Blending Mathematics Learning With an Early Field Experience: What Do Prospective Elementary School Teachers Learn?

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Paper presented at the Annual Meeting of the American Educational Research Association, April 2003. Chicago, IL.

This paper is based upon work supported by the National Science Foundation under Grant #9979902. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Mathematicians and mathematics educators have begun to recognize that the mathematics of the elementary school has an intellectual richness that has often been underestimated in the past (College Board of Mathematical Science, 2001). As researchers, including Ball (1990) and Ma (1999), have demonstrated the profound understanding necessary to teach the subject, mathematicians and mathematics educators have worked to develop courses to teach this understanding to prospective teachers (PSTs). This effort has proven to be a challenge not only because curriculum for these courses is limited but also because many PSTs do not appreciate the mathematics they are being offered (Philipp, Thanheiser, & Clement, 2002). Most have grown up in classrooms in which the emphasis is on a procedural approach to mathematics and have come to accept this approach as the norm.

Some PSTs need only a stimulating mathematics course to help them come to value and embrace a conceptual approach to mathematics. When they work with their classmates on interesting problems and engage in discussions about the variety of ways that problems can be solved, they develop a new orientation to mathematics (Ebby, 2000). Even when students change their views about mathematics as a result of coursework, they often have difficulty translating this new view into practice when they start teaching (Wilcox, Schram, Lappan, & Lanier, 1991).

Some PSTs fail to develop an appreciation for mathematics despite the engaging and comfortable learning environments that their instructors provide for them (Ebby, 2000). Many PSTs disregard mathematics because they find it irrelevant and difficult to learn. Some have been demoralized as a result of past mathematics instruction. Few have found mathematics empowering or the site of creativity. When they come to their university mathematics courses, some prospective teachers go through the motions of learning the material so that they can pass the course and proceed with their studies and fail to develop the appreciation and conceptual orientation to the subject that their instructors are hoping to cultivate

Practical experiences that go along with mathematics courses may stimulate more lasting change than a course alone. Practical experiences may persuade reluctant students that their university mathematics course is worthy of their attention. The practical

experiences may help them come to see how mathematics is taught, how children learn mathematics, or both. When they witness mathematics in action in school settings, prospective teachers may come to see their mathematical study as relevant and important. Although practical experiences seem to support PSTs' mathematical learning, the issue requires careful consideration. Several teacher educators, beginning with Dewey, have cautioned that practical experiences are not always educative or, in other words, do not always stimulate growth (Erdman, 1983; Feiman-Nemser & Buchmann, 1985; Zeichner, 1992). Before assuming that practical experiences should be incorporated into mathematics courses, educators should more closely examine the constraints and affordances of practical experiences.

The practical experience we explore in this paper was called the Mathematical Observation and Reflection Experience (MORE); in the MORE, PSTs in their first mathematics content course for teachers visited elementary school classrooms to observe mathematics teaching and then wrote reflections that were based on their observations. The MORE differed from the field experiences often included in other parts of teacher preparation programs. The MORE was intended to contribute to PSTs' understanding of and appreciation for mathematics whereas other experiences are designed to provide PSTs with opportunities to develop teaching skills. The MORE is in keeping with the California Commission on Teaching Credentialing recommendations (CCTC, 1998), which call for integrating subject-matter preparation with professional studies. The effects of early field experiences that accompany mathematics methods courses have been documented (e.g., Ebby, 2000; Mewborn, 1999). In our review of the literature we could not find studies of early field experiences that accompany mathematics courses, although we did find evidence that this practice is becoming increasingly common (e.g., OCEPT, 2000). We thought that systematically researching this practice, which seems on the surface to be a promising one, was important.

We use the frame of situated cognition to analyze the constraints and affordances of visits to elementary school classrooms as a site for learning. Next we describe and analyze the practical experience to determine the effect it had on the prospective teachers. We consider the degree to which the experience helped to authenticate various aspects of the mathematics class in which the prospective teachers were enrolled at the time. We consider the variation in prospective teachers' reactions to the experience and, finally, the extent to which prospective teachers developed the conceptual orientation that the mathematics course was intended to cultivate.

Situated Perspective Toward PSTs' Learning

Attention to authentic tasks in education is due in part to the failure of school learning to transfer to out-of-school situations. Researchers, operating under what has been called the *situative perspective* (Greeno, 1997), have noted the powerful learning that grows out of informal contexts, contrasting it with the impoverished learning that can result from formal school contexts (Brown, Collins, & Duguid, 1989; Lave, 1988). From the situated perspective, one draws attention to identity, environment, and practices as well as to authenticity, and these aspects of the MORE will be considered here.

Authenticity is of particular importance to preservice teacher preparation because many prospective teachers assume that their university course work will be of little value to them as teachers. Weinstein (1989) found that most PSTs have an *optimistic bias* toward teaching; that is, they assume that they enter their university programs knowing what they will need to know to teach. Book and Freeman (1986) found that most PSTs believe that the bulk of their learning will occur in elementary school classrooms, especially during their student-teaching experiences. Many fail to transfer what they learn in their course work to their teaching (Wilcox, Lanier, Schram, & Lappan, 1992). One would hope that engaging prospective teachers in learning that they deem authentic to teaching would help them find something of value in their university course work. In this sense, practical experience can serve to authenticate course work or, in other words, to demonstrate that the concepts being explored in the university course work are *real* in the sense that practicing teachers actually use them in their classrooms.

Part of becoming an expert practitioner is developing the identity of the practitioner, including the ways that practitioners talk and the specific vocabulary they use, their ways of interacting with one another, the way they dress and act, and so on. When apprentices participate in a real community, they have a role and develop an identity while they work alongside more experienced and skillful practitioners. Apprentices begin to feel like practitioners because members in the community begin to treat them as though they are practitioners. In the case of PSTs, this experience is particularly important because they know the environment in the role of students but have spent little or no time in the role of the teacher. We hope that part of a PST's evolving identity as an elementary school teacher includes an identity as a reform-minded mathematics teacher, specifically one who feels competent. In particular, we hope that the PST takes on the role of facilitator rather than authority, helping students to determine the correctness of their thinking rather than making the determination for them.

An important dimension of authenticity is what Barab, Squire, and Dueber (2000) called *ecological authenticity,* to refer to learners' tasks that are "embedded in ongoing

activity within the ecological niche in which the real-world practitioner functions" (p. 4). *Ecological niche* is a particularly appropriate metaphor for the elementary school classroom, because it captures the complexity of that environment. When 20–35 children are together in one room, a host of dynamics to which a novice might attend are found. Each child is unique, with distinct personality, learning style, and intellectual strengths. Children interact with one another in a variety of ways, some of which are related to the learning task at hand and others that are not. Interactions between the teacher and the students have various features, including tone, purpose, and content. Various teaching resources—blackboards, base-ten blocks, white boards, and so on—are available for the teacher to employ. The furnishings and organization of the classroom present another interesting feature. When apprentices enter this complex environment, they are bombarded with stimulation, and one challenge in helping them to learn in this environment is helping them to focus their attention. Although the complexity of the elementary school classroom makes it authentic and compelling, it also provides a constraint on learning. Given the breadth of stimulation to which the PSTs might attend, what the PSTs learn from their visits may not contribute to their learning in the university mathematics classroom but may, instead, be related to other aspects of the classroom environment.

