

LESSON STUDY: MEASURING GROWTH IN TEACHER KNOWLEDGE

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This study investigated how preservice elementary teachers experienced lesson study in their mathematics methods courses and how lesson study facilitated their knowledge development as teachers. Data utilized from mixed methods focused on the growth of three types of teacher knowledge: content knowledge, pedagogical knowledge, and pedagogical content knowledge. This report highlights how one group of preservice elementary teachers came to understand student learning, and how they used that understanding in planning and teaching.

Introduction

Teaching has been reduced to an overly simplified task, when in fact it is a very involved, complex process. When we examine the practice of a skilled teacher, it becomes clear that a highly developed knowledge of content, access to a wide repertoire of teaching strategies, and deep understanding of students is necessary (Ball & Bass, 2000; Lampert, 2001). In reality it can take years of practice to attain this level of knowledge and skill in becoming a proficient teacher.

Some believe that content knowledge and teaching strategies may be acquired in a quick, rather straightforward manner by beginning teachers. However, preservice teachers often lack exposure to students, making it a challenge for them to understand how content and pedagogy connect to student learning. Placement in schools, with the aid of an experienced cooperating teacher, can work to address this problem in part. Still, scaffolded examinations of student thinking can be advantageous as preservice teachers make sense of their emerging practice. Lesson study can serve to focus teachers' attention on the critical work of student learning (Fernandez, 2005).

Theoretical Framework

Lesson Study

Lesson study is a professional development tool that originated in Japan. Since the 1990s, it has spread rapidly in the United States (Fernandez, 2005; Lewis, Perry, & Murata, 2006; Lewis & Tsuchida, 1998). Some key features of lesson study serve to transform teachers' knowledge (Fernandez, 2005): lesson study enables teachers to work collaboratively in the lesson planning cycle (assess, plan, teach, reflect); and it provides contexts to demonstrate reform mathematics teaching in the classroom by helping teachers see the lesson through the eyes of the students. Participation in this form of professional development has the potential to transform teacher beliefs and knowledge.

Teacher Knowledge

Three types of teacher knowledge were formalized by Shulman (1987) and others (Grossman, 1990; Hill, Schilling, & Ball, 2004) that need to be transformed in order to support teacher learning: (1) content knowledge, (2) pedagogical knowledge, and (3) pedagogical content knowledge. In other words, teacher educators need to provide opportunities for teachers to: (a) deepen their understanding of mathematics content, (b) build a repertoire of effective teaching strategies, and (c) connect emerging knowledge of content and teaching strategies to reconceptualize how students can best think about and learn mathematics.

In lesson study, teachers are supported to go beyond a simple comprehension of the mathematics content (e.g., procedural understanding) and gain a stronger conceptual grasp of the material they teach.

Lesson study provides the impetus for teachers to examine current research findings on student learning, pre-assess their students based on these findings, and plan an effective lesson, broadening their existing ideas of effective teaching strategies. Through this process, lesson study continuously focuses teachers' attention toward students' thinking on certain mathematics topics, highlighting effective mathematics teaching with a conceptual focus.

Using the three types of knowledge conceptualized by prior research as a framework, this report describes how three cohorts of preservice elementary teachers experienced lesson study in their mathematics methods courses, and how these experiences facilitated their knowledge development and transformation. In particular, a case study of one group is used to highlight teachers' development of knowledge specifically related to student thinking. This study aims to answer the following research questions:

How does lesson study facilitate the development and transformation of content knowledge, pedagogical knowledge, and pedagogical content knowledge of preservice teachers? How does one lesson study group come to understand student learning and use that understanding for planning and teaching? What characteristics of lesson study are integral to the knowledge development process?

Methods

Three cohorts of elementary preservice teachers in their respective mathematics methods courses at a major research institution in the western United States participated in the study. All teacher education students engaged in the lesson study process which was central to one quarter's course(s). In order to identify if and how teachers' content knowledge, pedagogical knowledge, and pedagogical content knowledge were changed, and how lesson study played a role in this change, a combination of both a quantitative and qualitative research design was used.

