

Pre-service Teachers in Mathematics Lesson Study

Elizabeth A. Burroughs¹ & Jennifer L. Luebeck
Montana State University

Abstract: This paper presents qualitative evidence to answer the questions, “What are the outcomes of engaging pre-service and in-service teachers in a collaborative lesson study experience” and “How can the outcomes of this experience inform future ways to include pre-service teachers in lesson study?” The data gathered demonstrate that including pre-service teachers in lesson study can introduce them to lesson-building as a process and cross-grades teacher collaboration. It can give them opportunities to be critical thinkers in the context of mathematics education and encourages them to think as teachers. One weakness the pre-service teachers demonstrated was an incomplete understanding of the appropriate use of technology in algebra. Consideration of prior knowledge and anticipation of student responses was lacking among both pre-service and in-service teachers. Overall, the data show that pre-service teachers can contribute to the lesson study process as researchers.

Keywords: jugyokenkyuu; Japanese lesson study; pre-service teachers; reflective thinking; technology

Introduction

Teachers in Japanese schools have attributed much of their professional growth to the practice of *jugyokenkyuu*, translated as *lesson study* (Murata & Takahashi, 2002; Perry & Lewis, 2003; Stigler & Hiebert, 1999). This professional development model is used systematically to deepen content knowledge, increase understanding of pedagogy, and develop one’s ability to observe and understand student learning (Murata & Takahashi, 2002; Perry & Lewis, 2003; Stigler & Hiebert, 1999). Lesson study is a process for creating deep and grounded reflection about the complex activities of teaching that can be shared and discussed with other members of the profession (Fernandez & Chokshi, 2002). In lesson study, teachers spend about 20 hours working collaboratively, in teams of four to seven, to develop an over-arching lesson theme, plan, teach, observe, critique, and revise a lesson that supports this theme (Perry & Lewis, 2003). Research on the effects of American lesson study on teacher practice and student achievement is still in the nascent stage. Few publications provide descriptions of how to include pre-service teachers in lesson study (Fernandez, 2002; Hiebert, Morris, & Glass, 2003, Post &

¹ Department of Mathematical Sciences
Montana State University
PO Box 172400
Bozeman, MT 59717-2400
burrough@math.montana.edu

Varoz, 2008) and a review of literature found no examples of research results on the effects of lesson study on pre-service mathematics teacher education. The present study explores the effectiveness of engaging pre-service teachers in mathematics lesson study and suggests both benefits and challenges for pre-service teachers who engage with practicing teachers in lesson study. The results of this research demonstrate that pre-service teachers can participate in and contribute to lesson study in meaningful ways. The findings also reveal the limits of pre-service teachers' knowledge of teaching and suggest ways to improve future collaborations between pre-service and in-service teachers.

One impetus for including pre-service teachers in lesson study was to enable them to gain rich and authentic research experiences in mathematics teaching and learning. At the university where we teach, graduation requirements mandate that all students conduct independent research as part of their program of study. A few upper-division research courses are available in mathematics, as are others in other content disciplines, but most such courses are neither accessible nor relevant to students in the teacher preparation program. To address this need, we significantly revised our middle school mathematics methods course to include research experiences for pre-service teachers, beginning with a series of targeted classroom observations and task-based student interviews. The final research experience was completion of a lesson study cycle involving both pre-service and in-service teachers.

Why would it be important to include pre-service teachers in lesson study? In 1999, Stigler & Hiebert noted that "lesson study is a new concept for teachers entering the profession. If undergraduate methods courses were restructured to introduce students to collaboratively planning and testing lessons, new teachers would be ready to assume leadership roles more quickly" (p. 158). Fernandez (2002) reports that pre-service teachers in Japan frequently conduct lesson study as part of their student teaching: "They will prepare a study lesson in collaboration with their university-based mentors and the teacher with whom they have been assigned to work at their school site. They will then teach the lesson in this school, and all the teachers in the building, the university mentors, and other student teachers will come observe" (p. 395).

Research Questions

To assess the effectiveness of engaging pre-service teachers in lesson study, we posed the following research questions:

1. What are the outcomes of engaging pre-service and in-service teachers in a collaborative lesson study experience?
 - a. What do pre-service teachers perceive as beneficial about the experience?
 - b. What do pre-service teachers view as challenging about the experience?
 - c. What other outcomes can be identified?
2. How do the outcomes of this experience inform future modifications to the lesson study process that includes both pre-service and in-service teachers?