Participation in authentic activities affords apprentices opportunities to develop the kind of thinking required of practitioners. In elementary school classrooms, the activities in which PSTs might participate include helping individuals while they complete mathematical tasks, leading small groups in mathematical activities, or watching while the teacher presents an explanation of a concept. The activities to which the PST is privy depend on both the nature of the instruction in the classroom and the amount of responsibility the teacher is willing to share with the PST. If the PST is engaged only on the periphery of teaching, then he or she may neither have the opportunity to experience the full extent of the cognitive demands of teaching nor come to appreciate the importance of mathematical understanding in teaching.

When PSTs visit elementary school classrooms, they have opportunities to experience a familiar environment from a new standpoint, to begin to imagine themselves in the teacher's role while they consider their teaching identities, and to engage in the thinking activities of the practitioner. The opportunities afforded by their visits may serve to authenticate their university course work, in particular their mathematics classes. The PSTs might value the opportunities but not relate their learning to the mathematics class at all. When mathematics educators consider ways to bridge the worlds of the university and the elementary school classroom, they must examine the options available to them and determine what PSTs learn from each option. In this paper we examine the option of

visiting elementary school classrooms so that we can promote a better understanding of the constraints and affordances of this experience. The following questions guide our examination:

What do PSTs learn from being in elementary school mathematics classrooms early in their academic careers?
Do they begin to see the knowledge that they develop in the university mathematics classes as valuable to them as teachers?
Does the experience help them to develop a conceptual orientation toward mathematics?

Method

Participants

This study is a part of a larger research project, Integrating Mathematics and Pedagogy (see Philipp, Clement, Thanheiser, Schappelle, & Sowder, 2003 for more details), designed to study the effects of different kinds of field experiences. The 48 PSTs in this study were among the 159 project participants, students in their first mathematics content course for prospective teachers at a large regional university in Southern California. The PSTs, equally distributed across the 12 sections of the mathematics course, volunteered to participate in the larger research project and were randomly assigned to this study, which lasted for one semester. They were generously compensated for their participation.

Observation Format

University personnel found placements for the 48 PSTs who visited elementary school classrooms and watched a mathematics lesson once a week for a period of 14 weeks. Two types of placements were used. Twenty-three of the students were placed with teachers who had been selected on the basis of their knowledge of reform practices and were called the *reform* group—MORE-R. The other 25 students were placed with teachers whose schools were convenient to the university campus. We called this *traditional* group MORE-T because the district had a reputation for employing traditional drill-and-practice worksheets. We recognized that some teachers in this sample might be employing reform-minded practices. After the first 7 weeks of the semester, the PSTs received a new placement in a grade level different from the first they had visited. The MORE-R group continued to visit reform-minded teachers and the MORE-T group continued to visit conveniently located teachers. Visits were scheduled during the PSTs' free time. The teachers were recruited to participate in the study and were informed that PSTs would be visiting their classes. They were not asked to change their teaching practice in any way to accommodate the observations. We asked the teachers to decide the extent to which the

PSTs interacted with children in the classroom. They were provided with a small monetary gift for their participation in the project.

Data Sources

We collected three kinds of data: beliefs-survey responses, content-assessment responses, written reflections on the classroom visits, and individual interviews.

Beliefs survey. At the beginning and the end of the semester, all participants in the large-scale study completed a computer-based survey that assessed their beliefs about mathematics and mathematics teaching and learning. All items were open-ended and were situated in elementary school contexts (see Appendix A for a sample item). Survey responses were scored according to rubrics, and the rubrics were aggregated to yield a score on each of seven beliefs (see Appendix B for a list of beliefs assessed the survey was designed to assess). Responses for 20% of the participants were scored by two coders and interrater reliability exceeded 80%. Pre and post scores were used to determine change scores for each belief (for more information on the survey, see Ambrose, Philipp, Clement, & Chauvot, in press; Clement, Chauvot, Philipp, & Ambrose, in press).

Content instrument. At the beginning and end of the semester, all participants in the large-scale study completed an instrument designed to assess their understanding of the principles underlying the base-ten number system, rational numbers, and operations on whole number and rational numbers, central topics in their mathematics course. The items were open-ended and were scored according to rubrics. Pre and post scores were used to determine growth in mathematical understanding.

Written reflections. Within a week of each observation, each participant submitted a written reflection consisting of a description of the mathematics lesson observed and responses to several questions about the activities of the teacher and students during the lesson. Project personnel read each reflection to ensure that it was clear and complete. PSTs were occasionally asked to rewrite reflections. For the 7th and 14th reflections the PSTs responded to additional prompts for a summary of what they had learned and a reflection on how the visits had affected their experiences in their mathematics course, their thinking about becoming a teacher, and their thinking about mathematics instruction.

Interviews. During the semester when the PSTs were participating in the MORE, we analyzed all PSTs' 7th written reflections as a basis for choosing six target students to interview. In choosing PSTs to interview we first considered the nature of their written reflections. We wanted to talk with PSTs who would be forthcoming about their experiences and would be able to articulate their interpretations of their experiences. Then we looked for a range of responses to the MORE at that point in time. Two PSTs wrote emphatically in their written observations that they saw little or no connection between the

MORE and their mathematics course. We wanted to find out more about which experience they considered to be inauthentic and why they held that view. Two expressed excitement about what they were seeing in the classrooms, and we wanted to learn the source of their excitement. The other two PSTs saw some advantages and disadvantages to visiting classrooms, and we were interested in their balanced responses. We also had access to the interviews of three other PSTs who had been randomly chosen for interviews for the larger study. We felt that our target sample of 9 PSTs represented a fair cross section of PSTs in their responses to the MORE.

In the interviews, conducted during the 10th week of the semester, we asked the PSTs about the nature of the lessons being taught and how similar these lessons were to their own elementary school experiences. We asked them to describe the role of the teacher in the classroom and their roles as observers. We asked them to discuss what they were learning about how children learn mathematics and how the MORE related to their university mathematics class. On the basis of their written reflections, we formulated individualized questions to further probe some of their observations. The interviews were audiotaped and transcribed.

Analysis Quantitative data from the beliefs survey were used to determine whether the MORE groups performed differently from one another and differently from their peers in the mathematics class in terms of developing a conceptual orientation toward mathematics. Individual participants were assigned change scores representing either *no positive change, a small positive change,* or *a large positive change* between their presurvey and postsurvey scores. Each participant received one change score for each of seven beliefs. Because the data were ordinal instead of interval, distribution-dependent tests were not appropriate. Instead we analyzed the change scores using a polychotomous log-linear odds ratio using the ordered logit procedure in the STATA software package; *p* values were shared across pairwise comparisons using the Holms procedure.

Quantitative data from the content instrument were used to determine whether the MORE PSTs developed greater understanding of mathematics than the control group; 6 pairwise comparisons were performed comparing MORE-T, MORE-R, and control students' scores. We performed *t*-tests using change scores from pretest to posttest.

To determine what the PSTs had learned from visiting the classrooms, we used an emergent coding process on the 7th and 14th written reflections of all the MORE PSTs. The entire set of papers was read; dominant issues were identified and became codes. The entire set was reread, and passages related to the dominant themes were identified. In addition, other issues not addressed by the codes were identified. When two PSTS identified the same issue, a code was assigned to that issue. To ensure that the issues had

been properly coded and to find representative samples of the text related to specific issues, a final reading of the entire set was completed. Results of the coding were compiled in a spreadsheet to allow for cross-referencing, tallying, and examining of patterns in the sets of themes identified for individuals.

