THE IMPACT OF PROSPECTIVE ELEMENTARY TEACHERS' EXPERIENCES WITH REFORM-ORIENTED MATHEMATICS CURRICULUM MATERIALS

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Current reform efforts in the United States are based on views of mathematics, learning, and teaching that depart significantly from school mathematics traditions. Reforms aim to revise the conventional view of mathematics learning as the mastery of a fixed set of facts and procedures to more centrally locate the processes of investigation, sense-making, and communication in classroom activities. These changes place substantial demands on teachers. The recommendations presented in reform documents, and incorporated into newly-developed reform curricula, encourage teachers to use forms of instruction and representations of mathematics that most have never experienced themselves, as students or teachers. Moreover, reform visions of instruction are based on theories of learning that are difficult for teachers to reconcile with their own experiences and with the practicalities of classroom teaching. This situation gives rise to important questions for both research and teacher education: How can the experiences that prospective teachers gain in university settings better support their future classroom teaching? What processes are involved with prospective teachers' development of conceptions about appropriate mathematical activity for the classroom?

The study described in this paper attempts to address these questions by focusing on prospective elementary teachers' beliefs about mathematics textbooks – beliefs which relate importantly to teachers' more general views of mathematics teaching and learning. In particular, this paper discusses preliminary findings from a teacher education project that investigates the impact of undergraduate mathematics coursework with reform-oriented curriculum materials on the professional development of prospective elementary teachers.

BACKGROUND

Recent Reforms in Mathematics Education

The changes recommended by advocates of current mathematics education reforms in the United States invite teachers to establish mathematics classrooms in which students engage actively and cooperatively in exploration and discussion, and use a variety of representations and technological tools, to solve rich problems and reason mathematically (Mathematical Sciences Education Board [MSEB] & National Research Council [NRC], 1989, 1990; National Council of Teachers of Mathematics [NCTM], 1989, 1991, 2000). To illuminate the recommended changes, Cobb, Wood, Yackel, and McNeal (1992) draw a powerful distinction between *inquiry mathematics* and *school mathematics*. In contrast with traditional classroom activities that emphasize repetition, practice, and memorization of skills and rules, inquiry-based instruction emphasizes student development of understanding and connections among important concepts and procedures, both within mathematics and to the real world. Inquiry-based instruction can offer learning opportunities that do not typically occur in traditional classrooms by encouraging students to communicate their ideas and questions, agree and disagree among themselves, and negotiate the development of rich joint theories and ideas. Not surprisingly, such shifts in classroom activity can pose substantial challenges to teachers whose experiences have primarily been in the school mathematics tradition.

Reform-Oriented Curriculum Materials

Specific reform recommendations have resulted in, among other things, a flourish of curriculum development activity across grade levels (e.g., Investigations of Number, Data, and Space; Connected Mathematics Project; Core-Plus Mathematics Project;

Interactive Mathematics Program; Mathematics in Context; etc.). Although the reform-oriented materials of these programs have incorporated specific aspects of reform recommendations in diverse ways (emphasizing different themes or activities), the materials share certain qualities that distinguish them from traditional mathematics textbooks in at least two important ways.

First, reform curricula explicitly incorporate reform ideas about mathematics and pedagogy by emphasizing inquiry mathematics: student explorations of real-world mathematical situations and discussions of problem-centered activities. Furthermore, the materials are formatted to support these mathematical and pedagogical differences. Traditional texts are typically divided into chapters outlining self-contained daily lessons for the teacher to present (composed primarily of definitions and examples of the lesson's content) followed by practice exercises for the student. In contrast, most reform-oriented curriculum materials are published in unit booklets (offering greater flexibility in ordering) that pose large-scale problems and situations, centered on particular mathematical themes and content areas, for students to investigate and debate.

A second substantive difference is that reform-oriented materials generally offer more extensive information for teachers. In addition to providing correct answers to problems, most of these new materials offer details about different representations of content, historical information about mathematical and pedagogical ideas, examples of what students might believe or understand about particular activities and content, potentially fruitful questions for eliciting discussion, and so on. The inclusion of these details has been motivated in part by the failure of the "teacher-proof" curriculum materials of the 1950s and 1960s to facilitate substantial educational change. After all, it is teachers, not texts alone, who determine how the innovations envisioned by reformers and curriculum designers become implemented in classrooms.

