

The Effects of Participating in Lesson Studies on Practices of Teaching Mathematics

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Abstract

Lesson study has been identified after the Third International Mathematics and Science Study as an effective, practice-based professional development form. Teachers' attitudes and beliefs regarding teaching are slow to change, and teaching practices change even slower. Since a large percentage of Californian students fail to master basic mathematics concepts and study skills, and have very limited problem solving ability, Californian teachers must implement significant changes in their instruction.

This paper highlights the effects of long-term participation in lesson studies on the teaching practices of mathematics teachers in California's Central Valley. The investigated areas include teachers' subject matter knowledge, the use of real-world investigations and problem situations in the instruction, and the requirement of group-work and group-presentation.

Introduction

Professional development plays a critical role in improving classroom instruction (National Research Council 2001). Although there are various methods used for professional development, Lesson Study has become a very popular method in California during the past several years because it promotes teacher-driven instructional change. Protected by the carefully assembled protocols, lesson study can be used by the teachers to enhance their mathematical knowledge and pedagogical skills, and can lead to student centered teaching in the classroom (Amarasinghe & Premadasa, 2007; Stiegler & Hiebert, 1999).

The California State University (CSU), Fresno campus serves teachers in a large part of Central Valley in California. During the past three years, the mathematics faculty of the university has worked with teachers through three California Mathematics and Science Partnership (CaMSP) grants. Each of the three grants focuses on providing intensive professional development institutes during vacation time and requires the teachers to work in lesson study groups during the academic years. The work culminates in a year-end showcase/exchange with the involvement of every group. The 30-50 teachers in each grant earn hourly stipend for participating, and also have the option of receiving university credit for their work.

The first partnership is with Fresno Unified School District, which is one of the largest districts of California, the second is with Central Unified School District, and the third is with Sanger and Kings Canyon Unified School Districts.

Obstacles of High Student Achievement

The student population of each of these districts includes a very high percentage of English language learners. Many of the students come from low-income families where the parents have only minimal education, and have encountered frustrating job experiences and lots of instabilities in their lives. The students are many times uncomfortable and isolated in the classroom. Many of them need to change schools several times due to relocations. Gangs and "bullies" are also frequently present in the schools, frightening their peers. Most of the students crave attention, supportive social network, stability, and a chance to succeed.

Before starting lesson study, many teachers had used the traditional lesson structure identified in the video study part of the Third International Mathematics and Science Study: Giving out homework results, then short lecture on new material through examples, followed by seat work (Stiegler & Hiebert, 1999). This approach often had failed to engage the majority of the students. Through lesson study, the facilitators (selected by the districts) and the content experts (university faculty) have encouraged experimenting with the implementation of problem solving activities, group investigations and presentations, use of technology, visualization, and manipulatives for making the students active, socially connected, and successful learners, as it is also required by national teaching standards (National Council of Teachers of Mathematics, 2000). Teachers needed to get exposed to samples of these approaches during the intensive content institutes, and definitely needed the knowledge base and the support of the content experts and their peers during the design and implementation of the lessons developed in this spirit.

Another area of need was the development of good questioning techniques, including techniques for whole class discussions and small group discussions for promoting students' active engagement and for monitoring their progress.

The Intervention

The participating teachers have gone through a variety of professional development in the past, many of which were one-time workshops with no follow-ups, or connections to everyday teaching duties. Lesson study has provided them with classroom-specific professional development in content and methods. It also has established a culture of collaborative lesson development and peer support. In the past, teachers had their lessons seen by other professionals almost exclusively for evaluative purposes. During lesson study, each lesson, developed by a group of 5-7 teachers, was taught twice by two different teachers and observed by all of the other group members. Developing trust and confidence in each other took time, but was very rewarding for the teachers.

