

Promoting math teacher active learning with the lesson study approach

A case study of in-service teachers' perspectives

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Abstract

Purpose – Recent years have seen a movement toward using active learning to ground professional development in classroom practice. The paper aims to discuss this issue.

Design/methodology/approach – The present case study describes how a group of middle school mathematics teachers improved classroom instruction through the use of lesson study.

Findings – This case study suggests the success of the lesson study in supporting teachers' active learning.

Originality/value – For the lesson study, teachers' active learning is assessed across four dimensions.

Keywords Lesson study, Reflection, Professional development, Active learning

Paper type Research paper

In the USA, mathematics education has been in a constant state of reform for several decades (National Council of Teachers of Mathematics, 1989, 1991, 2000, 2014; National Research Council, 2002). Teachers are frequently asked to adopt new teaching philosophies and methodologies (Ball *et al.*, 2001; Ma, 1999). Reform-based teaching practices differ substantially from traditional approaches concerning the nature of mathematics, the role of the teacher and theories about student learning (Hiebert *et al.*, 1997). To adapt to changing expectations, teachers need support to assimilate and implement the findings of current research on student reasoning, pedagogy and mathematics content (Kilpatrick *et al.*, 2001; National Council of Teachers of Mathematics, 2000; Loewenberg, 2003).

Providing teachers with quality professional development improves classroom practice (Ball and Cohen, 1999; Kilpatrick *et al.*, 2001; Lieberman and Wood, 2002; Schifter and Fosnot, 1993). In recent years, there has been a movement to ground professional development in classroom practice, or in other words, link professional learning to teachers' concrete work circumstances (e.g. Darling-Hammond *et al.*, 2009, Vescio *et al.*, 2008). Vega (2016) argued that effective professional-development programs are job-embedded, which means they are integrated fully into the culture, community and location of the workplace. Also, Garet *et al.* (2001) identified the following three core features of effective professional development activities: a focus on content knowledge; the presence of opportunities for active learning; and a general coherence with other learning activities familiar to the teachers. However, the question remains: what specific approaches promote effective professional development activities?

Recent research literature attests to a consensus that lesson study exhibits characteristic features of high-quality professional development (Borasi and Fonzi, 2002; Darling-Hammond and McLaughlin, 1996; Garet *et al.*, 2001; Lewis *et al.*, 2006, 2012; Lewis and Perry, 2014). Using lesson study for professional development originated in Asia – in particular in China and Japan – and has spread rapidly in the USA since the turn of the century (Lewis *et al.*, 2006; Ngang and Sam, 2015). A lesson study refers to a group



of teachers observes a colleague's classroom during an activity or lecture, collecting data about the quality of the observed teaching, and analyzing these data to suggest improvements that will facilitate student learning (Hiebert *et al.*, 2002; Kilpatrick *et al.*, 2001; Loucks-Horsley, 2003; Stigler and Hiebert, 1999).

According to Lewis (2002a), a lesson study is a collaborative, teacher-led professional development approach in which teachers:

- engage in professional learning teams to determine short-term and long-term goals for students' learning;
- create a lesson that builds on the identified goals for students;
- choose a team member to teach that lesson while the other teachers act as critical observers;
- reflect on that lesson and what the teachers learned about their students;
- develop improvements to that lesson and instruction techniques;
- teach the revised lesson to analyze and improve it further (if needed); and
- report what they (the teachers) learned through this process.

Using lesson study for professional development has great potential for improving teaching and learning. However, in the USA, several challenges arise from the country's educational history and cultural context. Some researchers have argued that unique aspects of Asian cultural and educational contexts have helped lesson study succeed, and thus success may not translate well in the USA (Fernandez, 2002; Marble, 2007; Perry and Lewis, 2008). Moreover, although many believe lesson study holds promise, opportunities are missed because some participants lack the needed content knowledge and skills necessary to make lesson study viable, collaborative experiences (Parks, 2008). Despite these challenges, in principle, lesson study still offers teachers a chance to reflect collaboratively on their practice in a way that differs from other more passive approaches to professional development. Lesson study is "practitioner-driven inquiry because of its inherent focus on teachers as researchers" (West-Olatunji *et al.*, 2008, p. 97).