We used the interview data to confirm the results of the analysis of the written reflections. In addition we developed cases of each of the 9 PSTs who were interviewed to better understand their interpretations of the experience. We developed cases by first reading and rereading each of the 9 target PSTs' 14 written reflections. We then summarized the reflections to determine the nature of the lessons the students had observed and their interpretations of these lessons. We noted whether children in the observed classrooms spent most of their time working independently on routine problems or were engaged in problem-solving/exploration-type activities and whether children had opportunities to generate their own solution strategies, to explain their thinking, and to use tools. From these summaries, we determined whether the PSTs had seen reform-oriented teaching practices, traditional teaching practices, or a combination of reform and traditional practices, which we called *eclectic*. We characterized the level of teaching responsibility that the PSTs reported having in the classrooms. For each person, we developed a narrative on the basis of the interview transcripts, written reflections, and responses to the beliefs survey. We noted the mathematical activities and the nature of the instruction that the PST had observed, the effect the observations had on his or her thinking about mathematics teaching and learning, and the belief-score changes evident on the beliefs survey. In writing about the PSTs' experiences, we use pseudonyms so that readers can keep track of both individuals and the whole group.

Results

Performance on Beliefs Survey and Content Instrument

We begin by considering group differences in performance on the content and beliefs instrument. Changes on the content instrument showed that the MORE–R participants performed similarly to the MORE-T PSTs and that each group showed smaller gains than the control group. Visiting classrooms did not give the PSTs an advantage on the content test.

Table 1
Performance by Group on Content Instrument

Treatment	Pretest average	Posttest average	Average change score (Standard deviation)
Control	37.6	50.4	12.8 (8.08)
MORE-R	38.7	49.9	11.2 (7.98)
MORE-T	32.3	44.6	12.3 (7.69)

Note. Pretest and posttest scores are from 82 points total.

Each of the two MORE groups was compared to the control group in performance on the beliefs instrument. No significant differences among performances of these three groups were found on any of the beliefs. The lack of statistical difference may have been due to the small group sizes. Some general trends in the beliefs data warrant attention. Two beliefs will be considered to illustrate these trends. Belief 3 is "Understanding procedures is more powerful and generative than remembering procedures."

This belief was assessed using two items. In one item, PSTs were asked (a) to compare the standard subtraction algorithm to an alternative algorithm, (b) to discuss the understanding needed to use each approach, and (c) to predict whether children would be successful using each approach. On the other item used to assess Belief 3, PSTs were asked how a teacher should teach division of fractions. PSTs' scores on these two items were compiled into a final score. Their final pre and post scores on this belief were compared to yield a change score. More PSTs in the MORE-R group than in the other two groups had increases in their beliefs scores (see Figure 1): 65% of the PSTs in the MORE-R had some change in their beliefs scores whereas only 35% of the control PSTs' and 40% of the MORE-T PSTs' scores changed.

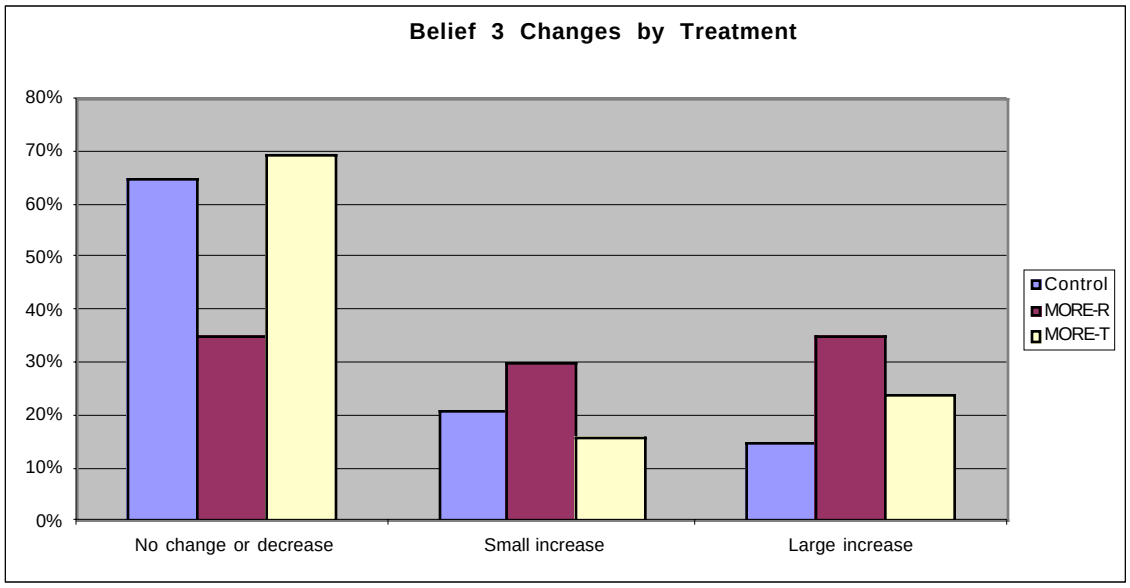

Figure 1. Performance by group on Belief 3 of beliefs survey.

For Belief 6, "The ways children think about mathematics are generally different from the ways adults would expect them to think about mathematics. For example, real-world contexts, manipulatives and drawings support children's initial thinking whereas symbols often do not," PSTs responded to 3 items. In the first item, they were asked whether first-grade children could solve particular story problems. In the second item, they were asked to rate the difficulty of four fractions problems, one of which was set in a context. The third item was used to assess both Belief 3 and Belief 6: PSTs were asked how they would teach division of fractions. Figure 2 shows the change scores for this belief and shows that none of the students in the MORE-T group had a *large increase* on scores for this belief. In addition it shows that 50% of the PSTs in all three groups failed to change their scores on this belief.

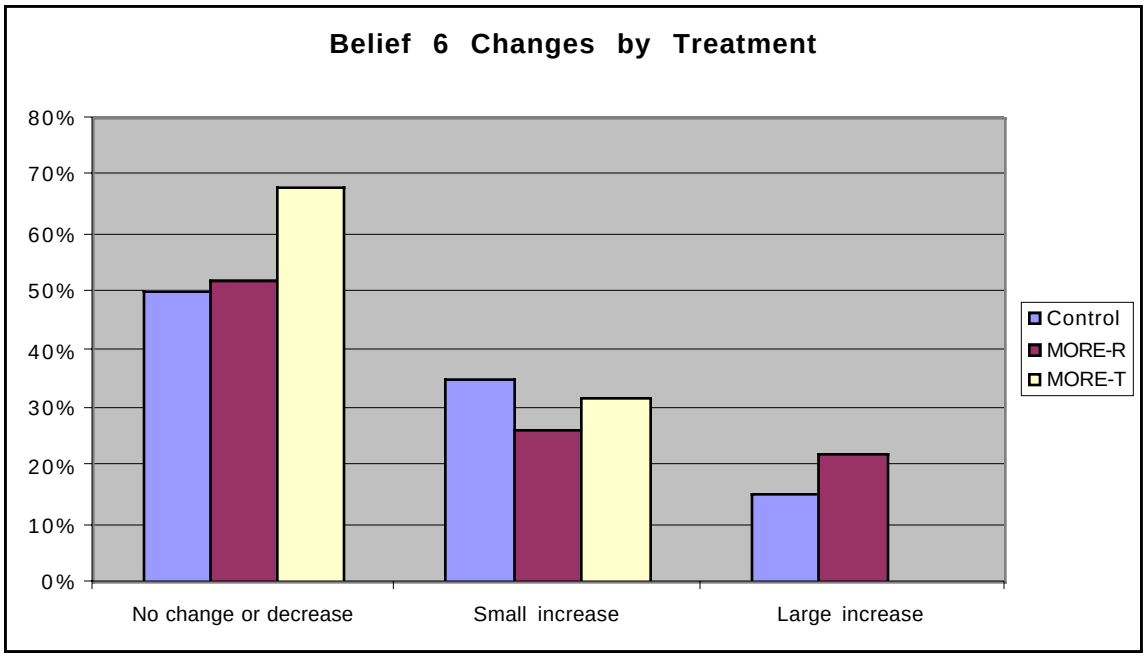

Figure 2. Performance by group on Belief 6 on the beliefs survey.