Teachers' Conceptions and the Process of Instructional Change

The role that teachers' conceptions and classroom experiences play in mathematics reform cannot be overemphasized. In various subject areas including mathematics, a growing body of research supplies consistent evidence that teachers' conceptions strongly impact instructional practice (Brophy, 1991; Fennema & Franke, 1992; Thompson, 1992). Accordingly, a teacher's interpretation and implementation of reform recommendations and new curriculum materials are influenced by his or her conceptions of mathematics teaching and learning (Lloyd, 1999; Lloyd & Wilson, 1998; M. R. Wilson & Lloyd, 2000). Several recent reports suggest that because teachers' existing beliefs and current practices are often deeply tied to traditional mathematics pedagogy, innovative curricula can be very difficult to implement (Cohen, 1990; Grant, Peterson, & Shojgreen-Downer, 1996; Lambdin & Preston, 1995; M. R. Wilson & Lloyd, 2000; S. M. Wilson, 1990). Further research is needed to understand how teachers' goals and conceptions influence the ways they interpret reform recommendations and materials in the classroom.

Preservice Teacher Education

What are the implications of these issues for the preparation of future teachers? Many prospective teachers possess weak knowledge and narrow views of mathematics and mathematics pedagogy that include conceptions of mathematics as a closed set of procedures, teaching as telling, and learning as the accumulation of information (Ball, 1990, 1991; Brown, Cooney, & Jones, 1990; Even, 1993; Frykholm, 1996; Thompson, 1992; M. R. Wilson, 1994). Such conceptions, most of which are bolstered by years of experience as students in traditional classrooms (Lortie, 1975; Zeichner & Gore, 1990), deeply impact the learning-to-teach process (Eisenhart et al., 1993). If reform themes are to be enacted in the mathematics classrooms of future teachers, conceptions of mathematics and teaching will need to be challenged and developed in ways that can support meaningful and lasting change (Knapp & Peterson, 1995; Prawat, 1992; Richardson, 1990).

In light of the differences in the instructional methods prospective teachers will be expected to use in schools and those they likely experienced as students of mathematics, teacher education programs are faced with the task of creating opportunities for prospective teachers to critically consider important mathematical and pedagogical ideas so that different conceptions may develop. As the MSEB and NRC (1989) state:

> Teachers themselves need experiences in doing mathematics—in exploring, guessing, testing, estimating, arguing, and proving ... they should learn mathematics in a manner that encourages active engagement with mathematical ideas. (p. 65)

Preservice elementary teachers, who often lack confidence in their abilities to develop effective mathematics classroom practices and who may not fully appreciate the complexities of mathematical subject matter, may particularly benefit from opportunities to revisit mathematical content from new perspectives. However we have much to learn about how to effectively create such opportunities.

CONTEXT FOR THIS REPORT

The results presented in this paper are preliminary findings that contribute to an ongoing analysis of a much larger body of data. The larger study examines preservice elementary teachers' development in the context of teacher education activities designed to challenge mathematical and pedagogical conceptions. In particular, the study aims to identify the potential impact of reform-oriented K-12 mathematics curriculum materials on the professional development of preservice elementary teachers.

During Fall 2001, in two sections of a *Mathematics for Elementary Teachers* course, different text materials were implemented. In one section, a commonly-used college textbook was implemented (*A Problem-Solving Approach to Mathematics for Elementary School Teachers* by Billstein, Libeskind, and Lott). This section of the course (Section A) was composed of 32 female students in the second year of a five-year elementary education program. In the other section of the course, selected units from reform-oriented middle school curriculum materials were implemented (*Mathematics in Context [MIC]* and *Connected Mathematics Project [CMP]*). This section of the course (Section B) was composed of one male and 28 female students in the second year of a five-year elementary education program. Students themselves chose the section in which to enroll based on their schedules, not on choice of text materials. (Students were informed about the textbooks on the first day of class.) The *MIC* and *CMP* units were chosen to correspond with the mathematical emphases of the traditional college textbook. Results of mathematical pre- and post-tests indicate that the students in the two sections had similar mathematical preparation and gained comparable mathematical knowledge in the course. (Descriptions of both sections of the course, and many course activities, are available online at http://www.math.vt.edu/people/lloyd/math1614.html)