The main goal of lesson study is to provide teachers with an opportunity to improve their teaching (Fernandez and Yoshida, 2004; Lewis, 2002a, b). By engaging teachers' knowledge, beliefs and dispositions in the interpersonal context of the teachers' learning community, lesson study improves instruction and curriculum (Lewis, 2016; Lewis and Perry, 2014). Huang *et al.* (2014) developed a framework to describe the facilitator-learner processes that take place while constructing knowledge during a lesson study. Their framework focuses on what roles the teachers and the facilitators play in teachers' learning during a lesson study, but their framework does not account for the role lesson study activities may play in teachers' learning experiences. Thus, it is essential to seek a better understanding of the role played by activities in lesson study, such as planning and presenting lessons.

The case study reported here took place in one middle school in the USA, under a team of researchers from a nearby large public university. Our case study focused on the role lesson study played in teacher professional development – more specifically, our case study investigated whether lesson study activities promoted math teachers' active learning.

Theoretical framework

From the constructivist perspective, active learning means learners construct knowledge and generate meaning through activities, especially constructing new knowledge by using the learners' prior knowledge (Anthony, 1996; Michael, 2006). The properties of active learning are cooperative and collaborative between the learners, plus learners' reflection

(Anthony, 1996; Brandon and All, 2010; Michael and Modell, 2003; Slavich and Zimbardo, 2012). In the recent study by Olson (2014), she examined the understanding and use of active learning theory and methods of the instructors in physical therapist education programs and found that all participants agree or strongly agree that students learn best when they are involved in the process of actively learning.

Studies indicate that active learning works for students (e.g. Michael, 2006; Olson, 2014). Active learning also works for teacher professional development (Garet *et al.*, 2001). A core feature of effective professional development is providing teachers with opportunities for active learning (Garet *et al.*, 2001). In Garet *et al.*'s (2001) research, they focused on the following four dimensions of active learning:

- (1) Observing and being observed: the opportunity for teachers to observe expert teachers, be observed teaching in their classroom, and obtain feedback.
- (2) Planning for classroom implementation: the opportunity to link the ideas introduced during professional development experiences to the workplace.
- (3) Reviewing student work: the opportunity to examine and review student work.
- (4) Presenting, leading and writing: the opportunity to give presentations, lead discussions and produce written work.

We applied these four dimensions of active learning as a theoretical framework, to examine a lesson study case, investigating whether a lesson study provides opportunities to promote math teacher active learning.

Methods

Participants and site

We collected data from 14 fifth- and sixth-grade mathematics teachers (five males and nine females) who participated in a three-year lesson study series at a school we will refer to as Athens Middle School. Of the nine females, two were Hispanic, and one was black. The participants' teaching experience ranged from 2 to 30 years. The turnover of the teachers in this school was high, with around 50 percent of teachers staying beyond three years. Five researchers (external team) from a nearby large public university also attended the lesson presentation and lesson reflections on one day, and a post-reflection session held a month later when teachers met for monthly professional development. The researchers also played supporting roles in the lesson study, such as helping the mathematics teachers better understand the meanings of lesson study and assisting with the pre-meeting to discuss what everyone might expect (Details about pre-meeting are presented in a subsequent section).

Design and procedure

A case study approach (Stake, 1995) was used to investigate whether lesson study activities promoted math teachers' active learning. Out of the 14 teachers who participated, 3 (Jane, Lori and Katherine, which are all pseudonyms in this study) were selected by their colleagues to plan the lesson. Jane presented the lesson to a 6th-grade class, and the rest of the teachers were involved in observing and reflecting on that lesson. The three teachers' teaching experience ranged from 3 to 15 years. They met several times to design and fine-tune the lesson to meet the state standards.

