Virtual Tools and Protocols to Support Collaborative Reflection during Lesson Study

Abstract:

Lesson study provides opportunities for teachers to collaboratively design, implement, and analyze instruction. Research illustrates its efficacy as a site for teacher learning. The setting for this article is a lesson study project involving preservice teachers, inservice teachers, and university faculty members. We supported collaborative reflection on practice among these individuals by using asynchronous and synchronous online tools and meeting protocols. Asynchronous online lesson video review and tagging helped participants prepare to debrief about lessons they had implemented. Midway through one of our lesson study cycles, the COVID-19 pandemic occurred, eliminating opportunities to meet face-to-face for lesson debriefing sessions. In response, we developed and field-tested two protocols for online synchronous lesson study debriefing meetings. The protocols prompted conversations related to pedagogy, content, and content-specific pedagogy. After the debriefing sessions, lesson study group members reported improvements in their knowledge growth, self-efficacy, and expectations for student learning. We describe our use of online virtual tools and protocols to contribute to the literature on ways to support collaborative reflection on practice.

Key Words: Lesson Study; collaboration; reflection; discourse

Virtual Tools and Protocols to Support Collaborative Reflection during Lesson Study

Differences in students' science and mathematics achievement across countries have sparked interest in examining corresponding differences in teacher education models (Stigler & Hiebert, 2009). One model that has drawn a great deal of attention is lesson study (Lewis & Hurd, 2011). Lesson study is a cyclical process carried out in small groups. The group begins by identifying student learning goals and then collaboratively designs a lesson to address them. The lesson is then taught to students. Group members teach and observe it. After the lesson, the group gathers for a debriefing session to discuss the strengths and weaknesses of the lesson. In some cases, but not all, debriefing leads to re-design and re-teaching of the lesson (Fujii, 2014). Debriefing provides an opportunity to collaboratively reflect upon issues such as student thinking, assessment mechanisms, and teaching tools (Author citation, 2011). For many years, this process of continuous improvement of practice has provided a vital support structure for teacher learning in Japan (Watanabe, 2002).

Over the past two decades, lesson study has become increasingly prevalent in the U.S. (Lewis, 2016). Momentum for its use has been bolstered by research indicating that lesson study can foster knowledge of content, pedagogy, and content-specific pedagogy (Cajkler, Wood, Norton, & Pedder, 2014; Fischman & Wasserman, 2017; Huang & Shimizu, 2016; Lewis, Perry, & Hurd, 2009; Sibbald, 2009; Xu & Pedder, 2015). One of the most powerful features of lesson study is the opportunities it creates for reflection-on-action (Schön, 1987). Practicing reflection-on-action can help newer teachers eventually begin to make the types of in-the-moment adjustments to practice that reflection-in-action requires (Saucerman, Ruis, & Shaffer, 2017). Lesson study provides opportunities to use reflection on practice to generate, test, and progressively refine ideas for improving teaching (Ricks, 2011). When inservice and preservice teachers collaborate during lesson study, a synergistic relationship between professional development for experienced teachers and clinical experiences for teacher candidates can take shape (Author citation, 2020).

Despite the benefits of having inservice and preservice teachers work together in lesson study groups, forming such communities of practice can be challenging. Logistical considerations such as coordinating schedules for all participants are often non-trivial. Such problems are exacerbated by the fact that teachers in the U.S. generally do not have collegial work built into their everyday schedules to as great an extent as teachers in countries such as Japan, where lesson study has flourished (Stigler & Hiebert, 2009). Additionally, preservice teachers often do not initially notice important aspects of students' thinking when observing lessons (Jacobs, Lamb, & Philipp, 2010). So, simply observing a collaboratively planning lesson as it is implemented may not be sufficient for them to reflect productively on its key elements.

Technology-based strategies can help address some of the obstacles to having preservice and inservice teachers collaborate in lesson study groups. Synchronous and asynchronous online discussions can help address logistical challenges of assembling groups at the same time in the same place. Lesson video can provide opportunities for drawing attention to key lesson events that may be missed during an initial observation (Star & Strickland, 2008). Such online discussions and analyses of lesson video provide opportunities for collaborative reflection-on-action, which is at the core of the lesson study approach. In this article, we explain how we leveraged these technological tools to support and enhance reflection by preservice and inservice teachers as they critically analyzed their own work during a cycle of lesson study.