The decision to implement different text materials in the two sections of this course was based on the researchers' desire to explore the notion that experiences with reform-oriented middle school materials in college mathematics courses might positively impact students' ability to operate in reform-oriented ways once they enter elementary classrooms as teachers. Because the text materials are based on different assumptions about mathematics teaching and learning, students in the two sections of the course likely had different learning experiences. For instance, when using the traditional college textbook, students are expected to first gain exposure to important information (via the book, the instructor, or both) and then to complete a collection of problems for further practice and understanding[1]. In contrast, the reform-oriented middle school units require students to engage in investigative activities to develop general rules and concepts *while* they solve problems. In spite of these differences, the text materials used in the two sections emphasize both conceptual and procedural aspects of the same mathematical ideas. Although *mathematically* the two sections of the course were comparable (both sections reached the same mathematical conclusions from their work), these *pedagogical* distinctions had potential to differently impact the students' views of teaching and learning. We wish to emphasize that this study was not designed to compare the impact of traditional versus reform-oriented materials. We are merely attempting to identify (by

[1] Although the college textbook is structured to follow traditional pedagogical routines, it incorporates many important reform-oriented themes such as problem-solving, connections within mathematics, real-world mathematical situations, and conceptual understanding.

means of comparison) some differences in students' conceptions that *might* be the result of differences between textbooks.

This paper represents a starting point in our analysis of the teachers' experiences with the different text materials. The findings presented in the next section are based exclusively on analysis of one segment of the data (from an extensive data corpus that includes fieldnotes and videotapes of mathematics class sessions, interviews with selected students, copies of all students' written work and exams, and several surveys). The piece of data analyzed in this paper is a set of student responses to a question posed once at the beginning and once at the end of the Fall 2001 semester. The question – to which the preservice teachers responded in writing – was: "What makes a good mathematics textbook?" Our analysis is concerned primarily with how students in the two sections of the mathematics course may have responded differently to this question, and what changes in teachers' beliefs may exist in their responses at the beginning and end of the semester. The purpose of this comparison is to identify unique aspects of preservice experiences with reform-oriented curriculum materials.

Analysis involved repeated scans of students' written responses leading to identification of major themes and categories suggested by the data (LeCompte & Preissle, 1993). A tentative list of categories from the first scan was revised and refined during three subsequent reviews of the data. Efforts were made to create categories that represent distinct but substantial segments of data. Data were then coded according to those categories, and tabulated as displayed in Tables One and Two.

We consider the results reported in this paper to be preliminary "empirical assertions" for which confirming and disconfirming evidence from additional data sources remains to be sought (Erickson, 1986, p. 146). Our findings have not yet been triangulated with other data, such as teachers' additional written survey responses, interview responses, spoken comments in class, and their written coursework. (Until triangulation occurs, our results are clearly limited in many ways. For instance, one concern with basing our results exclusively on written survey responses is that if a teacher did not mention an idea in her response, it does not necessarily follow that the idea is not one of her beliefs. Similarly, the mere mention of an idea does not necessarily indicate the prominence of that idea in her beliefs.) As we plan our next analytic steps, we are particularly sensitive to Erickson's recommendation to search not only for patterns that confirm existing hypotheses, but also for disconfirming evidence and alternative explanations. For this reason, we will remind the reader of the preliminary nature of the results again in the Discussion section of the paper. This aside, we believe that the results – however tentative – give rise to some potentially powerful questions and implications for both research and teacher education.

RESULTS

Initial Beliefs about Mathematics Textbooks

What views of mathematics textbooks did the teachers[2] communicate at the beginning of the semester? The most frequent comments portrayed a good mathematics textbook as one that contains example problems (solved for students), clear explanations, practice problems for students to solve, problems representing real-world situations, easy

[2] The subjects of this study are students in mathematics courses for preservice elementary teachers. We have chosen to use the term "teacher" rather than "student" to refer to the subjects of the study in order to draw a clear distinction between the preservice *teachers* and the comments they make about their future *students*.

to understand steps for solving problems, and helpful visual aids. Table One outlines the number of responses that included each of these ideas.