During the day of the official lesson presentation, the research team of four faculty members from the university, the remaining 6th-grade teachers, and the school's principal met to discuss expectations and establish protocols for how to analyze classroom discourse to enrich reflections on the lesson. A lead researcher from the University presided over the

session, which lasted about 1 h. The team headed to a classroom for the presentation of the lesson by Jane to 6th graders, and the other two co-planners watched with the rest of the 6th-grade teachers and the four researchers. After the lesson, the team met for a reflection session, which lasted about 1.5 h. Four weeks later, the research team engaged the teachers in a post-reflection session to reflect on the lesson and the previous reflection session. Lesson presentation, lesson reflection and post-reflection sessions were videotaped and transcribed. The three teachers who designed the lesson plan were also interviewed. Then, the following year, we followed up with Jane and another teacher to assess the role of the lesson study in their subsequent teaching practice.

Data sources

Lesson study video. Data collected for this study included videotapes of the preparation, presentation and reflection of the lesson by the 6th-grade teachers, their principal and the four researchers.

Other documents. Data also included lesson plans, researchers' field notes, interviews, student work, teachers' written reflections and teachers' evaluation notes for the lesson study.

Data analysis was conducted concurrently with data collection, and data interpretation was used in writing a narrative. In doing this, we focused not merely on collecting or ordering a mass of data, but on organizing the ideas that had emerged from the analysis of data (Strauss, 1987).

During the first stage of data analysis, the videotapes of the entire meetings of the teachers and researchers were examined. The meetings involved preparation of the lesson presentation, lesson presentation, lesson reflection, and post-lesson reflection. Also, videotapes of preparation of the lesson plan and classroom videotape follow-ups were analyzed. Additionally, field notes that were taken during the exercise were incorporated into the analysis. As the data were collected, video and audio (interviews) data were transcribed. Lesson plan, field notes, students' work, teachers' written reflection and teachers' evaluation notes were also uploaded to data analysis software and codes were created using NVivo software. Each code was linked to other data sources for data triangulation and development of categories to link to the research. Our research investigated whether lesson study activities promote math teachers' active learning from the four dimensions discussed in Garet *et al.* (2001).

Findings

Planning and preparing for the lesson

Preparing the initial lesson plan collaboratively. The goal of the lesson was to have students apply previously learned ideas of rates/proportions and unit conversions through an investigation of measurement, and have them predict, examine and compare/contrast possible solution strategies and organizational tools. The lesson was to expose students to real-world applications of measurement, relationships, algebraic thinking and problem-solving strategies.

The lesson was prepared collaboratively in the initial stages, and, subsequently, three teachers, Jane, Lori and Katherine, were selected to write the lesson. The three teachers met several times to prepare the intended lesson and were guided by Texas State Standards (Texas Education Agency, 2007–2011). The lesson had the following components: goal of lesson, rationale, student investigation, curriculum relationship, student knowledge and teacher preparation, materials/resources, lesson procedure, assessment and lesson evaluation.

The three teachers were interviewed to give their opinions about their experiences in preparing the lesson. Jane liked the idea of three teachers meeting together to prepare a

lesson and share ideas and strategies. Despite Jane's saying she liked the idea, she was also somewhat apprehensive. Not only were her colleagues observing her, but so were researchers from the university. When asked by one of the university researchers to talk about what she thought about planning together, Jane stated:

I would like to see more collaboration on writing the lesson, but I did enjoy getting together with the group and modifying the lesson and then having Lori come in the first time that I taught it and got her feedback on that. So instead of Katherine writing the lesson by herself and then the three of us meeting to discuss it, it could be a good idea for the three of us meeting and coming up with the lesson together and seek feedback from the other colleagues.

Lori and Katherine similarly argued that it could have been better for three of them to write the lesson as a group, rather than one of them writing it and then discussing and making modifications. They noted, though, that collaboratively discussing the written lesson and making changes to it made a big improvement to the lesson. Lori, Katherine and Jane noted that collaboration among them played a role in the success of the planning of the lesson.