Helping teachers to understand the underlying mathematical concepts and required reasoning skills of the school curriculum was a major part of the intensive content enhancement institutes. Most of the content was discussed through problem solving and participant driven activities. Problem solving has been a weakness of many of the teachers. They not only had difficulties to use a problem solving approach in their classroom instruction, but also to solve mathematical problems themselves (Tuska, 2006). In order to familiarize teachers with interesting problems and to improve their confidence and abilities, a mathematical "Problem of the day" was assigned at the end of each day for institute participants to be solved in groups using multiple strategies. The groups have shared their solutions with the rest of the participants during the next day morning. Participants compared their solutions and discussed the value of various strategies used. These discussions were facilitated by the instructors. It has been a useful exercise for the participants to become aware of ways other people think and use mathematics to solve problems, and to realize that their own students see and use mathematics in a variety of ways.

In order to improve communication between teachers and students as well as among students, participants read various articles related to improving classroom communication and viewed video clips of exemplary lessons with effective communication in mathematics classrooms during the summer institutes. Then, they discussed how those strategies could be implemented into their own classrooms.

Manipulative-based activities, using Quisenaire rods, algebra tiles, geoboards, pattern blocks, Zome tools, and power solids allowed participants to expand and connect the pieces of their mathematical knowledge. Also, many of them used these tools in their teaching in the

classrooms, particularly in the research lessons designed through lesson studies. The effective use of graphing calculators for Algebra and Statistics and utilizing Geometers Sketchpad for Geometry and Algebra was also demonstrated and promoted. Unfortunately, we found teachers to be very reluctant of using any of these tools in their classrooms. Part of their unwillingness might have been due to their unfamiliarity of designing conceptual tasks where technology can be used as an investigative tool. Other parts might have included the fear of losing control over the class and their own limited knowledge of the capabilities of these tools.

In addition to the content enhancement institutes, workshops were also provided about the strategies and tactics of conducting lesson study, as a second component of a comprehensive professional development. The third component was the actual implementation of lesson study at the school sites (Tuska & Amarasinghe, 2008).

Results

In successful lesson study initiatives in the United States, teachers benefited from increased knowledge of subject matter, increased knowledge of instruction, increased ability to observe students, stronger collegial networks, stronger connection of daily practice to long-term goals, stronger motivation and sense of efficacy, and improved quality of available lesson plans. Lesson study did not only improve a lesson. It challenged teachers to improve their classroom instruction (Lewis et al., 2004). We have detected the same changes to various extents in our three local grants.

The focus of lesson study is the design and implementation of lessons that achieve the long term, instructional and pedagogical goals set by the lesson study group. Since a large portion of the participating teachers worked at low performing schools, the improvement of student achievement as it is measured in state-wide testing, and the improved engagement of students in the learning process were included in the broad goals of the groups. So far, we have only anecdotal evidence about improved student achievement, but the pre- and post-tests, conducted as part of the content institutes, have shown significant gains of teachers' content knowledge.

During the first year of participation in lesson study, teachers have often underestimated the capabilities of their students to successfully complete the tasks they were developing in the research lesson. Many times, they were pleasantly surprised by the outcome of the lesson particularly because of the unanticipated valuable contributions done by some students whom they have considered weak or uninterested. Members of the group who were collecting data from the student groups often reported very interesting mathematical conversations among students and about the ways students acted within the groups. These observations have also helped teachers to better anticipate student thinking and to learn to listen more carefully to student discussions. As the teachers' content knowledge and comfort with the investigative, active lessons grew, their confidence in their students' abilities have grown, too.

Based on our experiences, designing a good lesson takes at least 6 hours, and at least three meetings. When groups met only once or twice, they have settled very soon on a conventional approach or on a lesson plan that was presented to them in the past. The rushed preparation has led a group of teachers in another project to design a lesson for seventh graders based on sixth grade standards, repeating an activity that many students have completed during the previous year. The creative ideas for a lesson started to evolve only during the second or third meeting. The careful design of the lessons, including the preparation of materials, worksheets, questions, and closures or extensions took at least two more meetings.