	Number of Initial Responses That Include This Idea	
	Section A (n=32)	**Section B** (n=29)
1. Mathematics textbooks should contain example problems (solved).	21 (66%)	18 (62%)
2. Mathematics textbooks should contain clear explanations.	12 (38%)	8 (28%)
3. Mathematics textbooks should include practice problems for students to solve.	10 (31%)	12 (41%)
4. Mathematics textbooks should contain problems that represent real-world situations.	7 (22%)	4 (14%)
5. Mathematics textbooks should outline easy to understand steps for solving problems.	5 (16%)	2 (7%)
6. Mathematics textbooks should include helpful visual materials (e.g. pictures, diagrams).	1 (3%)	7 (24%)

***Table One*. Initial Stated Beliefs of Teachers in Sections A and B.**

As the items in Table One illustrate, a significant portion of teachers' initial statements about mathematics textbooks involved ways in which textbooks present information to students. Through examples, explanation, and visual aids, a textbook displays mathematical knowledge that students should acquire. Moreover, the textbook displays that knowledge with *clarity* and *ease of understanding.* As Andrea [A][3] explains, "A good textbook has clear explanations of topics and clear, well outlined examples." When mathematical ideas are "explained in an easy and understandable way" (Beth [B]), students can learn more effectively. In Janine's [A] words, "A good textbook simplifies

[3] The letter following each teacher's pseudonym indicates the section (A or B) of the course in which she enrolled. (The traditional college textbook was implemented in Section A and reform-oriented middle school curriculum materials were implemented in Section B.)

the problems for the students." To simplify problems, the textbook should include methods that proceed "step by step" (a phrase used by several students).

Teachers' responses also communicate the importance of *multiple* examples: "The purpose of a textbook is to provide examples of the problems so if children have trouble they have a place to go back to refresh their memory. If I was choosing a textbook now I would choose one that has lots of examples" (Molly [A]). Molly's comments also suggest one purpose of clear explanations and many examples: "A book with lots of example problems would allow the children to have help when they are working at home" (Anne [B]). Many teachers' responses indicate that a textbook should help students to engage successfully with an assumed set of "practice problems" that rely upon the textbook's clear explanations and examples. Work on these problems requires students to "practice and apply the methods that have been instructed" (Molly [A]).

Implicit in the teachers' stated beliefs is the notion that students first *learn mathematical material* via clear explanations, examples, and visual displays, and then *practice what they have learned* by solving problems similar to the textbook's examples. This result is not particularly surprising— the teachers describe quite accurately the format and philosophy of most mathematics textbooks with which they have interacted in their careers as students.

Changes in Stated Beliefs about Textbooks

Responses at the end of the semester suggest that some interesting changes may have taken place. Tabulation of the end-of-semester responses suggests that teachers in Section A maintained the same generally traditional views as their initial responses, and in some cases, *strengthened* their adherence to traditional textbook formats. In contrast, the end-of-semester responses of the Section B teachers suggest that they may have experienced some notable shifts *away from* traditional views of textbooks. Table Two outlines the initial and end-of-semester responses of both groups of teachers.

One interesting pattern on Table Two is that in several categories depicting traditional textbooks (1, 2, and 3), the percent of related responses from teachers in Section A *increased* (from initial response to end-of-semester response) and the percent of related responses from teachers in Section B *decreased*. The Section A teachers as a group did not just make *more* comments that involved the idea of a textbook as one that includes clear explanations, examples, and practice problems - the teachers also made their comments *more emphatically*. For example, consider Jen's [A] comment at the beginning of the semester: "A good mathematics textbook explains topics clearly, gives plenty of example problems, and gives more than enough practice problems." At the end of the semester, Jen – like a substantial number of her classmates – communicated the same sentiment, but more strongly and with more specific reasons behind her statements:

> A good textbook for learning mathematics is a textbook with a lot of examples and clear explanations. It is hard when textbooks give you problems to do and you cannot find an example to help you with the problem. It is also difficult to learn from a textbook when examples are given but no clear explanation is given about what is going on in the problem. I also think a good textbook includes many problems of the same type to work on and answer keys in the back to check your answers.

