Analyzing Elementary Preservice Teachers' Development of Content and Pedagogical Content Knowledge in Mathematics through Microteaching Lesson Study

Roxanne Molina, Maria L. Fernandez, and Leslie Nisbet
Florida International University, USA

Abstract: This study examines the effect of Microteaching Lesson Study participation on the mathematics content and pedagogical content knowledge of 52 elementary preservice teachers. Preliminary findings, which are positive, are discussed.

Since the introduction of lesson study to the U.S. in 1999 by Stigler and Hiebert, United States mathematics educators have developed an interest in exploring the technique that has been credited with the success of Japan's elementary students in the area of mathematics. Lesson study involves a team of teachers with an outside expert working collaboratively on the lesson planning, implementation, analysis, and revision of a research lesson (Stigler & Hiebert, 1999; Takahashi & Yoshida, 2004). Within four years of the Trends in International Mathematics and Science Study, lesson study spread to more than 335 United States schools spanning 32 states (Lewis, Perry, & Murrata, 2006). While many schools are attempting to replicate the original Japanese lesson study experience, adaptations to lesson study have emerged as U.S. schools have begun to experiment with the technique.

At the university level, lesson study has been modified for use with preservice teachers. Research over the last decade into the effectiveness of U.S. lesson study variations including those used with preservice teachers report positive findings indicating the benefits associated with the professional development technique are substantial. These benefits include improved content knowledge for teachers, enhancement of teacher pedagogy, higher teacher self-efficacy and motivation, development of teacher ability to observe and focus on student learning, improved teacher reflection ability, and creation of collaborative networks for teachers (Fernandez, 2005, 2006, 2009; Fernandez, Cannon, & Chokshi, 2003; Lewis, Perry, & Hurd, 2004; Lewis et al., 2006; Parks, 2008; Puchner & Taylor, 2006; Taylor, Anderson, Meyer, Wagner, & West 2005).

One adaption of lesson study, first developed by Fernandez (2005), Microteaching Lesson Study (MLS), has been used with secondary mathematics preservice teachers. MLS is a professional development process that blends principles of microteaching with aspects of Japanese lesson study. Similar to lesson study, MLS participants, equipped with an overarching goal for student learning, engage in a cycle of collaborative planning and lesson revision in conjunction with a mentor. The course instructor or another qualified person such as a curriculum specialist or field placement supervisor may act as the mentor.

MLS has been found to help deepen secondary preservice teachers' content and pedagogical content knowledge while shifting their focus in lesson planning to be more student-oriented (Fernandez, 2005, 2006, 2010). Such results underscore the potential for use of MLS with elementary preservice teachers enrolled in a mathematics methods course. Elementary preservice teachers are often only required to take one to two college mathematics courses and one to two courses in teaching mathematics; yet elementary teachers are responsible for laying the foundation for students' mathematical development. The National Mathematics Advisory Panel (NMAP, 2008), as part of its recommendations for improving K-12 mathematics

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education, emphasizes the importance of mathematically knowledgeable classroom teachers. MLS may be thought of as a pedagogical approach that can be used as part of courses on learning to teach in order to promote preservice teachers' development of content and pedagogical content knowledge. The purpose of this study was to examine the effect of participation in MLS on elementary preservice teachers' content and pedagogical content knowledge in mathematics. The research questions guiding this study included: What was the effect of participation in MLS on elementary preservice teachers' content knowledge? What was the effect of participation in MLS on elementary preservice teachers' pedagogical content knowledge? What were elementary preservice teachers' perceptions of MLS?

Participants

This study involved 52 elementary preservice teachers enrolled in two different classes of a mathematics methods course at an urban university in the south. The first class met for three 50-minute sessions per week during the Spring 2010 semester for 15 weeks. The second class met twice a week for 2 hours and 40 minutes during the Summer 2010 semester for seven weeks. During each semester, prior to the implementation of MLS, each class was engaged in learning about the teaching of mathematics from K to 6^{th} grade including class sessions aligned with each chapter of the course textbook. Both classes of elementary preservice teachers were engaged in MLS toward the end of their respective semester (i.e., for both courses all elementary preservice teachers received the treatment and neither group served as a control).