Revising the lesson plan through a rehearsal of the teaching. Data collected for the lesson rehearsal were gathered through interviews with the three teachers involved in the lesson planning. In preparation, Jane taught the lesson to her colleague for feedback; as she noted, "I did teach it to another class before, so I didn't change much except the wording of the problem. I broke it up a little bit for the kids, but that is all we did." Asked to comment about that, Lori had this to say:

I went, and I watched Jane beforehand because she wanted to, and so did I. She wanted it to come off well, and so I gave her a few pointers, clarity, making sure that when we presented that it would be clear. It was always an open conversation and changing and adapting, as we needed to.

Overall, a rehearsal of the teaching before the actual presentation of the lesson provided the three teachers with an opportunity to meet for fine-tuning the lesson and ultimately to make the lesson better prepared and more targeted. For example, one teacher noted that they had learned ways to improve their lesson plans and the kind of questions to ask when teaching.

Preparing full lesson using internal and external resources. One lead university researcher, Naomi, played a supporting role in the lesson study by discussing in the pre-meeting what everyone might expect. This meeting was attended by 14 teachers, the school principal and university researchers. In preparation for the full lesson, Naomi began by stating what lesson study is all about – "Try it out and see if it works out, and how it can be improved." She noted that in the process, the researchers would have the opportunity to examine students' behaviors, but more specifically, the researcher would be interested in the mathematical content that the class would be working on. Naomi then passed out the lesson plan designed by the three teachers. Naomi used this time to prepare teachers for what to do during the lesson (such as acting as critical observers) and asking them to be more observant of the lesson that Jane taught.

In guiding teachers on what to do in the classroom as observers, Naomi directed them to watch either the whole class or observe interactions at a particular table, as the lesson has been written for small discussion groups. It was her stated opinion that the most important aspect of the lesson study activity was, after the teaching demonstration, to have teachers' input on the effectiveness of the lesson, and whether or not it facilitated the students' learning of this particular topic. As Naomi noted: "So I would like you to know what the intent of the lesson was so that you are not interpreting it through a different lens because there are so many aspects of the lesson that one could address, but this is very specific."

Naomi continued to note that teachers and researchers would be observing and looking at what the students were doing and listening to student conversations. She pointed out that the goal was to structure the lesson so that those particular facets of the lesson could

become public. Naomi wanted teachers and researchers to think about these issues and how lesson study could influence teachers to think about how their lessons could be written, to provide such opportunities for students to present the contents of their conversations and discoveries.

Presenting the lesson observed by other participating teachers and researchers. Jane, the teacher, started the class with four warm-up questions. Teachers and university researchers went around the room, watching what students were doing. After approximately 5 min, Jane asked students to share their responses to the warm-up questions in their small groups.

Main lesson. After the warm-up, Jane presented a problem and asked a student to read it:

Student: you are working at a small Zoo. The director has put you in charge of ordering food for the four horses. He has given you the following information

Horse data:

Average weight of a horse: 500 kg

Average amount of grain eaten by a horse each day: 500 g

Average amount of hay eaten by a horse each day: 10,000g

A hay bale weighs 500 kg and costs \$50

A 25 kg bag of grain costs \$8

You need to place an order for enough hay and grain for March. Determine the cost.

Jane analyzed the problem and asked her students the following question: “So what’s the first thing you are going to be looking for? What is the problem asking you?” She and her students then discussed the problem around those questions. After the discussion, Jane divided the students into eight groups of three. She gave supplies (big paper, work paper and coloring utensils) to each group and let them discuss the questions. Discussion among groups indicated that students were deciding on strategies for working out the problems. Some suggested changing units to grams and others kilograms. There was no strategic reason initially indicated as to why students preferred to use either kilograms or grams for their work.