Based on our experience with pre-service teachers in methods courses and related fieldwork, we expected that pre-service teachers would be able to engage professionally with in-service teachers. We expected their strength would be in their mathematical understanding, while their limited classroom experience would make it difficult for them to anticipate student responses and misconceptions or to estimate appropriate timing of lesson elements. This expectation was affirmed by experts in the field (J. Hiebert, personal communication, October 27, 2008) who predicted that anticipating student responses, a crucial part of lesson study, would be difficult for pre-service teachers.

Method

This research followed a qualitative design using a phenomenological perspective as we sought to understand the experience of lesson study as perceived by pre-service teachers. Evidence was gathered from one section of a middle school mathematics methods course offered in Spring 2009 at the university where we teach. The course is required for all pre-service secondary teachers and for pre-service elementary teachers earning a 15-credit concentration in mathematics. The course has been offered for nearly 20 years, but not typically in conjunction with a field experience and never before in a research format. We continued to revise the course as it played out, following Hiebert's (2003) model for including pre-service teachers as transparent participants in such a process:

A second strategy that can help prospective teachers treat lessons as experiments is based on the fact that the knowledge, dispositions, and competencies that enable prospective teachers to treat lessons as experiments parallel, quite closely, the knowledge, dispositions, and competencies that instructors must develop collaboratively as the courses themselves are improved. The process of course improvement in which the instructors are engaged can be made transparent for prospective teachers so that they can see how the courses they are taking are being planned, evaluated, and revised. This provides an image of how the process can work to generate knowledge for, and improve, teaching. (p. 216)

All 24 pre-service teachers enrolled in the course (eight secondary and sixteen elementary) were considered subjects in this research, representing a sample of convenience. Throughout their weeks of involvement in lesson study, pre-service teachers were given assignments as part of their course requirements in which they were asked to critique and reflect on their research activities and the lesson study experience. Elements of their participation in the lesson study cycle were video-recorded as well. All data reported are from these written artifacts and video-recorded sessions.

The data on which we base this analysis come from four distinct sources:

1. Lesson study artifacts contributed by pre-service teachers as part of their assignments.
2. Written responses to open-ended questions given to pre-service teachers at various points in the course.
3. Transcribed statements made by pre-service teachers during video-recorded lesson study sessions.
4. Oral and written comments from the semester-end workshop attended by the pre-service and in-service teachers.

Mirroring the development of the course itself, we adjusted our questions for pre-service teachers as the lesson study process unfolded and themes of interest emerged. To the extent possible, we followed Glaser's (1978) method of constant comparison, using initial data to inform the development of questions and the collection of new data. Written responses and classroom assignments were analyzed to develop initial codes; these were eventually refined and grouped into categories through a cyclic process involving both researchers. Validity was further addressed through the triangulation of multiple data sources (assignments, open responses, and

interviews) collected over time. Pre-service teachers were aware that we were using their responses to analyze and assess the lesson study process as well as their own performance.

We were integrally involved in this lesson study experience as researchers, coordinators, and participants. We directed the project that supported the in-service teachers' exploration of lesson study. One researcher was also the instructor of the methods course. Both were acquainted with many of the pre-service teachers from past coursework and with the in-service teachers from prior projects. This provided a level of familiarity and trust that supported the authenticity of the data gathered about the phenomenon of collaboration in lesson study.

The Lesson Study Experience

In lesson study, teachers spend about 20 hours working collaboratively in teams of four to seven to complete a full cycle. In separate sessions, they develop an over-arching lesson theme, then research, plan, teach, observe, critique, and ultimately revise and re-teach a lesson presented to students (Perry & Lewis, 2003). The group begins by developing a broad goal for students and identifying a lesson that will help them reach that goal. After researching all aspects of the lesson's content and different ways to approach it, the teachers collaboratively plan the lesson with careful attention to teacher actions and to potential student misconceptions and responses. One group member teaches the lesson while the others observe and gather data about the lesson and its effectiveness. Finally, the group critiques the experience, revises the lesson based on their data, and may re-teach it. For a more detailed description of conducting lesson study, consult Lewis (2002).

The lesson study cycle at the focus of this research was conducted by a core of five middle school mathematics teachers from the two middle schools serving the local district. One sixth and one eighth grade teacher from the first school joined one seventh and two eighth grade teachers from the second school. Both schools use the same curriculum. All five teachers were experienced educators with a minimum of 14 years in the classroom. However, they were relatively new to lesson study, having completed one cycle the previous fall as part of a professional development project. The 24 pre-service teachers were new to lesson study and had only a limited relationship with this group of teachers and their students. Each had completed several hours of observation in two or three of the teachers' classrooms prior to beginning the lesson study cycle.