In comparing the performances of the three groups on the beliefs survey, we compared the percentages of PSTs in the *large increase* group. We noted that the MORE-R group outperformed the MORE-T and the control group on all but one belief. The control group outperformed the MORE-T group on five of the seven beliefs.

Another way that we compared the beliefs-survey change scores was to examine the number of beliefs that that showed score change for each individual. Table 2 shows that the majority of the control group and the MORE-R group (58.82% and 52.17%, respectively)

showed changes in their scores on at least three of the seven beliefs. The MORE-T group tended to change on fewer beliefs, with the majority of the MORE-T PSTs changing on two beliefs and only 16% changing on at least four beliefs.

Table 2
Number of Beliefs for Which Beliefs Scores Changed, by Group

Changed on at least:	Control	MORE-T	MORE-R
One belief	94.12%	88.00%	95.65%
Two beliefs	79.41%	84.00%	82.61%
Three beliefs	58.82%	40.00%	52.17%
Four beliefs	44.12%	16.00%	39.13%
Five beliefs	26.47%	8.00%	30.43%
Six beliefs	2.94%	0.00%	17.39%
Seven beliefs	0.00%	0.00%	8.70%

Visiting reform classrooms helped PSTs more than attending a university class without visiting classrooms in developing a conceptual orientation toward mathematics. Visiting traditional classrooms inhibited the PSTs from developing a conceptual orientation. In general, the performances of all three groups were disappointing.

Connection to University Mathematics Class

In contrast to the somewhat disappointing outcomes of the content test and the beliefs survey, the outcome from the points of view of the PSTs was that they found the visits to be beneficial in a variety of ways. In the reflections 38 (79%) of the PSTs wrote in at least one of the two summative reflections that they saw connections between their classroom visits and the mathematics class (see Table 3). Some of these comments were quite enthusiastic:

> Sometimes one thinks that the stuff learned in math class is bogus, but by observing in schools, you can see the things we've learned in Math 210 in action.

> The visits have affected my thinking about Math 210 because I can see why we are learning the material in the class. I noticed what I was learning in Math 210 is what students in the 3rd-grade class were also learning. I now know that Math 210 is not just some math class that we have to take, but it will help in the long run for teaching.

The above quotes are representative of the writing of many PSTs who noted that without the visits, they would have doubted the relevance of the mathematics class.

Table 3

Comments (by Numbers of PSTs) on Connections Between Classroom Visits and Mathematics Content Course

Summative reflection number	Mentioned connections	Said saw no connection	Made ambiguous comments about connections	Did not comment on connections
7	33	6	3	6
14	31	5	2	10

Many of the PSTs who saw connections between the visits and the mathematics class wrote about the power of applying the concepts from the mathematics course to the elementary school classroom.

> This experience puts everything that I learned in Math 210 into a real-life situation where I could apply it and see it applied.

Other PSTs described how the visits helped the material to "come to life" when they saw concepts explored in the university classroom one day and in the elementary school classroom the next day; some noted that seeing the concepts being taught was better than hearing, second hand, about how they would be taught.

One element of the university mathematics class was a consideration of the variety of ways that children invent to solve problems, and the classroom visits allowed some PSTs to see these strategies being used by children.

> When we learned about the kids having 3 different ways of solving a problem, I didn't think much of it, but then when I actually saw it in class with the kids, I couldn't believe it.

> Before that point it was like any math class where you just solve equations and take tests, but the first time I saw one of those concepts in real life and a child actually using the methods we talked about in class, I just about fell off my seat.

> When looking at examples in class, I sometimes wonder if the examples were actually written by a student, but I found out by these visits the students are capable of breaking down problems and solving them in many different ways.

Some PSTs found that observing in the classrooms helped them to better learn the material from the mathematics class.

> I have been lost a few times during the class and then by going to Mr. A's class when they are doing the same things, it helps clear up what I may not understand.

> I really liked to learn something in my Math 210 class and then see it in the classroom. It helped me to remember and understand what we were learning.

Although most PSTs found connections between their classroom visits and their mathematics course, 13 (27%) wrote, on at least one reflection, that they saw no such connections, stating, for example, "The classroom visits have not affected my thinking about Math 210." A few PSTs noted that the mathematics at the grade level they observed was not what they were studying in the mathematics course (for example, some visited classes studying geometry). For a few PSTs, grade-level preference prevented their making connections between the university mathematics class and the classroom visits. They dismissed the mathematics class because they planned to teach only young children. They assumed that the content was irrelevant to them because they believed that the curriculum for young children is simple. One PST wrote,

> I know that I want to teach anywhere from Kindergarten to Second grade. I now know that they are not learning some of the concepts that Math 210 is teaching me. Some of those concepts are too difficult for me to learn, let alone for children to learn.

One PST noted that the teacher she visited did not teach mathematics lessons but had the children complete worksheets; thus the PST saw no connections to her course. Another PST saw no connections because the language she heard the classroom teacher use was not the vocabulary (part-part-whole, base ten) used in her university mathematics class. A few of the PSTs wrote that they had already learned the content of the mathematics course and so found it "useless," and the classroom visits did not change their opinions on this issue.

PSTs' Perceptions of What They Learned From Classroom Visits

In their summative reflections (7 and 14) PSTs responded to questions designed to determine how the they had been affected by their classroom visits. They were asked specifically what they learned from the visits, how the visits had affected their thinking about becoming elementary school teachers, and how the visits affected their experiences in their university mathematics course. The PSTs' responses about the visits encompassed a

wide range of issues, some general issues related to their future teaching careers and some specific to mathematics. (See Table 4 for an overview of the most frequently cited issues.)

Table 4

Issues Cited Frequently by PSTs in Their Summative Reflections

Issues	Numbers of PSTs who raised the issue		
	MORE-R (n = 23)	MORE-T (n = 25)	Total (n = 48)
General Teaching Issues			
Grade-level teaching preference	13	9	21
Relationships with children	6	9	15
Management	6	7	13
Complication of teaching	5	6	11
Satisfaction of affecting children's learning	3	6	9
Mathematics Issues			
Differences in ways children within a classroom learn mathematics	8	10	18
Variety of ways to teach mathematics	1	10	11
Hands-on activities	4	8	12
Benefits of eliciting ideas from students over providing answers	7	3	10
Difference between observed mathematics instruction and PSTs' childhood experiences	6	3	9

General teaching issues. The most common issue raised among the PSTs related to the grade level the PST might prefer to teach. This issue was raised by 21 (44%) of the PSTs. One student wrote

> These visits have been extremely helpful. They have taught me the differences between younger and older elementary school children. They have made me want to work with the older children.

The MORE experience was credited by 3 PSTs with broadening their perspectives on the grade level they would like to teach and by 7 with helping them decide which grade they would like to teach. Through the experience, 3 PSTs changed their choice of grade level to teach and 3 others decided on grade levels they did not want to teach. The others among the 21 PSTs wrote that the MORE helped them better understand the differences among children of different ages.