Such comments suggest that Section A teachers may principally view textbooks as highly structured documents that clearly communicate valuable information for students to

	Number of Responses that Include This Idea			
	Initial Response **Section A** (n=32)	**End-of-Semester** Response **Section A** (n=32)	**Initial** Response **Section B** (n=29)	**End-of-Semester** Response **Section B** (n=29)
1. Mathematics textbooks should contain example problems (solved).	21 (66%)	26 (81%)	18 (62%)	13 (45%)
2. Mathematics textbooks should contain clear explanations.	12 (38%)	18 (56%)	8 (28%)	4 (14%)
3. Mathematics textbooks should include practice problems for students to solve.	10 (31%)	15 (47%)	12 (41%)	5 (17%)
4. Mathematics textbooks should contain problems that represent real-world situations.	7 (22%)	7 (22%)	4 (14%)	12 (41%)
5. Mathematics textbooks should outline easy to understand steps for solving problems.	5 (16%)	11 (34%)	2 (7%)	3 (10%)
6. Mathematics textbooks should include helpful visual materials (e.g. pictures, diagrams).	1 (3%)	10 (31%)	7 (24%)	15 (52%)
7. Mathematics textbooks should contain answers to selected practice problems so that students can check their work.	1 (3%)	11 (34%)	1 (3%)	1 (3%)
8. Mathematics textbooks should include fun games, interesting lessons, and group work.	0	2 (6%)	1 (3%)	14 (48%)
9. Mathematics textbooks should allow students to think about concepts and problems first before providing examples and should help students develop solution methods for themselves.	0	0	1 (3%)	9 (31%)
10. Mathematics textbooks should illustrate different ways to solve the same problem.	0	12 (38%)	0	4 (14%)
11. Mathematics textbooks should provide a variety of problems for students to solve without excessive repetition or redundancy.	0	2 (6%)	0	4 (14%)
12. Mathematics textbooks should help students to understand both how and why mathematical procedures work.	0	1 (3%)	0	4 (14%)
13. Mathematics textbooks should offer *teachers* new ways of understanding mathematical concepts and student perspectives.	0	0	0	6 (21%)

***Table Two*. Changes in the Stated Beliefs of Teachers in Sections A and B.**

learn. In this view, the purpose of textbooks is to prepare students with the skills necessary to solve certain types of mathematical problems.

An interesting result involving the Section A teachers appears on line 10 of Table Two. A substantial number of teachers identified the value of multiple solution methods. As Jacky [A] describes,

> A good textbook gives various examples so student can learn in different ways. If the student doesn't understand one way, he or she can learn another way the book gives. For the problems in a textbook they should cover different techniques to solve problems because students should know various techniques to see what best fits them.

This view represents a slightly more relativistic perspective toward mathematics than is traditionally held. However, it is still *the textbook* (not the students, for instance) that offers these multiple approaches: "A good textbook should have different approaches to the same problem if a different approach is possible" (Lisa [A]).

The responses of a fair number of teachers in Section B echoed the same traditional images of mathematics textbooks as communicated by teachers in Section A. However, these responses represent a decrease in the overall number of responses containing the first three ideas of Table Two. This decrease is accompanied by the emergence of some new ideas about textbooks. These responses identify alternatives to traditional textbooks and teaching practices. For example, Kate [B] suggested that "a textbook should help the teacher to guide the students through their own learning of the chapter and not just lecture." Anne [B] stated that "children should be encouraged to think about a problem first, without knowing an exact method for solving it." These comments establish a new image of how students might engage and learn with a textbook, and the role that a textbook might play in students' and teachers' classroom activities. Additional evidence that some Section B teachers had experienced shifts in their views of appropriate classroom activities is the result displayed on line 8 of Table Two. At the end of the semester, approximately one-third of Section B responses described activities that engage students in doing mathematics in the context of lessons that require some sort of active participation, cooperation, and/or discussion.