After a while, Jane asked everybody to pay attention:

Okay, I see some great work happening here. So, I’ve asked four groups to present and a lot of you worked the same problem a lot differently, and you got different answers. So, when you present, I want you to explain your thinking and how you got those answers. So, Elias, will your group go first, please? And you can peel back your sticky part and attach it to the board up there.

At this point, students were busy organizing their thoughts and presenting materials as they waited for their turns. Those who finished first were selected to present. The students seemed excited and were busy discussing who was going to present and what to talk about. Jane then gave Elias’ group a chance to present.

After the group presentations, Jane asked other students if they found anything different regarding cost and amount. She was not letting the others know whether these groups that presented before had answered correctly or not. The reason for this reticence was to encourage other students to provide answers they had without being influenced by previous presenters. She also emphasized the concept of answers being reasonable by providing the students with real-life experience. Jane said, “I told them how much I made in a year, and it was pretty close to the amount the zoo was spending per month on hay. So, they decided to revisit their work, and here is what they came up with.” She demonstrated the answer provided by students for the rest of other students to make sense of it all.

After presentations, the teacher engaged students in discussions of the answers that had been presented. It was agreed upon that they all came up with the same answer, but they followed different ways. Then the class was dismissed.

Reviewing student work

Reviewing student work in class

Student Work 1: Elias' group. Student: we need to find out how many grams of hay four horses ate in a month, and we got 1,240,000 ($310,000 \times 4$) grams of hay, and there are 500 kg for \$50.00. So then 500 kg was 500,000 grams. So when we had that, we subtracted 1,000,000 from 1,240,000, and then we had 240,000 left over. So, we divided three hay bales and the cost of all three of them by \$150.00.

Reviewing this group's work in Class

It was observed that the students noticed that there were 500,000 grams for \$50.00. Since the horses consumed 1,240,000 grams of hay, the students realized that two bales of hay would be 1,000,000 grams. A total of 240,000 grams were left over, and this was not enough for a bale. One cannot buy a part of a bale; therefore, the students rounded up. That accounted for the three bales of hay they presented, as noted in Figure 1, at the left corner of the poster board as one student from the group noted: "buy an extra bale of hay to fill the left over to make 3 bales in total."

Student Work 2: Myrie's group

As one of the students noted:

We found that each bale of hay was 500 kilograms, so we changed that to 500,000 grams. We divided 500,000 by 10,000, and we got 50. Each horse eats $1/50$ of a hay bale. With 4 horses then $4/50$ and 4 goes into 50; 12 times and so we divided 31 into 12 and got a little under 3. And so we got about 3 bales of hay a month. And we multiplied 50×3 , and we got \$150.00.

Reviewing this group's work in class

This group started with the weight of one bale of hay and then figured out what fraction of one bale one horse eats in a day. The units of their fraction are grams eaten per day over

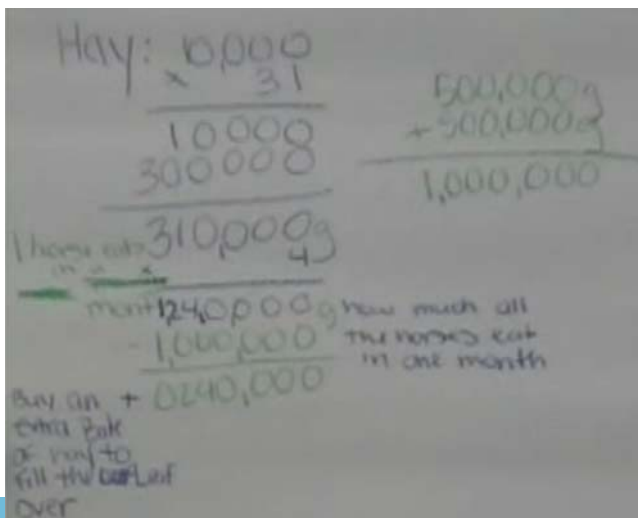


Figure 1.
Student Work 1:
Elias' group

grams of an entire bale of hay. Then, they multiplied that fraction by 4 to get the fraction of 1 bale that all four horses eat in one day. Next, by dividing the numerator into the denominator (4 into 50), they found the number of days required for the four horses to consume one entire bale. Next, they divided the number of days it takes to consume an entire bale into the number of days in the month. This gave them the number of bales they would need for the entire month. Finally, they multiplied the number of bales needed by the price per bale.