Of the 52 participants, 50 were female and 2 were male. For the Spring 2010 semester, participants were divided into a total of 10 groups as follows: 9 groups with three members in each group and 1 group with two members. For the Summer 2010 semester, participants were divided into a total of 8 groups as follows: 7 groups each with three members and 1 group with two members.

Both classes were taught by the same instructor, who also acted as a mentor for six groups during the Spring 2010 semester and all eight groups during the Summer 2010 semester. The instructor was a female doctoral student pursuing a Ph.D. in Curriculum and Instruction with a focus in mathematics education. She has taught mathematics from grade 5 to the university level and mathematics methods courses over the last 11 years. She holds a Bachelor of Science in Mathematics and a Master of Science in Secondary Mathematics Education. The Spring 2010 semester was the first time she served as a mentor for the MLS process.

Given this was the first experience in MLS for the instructor, a second female doctoral student pursuing the same degree and a coresearcher in this study assisted during the Spring 2010 semester. She has 11 years teaching experience in elementary, middle, and university level courses and holds a Bachelors degree in Mathematics and English Education and a Masters in Educational Leadership. It should be noted that the third coresearcher involved in this study developed MLS and has served as mentor for numerous groups. She is a faculty member at the university and has taught mathematics in elementary, middle, and high school levels and both mathematics and mathematics methods courses at the university level.

MLS Implementation

During the initial part of the semester, the preservice teachers watched videos, read case studies, and engaged in class discussions and activities all modeling a reform-oriented approach to mathematics teaching. The preservice teachers also completed a short questionnaire containing questions designed primarily to assess their pedagogical dispositions. MLS groups of at most three were formed so that a participant whose responses were indicative of a traditional approach to teaching, a student whose responses were mixed between a traditional and

constructivist teaching approach, and a student whose responses were representative of a constructivist approach to teaching worked together.

As the course progressed in both semesters, each MLS group was assigned a topic along with an overarching student learning goal. The overarching learning goals and mathematics topics were chosen based on the instructor and co-researchers' experiences with and knowledge of gaps in elementary preservice teachers' understanding of elementary mathematics. Examples of topics included multiplying fractions without the use of an algorithm or developing the connection between the area formulas for parallelograms, triangles, and trapezoids. Each MLS group was also assigned one of the two following overarching goals in conjunction with their topic: (a) to develop students' ability to build new mathematical knowledge through problem solving by applying or adapting a variety of appropriate strategies and (b) to develop students' mathematical reasoning and ability to study patterns in constructing relationships or concepts through experimenting, analyzing, conjecturing, and defending or justifying mathematical ideas.

At the start of the MLS implementation, time was allocated for MLS groups to develop their first lesson for their assigned topics and goals during class. During this time, a mentor (i.e., instructor or co-researcher) consulted with each group and posed questions to help guide participant thinking as they created their first lesson. Each MLS group developed, taught to their peers, and revised three versions of their research lesson on their assigned topic. Each group member taught one of the lessons, while the other two members acted as either observer or video recorder. The participants decided the order in which they taught in the three teaching cycles. All lessons were video recorded and given to the respective groups for viewing.

Following the viewing of each lesson (either live or by video), a mentor engaged each MLS group in a debriefing session. To begin the debriefing session, the MLS group observer shared observations related to the effectiveness of the lesson. The mentor used the observer's ideas to generate a discussion amongst group members to address any issues or concerns related to the lesson. In the case that participants were unable to resolve an issue related to content or pedagogy, the mentor posed questions to help guide the MLS group to a resolution.

Participants were required to submit a final report, which included the original three lesson plans developed by the group along with a group reflection after each debriefing. Also, included in the final report was a discussion of initial issues the group experienced while developing their first lesson and an analysis of each lesson implementation.

Theoretical Frameworks and Methods of Analysis

To measure participants' content knowledge prior to completing the MLS experience, a pre-assessment that covered the mathematics topics the MLS groups would be presenting was administered during each semester. The same instrument was later administered as a post-assessment for comparison after all groups had presented their lessons. The questions on the pre- and post-assessment were classified as related to content or pedagogical content knowledge in mathematics. The pedagogical content knowledge questions were developed using Shulman's (1986) framework. Pedagogical content knowledge as explained by Shulman (1986) includes two main points. First, teachers should have knowledge of the most useful forms of representation, examples, analogies, illustrations, or explanations for the most regularly taught topics in a subject area. Second, Shulman (1986) advocates teachers understand what makes the learning of specific topics easy or difficult. This includes knowledge of preconceptions, which may be misconceptions, that students of different ages and backgrounds bring with them into the classroom. A paired t-test was used to compare the overall results of the pre- and post-assessments for all the participants and then again to compare results separately from content and pedagogical content knowledge items.