For quantitative data, all three cohorts of elementary preservice teachers took a pre- and post-survey (Hill et al., 2004) at the start and end of the teacher education program. This survey was developed by the Study of Instructional Improvement (SII)/Learning Mathematics for Teaching/Consortium for Policy Research in Education (CPRE) at the University of Michigan and primarily assesses preservice teachers' pedagogical content knowledge and content knowledge. All questions from these pre- and post-surveys were coded as corresponding to the types of teacher knowledge. This enabled analysis of each knowledge on a separate basis. The groups' overall scores were also used to determine the teachers' learning in the courses. Furthermore, cohort three teachers took a short pre- and post-survey specifically focused on geometry, as their lesson study content topic was geometry. The purpose of the surveys was to determine whether there was a relationship between participation in lesson study around geometry and teachers' content knowledge of geometry.

Qualitative methods, including unstructured interviews and classroom observation of the lesson study groups' planning processes and final lessons, were utilized to understand the complex learning shift. Teachers wrote open-ended reflections immediately after their lesson study experience as well as at the end of the program. Data were collected in the form of reflection papers of all the teachers. Teacher reflection data were first coded and analyzed for the types of knowledge that teachers formalized through the lesson study process as a whole. Percentages were calculated to determine which codes were referenced most often. Then, characteristics of lesson study were identified and linked to the teacher learning.

Results

The pre- and post-survey results show overall increases across the knowledge types and across all cohorts (see Table 1 for a summary of the results).

	Cohort 1 (2005-2006)			Cohort 2 (2006-2007)			Cohort 3 (2007-2008)		
	Overall	Content Knowledge	Pedagogical Content Knowledge	Overall	Content Knowledge	Pedagogical Content Knowledge	Overall	Content Knowledge	Pedagogical Content Knowledge
Pre-Survey	72%	69%	73%	75%	68%	78%	69%	70%	69%
Post-Survey	78%	78%	78%	85%	84%	85%	76%	73%	77%
Gain	6%	9%	5%	10%	16%	7%	7%	3%	8%

Table 1. Percentage of correct answers on pre- and post-surveys

While it is important to note the increase in overall scores for all cohorts, it is also notable how both the content knowledge and the pedagogical content knowledge scores increased.

A close look at the change in geometry content knowledge for Cohort 3 shows that the group improved by 7%, growing from 74% to 81%. Due to the small sample size for Cohort 3, however, our confidence level is not very high indicating that these results are not statistically significant. Still, eight out of eleven preservice teachers did improve in their geometry content knowledge.

Case Study of Lesson Study Group

Fernandez (2005) defines pedagogical content knowledge:

Such knowledge entails understanding how students think about specific content, in particular the difficulties it presents to them, and being familiar with productive strategies that can be used in the classroom to further develop students' thinking and help them overcome their difficulties (Fernandez, 2005, p.2).

Our research shows that lesson study focused teachers' attention on development of their pedagogical content knowledge. As expected, the preservice teachers entered and exited the program with a range of levels of understanding in this area. Most teachers related their increased awareness of the importance of closely paying attention to student thinking. In order to showcase preservice teachers' learning, we share specific findings of one lesson study group's learning process. The group consisted of three teachers, Shelley, Karen, and Victor, from the 2007-2008 cohort (cohort 3).

Research Lessons

The teachers spent several weeks in planning a research lesson related to helping students understand the properties of various three-dimensional shapes. The lesson objective was to help develop students' spatial sense by constructing three-dimensional shapes from two dimensions, and by deconstructing three-dimensional shapes into two dimensions. The group members also indicated a desire for students to develop relevant mathematical vocabulary through the process. Shelley, Karen, and Victor agreed that to bring about this type of understanding in students, they would need to craft a hands-on, exploratory activity.

During the main research lesson, Victor briefly modeled the activity that the students would engage in (sorting various shapes into the categories 'triangle' and 'not triangle'). He then gave students the opportunity to explore and sort many types of three-dimensional shapes in a group setting, with a handout as a scaffold. Essentially, the students were asked to sort the shapes into similar groups based on their properties. At the end of the lesson, Victor led a whole-class discussion on the learnings that resulted from the activity, and solicited input from students on what they hoped to learn for the rest of the unit. The purpose of the whole-class discussion was to make the properties more clear, while also modeling use of mathematical vocabulary.

Learning Through Assessment

The lesson study groups were asked to design a pre-assessment to administer to a sample of their students. After students had a chance to work on the problems, Shelley, Victor, and Karen asked students to describe their thinking and process on each of them. The preservice teachers assessed how students were able to think about and manipulate shapes in their minds. Most of the problems given to students focused on determining students' spatial visualization skills. For example, one problem showed a shape and its mirror image, and asked students if these were the same shape. A majority of students had this understanding. In another problem, students were given a three-dimensional object that they could examine and physically manipulate. They were asked to circle the two-dimensional shapes that came together to form this three-dimensional shape. On this problem, students scored overwhelmingly poorly.