Reviewing student work after class with teacher reflection

After the lesson presentation, researchers from the nearby university, the team of teachers and the lesson teacher (Jane) met to reflect on the lesson. Naumi asked Jane to talk about the execution of the lesson, her thoughts on how it went, and any elements that struck her.

Jane reported that the students had been previously studying unit rates and how to set up ratios, she was glad to see that pretty much all of the groups did that. The students had also been working on their multiplication skills. In responding to what worked well and what did not, Jane thought the brainstorming worked well and at the same time, how the students immediately got to task and looked back at their brainstorming ideas to help them move forward.

Another issue that came up was that students were not labeling their units, and that made it a challenge for them to navigate through the problem-solving process. One teacher noted that the students needed prompting to communicate their understanding satisfactorily to the other students. In response, Jane observed:

The group noted that they enjoyed the lesson and were amazed at the different strategies that came up, particularly the $\frac{1}{50}$ th – that was pretty interesting. When they started doing $\frac{1}{50}$ th, “I (Jane) was like oh my god what are they going to do, but they managed to get the answer.” Teachers also indicated that it was a good idea to present different approaches but it was suggested that it might have been a better idea to bring the simplest approach first and then bring the groups who were doing different kinds of thinking later on so that more of the students could get involved in the beginning and say “I understand this,” and then understand the last one, especially if the last one is more complicated or has more difficult calculations or is otherwise more difficult to follow.

Discussions led by teachers

Discussion Point 1: how to improve the group studying practices

The teachers believed that Jane asked good questions when they needed to be asked, and they were all open-ended questions. The use of “what else?” was very common.

They also noted that having the students in groups and the general arrangement of the room facilitated the students’ helping each other and correcting each other’s mistakes. As one teacher noted, “They started doing their multiplication and their work, and then finally one of them said, ‘no, but that’s for grain.’” Working in groups helped the students keep track of what information belonged to hay and grain to avoid that mix-up. Some teachers suggested that Jane should not have jump-started the problem but given students the opportunity to figure it out. They thought that the lesson should not be changed, but that students need to realize that working in kilograms makes the problem somewhat easier. Perhaps there should be some discussion to point out that those who were working in grams may have been using the same approach, but the computational part was a lot harder.

The teachers noted that an opportunity was lost by not asking students why they employed the arguably easy way – was it by chance or was it a considered smart strategy? Another teacher added “Maybe by luck. So it would have been good for them to experience kilograms to grams that are a reasonable thing to do but it ends up not working as well in

this problem.” Other teachers opined that the children who did employ kilograms knew they were looking at a lot of zeros, and so did not choose that unit by chance. In response to that observation, one of the researchers suggested that what the students experienced in the group work about the unit change is a kind of “insight.”

Regarding group dynamics, it was suggested that the groups knew what they were supposed to do because Jane said they were going to work in groups, and the task was laid out for them. It was suggested that if one plans to use a lesson like this, group norms and group work would need to be decided beforehand. In response to that, one teacher noted:

One thing that you can do is to give just a few moments to say okay everybody thinks about the problem, how would you approach the problem? What would be the first two steps that you would do to solve this problem – write that down on your piece of paper. Okay, now discuss in your group – see if you have the same steps, argue about the steps – that kind of thing, and it also gives a little bit of accountability because when you come to a group, you’re looking at group work, right? But if they are supposed to have written down some steps, then you can come to a person, and that person has to have at least written down those steps, so that forces them, hopefully, encourages them to do that.