Context for Lesson Study

This article describes work that took place in two lesson study groups that worked in parallel to one another. In each group, preservice and inservice teachers collaboratively designed, implemented, and analyzed lessons that integrated science and mathematics. There were two preservice science teachers and two preservice mathematics teachers in each group. Group 1 worked with an inservice middle school science teacher. They created a lesson about Punnett squares and the probabilities associated with potential outcomes shown in their cells. Group 2 worked with an inservice mentor middle school mathematics teacher. They focused on a lesson requiring students to reason proportionally in scientific contexts such as examining ratios related to body length measurements and microscopic images.

We used two technology-based strategies to support reflection in each group: asynchronous lesson video analyses and synchronous debriefing sessions. Group members were prompted to analyze their lesson videos asynchronously in preparation for debriefing sessions. Debriefing sessions were then to occur during face-to-face meetings of each group. However, after each group's lesson was implemented, the COVID-19 pandemic caused cancellations of in-person meetings. Given the situation, we devised and implemented protocols for online synchronous debriefing sessions. The placement of the asynchronous and synchronous activities within the overall lesson study cycle is shown in Figure 1. Next, we describe the nature of the synchronous and asynchronous activities and how they supported collaborative reflection.

<INSERT FIGURE 1 HERE>

Figure 1. Placement of synchronous and asynchronous activities within a lesson study cycle.

Asychronous Lesson Video Analyses

In each lesson study group, each group member implemented a portion of their collaboratively planned lesson as their entire group observed in-person. They video recorded each lesson as it was taught. Each video was then uploaded to a password-protected platform (www.vimeo.com) for group members to review. We took this step because having educators analyze videos of their own lessons can foster critical self-reflection and more careful attention to student thinking (Hamel & Viau-Guay, 2019). Video review of lessons is a powerful and rapidly growing teacher education practice (Arias et al., 2020; Barth-Cohen, Little, & Abrahamson, 2018, Hawkins & Rogers, 2016; Tripp & Rich, 2012).

We provided group members a link and password to access their lesson video and asked them to start by reviewing it on their own. As they viewed it, they clicked on the lesson videos to add time-coded notes about the different events they believed to be significant. We asked them to add notes on what they would want to do again if teaching this lesson again and also what they would want to change. Each individual did this for the portion of the lesson they taught as well as the other portions.

Figure 2 shows the interface that supported asynchronous video analyses. The play button appears in the lower left corner. As viewers played the video, they could move the pointer anywhere on the screen and click to make a comment. Figure 2 shows comments that were made about how it would have been helpful to have a word wall for students at the 20:28 mark of Group 1's lesson. Remarks made by a preservice teacher in the group appear at the top of the pane on the right side of the figure. Another preservice teacher and the inservice teacher for the group responded to the initial comment to form a conversation thread. All of the conversation threads for the video could be viewed by scrolling through the pane on the far right or by using the vertical white hashmarks at the bottom of the video screen. Each hashmark indicated a point at which viewers made comments on the video.

<INSERT FIGURE 2 HERE>

Figure 2. Online interface used to support asynchronous analysis of videos.

As comments about the video were posted, the university faculty members who would later facilitate synchronous debriefing sessions (the first and second authors of this article), monitored the posts and offered some of their own thoughts on the lesson. We took this approach because research illustrates that knowledgeable others can add value to the lesson study process by introducing perspectives the group otherwise may not consider (Fernandez, 2002). We also monitored the discussions to check that all group members were participating, sending reminders to those who still needed to contribute. Having contributions from all group members on an array of strengths and weaknesses of each lesson helped set the stage for each group's debriefing session.

Synchronous Debriefing Sessions

Our overarching goal for debriefing sessions was to engage participants in metacognitive discourse (Shilo & Kramarski, 2019); that is, discourse focused on analyzing their thinking related to designing, implementing, and reflecting on each lesson. Facilitators can foster this type of discourse by asking educators to consider the impact of their teaching decisions on student learning (Santagata & Angelici, 2010). Conversations that foster metacognitive discourse about lesson videos in this manner can be structured in many different ways. Next, we describe two slightly different structures we used to facilitate such debriefing sessions in a synchronous online environment.

The facilitation protocols for each debriefing session are shown in Table 1. Although debriefing sessions were conducted virtually, neither protocol strictly requires a video conferencing platform to implement. Group 1's debriefing session had a mix of small-group/pair and large-group interactions. Group 2's debriefing session kept the entire group together for the duration. The debriefing sessions occurred 3-4 weeks after lesson implementation in order to allow sufficient time for group members to complete their asynchronous lesson review and tagging. Each session lasted approximately one hour and was conducted via video conferencing (www.zoom.com). Participants' video tags were used to catalyze discussion in each debriefing session, because the tags made participants' thinking about the lesson readily visible for analysis, reflection, and critique.

