching he did not make use of anything other than the graphing calculator, in his most recent questionnaire he explained that he has made use of many different technological tools in his teaching.

> I have used technology such as PowerPoint, TI calculator, overhead projector, Geometer's Sketchpad. They have worked fine with my classes. Students paid more attention and showed more interest. (2/03)

He wrote further,

> At this point in my teaching, I want to spend more time on technology than anything else. I truly see the future in this area and there are plenty of things to be discovered. (2/03)

Jason's love of technology has created a new avenue for him. Recently, he admitted that his original intentions were not to become a mathematics teacher, but to start a

business. He is now thinking about combining his love for teaching with technology with his business interests. He and another participant in the program, Edward, have decided to investigate the possibility of designing and publishing PowerPoint lessons. They have already designed several together that they have both used in their classrooms. There is no predicting the future for Jason. The sky is the limit.

Discussion

Similar to Ensor (2001), Steele (2001), and Wilcox et al. (1992), this longitudinal study followed preservice teachers into their first year of teaching. However, since we have worked with and observed these students since the first semester of their freshman year in college, we had the advantage of being able to follow their evolving knowledge, beliefs, goals, and behaviors through many different communities of learning: as learners of mathematics, as learners of pedagogy, as learners within the mathematics education community, as student teachers, and as teachers. Although we have a multitude of data for each of the participants, and still continue to meet with them on a monthly basis, we have only had two opportunities to observe them teaching and conference with them during the 2002-2003 academic year. Therefore, admittedly, our assessments of these participants' teaching behaviors are based on snapshots of their instructional practice. That being said, having worked closely with these participants for what has now been five years, we feel relatively confident about how much we know about their knowledge, beliefs, and goals that help us in our interpretations of their teaching behaviors. What we have learned about teacher learning is not much different from what research in cognitive psychology has reported about learning in general (Cobb, 1994; Piaget, 1952; Vygotsky, 1962, 1978). Specifically, what preservice teachers learn in college is built on and filtered through their previously held knowledge and beliefs and incorporated with their own interests and typical behaviors.

The participants in this study were influenced by their past experiences in different learning communities: as school level students, as members of the TIME 2000 Program, and as student teachers, and then teachers. Viewing the differential paths that the participants have taken on their journey to learn how to teach secondary mathematics, we have seen the role that these different experiences, as well as their initial knowledge, beliefs, interests, and behaviors have played in their learning processes. We have seen how participants who have excelled in school classes where they have strictly been passive recipients of mathematical knowledge, have had a more difficult time incorporating student-centered instructional strategies in their classes. Only through repeated college experiences that immersed them in active learning experiences did they come to acknowledge the value of active involvement for learners of mathematics. Nevertheless, their journey to student-centered teaching was more fragile and subject to regression to a lecture approach at the first sign of difficulty than participants who entered the program with a less rigid educational background.

We have also seen how participants who have specific interests and talents have incorporated these interests and abilities in their developing teaching practices. Although all of our participants came to appreciate the value of mathematics from many perspectives, as teachers they tended to focus on those areas that integrated well with their own particular interests and talents.

Interestingly however, we have seen how participants who may seem to have adopted a more passive role in their college classes, as indicated by making few comments and asking few questions during whole class instruction, appear to take more of a listener's role when they are teachers than their more outspoken counterparts who tend to do more talking and telling when they are teachers. We now question whether being quiet in class gives any indication of the student's ability to conduct a class in which active student involvement is insisted upon.

We have also seen how participants' behavior patterns as students have transferred to their behaviors as teachers. That is, participants who have consistently demonstrated a hard work ethic as students continue to do so when they are teachers. The heavy workload of a typical teacher is not much of an adjustment for them and their lessons tend to be meticulously planned well in advance. In contrast, those participants not accustomed to exerting their full effort into their studies tend to find the new teaching workload more demanding than expected and run into difficulties with their lessons that are often caused by inadequate planning. In general, we have seen that through this four-year program and post-graduate monthly meetings and semi-annual observations with conferences, all of the participants have made considerable progress in achieving a high level of student-centered instruction. Even the participant who was ranked lowest for student-centered instruction was last observed teaching a bilingual mathematics class using cooperative learning. These participants appear to be on a promising path that we intend to follow over the coming years.

Implications and Closing Comments

After following this small group of participants so closely for the past five years we have learned a great deal. We have seen the effects of offering preservice teachers a program that builds on their strengths and interests. We have seen the effects of maintaining ongoing support as they take their difficult journey of learning how to teach.

Most of all, we have seen how resistant to change are past behaviors and beliefs. Such cognitive scientists as Brown (1975) and Flavell (1973) have indicated the importance of metacognitive strategies in learning. While they are undergraduates, participants in the TIME 2000 Program are routinely asked to reflect on the instructional strategies they are experiencing as learners, evaluating the potential for use in their future teaching practice. Furthermore, during student teaching they are required to engage in structured reflective activities regarding their lessons and their cognitions with regard to these lessons (Artzt & Armour-Thomas, 2002). We have seen how all of these reflective activities have heightened our preservice teachers' awareness of the effects of different learning and teaching strategies and have facilitated their own personal understandings of the positive effects of being actively involved in one's own learning.

The implications of the themes that have emerged from this study are many for preservice secondary mathematics teacher preparation programs. Early identification of participants in the program is essential. Such early involvement allows for engaging participants in carefully designed and sequenced learning experiences over the course of many college semesters and opening the doors for their participation in other learning communities (e.g., professional organization conferences; real-world mathematics community). Teacher preparation candidates should be given the opportunity to study,

write about and reflect on these learning experiences as a context for forming ideas about best practices in teaching.

Moreover, programs should provide opportunities for teacher preparation candidates to incorporate their unique interests and talents. The full potential of future teachers can only be realized if they are given an outlet for expressing their special abilities and inclinations. Such experiences will not only make them better teachers but will sustain their interest in becoming teachers.

Finally, ongoing dialog and support is essential between and among candidates and instructors. Teacher preparation candidates need to have a support system that encourages the taking of risks and creates a venue for interpretation when the attempts fail. The road to learning strategies for student-centered teaching is complex and fraught with pitfalls. To forge forward, beginning teachers need to be convinced that the road ahead is worth taking and that the path is not always smooth. For this to happen a strong foundation must be built and a support structure must be available at all times. Given these conditions, there is a greater likelihood that student-centered instruction can be incorporated into the teaching styles of the infinite variety of people who enter mathematics teacher preparation programs regardless of their previous deep-rooted beliefs, experiences, behaviors and interests.

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