We sought to create a realistic lesson study experience for pre-service teachers without compromising completion of the full lesson study cycle for the in-service teachers. The model was confined by the logistical constraints of accommodating both pre-service and in-service teachers' schedules. Teachers' time is a limiting factor in conducting lesson study in the U.S. (Campbell, 2003; Abel & Sewell, 1999); adding pre-service teachers' college schedules into the mix multiplied the complications. Our eventual solution was to commit the pre-service teachers and in-service teachers to three late afternoon face-to-face meetings and to supplement the spaces between with written documents and digitally recorded discussions.

The entire group of pre-service teachers participated in the first stage of the lesson study cycle by attending an after-school session where the in-service team reviewed their broad goal and chose a content topic for the current cycle. They had focused on slope in the previous cycle, and chose to return to this topic in the context of parallel and perpendicular lines, even though it was not typically taught within the current unit. The pre-service teachers observed this meeting, sitting in a perimeter around the five in-service teachers who were seated at a table in the center.

This design respected the wishes of the participating in-service teachers, who wanted to continue their own lesson study experience as an intact team, rather than separating to lead smaller groups of pre-service teachers. While this placed limitations on the pre-service teachers' lesson study experience, it provided an authentic view of teachers engaging professional activity.

The pre-service teachers were assigned to carry out the research stage of the lesson study cycle. The methods course instructor assigned pairs of pre-service teachers to investigate specific aspects of mathematical content, prerequisite knowledge, and potential misconceptions related to the lesson topic. Each pre-service team developed a one-page summary of their research and gave oral presentations to the core group of five teachers in a second after-school meeting. The following week, the teacher team used this information to refine the content and focus of the research lesson as pre-service teachers observed in a third face-to-face session.

The actual development of the lesson took place without the pre-service teachers. This was a logistical choice due to conflicting schedules among the five in-service teachers and the 24 pre-service teachers. The teacher team completed a four-column planning document (Lewis, 2002) which allowed them to make a record of specific lesson tasks, procedures, and questions along with anticipated student responses and teacher notes. In the next methods class, the pre-service teachers were provided with this lesson plan document which allowed them the opportunity to make observations and suggestions. We shared these comments with the teacher team during their final lesson planning session.

Because of limitations of space and time, only two pre-service teachers observed the research lesson and participated in the teacher team's subsequent debriefing session. The impressions they shared with their classmates served to enhance the experience of the remaining pre-service teachers, who watched these sessions via video during their methods class later that day. After watching the video, the pre-service teachers had an opportunity to critique both the lesson and the debriefing session where the teacher team analyzed and revised the lesson. A few days later, the pre-service and in-service teachers reconvened at a Saturday workshop where they viewed and discussed video segments of a re-teaching of the lesson and debriefed the entire lesson study experience.

Interpretation of Data

We collected qualitative data from written assignments linked to the lesson study cycle, open-ended reflections about the lesson study process, transcripts from video-recorded lesson study sessions, and end-of-course focus group interviews with both pre-service and in-service teachers. Many of the pre-service teacher responses arose out of group discussion, while others represented individual reflection. The following discussion illuminates the most significant themes that emerged from this compiled data. The results and interpretations drawn from the data may not be representative of methods courses or pre-service teachers in generalized populations. However, the findings demonstrate that pre-service teachers can both contribute to and gain knowledge from participation in the lesson study process.

What Pre-service Teachers Learned about Lessons

The pre-service teachers made specific observations about various elements of the research lesson. In this respect, participation in lesson study richly supported the traditional

methods course goal of examining important elements of lesson planning and implementation. Watching the planning and teaching of a lesson also concretely demonstrated the importance of planning when teaching. Several components of the planning process are discussed below.

Lesson-building as a process. The pre-service teachers acquired new ideas about how lessons are developed and enacted: “Seeing lesson study and the development of the lesson was one of the most valuable aspects of the course.” They noted “all the steps involved in preparing a good lesson” and “the amount of work that actually goes into lessons.” Approaching a lesson as a process building up to a focal idea was new to them. They recognized that an important feature of a successful lesson is to “focus on the one thing you want them [students] to do in the lesson.” They also recognized the importance of placing lessons in context:

Teachers had a great idea with the slope, but I think that either they should have used the lesson study when they were learning slope or changed the subject to what the students were currently working on.