In one of the successful lessons, student groups were assigned to have a particular profession, such as carpenter, waiter, accountant, fire fighter, doctor, or nurse. Each group have received a short description about the way they get paid. Hourly wages, tips, "overtime" payments and

taxes were discussed. The group's task was to figure out their monthly earnings, to graph their earning as a function of the number of hours they work, and to use the graph for predicting the number of hours they need to work in order to reach a particular amount of take-home income. As a preparation for this lesson, students' homework was to make choices about their living conditions and preferences with realistic prices. The choices were presented in a menu format. Their task was to estimate the income they would need to have for being able to afford that life style. Choices included buying a house, renting a room, or living with parents, having children, having a working spouse, traveling a lot, having a fancy car, a used car, or using public transportation, etc. Most of the students were very much interested in these investigations. Each group had to show their graph and present their findings. The meaning of differences in slopes were discussed and further examined. The lesson was very useful for introducing the slope of a line in a real-world situation, and to improve students' graphing, estimation, and presentation skills. The requirement of working in groups allowed students to socialize, take roles, read and interpret mathematical problems, and write and discuss solutions.

Another good lesson was focused on planning a family trip to a popular entertainment park. Information was given from the web regarding admission fees, hotels, mileages of various cars, maps, and student groups had to make estimations about the total price of a trip for a family. Since different groups had different destination points and different family sizes, the particular presented results gave a solid ground for asking further questions about various relations. For example, students were asked to write a formula to predict the price of the gas for a particular car as a function of the number of miles traveled. Another question was to use the car's mileage as a variable for the gas price on a particular trip.

During the first year of designing problem- or investigation-based lessons that utilized group work, the instructors frequently ran out of time before any conclusion, summary, or even the presentation of results were done. Many lessons left students in confusion. A major part of this problem came from the teachers' lack of experience of setting the tasks clearly, and to let the students work using their own approaches. By the second year of participation, most of the time the tasks were presented to students with specific timeline and with a clear statement of what kind of outcome is expected from them. The disruptions from the teachers trying to state, re-state, or modify the tasks, and to suggest particular methods or giving out solutions to groups separately during group work times, were significantly reduced, and the effectiveness of the lessons have considerably improved.

The majority of the lessons had focused on a particular problem situation, that was investigated by student groups. After a "warm-up" activity, students had ample time for discussing the situations and prepare a report of their findings. Many times, the same lesson was used in algebra classes for 8th graders and 10th graders. The overwhelming majority of 8th graders had better presentation skills, mostly due to more self-esteem and more motivation towards learning. Nevertheless, even the weak and shy students were more engaged, and made more positive comments in the end-of-lesson questionnaires about these "active" lessons than about "traditional" mathematics lessons.

Through the years, working with the same group of teachers, many of the university faculty observed positive changes in teachers' commitment to teaching, too. Teachers became more and more striving for improvement in their teaching. They also appear to be more motivated about staying in their profession now than when they started the project.

Final remarks

The extensive long-term collaboration with the various teacher groups has provided valuable learning experiences to the participating university faculty, too. We could improve our content

courses for prospective teachers with field-tested examples of lesson ideas and with connections between the college and K-12 curricula. Some of our pre-service teachers participated in lesson studies, and gained valuable early field experience during their undergraduate studies. We believe that the inclusion of lesson study in teacher preparation programs would be very beneficial.

We have recognized that achieving substantial improvements in instructional practices require consistent long-term efforts and close collegial communications among experts and peers. In the process of designing and providing on-going professional development for K-12 teachers, we, the university faculty, have also gone through a lesson study process, and have gained deeper content knowledge, became familiar with a wider variety of instructional methods, and reached a better understanding of and a greater respect for the teachers who work extremely hard to help the next generation of students to succeed. According to the traditional saying “it is not the destination but the journey that counts” the value of the lesson study is not the final lesson but the experience teachers go through developing and experimenting that lesson. From our experience those groups who choose to spend considerable time in that process seem to have clearly benefited from it and gained long lasting professional development.

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