Changes in Section B teachers' comments about the types of problems that might appear in textbooks were apparent as well. There was a large increase in the number of Section B teachers who mentioned real-world problems in their responses (i.e. item 4 of Table Two). This response is typical: "Realistic situations help children understand why they would need to know concepts" (Melissa [B]). This remark is similar to those made by Section A teachers. For instance, as Sarah [A] wrote, "It is important to use realistic examples so children can see how this information will be beneficial to them in the future." However, in Section A, there was no increase in comments about real-world situations from the beginning to the end of the semester.

Although the numbers are small, it is worthwhile to highlight the increase in Section B responses that involve the notion that students should learn both how and why mathematical procedures work. The emphasis on "why" reflects a departure from traditional tendencies to drill students until they can demonstrate proficiency with "how" rules work. Consider, for example, Liz's [B] comments:

> A good textbook for learning is a textbook that requires thought from the child . . . If a child can understand why he/she is doing a mathematical concept, they [sic]

> will understand it and know how to do it in everyday life. I think students in my generation are not good at word problems because we were just taught how to do it.

Liz's comment about being "just taught how to do it" suggests the struggle for these teachers of redefining what it means to "teach." The Section B teachers' responses suggest that they may have begun to reflect critically upon their own experiences as students. For some teachers – even those who continued to adhere to largely traditional views – dealing with new ideas about how to engage with textbooks appears to have created confusion, and perhaps some discomfort. Saskia [B] wrote at the end of the semester:

> A good textbook would be a book with a lot of examples. Repetition seems to be the best way to teach children how to do math. For learning math you would listen to what instructor says, read the instruction (if any) in the book and then do examples to practice. This was the way I learned math as a child and throughout high school and it seemed to work *until I took this course*. (italics added)

We cannot say what changes have occurred (or will occur) in Saskia's conceptions, but is does appear that Saskia's years of experience in traditional settings, supported by traditional curriculum materials, have been challenged.

One of the most noteworthy patterns in the end-of-semester results was the emergence of a set of Section B responses about *teachers* and textbooks (item 13 of Table Two). The notion that textbooks can offer learning opportunities for teachers as well as students appeared in approximately 20% of the Section B responses, and in *none* of the Section A responses. In all of the Section B responses about this issue, the teachers wrote about the important role that textbooks can play in helping teachers to learn mathematical material. Anne [B] wrote that "the teacher has to relearn in order to teach… The textbook provides the teacher with new ways of looking at a concept." Similarly, Liz [B] described the need for textbooks to "not only challenge students but the teacher to think of how 2 + 2 = 4 instead of just saying 2 + 2 = 4." Some teachers also identified the possibility that textbooks can help teachers to understand students' developmental levels and current understandings. Jill [B] suggested that "a good textbook puts the teacher on the students' level . . . and helps her to see where the child is coming from." Though made by only a small segment of the teachers, these comments suggest that some Section B teachers may have begun to think of themselves not exclusively as *students* of mathematics, but also as *teachers* engaged in learning about mathematics and how students learn mathematics.

DISCUSSION

In this section, we propose potential explanations for differences in the responses of the two groups of teachers. In so doing, we are careful to avoid making conclusive statements, particularly given the limited nature of the data we have analyzed and the tentative status of our results.

As stated previously, the *MIC* and *CMP* units utilized in Section B were selected to correspond with the same mathematical emphasis as the traditional college textbook used in Section A. As the semester progressed, we found evidence that teachers were gaining the same *mathematical* knowledge (i.e. as demonstrated on identical pre- and post-tests completed by both sections), but that the claims of teachers in Section A and B about what constitutes a successful mathematics textbook were beginning to differ. Our initial analysis of this data therefore takes into consideration the differing approaches of the textbooks used in each section.