After giving the assessment, the preservice teachers came together and discussed their findings. They deliberately used the data to build a lesson based on students' emerging understanding. What was most powerful about these preservice teachers' thinking around student assessment was that it was a valuable exercise that revealed the importance of uncovering the student thinking behind a problem, rather than merely calculating the students' scores. Teachers were stretched to think about why various problems were most difficult for students.

Victor wrote, "Rather than thinking of student misunderstanding as them getting it wrong, now I think of this as learning opportunities. When a student says something that is incorrect, rather than quickly fixing their errors and getting them on the 'right track,' my focus now is to understand how my students understand the material. After giving them a chance to demonstrate their understanding, then I would give them an opportunity to test their concepts to see if it works. In teaching math this way, students are able to organically come to their own understanding of material."

Karen corroborated Victor's sentiment: "I am so much more critical of the mistakes that students make, and use that as a way to pinpoint where I need to be more explicit as well as exactly where and how I can help my students understand the material. I am not afraid to ask students to explain further things that they say in response to questions that I ask during a lesson. There might be something there that will really help others in the class, and who am I to dismiss something a student says because I don't know what they are initially saying."

She also directly credited lesson study in her increased learning on the use of assessment. "This past lesson study unit was such a wonderful thing to be a part of in helping me think about math lessons and use direct evidence from students as to how to better a lesson."

Learning Through Group Planning

The group planning process in lesson study seemed to affect the preservice teachers' ideas about teaching in different ways. For example, Shelley mentioned the positive experience of working with a group in planning exploratory lessons. She stated, "We wanted to give our students plenty of opportunities to explore materials, so that they could discover the properties of cubes on their own. It was a good experience for us to try to plan lessons that would be effective for the students in each of our classrooms. We ended up making our lessons very hands-on and experience-based, which is something that we thought would work for all of our students. The more I think about these lessons that we made, and how they worked out in our classrooms, the more I appreciate the lessons in which students learn through experiences." Clearly, the sum is greater than its parts and teachers were able to develop a better lesson through group think. Also, as indicated by Shelley's comment above, future ideas of teaching in their own classrooms were influenced by participation in the group planning process.

Learning Through Teaching and Observing

Shelley also noted the way in which observing her colleagues aided her in making changes: "The

lessons themselves were a good learning experience. I got to see Karen and Victor teach their first lessons before I taught mine, so I got to modify our lesson plans for what seemed to work, and also what I imagined would work with my students. I realized that worksheets need to be very clear and explicit, and it's always a good idea to model exactly what you want the students to do to get them started.” Pedagogical strategies were obtained through observation of other teachers.

Specifically in relation to preservice teachers' growth in student thinking, lesson study seemed to play a major role. In engaging in lesson study, preservice teachers were encouraged to teach exploratory lessons. All three of the case study teachers noted that the discovery aspect of their collaboratively-planned lessons was critical in maintaining student interest. However, some also noted that while the students enjoyed this style of teaching, they were not accustomed to it. The students struggled somewhat in coming up with their own solution methods, as they were used to being given a step-by-step solution process.

Despite the challenges we expect preservice teachers to face in implementing reform methods, the scores on the pre- and post-survey items on student thinking grew over time for all cohorts. See the figures in Appendix A for the mean score increases, along with the standard deviations.

Learning Through Debrief and Reflection

Victor discussed the benefits from being observed and engaging in a debrief session after the formal lesson, “During my research lesson, my colleagues were able to collect data as I was teaching. I found this beneficial because as a teacher, my mind was narrowly focused on lessons and management of materials and students. Conversely, my colleagues were able to focus almost entirely on student learning. My colleagues thus offered me a different perspective on what was happening in the classroom.”

Many preservice teachers also left the lesson study experience with more skill in how to address gaps in student thinking. Certainly the lesson study experience has propelled preservice teachers in the right direction. With more classroom experience, they will become adept at dealing with all students.

