# TEACHING ASSISTANTS' USES OF WRITTEN CURRICULUM IN ENACTING MATHEMATICS LESSONS FOR PROSPECTIVE ELEMENTARY TEACHERS

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*In research universities, teaching assistants often act as instructors in lower division mathematics courses. Typically, they are provided with a written curriculum (e.g. textbooks and/or lesson plans) for their courses. In this study, we explore how these resources are utilized or adapted. Two teaching assistants were observed while they taught three fraction lessons in a mathematics course for future elementary teachers. Interviews were conducted before and after the lessons to gather further information on their views of the course and the written curriculum. Results showed that the instructors enacted only a little over 50% of the textbook content. We discuss several factors that influenced how they adapted the written curriculum.*

## OBJECTIVES

Teaching assistants (TAs) play a vital role in undergraduate mathematics instruction. Acting as sole instructors, recitation instructors, tutors, or homework graders, they are in frequent contact with undergraduate students in the lower division mathematics courses such as college algebra, pre-calculus, and mathematics courses for prospective K-8 teachers (Speer, Gutmann & Murphy, 2005). Typically, new and less experienced TAs are given specific syllabi, curriculum materials, timelines, and lesson plans to follow when preparing their lessons. Often, they also receive some support from a course coordinator and more experienced teaching assistants. However, very little is known about how TAs utilize various types of resources in planning and teaching their courses. Such information is needed for designing effective professional development opportunities for TAs. In this paper, we report results from a study with two teaching assistants conducted during a fraction unit for prospective elementary teachers. Specifically, we seek to identify 1) the roles the written curriculum played in the planning and enactment of these fraction lessons, 2) the adaptations TAs made to the written curriculum when enacting the lessons, and 3) the factors that influenced the TAs' decision-making.

## THEORETICAL FRAMEWORK AND PRIOR STUDIES

Our study focuses on two components of Stein, Remillard, and Smith's (2007) temporal phases of curriculum use: written curriculum and enacted curriculum. Stein et al (2007) describe the written curriculum as the printed materials available to the teachers such as teacher editions and implementation guides. The enacted curriculum

2008. In Figueras, O. & Sepúlveda, A. (Eds.). *Proceedings of the Joint Meeting of the 32nd Conference of the International Group for the Psychology of Mathematics Education*, and the XX North American Chapter Vol. 1, pp. XXX-YYY. Morelia, Michoacán, México: PME. 

consists of the interactions between the teacher and students as the lessons unfold within the classroom (Remillard, 2005). Teachers implement curricula in many different ways. A large survey on the extent of textbook use by 39 middle school mathematics teachers found that many teachers supplemented their regular curricula routinely with practice worksheets regardless of whether it was an NSF-funded or a commercially published curriculum (Tarr, Reys, Barker, & Billstein, 2006).

Stein et al. (2007) identified three types of teacher factors that have been used to examine the adjustments teachers made between the written and the enacted curriculum: beliefs and knowledge, orientation toward the curriculum, and professional identity. Remillard & Bryan (2004) found that it was teachers' orientations toward the curriculum (e.g. adherent and trusting, quietly resistant, skeptical, etc.) rather than their views of mathematics or teaching that had a significant impact on their enacted curricula. Teacher's professional identity, defined as "individual's way of understanding and being" in the profession (p. 208) by Spillane (2000), has also been identified as a factor influencing curriculum use and the construction of the teacher's role in the class (Spillane, 2000). He found that a fifth grade teacher formed a different identity when teaching language arts than when teaching mathematics. This difference led to different enactment of reform curricula. In this study, we use the concept of teacher's identity in a limited way: focusing on how TAs view their roles as instructors of a mathematics class for elementary teachers and how they conceive the goals of the course.

While there is research in K-12 settings about the relationship between the written and enacted curricula, no study exists examining this relationship in college mathematics classes with a specific focus on graduate teaching assistants. The results of this study will help fill that gap.

## METHODS

The study was conducted during the fall semester 2007 in a course *Mathematics for Elementary Teachers* at a large research university in the Midwest. The course is one of two mathematics courses required for elementary certification. During the semester of the study, there were eight sections taught by five different TAs. One full professor acted as supervisor of the course who provided instructional and curricular support through weekly meetings. This course focuses on numbers and operations, and uses *Elementary Mathematics for Teachers* (Parker & Baldridge, 2003) as the primary textbook. This textbook is unique in that it is designed to be used in conjunction with the *Primary Mathematics* textbook series (Singapore Ministry of Education, 2003).