Discussion Point 2: how to take the lesson and work it with different groups of students

While thinking about anything that needed to be changed to fit other teachers’ particular classrooms, one of the researchers noted “So maybe you all just for a second can envision the classroom that you would be doing this lesson in. Is there anything that you would change about it? Do it differently because it’s you in that particular classroom and then why? Maybe you can think a little bit.”

In response, teachers suggested that they might guide the class step-by-step throughout the activity and include the conversation at the beginning about a lot of zeros. Another teacher noted that the idea of a warm-up task was to address that, and there was no need to address it again. Discussion ensued as to why changes were needed, and what points of the lesson worked best in the class they were envisioning. Other teachers suggested that it could have been a good idea to have the question written down on index card, as it is often hard for children to work with numbers with multiple zeros when they are scanning between their work and a whiteboard.

There was a consensus that the lesson was well executed, and there was a lot to be learned from it; and it was agreed to meet again to reflect more on the lesson, specifically to reflect on their initial reflections after having time to think about the lesson and the experience. Hence, there was to be a reflection on the first reflection.

More reflections and discussions led by researchers

This session began with the researchers from the university distributing a lesson study reflection handout. In that handout the following questions were posed:

- What do you remember about the lesson study demonstration lesson? Explain in detail two concrete observations/incidents.
- What do you remember about the post-lesson Reflection? Explain in detail two concrete recollections.
- What was your takeaway from the lesson study? Have you used any practices or done anything differently in your classroom as a result of the lesson study?

The teachers were asked to give written responses to the three stated questions. The comments offered by the teachers were general in that they stated what the students did under the guidance of Jane and what they remembered about the discussions.

Concerning the last question, a few excerpts that addressed the role that lesson study played in teachers' instructional choices were selected. The following excerpts were notable in the teachers' written handouts:

I have used this type of practice in my classroom several times. I often assign a group of students a word problem; I give them paper, have them solve it, and present the solution and problem-solving strategies. (Jaime)

Since I taught a lesson, I still use the notecards to hand the kids when they finish each question. (Jane)

I try to ask more questions that force my students to elaborate on their answers. I have increased use of technology, focusing on adaption for different levels of learning. (Michelle)

After the teachers had completed their reflections on the handout, they shared what they remembered from the lesson demonstration. They reviewed what they discussed during the first reflection session and outlined the main issues that were discussed. Terry asked Jane to reflect on the impact of the experience she had in teaching a lesson and afterward sharing reflections of the lesson with her colleagues. Jane noted that there were modifications to her lesson as a result of the experience. For example, Jane made sure that the difficulties posed by the students' mixing the variables for hay and grain were taken care of by separating the variables at the beginning to avoid confusion. Another teacher noted that:

I remember thinking after the lesson, and while the lesson was going on, I kept looking at my situation and my students and thinking how would this play out with my students and how you know actually how would they work together. It would be interesting to see how it plays out with different populations.

Teachers stated that they had adopted some other practices displayed in the teaching demonstration. For example, whenever a student gives a statement or response, they have started to ask probing questions – “What else?” – to gain insight into the students' thinking. There was a suggestion that teachers need to supply students with a vocabulary list of the required mathematical terms that they would need to use during their presentations. That way, the children would be aware that these were terms they would almost certainly use. It provided an opportunity to think about those terms and ensure they were getting the required and complete concept, using correct mathematical language. Having a vocabulary wall was suggested to be a good idea as Jane noted:

It's just a piece of construction paper and that folded in half again the word on one side and then the definition on the inside, and then I have it posted alphabetically, and so if they forget the definition, they just go over, lift it up, look at it, put it back down.

Other teachers suggested that they needed to visit Jane's room to see what they could learn from the vocabulary strategy that Jane described. Another point noted by a researcher was that as teachers reflect on lessons, it was suggested to have students' reflections to challenge the teachers' opinion about the lesson.

After the teachers had finished talking about what they remembered, the focus shifted to discussing the reflections captured on the video. One of the researchers presented selected video footage of teachers going over the first reflection to use to generate further reflections.