Comments about grade-level teaching preferences were unsolicited, but we did place the PSTs in two different grade levels to give them the widest possible exposure to the elementary school mathematics content. The chance to compare children of different ages may have contributed to the prominence of the grade-level teaching-preference issue.

In reflecting on their visits 15 (30%) PSTs discussed issues of emotional attachments between teachers and their students. Some had observed the close teacher/student relationships in the classrooms and found them to be inspiring

> After watching Mrs. D teach, I definitely want to become a teacher. She inspired me the way she bonded with her students and how all of her students loved and respected her so much.

> The satisfaction of helping kids is rewarding, and seeing how close the teachers and students can get is a really special experience. I walk into these classrooms and feel like it is where I need and want to be.

Others noted that they had formed close relationships with the children in the classrooms they visited and enjoyed the observations because of these bonds.

> I had a blast with each and every one of these kids, and I actually didn't want to leave them on the last day.

> It was fun being in this class because I really enjoyed the kids. They actually got to know me pretty well, and they were even sad that we weren't coming back"

> This was my last observation with the first graders. It was a little sad because I had come to love these kids. I knew them and they knew me.

Of the 15 PSTs who mentioned emotional attachment, only one mentioned how mathematics could enhance the bond between students and their teacher. This PST noted

> The relationship I see between student and teacher is extraordinary. She knew her students very well and was able to detect when there needed to be further discussion of a particular skill. … The class has come up with many distinctive names for specific things they do in math. It has provided almost an exclusive relationship between students and teacher. Once again this is a form of Mrs. R's bonding with her students.

For the other 14 PSTs who noted emotional attachment as an issue, it was separate from mathematics. One noted that she made a conscious effort to keep the two issues separate so that she "was able to get the most from the experience with the kids."

Class management was an issue raised by 13 (27%) PSTs, several of whom noted that management was one of the most important things that they had learned. One wrote

> I have learned that the most important thing in a classroom is the way it's controlled. If the teacher is in control and the students know that, then there is a lot that can be accomplished.

Some PSTs noted that they had learned specific management techniques, for example, "how to handle children and what kind of tone of voice is appropriate." A few noted that unruliness in the classrooms they visited had prevented their seeing mathematics teaching.

> The teacher spent most of his time disciplining the students, and very little time was spent actually teaching the students.

Another general teaching issue raised by several PSTs was related to the complexity and difficulty of teaching; 11 (23%) PSTs wrote that they were aware of the many components of a teacher's work. Some mentioned witnessing the "juggling" that teachers have to do, that the job was trying and required patience. Some wrote about amount of time that teachers put into their planning and the limited time that they had to themselves.

An issue raised by 10 (21%) PSTs was the satisfaction they felt in helping children to learn, a highlight of their experiences for some. One felt proud when a student shared with his classmates an approach to comparing decimal numbers and attributed the approach to her. Of this experience the PST wrote

> Having Daniel acknowledge me in his explanation was an incredible feeling. It was more rewarding than many things I have ever felt.

Others wrote more generally about their experiences in helping children:

> It's a great feeling to get through to a child and have them understand a certain problem you're trying to teach them.
>
> It was such a wonderful feeling to be needed by the students.

Among the 48 MORE PSTs, 44 (92%) raised at least one of these general teaching issues in their reflections, and for 10 (21%), the bulk of their learning was about general teaching issues. The MORE-R and MORE-T groups differed regarding general teaching issues only in satisfaction in helping children learn, perhaps because in most of the reform classrooms emphasis was not on generating correct answers using proscribed procedures so the PSTs had few opportunities to help children. The children were expected to solve problems for them themselves and to communicate with their classmates; the PSTs were not supposed to show them how to solve problems.

Issues related to mathematics teaching. Of the 38 (79%) PSTs who mentioned issues about mathematics teaching and learning in their reflections, 18 (37%) commented on having learned about the variation in how children learn mathematics. Of these 18 PSTs, 8 (17%) noted that the variation teachers encounter comes from children's having different ways of thinking about problems. The following comments are representative of that group:

> One main idea that I learned was that children all learn differently, and it is good to go over several ways to answer a problem so they can all learn.
>
> Each student views math in a different way. It is okay for students to understand the math different from each other. They each seem to get the subjects in different ways.

In this group, 14 (29%) PSTs noted that some children learned mathematics more readily than others, and 13 of these 14 PSTs mentioned that this variation in learning is the factor that would make mathematics instruction particularly difficult.

> Each student learns at their own unique level, and it's important to focus on where each student ability level is at.

> Math instruction is not as easy as it seems. Some kids learn it quickly, and others are very slow.

> What I have learned during these last seven visits is that the mathematics covered may seem so easy and comprehendible to an adult, but to a first grader the math at first might be like learning a new language for the first time. Some students pick up on math easily while some still work hard at it to understand what they are doing.

Related to variation in student learning, 12 (25%) PSTs noted variation in approaches to teaching topics in mathematics. Several PSTs did not elaborate on this idea but stated simply, "I have learned different ways to teach kids math." Others were more specific:

> Basically I learned as a teacher you have to be flexible. Not all kids learn the same way or at the same rate, so you have to accommodate that. Being creative is a big help because if one kid doesn't understand what you are trying to say, you need to be able to think of another way to explain it that will make sense to him.

> I have learned that math can be taught in a variety of ways. I have always thought of math as a regulated system, but I saw that math can be creative and fun.

PSTs in the MORE-T group (10), more than those in the MORE-R group (1), tended to mention teaching mathematics in a variety of ways. Among those who explained further, several noted the value of presenting material in a variety of ways and having several explanations for the same concept. This view reflects the role of most MORE-T teachers: explaining procedures. The teachers in the MORE-R classrooms tended to facilitate the children's discussions of mathematics. PSTs in MORE-R classrooms saw children engaging in a variety of activities, not teachers explaining procedures.

A mathematics-related issue raised by 12 (25%) PSTs was hands-on activities. A few of the PSTs mentioned that they saw hands-on activities in the classrooms they visited. Most PSTs who mentioned hands-on activities briefly commented on their importance: "These last seven observations proved to me that hands-on activities are what make learning fun." A few explained why they consider manipulatives to be important:

> I prefer math when it involves more hands-on learning because I think that rows of problems get repetitive and boring, and kids may develop a pattern instead of really learning the material.

> I think it helps them understand so much more when they are learning hands on. Instead of having a teacher stand in front of the class and go on about math problems, it helps the student recognize the answer to the problem and the steps it took for them to get it.

We noted that twice as many PSTs in the MORE-T group as in the MORE-R group mentioned hands-on activities, but we are uncertain of the reason for this disparity. This fact indicates that manipulatives are becoming increasingly common in classrooms and that PSTs are interested in using them.

Teachers' questions and the important role they play in promoting mathematical thinking was noted by 10 (21%) PSTs. Some wrote that questions help engage students. Others wrote about how questions promote thinking and understanding.

> I have seen that if the teacher asks the students what they know or how to do a certain method, it challenges them much more so than if they just tell the students and don't give them a chance to think and stretch their minds.

> I noticed that when a student would ask the teacher a question he would answer him/her with a question. This helped the students to really think and not just ask questions expecting answers.

Some of the PSTs noted that teachers can use questions to assess children's understanding.

> I have learned the benefits of asking the children to explain how they got their answers. Just because they got the right answer doesn't mean they understood the problem.

The importance of eliciting children's thinking was noted by 7 of the MORE-R PSTs but by only 3 of the MORE-T PSTs. The MORE-R teachers tended to ask their students to describe their thinking, and one third of the MORE-R PSTs noted the importance of this practice.