Lesson plans were analyzed using the Creating and Analyzing Lessons from the Viewpoint of Mathematical Activities (CALMA) framework (Hiraoka & Yoshida-Miyauchi, 2007) to determine growth in the elementary preservice teachers' pedagogical content knowledge. CALMA suggests levels of mathematical richness of lessons. Level I Concrete Levels consists of two phases: Ia, Introduction of a Concrete Phenomenon and Ib, Develop Mathematical Nature of Phenomenon. Level II Mathematical Levels consists of two phases: IIa, Related Mathematical Problems and IIb, Mathematical Solutions. Level III Broader Levels consists of two phases: IIIa, Concreteness of Mathematics in Broader Contexts and IIIb, Development, Creativity and Appreciation of Mathematics. Lessons are analyzed to determine levels reached, which reveal the mathematical richness of the lesson activities.

Upon completion of the MLS process, participants completed a feedback survey that contained a series of Likert questions requiring a numerical rating ranging from 1 to 5 (Strongly Disagree to Strongly Agree) along with a qualitative comment or explanation of the rating chosen. Questions were intended to capture preservice teachers' perspectives related to the MLS experience. Also, included in the feedback survey were open-ended questions related to content and pedagogy.

Preliminary Findings of MLS

Preliminary findings indicate elementary preservice teacher participation in MLS helped deepen participants' content and pedagogical content knowledge. Comparison of the pre and post-assessment using a paired t-test revealed the difference in the scores was significant for $p <$ .001. When the scores for the content questions and pedagogical content questions were analyzed separately, a paired t-test on the pre and post content scores revealed a significant difference at $p <.001$. Similarly, a comparison of the scores for the pedagogical content knowledge questions revealed a significant difference at $p <.001$. Results from the content questions suggested that their peers' teaching during the MLS lessons helped all the preservice teachers increase their understanding of the mathematics being taught. The MLS experience also helped the preservice teachers increase their pedagogical content knowledge in mathematics.

Analysis of lesson plans using the CALMA framework (Hiraoka & Yoshida-Miyauchi, 2007) for individual groups across the three research lesson revisions revealed growth in the participants' pedagogical content knowledge. Two groups' lessons were selected for analysis based on qualitative observations made by the co-researchers who had acted as mentors. The groups were chosen to represent extreme cases (i.e., one group was selected to represent the most pedagogical content knowledge growth and the second group was selected to represent the least growth made by MLS participants). Based on an initial analysis of the lessons, MLS groups have demonstrated growth in the mathematical richness of their lessons. For example, analysis of the first lesson plan for the group chosen to represent the most pedagogical content knowledge growth was found to fit the criteria for CALMA level Ib, while the final lesson plan was found to represent level IIIa on the CALMA scale. The group selected to represent the least growth in pedagogical content knowledge expanded their lesson activities according to the CALMA scale, from level Ia for their first lesson to level IIb for their final lesson. This finding suggests MLS participants' lesson plans may have improved a minimum of at least one level and a half on the CALMA scale indicating growth in their pedagogical content knowledge in mathematics.

As part of the feedback survey, participants responded to a series of Likert-type statements designed to gauge their perceptions of the experience, from 1 (Strongly Disagree) to 5 (Strongly Agree). Analysis of participant responses from both semesters revealed participants valued collaboration with their peers. This is evidenced by the mean response values for statements such as, "Planning together with other group members helped me broaden my

knowledge of possible ways of teaching the desired lesson" and "Feedback from my group members helped me understand my teaching strengths and areas for improvement" were 4.4 and 4.3 as seen in Table 1.