There was a sense among the teachers that watching a clip of the first reflection helped them recall that moment once again. They discussed the video and teachers took the time to reflect on what they said and did, as well as a self-examination of what they had done in their classrooms since then. Other teachers suggested that more such experiences should be encouraged so that teachers can reexamine their thought processes and think carefully about the impact of the experience.

Conclusions, more considerations on lesson study and suggestions

Conclusions

Dimension 1 of active learning (observing and being observed) was incompletely addressed in the study. This was articulated through the lesson taught by Jane being observed by other participating teachers in her classroom; Jane received feedback when reviewing student work after class and discussing the lesson led by teachers.

Regarding Dimension 2, planning for classroom implementation, the planning process was guided by the idea that such “lesson study is all about: try it out and see if it works out and how it can be improved,” with the following three activities: preparing the initial lesson plan collaboratively, revising the lesson plan through a rehearsal teaching, and preparing full lesson using more internal and external resources. Thus, Dimension 2 was addressed in this lesson study case.

Dimension 3, reviewing student work, was addressed via the opportunity for teachers to examine student work in class and after class.

The last dimension of active learning was addressed via the opportunity to give presentations, lead discussions and produce written work. In the Findings Section of this paper, we provided detailed descriptions of the lesson taught by Jane. Other teachers likewise had an opportunity to present the lesson on the same topic. However, these are not included here. Furthermore, we found that there were two different types of discussions in this case of lesson study. Type 1 is the discussions led by teachers and type 2 is discussions led by the researchers. Type 1 discussion focuses more on the lesson itself by reflecting the lesson and thinking to improve the lesson, which is centered on more specific or micro aspects of lesson study. However, type 2 discussion leads teachers to reflect or think about more general or macro aspects of lesson study. Since the two types of the discussion are referred to different aspects of lesson study, it would be helpful to have teachers involved in the two types of discussion. Meanwhile, the participating teachers were required to write up their thinking around the three questions posed by the researchers.

In summary, with the theoretical framework of the four dimensions of active learning, except for not observing expert teachers, this case suggests that lesson study covers the four dimensions, which indicate that active learning may happen to the participants of lesson study. In other words, lesson study provides “the professional development activity for teachers to become actively engaged in meaningful discussion, planning, and practice” (Garet *et al.*, 2001, p. 925).

More considerations for lesson study

Evidence shows that work was done collaboratively and that there was a sense of collegiality among the teachers and the researchers from the nearby university, which resulted in a successful lesson study. Similar studies have also noted similar findings. Puchner and Taylor (2006) states, “The link between collaborative work, collegiality, and positive outcome in schools is well established” (p. 931). The collaborative nature of the lesson study has made some mathematics educators believe it to be an effective method of professional development (such as Puchner and Taylor, 2006). The data collected at Athens Middle School demonstrated ways in which the teachers and researchers experienced the lesson study in the spirit of collaboration and reflection. As for the differences applied between Jane and the other two teachers regarding instructional development (or active learning) compared to the other “outsirt teachers,” and the role of the researchers played in this case of lesson study, we will discuss in subsequent research papers.

Suggestions for future research

This case study focuses only on one of the three core features of effective professional development activities. Lewis *et al.* (2012) identified three components of well-designed

lesson study: high-quality instructional resources (including teacher's manual and assessments), structures for learning within the practice and collegial learning. In a future study, we would like to explore the other two core features of effective professional development activities.

More data needs to be collected in future studies to verify the impact of teachers' active learning on their teaching and their students' learning. In this case study, we found evidence that the teachers' active learning occurred in the process of implementing the lesson study. However, we are yet to investigate the results of teachers' active learning. We may have follow-up observation of the teachers' teaching with no lesson study preparation and evaluate their students' learning outcomes. Therefore, it would be meaningful to explore empirically the positive impact of active learning. Also, this case study presents only one lesson study cycle with one topic. In future studies, we will analyze second or third lesson cycles on the same topic or different topics, to be able to compare and determine the changes between different cycles.

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