Shelley wrote, “While it is difficult to have a curriculum that allows for students who are at different levels in math, it is possible. In my...lessons, I got to use whole-class instruction, but the lessons allowed for students to work individually or in small groups. Lessons that are based on explorations, and what students notice about what they are exploring, can get students at all levels engaged. At the end, students think about and then share out something that they noticed, and this can be anything. I think that if my class goes into a unit with one or two main, guiding questions that all students should be able to think about and explore, then the unit will be successful for all students. For the more advanced students, though, it is important to be thinking of questions to ask them that will advance their thinking. And it is important to think of these questions beforehand”

All three teachers watched video of their own teaching of the lessons. This reflection process further enhanced teacher learning. Victor noted, “We asked our students to work in groups. What I realized [was] that most of these students although ostensibly working together were not engaging in group-work in a way that was most beneficial. In looking at video and observations, it became apparent to me that students need to have solid expectations for how they should be expected to work in groups.”

Discussion

The study suggests that lesson study has the capacity to influence preservice teachers' beliefs and transform their knowledge which is crucial for effective teaching. At the very least, lesson study pushes preservice teachers to examine their existing mathematics content knowledge, pedagogical knowledge, and pedagogical content knowledge. The lesson study experience forces teachers to examine critical elements of teaching in an authentic way – through the lesson planning-teaching-reflecting cycle.

What is specific to lesson study that allows this type of learning to occur? First, the opportunity to

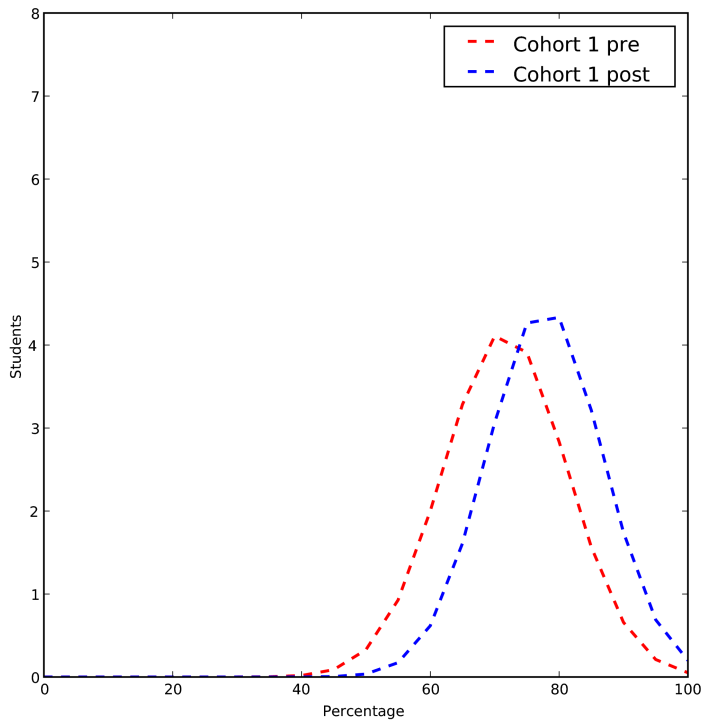
experience the coherent lesson planning cycle is critical. Preservice teachers seldom have the chance to engage in the entire cycle in their own classrooms. Second, the lesson debrief with colleagues and experts enables teachers to gain assistance in interpreting student thinking. We cannot expect teachers to have mastered this skill upon entering the classroom. Rather, they need scaffolded learning opportunities such as those provided by lesson study. Third, because lesson study is based on collaboration with colleagues, multiple voices can contribute to the creation of the best learning environment for students. Preservice teachers identified how helpful it was to experience each other's teaching process (by observing and debriefing) to make sense of their own teaching. Finally, lesson study places the student at the center of the professional development, rather than the teacher. This allows for a judgment-free experience, encouraging teachers to speak freely and openly about questions and issues that are central to their advancement as professionals.

References

- Ball, D. & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.). *Multiple perspectives on mathematics teaching and learning*. Westport, CT: Ablex Publishing. pp. 83-104.
- Fernandez, C. (2005). Lesson study: A means for elementary teachers to develop the knowledge of mathematics needed for reform-minded teaching? *Mathematical Thinking and Learning*, 7(4), 265-289.
- Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.
- Hill, H.C., Schilling, S.G., & Ball, D.L. (2004) Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal* 105, 11-30.
- Lampert, M. (2001). *Teaching problems and the problems of teaching*. New Haven: Yale University Press.
- Lewis, C., Perry, R., & Murata, A. (2006). How should research contribute to instructional improvement?: The case of lesson study. *Educational Researcher*, 35(3), 3-14.
- Lewis, C. & Tsuchida, I. (1998). A lesson is like a swiftly flowing river: Research lessons and the improvement of Japanese education. *American Educator*, Winter, 14-17 & 50-52.
- Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1-21.