The college mathematics textbook from Section A and the middle school units from Section B consistently approach the teaching and learning of the same mathematical topics in different ways. One mathematical topic covered by both texts that was frequently mentioned in survey responses dealt with the multiplication of fractions. The Section A textbook introduces multiplication of fractions with examples of a visual model that demonstrates the process of fraction multiplication, and then presents a procedure for computing (numerically) products of rational numbers. Problems that follow this introduction invite students (and the pre-service teachers taking this course) to use the visual model to demonstrate several products of fractions, to compute numerically several products, and to solve a variety of word problems involving multiplication of fractions. The *CMP* text (*Bits and Pieces II*), in contrast, contains several investigations about eating or selling a fraction of the brownies currently in a brownie pan -- a fraction of the original pan. Students must develop their own strategies for visualizing and identifying some fraction of a fraction of a whole pan of brownies. By doing so, students develop a method for multiplying fractions. Consideration of such differences in the approaches of the text materials implemented in Section A and Section B of the course may give rise to possible explanations for differences in written survey responses. In the paragraphs that follow, we propose several potential relationships between the different textbooks and the teachers' different statements about what makes a good mathematics textbook.

Table Two shows an increase in the percent of Section A responses related to traditional aspects of textbooks (categories 1, 2, and 3) and a decrease in Section B teachers rating traditional textbook categories as important aspects of mathematics textbooks. One possible explanation for the increase in the number of Section A teachers claiming that example problems, clear explanations, and practice problems are necessary components of mathematics textbooks is that those features were prominent features of the textbook they used throughout the semester (and probably throughout much of their careers as mathematics students thus far). The explanations of concepts and procedures in their text left little room for individual exploration of the topics. The practice problems assigned at the end of each chapter called for application of rules demonstrated in the text. (Although conceptual aspects of each topic are addressed in the textbook, the problems at the end of the section focus on primarily procedural aspects of the topic.) This routine followed by the Section A teachers may also help to explain the Section A increase in item 7 of Table Two that specifies the importance of textbooks containing answers to selected practice problems. This increase may relate to the fact that teachers in section A were accustomed to relying on an outside authority, the textbook, for answers and possible solution methods.

In contrast to the increase in Section A teachers' percent of responses in the categories depicting traditional textbooks, Section B teachers' responses decreased. This decrease is likely related to the alternative approaches of the *MIC* and *CMP* texts. As the multiplication of fractions example illustrates, students who use the *CMP* unit *Bits and Pieces II* develop methods for visualizing and recording the process of multiplying fractions, allowing them to explore for themselves why familiar procedures for fraction multiplication make sense. Because the Section B teachers utilized conceptual tools to understand why their answers were or were not making sense, they may have experienced a decreased need for clear explanations, practice problems, and solutions to practice problems in their end of semester responses. Throughout the semester, Section B teachers were exposed to novel ways of learning and understanding the mathematics.

A new idea that arose in the end of semester survey responses, particularly from Section A teachers, was the idea that mathematics textbooks should illustrate different ways to solve the same problem (item 10 in Table Two). This result may arise from the organization of the information presented in the college textbook. Typically, the introduction of each new mathematical topic is accompanied by three or four example problems. In many instances, the text demonstrates differing steps that could be followed to arrive at the same conclusion. In contrast, teachers in Section B were faced with problems and questions that asked them to explore on their own and develop their own conjectures about how to solve a problem. They were not able to rely on the text for possible solution methods. To a greater extent, Section B teachers had the opportunity to draw their own mathematical conclusion based on their own explorations. These differences may also relate to some of the other end-of-semester responses from Section B. Although relatively small in numbers, the addition of categories 9 and 12 to Table Two carries much importance. The teachers in Section B included the ideas that mathematics texts should help students develop solution methods for themselves and that texts should also help students begin to understand both how and why mathematical procedures work.

Another addition to the end-of-semester responses in Table Two is category 13. Approximately 21% of teachers in Section B (and no teachers from Section A) wrote that textbooks should offer teachers new ways of understanding mathematical concepts and student perspectives. This outcome may relate to the fact that teachers in Section B were forced to explore mathematical topics in new ways (many times differing greatly from the ways teachers had learned previously). They were given the opportunity to revisit mathematical topics from new perspectives as they worked through the texts that are normally used by middle school mathematics students. Because Section B teachers were using student texts for their own learning, they were much more likely to explore mathematical topics through the eyes of their future students.