Key issues in planning lessons. The four-column lesson template was an effective tool for encouraging pre-service teachers to view a lesson as a carefully sequenced integration of content and pedagogy and for engaging them in serious inquiry about both planning and implementing lessons. They identified issues of timing and sequencing. For example, they noted that the lesson was too full for the allotted 50 minutes, wondering “Is there enough time?” and “What will happen if they don’t achieve the necessary discoveries in the [warm-up]...How do you move to Challenge #1?” Some pre-service teachers suggesting that time was not well-spent in the lesson planning sessions and should have focused more directly on fine-tuning the lesson:

Parts of the actual lesson at times were not thought through. An example of this is the lines they chose to have the students graph. The four lines the students put into their calculators were so close together that it was hard to tell them apart. This was a sign that they may have needed more time to put this lesson together.

Assessing prior knowledge. Pre-service teachers also recognized the need to attend to student understanding throughout the lesson. They wondered if the lesson was introduced effectively, because it assumed and relied on students’ prior knowledge about parallel and perpendicular lines. Pre-service teachers worried, “Do students know perpendicular?” and wondered if students could “identify perpendicularity just by looking at the calculator screens versus observing simply that they intersect.” They recognized potential pitfalls: “Do students get that if they make two [perpendicular] lines to one original line that the two [perpendicular] lines are parallel to each other?” and referenced broad goals: “Do students have a deeper understanding of slope now?” These comments seem particularly astute in hindsight, because one conclusion the teacher team reached following the lesson study cycle was that students didn’t really understand the difference between two lines that are perpendicular and two lines that intersect.

Anticipating student responses. We had predicted that pre-service teachers would have difficulty anticipating student responses to the research lesson. In fact they anticipated student responses that did not play out in the classroom, and failed to anticipate responses that emerged during the teaching of the lesson. This deficit could be the result of a general lack of knowledge of student thinking or limited experience with the particular students involved in this research lesson. It is worth noting that the in-service teachers also neglected the issue of anticipating student responses, a gap in planning that the pre-service teachers were later able to identify:

The aspect of this process that appeared very difficult for these teachers was focusing on what gaps of knowledge or misconceptions their students really might

have about slope...instead these teachers continued to focus on what was coming next in the curriculum.

A pre-service teacher noted as a weakness “the teachers’ abilities to predict students’ successes and difficulties. Even though students’ struggles were discussed previously, strategies were not discussed to prepare for such struggles.” Another saw a lack of formative feedback, concluding that “there was no data as to how many students succeeded in either lesson presentation.”

Appropriate use of technology. Pre-service teachers showed an apparent lack of understanding regarding the instructional purpose of technology in the lesson. One pre-service teacher recognized that “If you have the kids hand graph, messier kids won’t see that [the lines] are parallel or perpendicular” and added “But does graphing with the calculator hinder understanding?” Even after identifying a specific need for the calculator, the pre-service teacher remained suspicious of technology use in general. Another pre-service teacher suggested that students “do this lesson manually with graph paper to make sure they acknowledge everything and understand it, then do a problem where they can use a calculator.” A third wondered, “Does using the calculators help students learn? It seems they may cause more concerns, especially when used to introduce the concept for the first time.” Such reactions hint at a preconceived notion among the pre-service teachers that technology can not be used to build mathematical understanding among students. It may be true that in this lesson technology was not used effectively as a tool to build mathematical understanding, but the pre-service teachers did not offer comments about its *appropriate* use; they were suspicious of *any* use of technology. This indicates a need to address technology use more thoroughly in the methods course.

What Pre-service Teachers Learned from Lesson Study

Contributing researchers. During the research phase of the lesson study cycle, the pre-service teachers investigated how slope and parallel lines are addressed in research journals, practitioner articles, and other curricula, and orally presented their findings to the teacher team. They were surprised at the enthusiastic reception they received. One student said, “I had presumptuously assumed these teachers knew and had considered [already] all we had to offer.”

Cross-grades collaborators. The pre-service teachers valued the opportunity to actively interact with practicing teachers. They also recognized the “importance of opening up dialog between grades.” They saw the exchange of ideas between 6th-, 7th-, and 8th-grade teachers as parallel to their own experience in a methods course combining elementary and secondary teachers. One student noted:

Collaboration between teachers across different grade levels is very important for both teachers and those of us who are observing. It gives each teacher for different grade levels insight into what their students need to know and it is important for us to realize that as well.

Critical colleagues. Pre-service teachers analyzed the lesson study cycle with insight and often provided sound advice for improvement. One of their primary concerns was the selection of the person who would teach the research lesson. For the sake of expediency, the teacher team had pre-determined who would teach and re-teach the lesson. The pre-service teachers saw that assigning a teacher to the lesson too early caused the others not to take group ownership of the lesson. One student advised, “I think that not knowing who is going to be teaching the lesson is

ideal; this way all the teachers can research and go through the process as though they will be the ones teaching the lesson.” Another observed that assigning a teacher immediately prior to the lesson “would have added another level to the lesson, making it more effective.”