### Participants

Two TAs, Jamie and Sam (pseudonyms) who were instructors of *Mathematics for Elementary Teachers,* participated in this study. Both are working toward PhD's in mathematics education. Jamie has a master's degree in mathematics education from

Korea and a master's degree in mathematics from the institution at which this research was conducted. She taught high school mathematics in Korea before she came to the United States. This is her third time teaching this course using the same curriculum materials. Sam has bachelors and master's degrees in mathematics from an institution in the United States. Although she taught Chinese in elementary and middle schools in the United States, she had never taught mathematics until she taught this course. She was a research assistant for two years before applying for this TA position in the mathematics department.

### Data Sources and Analyses

Several types of data were collected for this study. The written curriculum includes: units 6.1, 6.2, and 6.3 in *Elementary Mathematics for Teachers* (Parker & Baldridge, 2003), detailed lesson plans written by one of the authors, and handouts TAs received from the course coordinator. The topics of these lessons are fraction definitions, models, ordering, addition, subtraction and multiplication. The data on the enacted curriculum includes video tapes and field notes taken during the teaching of those three units. These TAs' enacted curricula were analysed for adaptations by comparing them to the written curriculum. In addition, the two TAs were interviewed about curriculum use, additional resources, their interpretation of the goals and their roles in this course, and their ideas about teaching fractions.

To understand the nature of the adaptations made by the instructors, we first analysed the textbook, identifying main ideas, examples and exercises in those three sections. We then went through the corresponding video tapes and coded each element from the textbook analysis as being discussed or skipped. For each discussed idea, example or exercise, we coded them further as faithful (i.e., identical to the textbook description), or modified. We also identified any new idea, example, or exercise that was added by the instructors.

We identified emerging themes within each subgroup of adaptations: discussed faithfully, discussed with modification, skipped, and added. Once these themes were identified, hypotheses were formed about the factors that might have influenced their decisions. Similar analysis of the interview notes were used to help with triangulation to form and verify hypotheses generated for the three research questions.

## RESULTS

### The roles of the written curriculum

Both instructors had similar orientations toward the use of written curriculum. They used the textbook not only as the main resource for planning and conducting their classes but also as a tool for classroom management and communication between the instructor and students. Since neither instructor had experience teaching elementary school mathematics before they taught this course, the textbook and the accompanying books from the *Primary Mathematics* were important resources for

their own learning. Also, the textbook provided them with information on the topics and sequence of this course as well as how the main concepts could be explained. They expected their students to read the textbook before coming to the class and they assigned homework problems from the textbook.

Even though both instructors used the textbook as a guide for their planning and instruction, they both regularly chose not to use the activities and examples directly from the textbook. Jamie said that if she followed the textbook exactly, some of her students might think that she did not prepare for class. She worried that students might decide not to engage if class work duplicated the textbook, thinking that they could just catch up on their own by studying the textbook themselves.

Sam believed that introducing new activities or problems could serve as a motivator. She felt that when she brought in non-textbook activities, her students were more engaged, which entailed more interaction with her students and helped build more trust between her and her students. These comments pointed to some factors that influence TAs uses of the textbook. In the next two sections, we will first characterize the types of adaptations these TAs made when enacting three fraction lessons and then explore possible factors that influence their decisions both from their actions and from additional comments that they made during the interviews.

**Adaptations made by the two TAs**

The textbook authors recommended three 50 min. lessons for these three units for a total of 150 minutes. While Jamie spent about 178 min. and taught 58% of the ideas, examples and exercises in the textbook, Sam spent about 196 min. and taught 55% of the content of the textbook. The amounts of time noted above were instructional time on those three units not including time spent on administrative tasks or quizzes.

Both TAs made modifications to a significant portion of the ideas, examples and exercises that were in the written curriculum when enacting them in the classroom: only 42% of Jamie's instruction and 30% of Sam's instruction were faithful, that is, identical to the textbook description. And these are mainly rules, models, exercises and examples discussed in the book.

*Modifications*: Our analysis indicated that the majority of the modifications made by Jamie and Sam were either changing the numbers or the contexts of the given examples or exercises. However, these modifications occurred quite differently in these two TAs' lessons. Sam frequently asked students to give examples to the ideas being discussed. For example, when discussing the meaning of mixed numbers and improper fractions, Sam asked students to give definitions and examples for both. Students came up with $1\frac{1}{8}$ and $\frac{5}{2}$ while the textbook gave three examples, $2\frac{1}{8}$ for the mixed numbers, $\frac{8}{5}$ and $\frac{7}{7}$ for the improper fractions to highlight both the ">" and "=" in the definition of "a/b, a ≥ b". In Jamie's lesson, she chose three examples herself:

$2\frac{1}{3}$, $\frac{7}{2}$ and $\frac{5}{5}$. While Jamie's adaptation did not change the intent of the textbook, Sam's failed to address one important feature of the definition for improper fractions: a fraction a/b is considered improper if a=b.