The other mathematics-teaching issue raised by several PSTs was raised by 9 (19%): the difference between how mathematics was taught in the classroom they visited and those they had attended as children. Some noted that the expectations for children were more rigorous than they remembered.

> The main thing I learned is that math has changed a lot since I was in elementary school. These kids were introduced to concepts I didn't see until I was in seventh grade.

Others noted that the classrooms they visited were more stimulating than the ones they remembered and that teachers placed more emphasis on multiple approaches.

> I saw how math was taught in a fun way, a way that I would have liked to have learned math. I never had a bad math experience, but I understand why these kids are excited for math.

> When I was in elementary school we were taught to memorize and use standard algorithms and not to explore our sense of numbers and value.

The differences between their own mathematics learning experiences and those they observed were noted by 6 of the MORE-R PSTs and 3 of the MORE-T PSTs. The MORE-R PSTs were more likely than the MORE-T PSTs to see practices that differed from those they had experienced, but few of them noted the differences in their writing.

The other mathematics-teaching-related issues raised by the PSTs in their reflections included students' having more opportunities to share their thinking and ask questions (8 PSTs), the difficulty of mathematics teaching (8), increased comfort with the idea of teaching mathematics (6 PSTs), underestimation of children's mathematical abilities (7 PSTs), the value of multiple solution strategies (4 PSTs), and the importance of repetition in teaching mathematics (4 PSTs). The only issue troubling to us was the last one. For the most part, the PSTs were attending to elements of mathematics instruction that would contribute to effective instruction in the future.

Commitment to becoming a teacher. In addition to asking the PSTs to comment on how the classroom visits had affected their thinking about their university mathematics class, we asked them to write about how the visits had affected their thinking about becoming an elementary school teacher. More than half (28 or 58%) of the PSTs wrote that the visits had increased their commitment to becoming an elementary school teacher.

> "The more I am inside classrooms, the more that I know that I am going towards the right profession."

> "These visits have helped me to see that I really want to be a teacher. The environment I was in throughout these visits is the kind I want to be in my career."

Several PSTs noted that visiting the classrooms was fun for them and got them excited about their future work. For example, one wrote, “I am excited and I can’t wait to have my own class.”

Fourteen (30%) PSTs noted that they appreciated the chance to better understand what was required of the job.

> I really think that I have a much better understanding of what I am getting myself into. I did not understand everything that went into being a teacher. I still don’t. But now I have a somewhat better understanding.

Many students wrote that they welcomed the chance to test out their choice to be a teacher and suggested that it was something that all PSTs have a chance to do early in their course taking. One decided not to become a teacher after spending time in the classrooms. She noticed how consuming the work was and felt that she did not have the drive or the patience necessary to do the job well.

In at least one of the two reflections, 6 (12%) PSTs noted that the visits had not affected their thoughts about becoming an elementary school teacher. These PSTs wrote that they were committed to their decisions to be teachers and that the classroom visits had not affected their decisions.

The tone of the reflections was overwhelmingly positive. Few PSTs were critical of the teachers they visited. Only 2 PSTs would not recommend the experience to a friend, one because she thought that it was not long enough and required too much writing; the other thought that the middle school class she visited was redundant. The other PSTs welcomed the experience and found it beneficial because it helped motivate them in their mathematics class, gave them the classroom experience they craved, or both.

Description of visits and level of participation. Through analysis of the case studies, we see a more detailed picture of what the PSTs observed, what they did in the classrooms, how they interpreted their experiences, and how their visits affected their attitudes. The 9 PSTs in the target sample saw a variety of classrooms and instructional practices. On the basis of the descriptions they provided in their written reflections, we inferred that 8 of the 9 PSTs were exposed to at least some form of reform practice, because they saw children use tools to solve problems and explain their approaches to problems at least once during their 14 visits; 7 of these 9 PSTs observed children who were generating their own solution strategies. Table 5 shows the kinds of classrooms the PSTs visited. The traditional teachers focused instruction on a series of worksheets and emphasized the acquisition of skills. The eclectic teachers used the same skills-focused

worksheets along with other teacher-made materials that were more engaging to the children. The reform teachers used a variety of materials and emphasized student understanding.

Table 5

Relationship of Classroom Types and PSTs Noting Changes in Mathematics Instruction

Classroom type	PSTs with this experience	Numbers of PSTs noting reform features as difference between childhood mathematics experience and observations
Traditional/traditional	Dan	0
Traditional/eclectic	Sylvia, Tina, Nerut	0
Eclectic/eclectic	Janet	1
Reform/eclectic	Lynna, Steve, Gloria,	3
Reform/reform	Diane	1

Of these 9 PSTs, 7 found the mathematics lessons they observed to be different from those they had as children. Of the other 2, Dan, who visited two traditional classrooms, could not remember his elementary school mathematics experiences, and Tina, who visited a traditional and an eclectic classroom, remembered as a child doing the same entertaining, hands-on activities she saw during her visits. Of the 7 PSTs who found the lessons to be different from their experiences as children, 1, Nerut, who visited a traditional and an eclectic classroom, remembered doing hands-on activities and having to explain her thinking and noted that she did not see these practices much in the classrooms she visited. Another, Sylvia, was impressed with the emphasis on mental calculation that she though was absent from her schooling experience; 5 of the PSTs cited features that we would call reform minded as the differences between the lessons they observed and those they had as children. The features they noted in the classrooms they visited included group work, hands-on activities, children's explaining their thinking, multiple solution strategies, de-emphasis on memorization, and emphasis on understanding.

The PSTs tended to participate in similar ways during their visits. For the most part, they observed the class while the teachers lectured or conducted whole-group discussions. All the PST, but some more than others, worked with individual students during independent-work periods. Sylvia wrote about helping a child one time, whereas

others wrote about interacting with individuals during most of their visits. When working with individual students, the PSTs either talked with them about their work or helped them to solve a problem.

Each PST focused on different aspects of the classrooms they visited, and the classroom had unique features, so each PST valued the experience for a distinct reason. These reasons are organized according to the amount of reform teaching to which each PST was exposed.

Dan visited two classrooms in which the focus of instruction was on drill and practice. In the first classroom, at the request of the teacher, he drilled students on their multiplication facts. Dan appreciated the visits and the chance to learn from seasoned professional. He focused on the distinct management style of each teacher he visited and explained in great detail the management techniques that he had learned from each. He liked the casual, open style of one teacher but was troubled with her lack of organization. He liked many traits of the other teacher, whom he described as strict, because she was able to accomplish a great deal because of the efficiency of her transitions and her advanced preparation of materials. He noted

> I don't think you can do it with both styles. The first style is more of a warm and everyone is involved where everyone can participate kind of thing. Where the second teacher is saying, "This is what happens. This is what comes next". It was not very participatory. So the kind of two different styles, if there was a way to make that flow in between both of them, I think that would be the best.

In terms of learning about teaching mathematics, he noted the importance of repetition and explaining things in a variety of ways. Dan's scores on the beliefs survey decreased.

Tina visited one traditional classroom and one classroom in which the teacher employed manipulatives to demonstrate concepts before having her students' complete worksheets. Like Dan, Tina noted the importance of repetition in mathematics teaching: "The most important thing is repetition." Tina also thought that "to keep children entertained" and the class under control were important. She noted that children solve problems in various ways but thought that having them all come to solve problems the same way was necessary: "Well that's one way to solve it, but this is the way I want you to solve it." She noted that through the classroom visits she had opportunities to see children using strategies like those she had heard about in her mathematics class. Tina had small score increases for two of the seven beliefs on the beliefs survey.