The pre-service teachers were also able to assess the social dynamics behind the in-service teachers’ collaboration, as with the comment, “I think that the teachers did a pretty good job of getting together and talking about the subject to be taught. I do not think they worked as a team very well...Here in [this team] I never heard the teachers say ‘we’ and ‘our lesson.’”

Reflective practitioners. The pre-service teachers seemed to take to heart their role as co-developers of the new research aspects of the methods course. They offered many comments demonstrating their ability to reflect not just on the results of this particular lesson study, but also on participating in lesson study as a research experience. One pre-service teacher concluded: “I really enjoyed the research aspect of this class, as well as working with the teachers. I gained a lot of insight from the observations and lesson study process. I would have enjoyed incorporating more if it into the class.” They were clearly conscious of their role as observers rather than participants during the lesson study cycle. “Looking back on the experience I wish that [pre-service teachers] had had a little more input into the lesson. Although we did have some input I felt that we were largely observers of the process, with the decisions made over our heads.”

Over the course of the lesson study, the pre-service teachers became more invested in the process and proved themselves quite capable as a group of understanding and valuing the lesson study process. They were able to see that lesson study, even though imperfect, was worthwhile for the teacher team as they “gained insight on how the lesson directly influences the students’ learning.” However, they were also cognizant of the need to embed the practice in a broader context:

As the teachers planned the lesson, I did believe that we slightly lost sight of our overarching goal and became too focused on the topic alone. I thought we needed to stop and consider how the activities were promoting ‘confident, independent problem solvers’ as well as how the goal of the lesson study process was being achieved.

A final student comment reflects on the pitfalls of doing lesson study for its own sake, a piece of wisdom that can be applied to any effort at teacher professional growth and development:

Another important thing to note is that lesson study by itself does not improve teaching. If the group of teachers does not put the time and effort into it, or do not have the knowledge or don’t research their topic, the study is ineffective.

Implications for the Preparation of Mathematics Teachers

The above discussion illuminates the nature of pre-service teachers’ contributions to a mathematics lesson study cycle. In summary, our findings suggest that pre-service teachers can indeed participate meaningfully with in-service teachers in the practice of lesson study. They engaged in professional dialog as peers and perceived themselves as valued contributors. At the same time, they learned valuable lessons about teaching, learning, and collaboration in a mathematics community.

Reflective thinking emerged as a strength among the pre-service teachers as they critiqued both the research lesson and the lesson study process. At the lesson level, the lesson study cycle pushed the methods course experience beyond merely providing ideas about

planning and implementing future lessons to developing a deep, experiential understanding of lesson development. In the words of one observer, it helped make a somewhat covert planning process highly visible to prospective teachers. At a process level, the pre-service teachers gained enough knowledge about what lesson study should be to recognize the shortfalls of the particular lesson study in which they participated. This came partly through readings and watching video of another lesson study conducted by teachers in a different district. The pre-service teachers were also able to critique their own involvement in the course model chosen by the course instructor to implement the lesson study.

As anticipated, the pre-service teachers are not yet equipped to accurately predict student responses and address misconceptions. However, the in-service teachers were also weak in this area, and the pre-service teachers recognized that as they observed the lesson study process. Overall, this should not be considered as a limiting factor in the use of this model for including pre-service teachers in lesson study.

A more significant limitation was the fact that logistical obstacles effectively removed the pre-service teachers from the detailed process of planning the research lesson, one of the most critical parts of the process and a rich example of applying the mathematical and pedagogical knowledge needed for teaching. Even in sessions they could attend, watching and not contributing to decisions left several pre-service teachers feeling powerless. They participated according to our expectations, but were left feeling less like researchers or participants than simple observers. This is contrary to the philosophy that guided our revision of this course.

In the future, we will strengthen the role of pre-service teachers in planning the actual components of the research lesson. There are now two lesson study teams prepared to work with pre-service teachers, allowing a better balance of pre- and in-service teachers on a team. Teachers have also offered to come to the university campus to conduct their lesson study sessions during the methods course, which will help to reduce logistical problems. Other models may also be explored, such as creating smaller mixed groups of pre- and in-service teachers for multiple lesson studies.

This examination of pre-service teacher involvement in lesson study has clarified the true capabilities of pre-service teachers as reflective and collaborative pre-professionals. It has also revealed the high levels of appreciation and acceptance extended by in-service teachers to their colleagues-in-training. The practice of lesson study in our methods course will continue and, we expect, will prompt further improvements in the classroom research experiences we provide for our pre-service teachers.

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