IMPLICATIONS AND QUESTIONS

The course in which the teachers discussed in this paper were enrolled is intended to prepare them to deal successfully with the mathematical subject matter of the elementary school curriculum. Our rationale for using middle school curriculum materials in one section with the course was to better understand, from a research perspective, what it might mean for teachers to learn reform-oriented mathematics in reform-oriented ways. By comparing implementation of middle school curriculum materials with implementation of a traditional college-level text written for teachers, we aim to detect ways in which reform-oriented materials might offer learning opportunities that depart from more typical teacher education experiences.

Our results suggest that the text materials with which preservice teachers engage impact not only their conceptions of textbooks, but their conceptions of mathematics teaching and learning as well. Teachers in Section B, who worked with middle school materials, appear to have developed several exciting new perspectives including the notion that students can generate ideas and determine mathematical correctness for themselves. This notion, coupled with the suggestion that mathematical understanding includes more than just procedural competence, represents a significant shift from traditional views of mathematics teaching. Section B teachers also identified the idea that teachers can learn about both mathematics and teaching from students' textbooks. Although they were using middle school textbooks, the preservice teachers in Section B were *not* middle school students. Their work with the materials was shaped by their past experiences as students, their beliefs about mathematics and mathematical activity, and their emerging visions of themselves as future classroom teachers. In turn, it seems that – as least for some teachers – the teachers' beliefs and visions were impacted by their work with the middle school curriculum materials.

We do not claim that experiences with the *CMP* and *MIC* materials resulted in quick or widespread changes in teachers' conceptions. In fact, most of the preservice teachers in Section B continued to communicate fairly traditional views of teaching and learning. For example, most of the teachers continued to describe their future role as teacher as one that involves *explaining* important mathematical concepts to students, despite the fact that the *CMP* and *MIC* materials emphasize exploration and cooperation among students, in addition to teacher-facilitated discussions of students' perspectives and ideas. Although many Section B teachers maintained strong traditional views, a fair number of Section B teachers also appear to have *begun* to make some important changes that distinguish them from the Section A teachers. It is not surprising that the teachers held on to their traditional views of teaching – teacher explanation has been the primary mode of instruction throughout their careers as students. Our goal as teacher educators is help these teachers to extend their views of teaching by offering new experiences and helping them to reflect upon their learning. Bringing about significant change in preservice teachers' conceptions will likely require many challenges of many types to help teachers break away from the familiar routines of their past experiences as students.

Our results suggest numerous questions for further consideration. Most immediately, we wish to develop a much richer understanding of processes through which preservice teachers might learn from engagement with innovative curriculum materials. In light of the importance of changing teachers' conceptions, it is of utmost importance that we document the experiences of teachers as they use reform-oriented materials for their own learning. Our future work involves continuing the analysis presented in this paper to include information from additional data sources and to address related issues. For instance, the analysis presented in this paper does not take into account the mathematical and pedagogical emphases of the course instructors. Careful consideration of the nature of the instruction that accompanied the textbook implementation is essential for understanding the preservice teachers' experiences.

We also need more information about how experiences learning mathematics with reform curricula might play out when teachers engage more formally in learning about teaching during methods classes and field experiences. What differences might we observe in Section A and Section B teachers as they progress through their teacher education programs and early teaching experiences? Later in their careers, when faced with decisions about mathematics textbooks, curriculum materials, and other teaching resources, how might the teachers' decisions-making processes relate to their experiences in the *Mathematics for Elementary Teachers* course? On a similar note, how might the teachers' classroom practices with mathematics relate to their course experiences as preservice teachers? Investigation of such questions will bring us a deeper sense of what it means for teachers to learn in reform-oriented ways and how such learning much benefit teachers as they interact with children in elementary classrooms.

Preservice teachers need to not only be informed of, but also have personal experiences with, the representations of mathematics and types of mathematical activities they will be expected to facilitate in the classroom. Because they present reform visions through investigative mathematical activities, reform-oriented curriculum materials appear to offer one potentially fruitful way to help teachers change and develop their views and understandings of mathematics teaching. Continued research about this issue will greatly advance our understanding of how teachers' conceptions of mathematics and pedagogy develop over time and how these conceptions may support the eventual transition to more mathematically and pedagogically rich instructional practice.

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