In addition, both Jamie and Sam often encouraged their students to utilize fraction models (e.g. set, area/region, and linear measurement) that were different from those specified in the textbook. This type of modification tended to arise naturally in Sam's class as she encouraged her students with questions such as, "how can you explain this problem to the second graders?", and "If your student makes an error like this, how could you help him or her?" Furthermore, she encouraged her students to consider the strength and weakness of each model for solving a problem. Jamie initiated various fraction models as part of her planned lessons for additional practice. The focus of the discussion was explaining the solution of a given problem with different ways of using model.

*Skipped Content:* Further analysis of the skipped ideas and exercises indicated that they fell into three main categories. The first category is connections with whole numbers or algebra. In the textbook, these are discussions that extend rules, models and properties for whole numbers to fractions. The second category is ideas and examples related to teaching elementary students. For example, both Jamie and Sam skipped the discussion that once elementary students learned the rule for fraction-division equivalence (a ÷ b = a/b), they would be able to understand that the question "what is 17 divided by 4?" has four answers (4R1, $\frac{17}{4}$, $4\frac{1}{4}$, 4.25) depending on the context of the question. The third category includes specific examples and exercises for illustrating or practicing certain mathematical ideas, such as comparing two fractions by comparing them both to an intermediate fraction. While both Jamie and Sam skipped about the same number of textbook ideas, examples, and exercises – 28 and 29 respectively– they distributed differently among the three categories.

| Primary foci | Mathematical Connection | Teaching Connection | Mathematics Examples/Exercises |
|---|---|---|---|
| Jamie (n=29) | 11 (39%) | 15 (54%) | 2 (9%) |
| Sam (n=28) | 8 (21%) | 14 (48%) | 7 (24%) |

Table 1: Distribution of skipped textbook content

*Added Content*: Even though neither TA taught all the main ideas and examples in the textbook, they each added examples during the classes. In total, Jamie added 7 examples, and Sam added 9. All Jamie's added examples had more mathematical complexity than the cases given in the textbook. For example, the textbook used only examples involving proper fractions when looking at cases of whole numbers times fractions and fractions times whole numbers, while Jamie's examples involved

improper fractions. She also added a multi-step fraction word problem that required explicit attention to shifting quantities used to represent the wholes.

Sam added nine examples throughout the three units. In contrast to Jamie's added examples that all appeared to push students by using more complex fraction quantities or situations, Sam's examples were intended to provide additional opportunities for students to think through exercises they might have difficulty with, to compare/contrast with what they had done earlier, or to motivate her students with activities that were taken from the elementary mathematics curriculum. For example, Sam started the fractions unit with an activity "Fractions of a Square" where students were asked to decide what fraction each of the nine pieces (of various shapes) is in relation to the whole square. Toward the end of section 6.3 Sam added two additional exercises, solving $\frac{1}{2} + \frac{1}{3}$ and $\frac{1}{2} \times \frac{1}{3}$ and to make clear the difference between the fraction addition and multiplication.

## FACTORS THAT INFLUENCE THE ENACTED CURRICULUM

Our analysis of the interview data and the nature of adaptations made by these two TAs suggest that the instructors' role and the goals that they set up for their classes shaped their decisions about how to use the curriculum. Jamie viewed herself as a *mathematics instructor* and wanted her students to learn more rigorous and profound mathematical knowledge from this class. She commented during the interview that even though her students would be teachers in elementary schools, they should know more than elementary school mathematics. She thus saw herself as a mediator who provided a bridge between the mathematics that mathematicians do and the mathematics her students were learning. She attempted to provide her students with more complicated mathematical problems that required complex reasoning.

Sam, on the other hand, saw herself as a *mathematics teacher educator* and wanted to help her students understand elementary mathematics as it applied to their future teaching. She pointed out that even though this course was a mathematics course, it was important to consider that her students would be teachers in elementary schools. She wanted to encourage her students to think about how to teach and what made mathematics difficult for elementary students. She thought she could be a facilitator and role model to develop their knowledge for teaching. She aimed to offer her students more opportunity to think about various ways of teaching a mathematical concept. The TAs' different conceptions of goals and their roles as instructors led to different curriculum transformations.

Another factor we found was contextual restraints such as time, content coverage, and administrative pressures. Since this course was taught by different instructors, the TAs felt the pressure of maintaining certain level of consistency in terms of content coverage and pacing. Both TAs thought that they were behind other instructors. They both commented that even though they wanted to use more elementary students' activities with their students, they were not able to do so because of the lack of time.