Sylvia visited two classrooms in which worksheets were used as the primary means of instruction, but she saw the teachers do more explaining and questioning than Dan and

Tina had seen. Sylvia also noted the importance of repetition and explaining things in a variety of ways. In addition, she mentioned the difficulty of teaching mathematics:

> Before [the visits] I thought that I would have no problem teaching simple mathematics concepts to my students, but through these visits I learned that it is more than just knowing how to do simple math. The difficulty is on how one will express the concept to the child who has never seen or heard such a concept.

Sylvia had a small increase on two of the seven beliefs scores on the beliefs survey.

Nerut came from Israel, where she remembers having had hands-on experiences and opportunities to explain her thinking. She visited one traditional class and one class in which the teacher performed demonstrations to illustrate concepts. She was disappointed with the instruction that she saw, and she noted that the children had few opportunities to explain their thinking. She wrote, “The teacher should let kids work things out by themselves rather than just telling them their mistakes.” She noticed that teaching mathematics would be difficult: “When a child came and asked me a question and I tried to explain to that child what to do and how to do it, I realized that I did not explain it the best way.” Nerut was one of the few PSTs who was critical of the teaching practices she observed. She worked with her 6-year-old brother on mathematics, an experience that may have helped her to develop the conceptual orientation promoted in the mathematics course. Nerut had large increases on scores for five of the seven beliefs on the beliefs survey.

Of the 4 PSTs who saw traditional practices, Nerut was the only one to develop a conceptual orientation to mathematics instruction. The other 3 had more procedural orientations and emphasized the importance of repetition. These 3 identified with the teacher as dispenser of information and in the case of Tina, also as one to make mathematics fun. Two of the 4 decided that mathematics teaching would be more difficult than they had anticipated and that they needed to be prepared to give better explanations. Form this group, only Nerut noted the importance of learning about children’s mathematical thinking.

In the group that saw more reform-oriented instruction, PSTs showed similarities and differences in their interpretations of the visits. Janet visited one teacher who used manipulatives to demonstrate concepts and one who emphasized the use of alternative strategies. Janet was particularly impressed to see the teacher help the children learn the lattice approach to multidigit multiplication. Janet noted that hands-on activities contributed to children’s learning and felt that group work provided children important opportunities to explain their thinking:

> They work together and they help each other. They are also eager to show each other their answers and even get up in front of a class of students and show what they got.

Jeanne had a large increase on scores for three of the seven beliefs on the beliefs survey.

Lynna visited a teacher who emphasized conceptual understanding by asking her fifth-grade students to explain their thinking and a second-grade teacher who used a variety of manipulative activities to support her students' understanding. Lynna did not seem to be impressed by the classes that she saw, noting, "They are teaching the same concepts I was taught as a child in basically the same way." Lynna commented that the teachers' emphasis on understanding "really opened my eyes to see how each person thinks differently." She also came to see that "there's so much about math that I didn't know." Lynna had a small increase on two of the seven beliefs scores on the beliefs survey.

Steve visited the same second-grade classroom that Lynna had and another sixth-grade classroom in which the teacher presented material and engaged in discussion with students. Steve was particularly impressed with the second-grade teacher, noting how she used questions to stimulate children's thinking:

> The kids were talking about what they were doing. They were talking about each others' methods in groups. They were working in pairs. There was no rote, drill and kill exercises at all. It was all conceptual. It was just non-stop."

He talked about how this instruction had changed his view about elementary school mathematics.

> Now my thinking has changed dramatically and I see how the students can benefit from good math instruction in elementary school grades. I wouldn't have put such emphasis on the math instruction without this experience. Now having seen how primary school math can be taught and connected to higher math, I'm a lot more interested to teach that math to them. It's clear to me now that students have got to understand the process behind the technique for them to retain it easily.

Steve had a small increase on three beliefs scores and a large increase on the other four scores.

Diane visited a fifth-grade classroom in which the students explored concepts by solving problems and discussing their strategies with one another. She also visited the second-grade classroom visited by Steve and Lynna. Diane had a weak mathematics background and was relieved to see one could teach mathematics without having to lecture students. She wrote that the visits were "thrilling" and "invigorating," because she saw so much interaction among students. She was particularly happy to see that the students felt free to admit when they did not understand something. She wrote

> It was great to see the teacher allowing this interaction amongst the students because they are learning so much from each other. By students sharing their method of solving the problem, others are learning as well.

Diane had a small increase on scores of two beliefs and a large increase on the score for one belief.

Gloria visited a first-grade teacher who used story problems as the focus of her instruction and encouraged children to solve them in a variety of ways. She visited another teacher who was using a reform-oriented textbook. For each of her visits to the first-grade classroom, Gloria described in detail what several children had done to solve story problems. For example, she provided the following descriptions of children's solutions to the problem "Hamish has 3 bags of skittles. Each bag has 4 skittles in it. How many skittles does he have altogether?" She wrote

> One child drew three rows with four sticks in each row and counted each stick. Two children thought the answer was seven because they added three plus four. One child who I thought was really interesting held up four fingers in each hand that equaled eight, then he went to the calendar and started counting on the number 9—9, 10, 11, 12; therefore his answer was 12.

Despite this attention to individual's thinking, Gloria emphasized in her reactions the concerns she had about the resources at the schools she visited. She thought that the teachers had insufficient help in the classroom to individualize instruction to the extent that the children needed. One school she visited had been identified as a low-performing school and had recently been part of an effort by the school district to improve the mathematics learning of the students through introduction of a mathematics-specialist program. Gloria was not impressed by the mathematics instruction that she observed; instead she focused on the poor conditions of the school.

> I mean, it frustrates me that there's not much attention given to the schools, to the children. I look at the children, and it gets me sad that there's nobody there to get them out of the hole that they're in. That little boy who doesn't speak any English, how is he supposed to grasp the next lesson, if he's stuck? There should be more help in the classroom. … Being in the program, I'm seeing these things that make me wonder, "Do I really … ?" You know, it makes me wonder … I mean, I would hate to teach at XXX Elementary. I mean, I wouldn't want to teach there.

Gloria had a large change on her score for one belief on the beliefs survey.

From analyzing the case studies, we had difficulty determining why Steve and Janet had large score changes on the beliefs survey whereas the other PSTs did not. In their written reflections, all 5 PSTs who visited reform-oriented classrooms noted the

importance of conceptual understanding. Diane, Janet, and Steve noted the importance of children's communicating with one another about their thinking. Gloria showed the most sensitivity to children's mathematical thinking by explaining in great detail how the first graders she observed solved problems. This close observation did not affect her responses on the beliefs survey. Although, in describing their visits, the case-study PSTs who visited reform classrooms recognized several features of reform, the observations did not support them in changing their responses on the beliefs survey.

Discussion

We use the ideas of authenticity, identity, environment, and activity address each of our research questions.

1. What do PSTs learn from being in elementary school mathematics classrooms early in their academic careers?

Many of the PSTs discussed issues related to their emerging teaching identities. The age of the children with whom a teachers works seems to be a critical element in the teacher's identity. When prospective teachers begin to picture themselves in classrooms with children, one of the first features to come into focus for them seems to be the age of the children in the room. The PSTs also discussed the kinds of relationships they wanted to have with children, imagining whether they would be strict or lenient, how they would use humor, and so on. The PSTs worked on determining the ways they would like to run their classrooms. Several came to see that the lives of teachers are complicated because teachers have to attend to a variety of issues. As noted by one PST, "I was able to put myself in the teacher's position. I pictured myself as the teacher. "Many of the PSTs seemed to take this opportunity to refine their images of what they would be like as teachers and their images were the foci of the learning that they did. Because so many PSTs mentioned the importance of testing out their decisions to become teachers, working through this emergent identity seemed to be a priority for the PSTs.