Table 1
Mean Response Values for Likert-Type Statements Taken From Participant Feedback Survey Completed After MLS Participation

Statement	Mean	Std. Dev.
Planning together with other group members helped me broaden my knowledge of possible ways of teaching the desired lesson.	4.4	.723
Analyzing each other's teaching of the lesson helped me think more deeply about my own teaching.	4.5	.610
Feedback from my group members helped me understand my teaching strengths and areas for improvement.	4.3	.896
Planning together with other group members helped me deepen my knowledge of the mathematics topic we taught.	4.1	.825
The actual teaching of the lesson helped me deepen my understanding of the mathematics topic.	4	.894
Preparing to teach this topic and planning the lesson caused me to engage in mathematical reasoning and problem solving.	4	.883
Engaging in MLS helped me understand the importance of carefully developing mathematics exercises, problems, questions, or activities during the planning of my lesson. [1]	4.5	.512

Note: Ratings were from 1 (Strongly Disagree) to 5 (Strongly agree).
[1] Data for last statement only collected for Summer 2010 participants.

Discussion and Concluding Remarks

Results from the feedback survey suggest that MLS participation led to improved content and pedagogical content knowledge for group members. For content, this result is supported by participants' ratings of the following statements: "Planning together with other group members helped me deepen my knowledge of the mathematics topic we taught", and "The actual teaching of the lesson helped me deepen my understanding of the mathematics topic," received mean values of 4.1 and 4 respectively. The following statements support participants' growth in pedagogical content knowledge: "Analyzing each other's teaching of the lesson helped me think more deeply about my own teaching," "Preparing to teach this topic and planning the lesson caused me to engage in mathematical reasoning and problem solving," and "Engaging in MLS helped me understand the importance of carefully developing mathematics exercises, problems, questions, or activities during the planning of my lesson." Mean values for these statements were 4.5, 4, and 4.5 respectively.

An initial review of preservice teacher comments reported in the feedback survey provided further evidence that participation in MLS helped develop their content knowledge. A member of the group whose topic was to develop the properties of quadrilaterals wrote,

> I did not know much on different properties of quadrilaterals other than taking geometry. The teachers (all 3) helped me understand the properties of each and why. Preparing for the teach helped me engage in reasoning because I had to not only know each quadrilateral's property but had to know why the property was given.

Another participant whose topic was to develop the relationship between fractions, decimals, and percents wrote,

> In order for me to plan the lesson I had to try to solve it. So I would use the grids and see how students would approach the problems and how they would be able to use the grids to discover the relationship we wanted to get. I think that through this lesson I better understand the relationship between decimals, fractions, and percentages.

Results of all three comparisons of the pre-test and post-test suggest participants' content and pedagogical content knowledge improved over the course of the MLS experience. Although these scores might have been influenced by factors other than the MLS experience, it is unlikely that the extent of the significance in the paired t-test would have occurred irrespective of the MLS experience. The focus of the MLS was to engage participants in the teaching of content for which their peers lacked understanding, thus specifically targeting the development of content knowledge and pedagogical content knowledge. Similar findings were reported by Fernandez (2005, 2010) in the context of secondary preservice mathematics teachers.

Analysis of lesson plans from select groups using the CALMA framework (Hiraoka & Yoshida, 2007) revealed growth in elementary preservice teacher pedagogical content knowledge indicating the benefit of participation in MLS on preservice teachers' lesson planning. Fernandez (2010) also reported changes in preservice secondary mathematics teachers' lesson plans toward more reform-oriented approaches to teaching mathematics as aligned with the standards for teaching mathematics of the National Council of Teachers of Mathematics (NCTM, 1999).

Analysis of the feedback survey data suggests participants valued MLS as part of their course on learning to teach mathematics. One participant wrote, "I LOVED IT! I would have liked to [have] experienced more projects such as this one in my other courses, but now I am a senior and don't have the opportunity." The results of the feedback survey also indicate participants felt they learned mathematics content as well as approaches to teaching mathematics through collaborating with their group members. This finding is aligned with that of Fernandez (2006) in a study that captured preservice secondary mathematics teachers' perceptions of MLS.

While the findings discussed in this paper require more analysis, initial results indicate participant engagement in MLS is a valuable experience. Further investigation of MLS and the mechanisms that produce growth in preservice teachers' knowledge should be conducted. Also, studies should explore how the learning during MLS transfers to their teaching during their field experiences.

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