Finally, we found that students' engagement and responses were one of the factors that influence the use of the written curriculum. Both instructors felt that it was hard to motivate their students to engage in the class. Thus, it became more important to invent other ways to encourage their students such as providing new problems and activities that the textbook did not cover. Jamie, who taught two sections of the class, adjusted her instruction according to students' engagement and readiness. She said that since her students in the class that we observed were less active and usually less prepared for the class than the other section that she taught, she said that she eventually supplemented with fewer problems and activities in the class than the other section and stayed with lecture and less discussion in the class we observed.

## DISCUSSION

Our data suggest that even though the instructors' orientation toward the written curriculum were similar and they taught the same course with the same written curriculum, a variety of factors influenced the TAs' use of the written curriculum. These include their interpretation of the goals of the course, their perception of their roles as instructors, contextual constraints and support, and students' engagement and readiness. Since this course is designed for prospective elementary teachers, it makes sense that TAs could be more mathematics-oriented or more pedagogy-oriented in their interpretation of the goals of the course and their self-determined roles in this course. The results from a recent survey with 63 college instructors of courses for prospective elementary teachers also showed variety in their goals for such courses (McCrory et al, 2008). Such variety may produce different ways of using the written curriculum and different learning opportunities for prospective teachers.

Both TAs spent more time than the textbook authors had suggested (178 and 196 minutes compared to 150 minutes suggested) but they were able to address only a little over 50% of the textbook content. Interestingly, the majority of the materials they skipped were connective pieces in both mathematical and pedagogical senses: they skipped ideas connecting fractions to the whole number system or the algebraic properties, and issues connecting to the elementary curriculum or K-8 students' reasoning. Why did they both give lesser attention to the mathematical and pedagogical connections? How might such adaptation influence prospective elementary teachers' mathematical learning in this course as well as their opportunities to make connections to their future studies? These are questions need further study.

A related issue that we have not addressed in this study is the level of the alignment between the adaptations these TAs made and the written curriculum. Seago (2007) introduced three categories of adaptation: fatal, no impact, and productive. "Fatal" adaptations run counter to the essential characteristics of the materials. "No impact" adaptations do not contradict the important design principles of the curriculum nor are they aligned with these principles. "Productive" adaptations are aligned with the essential characteristics of the curriculum. Currently, we continue to analyse the

adaptations made by these two TAs to determine if they were productive in promoting the deep understanding of mathematics as called for by *The Mathematics Education of Teachers* (Conference Board of the Mathematical Sciences (CBMS), 2001).

**ACKNOWLEDGEMENT**

This research is funded by the National Science Foundation (Grant No. 0447611). The authors wish to thank the two instructors who generously participated in this project and the other team members – Zhang Hui Chang, Andrea Francis, Helen Siedel, and Sarah Young – who collected data and participated in discussions that made our analysis possible.

**REFERENCES**

Conference Board of the Mathematical Sciences (2001). *The mathematical education of teachers* (Vol. 11). Providence, RI: American Mathematical Society American Mathematical Society & Mathematical Association of America.

McCrory, R. S., Francis, A. P., & Young, S. H. (2008). Resource Use by Instructors of Mathematics Classes for Future Elementary Teachers: Results of a Survey. ICMI 11, Topic Study Group 27, Deborah Ball and Jill Adler, Chairs.

Parker, T. H. & Scott J. B. (2003). *Elementary Mathematics for Teachers*, Okemos, MI: Sefton-Ash Publishing.

Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research*, *75*, 211-246.

Remillard, J. T., & Bryans, M. (2004). Teacher's orientations toward mathematics curriculum materials: Implications for teacher learning. *Journal for Research in Mathematics Education*, *35*, 352-388.

Seago, N. (2007). Fidelity and adaptation of professional development materials: Can they co-exist? *NCSM Journal*, *9*(2), 16-25.

Singapore Ministry of Education (2003). *Primary mathematics*. Oregon City, OR: Singapore: Times Media Private Ltd.

Speer, N., Gutmann T., & Murphy, T. J. (2005). Mathematics teaching assistant preparation and development. *College Teaching*, *53*, 75-80

Spillane, J. P. (2000). A fifth-grade teacher's reconstruction of mathematics and literacy teaching: Exploring interactions among identity, learning, and subject matter. *Elementary School Journal, 100*(4), 307-330.

Stein, M. K., Remillard, J., & Smith, M. S. (2007). How curriculum influences student learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 319-369).

Tarr, J. E., Reys, B. J., Barker, D. D., and Billstein, R. (2006). Selecting high quality mathematics textbooks. *Mathematics Teaching in the Middle School*, 12(1), 50-54.