2. Do the PSTs begin to see the knowledge that they develop in the university mathematics classes as valuable to them as teachers?

The majority of the PSTs reported making connections between their visits and the mathematics course. Many noticed that the mathematics topics they saw in the elementary school classroom were the same as those taught in the university course. This experience is a form of curriculum authentication and perhaps addressed PSTs' Ivory Tower concerns that university work tends to be esoteric and unrelated to the real world. This kind of general curriculum authentication might be better achieved by providing PSTs with copies of state documentation about the topics taught at particular grade levels as well as copies of

textbook materials (see Lloyd & Behm, 2002 for a discussion of curriculum authentication using K-12 texts with PSTs). These written materials could accompany the materials in the course textbook so the PSTs could see the alignment. Many of the PSTs mentioned the compelling nature of the "real" world, and if this aspect proves to be essential for curriculum authentication, then perhaps a small number of visits would achieve the same goal.

In another form of curriculum authentication, some PSTs noted that they saw the children using some of the alternative addition and subtraction strategies that were articulated in the course textbook and had been discussed in the university mathematics class. Some PSTs also noted that children learn mathematics differently from one another, so the teacher needed to be able to approach concepts from variety of perspectives. This was one of the themes of the mathematics course, and the visits amplified this aspect of the course for some PSTs. The goals of authenticating children's invented strategies and showing the diversity of thinking that exists in classrooms might be accomplished more successfully by other means, including videotapes of individual children or interviews with children.

For some PSTs the visits served to inauthenticate the university mathematics class. They did not see the specifics of the mathematics class being taught in the elementary school classrooms, and this fact confirmed their opinion that what they were being asked to do in the university classroom was inauthentic and unrelated to their work as teachers. For these PSTs, the classroom visits proved to be an obstacle to learning rather than a support.

3. Does the experience help them to develop a conceptual orientation to mathematics?

The beliefs-survey and content-test results indicate that few PSTs developed the ideas and beliefs that the mathematics faculty would like them to have. The performance of the PSTs who visited classes differed little from the performance of the control group. The MORE-T group, in particular, performed worse than the control group, indicating that one should avoid placing PSTs in average elementary school classrooms if the development of a conceptual orientation is one's goal.

Conclusions

We conclude with a few thoughts on classroom visits as a component of early teacher preparation. PSTs need opportunities to develop their teaching identities. They want to "picture" themselves as teachers. Teacher education programs should address this need because it dominates the thinking of many PSTs and interferes with their attending to other aspects of the classroom environment. Field experiences may be designed around this goal. This need might be the first one addressed by teacher education programs, and one

principle behind addressing this need would be to have the PSTs develop an identity as a reflective practitioner who is constantly inquiring about his or her practice.

For bridging the university classroom and elementary school classroom to enhance the mathematical learning of the PSTs, alternatives to unsupervised visits to elementary school mathematics classes should be considered. The PSTs might be coached on how to observe a mathematics class so they can better analyze children's thinking. They might watch videos of teachers teaching so they can collectively analyze the teaching and consider reform-minded practices. They might work with individual children who are solving problems. The elementary school classroom is a complex environment, and it is not designed to optimize the learning of PSTs. It is perhaps not the best place in which to situate PSTs' learning about mathematics.

The data from this study indicate that few PSTs develop conceptual orientations when they visit elementary school classrooms, and those few must be in special classrooms. Even when the PSTs do visit carefully chosen classrooms, many fail to develop conceptual orientations. Keep in mind that the PSTs' procedural orientations grew from many years in a classroom and will probably not change quickly. Varied experiences over a long time period are needed for alternative orientations to develop. We recommend that mathematics educators looking for ways to authenticate their mathematics course look for alternatives to sending their PSTs to elementary school classrooms to watch mathematics classes.

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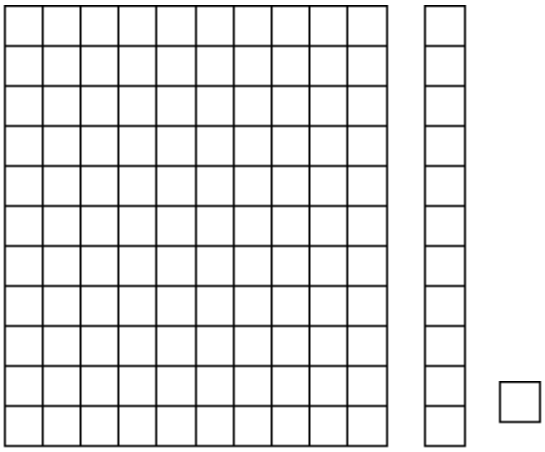
Appendix A

IMAP Web-Based Beliefs Survey Item

Carlos 149 + 286 Written on paper 1 1 149 +286 435	Henry 149 + 286 Henry says, "Because 40 and 80 is 120, and 100 and 200 makes 300, and 120 and 300 is 420, and 9 and 6 is 14, so 420 and 10 is 430, and 4 more is 434."	Elliott 149 + 286 Written on paper 149 +286 300 120 15 435	Sarah 149 + 286 Sarah says, "I know that 149 is only 1 away from 150, so 150 and 200 is 350, and 80 more is 430, and 6 more is 436. Then I have to subtract the 1, so it is 435."

Maria
Manipulatives

100 is called a “flat”
10 is called a “long”
1 is called a “single”



Maria uses manipulatives (base-ten blocks) to solve the problem. Maria says, "I took one flat for the 100 in 149 and two flats for the 200 in 286.

I took 12 longs: 4 for the 40 in 149 and 8 for the 80 in 286.

I took 15 singles for the 9 in 149 and the 6 in 286.

Then I counted like this: '100, 200, 300'; then for the longs, '310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420'; then the singles, '421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435.' So the answer is 435."

3.2. If you were a teacher, which of the approaches would you like to see children share? Select *Yes* or *No* next to each student’s name and then explain your choice.

Carlos: O Yes O No

Henry O Yes O No

Elliott O Yes O No

Sarah O Yes O No

Maria O Yes O No

Appendix B

Beliefs Measured by IMAP Web-Based Beliefs Survey

Beliefs about mathematics

1) Mathematics, including school mathematics, is a web of interrelated concepts and procedures.

Beliefs about knowing or learning mathematics or both

2) One can perform standard algorithms without understanding the underlying concepts

3) Understanding mathematical concepts is more powerful and more generative than remembering mathematical procedures.

4) If students learn mathematical concepts before they learn standard algorithms, they are more likely to understand the algorithms when they learn them. If they learn the algorithms first, they are less likely ever to learn the concepts.

Beliefs about children's (students') doing and learning mathematics

5) Children can solve problems in novel ways before being taught how to solve such problems. Children in primary grades generally understand more mathematics and have more flexible solution strategies than their teachers, or even their parents, expect.

6) The ways children think about mathematics are generally different from the ways adults would expect them to think about mathematics. For example, real-world contexts, manipulatives, and drawings support children’s initial thinking whereas symbols often do not.

7) During interactions related to the learning of mathematics, the teacher should allow the children to do as much of the thinking as possible.