Appendix A - Distribution of Three Cohorts' Pre- and Post-Survey Results

Cohort 1 (2005 – 2006)

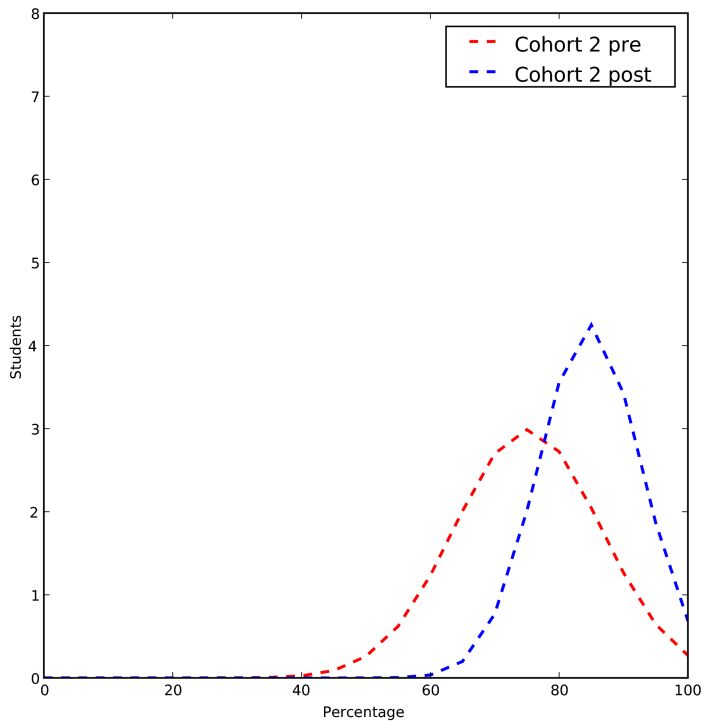


Group	Mean	Std Dev
Cohort 1 Pre	71.6	9.3
Cohort 1 Post	77.8	8.7

t-test: 95.8% confidence

Figure 1. Distribution of Cohort 1 pre- and post-survey results

Cohort 2 (2006 – 2007)

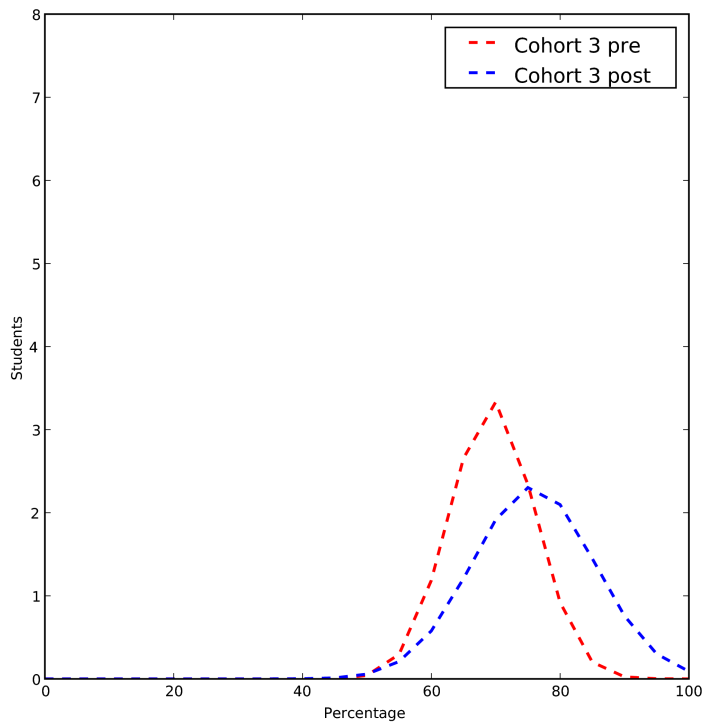


Group	Mean	Std Dev
Cohort 2 Pre	75.1	11.0
Cohort 2 Post	84.8	7.7

t-test: 99.3% confidence

Figure 2. Distribution of Cohort 2 pre- and post-survey results

Cohort 3 (2007 – 2008)



Group	Mean	Std Dev
Cohort 3 Pre	69.5	6.3
Cohort 3 Post	75.8	9.1

t-test: 91.8% confidence

Figure 3. Distribution of Cohort 3 pre- and post-survey results