<INSERT TABLE 1 HERE>

Table 1. Two Facilitation Protocols for Lesson Study Debriefing Sessions

The two debriefing sessions differed in how they structured participants' interactions. Group 1 broke into smaller groups to review all of the video tags and compile their observations about what they would and would not change when teaching the lesson again. They then re-assembled for a large group discussion to share their notes and observations. Group 1's session culminated with discussion of an exit ticket writing prompt about the main changes they would make to support student learning when implementing the lesson again. In Group 2, the facilitator initiated conversation by pointing out specific lesson video tags pertaining to content, pedagogy, and content-specific pedagogy and inviting participants to respond. The Group 2 facilitator sustained conversation throughout the session by continuing to invite comment on specific tags. Along the way, Group 2 participants were invited to share thoughts on what they would keep and what they would change when implementing the lesson again.

Each debriefing session protocol leveraged capabilities of the Zoom conferencing platform in unique ways. In Group 1, Zoom breakout rooms were used to form smaller groups at the outset. The Group 1 facilitator visited each breakout room to provide help as the smaller groups reviewed video tags. Group 1 also made use of the Zoom whole-group chat feature at the conclusion of their session to have participants summarize key changes to make when implementing the lesson again. Group 2 members used the whole-group chat feature to share observations throughout the session as others were speaking. The Group 2 facilitator also used Zoom's screen-sharing capabilities to play segments of video that had been tagged by group members. Key video segments were played for the group to stimulate their recall of lesson events and the tags they had assigned. Both debriefing sessions were video recorded in Zoom to allow for later analysis. Although the motivation for holding sessions on Zoom was to work around COVID-19 meeting restrictions, the capabilities can be equally valuable post-pandemic in helping facilitators overcome challenges associated with assembling preservice and inservice teachers all in one place at the same time and also in providing structure to their reflection processes.

Debriefing Session Discourse Themes

After the debriefing sessions occurred, we reflected upon the video recordings. In previous work, we found that debriefing session conversations foster conversations about content, pedagogy, and content-specific pedagogy (Author citation, 2020), so we sought to determine the extent to which our synchronous online debriefing sessions had done so. To begin the process, the recordings were uploaded to the same Vimeo platform we used for storing the groups' lessons and having them tag important events (Figure 2). Next, the third author of the paper, who was not involved with either lesson study group, viewed the videos and inserted tags to identify instances of discussion about content, pedagogy, and content-specific pedagogy. A tag was inserted whenever a new conversation related to one of the three categories began. These tags essentially helped us debrief about our debriefing sessions.

As we took inventory of tags and discussed them, we found that the two debriefing sessions differed in their emphases. Table 2 contains a summary of the number of times each type of tag was inserted. Group 1's conversations leaned more heavily toward general pedagogy. Group 2's session contained examples of how debriefing sessions can foster conversations about content. Each group discussed content-specific pedagogy. Next, we provide examples to illustrate how each theme entered the debriefing sessions.

<INSERT TABLE 2 HERE>

Table 2. Frequencies of Conversation Tags Related to Content, Pedagogy, and Content-Specific Pedagogy for Each Debriefing Session

Discussions about Content

Group 2's discussions about content focused on ideas related to ratio and proportion. One of their lesson activities was to have students compare body lengths. In reviewing the lesson, they noticed that students at times made simple comparisons such as saying that one person's head was longer than another's. The group wanted students to transition to comparisons that incorporated ratios such as looking at the length of one's head versus one's overall height. The former comparison was correct, yet not helpful, in addressing the lesson goal of using proportional reasoning to make comparisons in scientific contexts. This debriefing session interaction provided a distinction useful for assessing and guiding students' work on the lesson activities, namely, that of correct versus helpful comparisons.

Group 2 also discussed appropriate measurement techniques for the problems they had assigned. During their debriefing session, the inservice mentor teacher for the group explained she wanted students to see that some of the problems in their lesson could be approached with non-standard units, saying, “Really, the ratio is just a comparison of, depending on what body parts you’re comparing them to...you don’t always have to have a standard unit of measure, so I was just trying to pull that into the conversation.” The university faculty member for group 2 expanded on this thought by talking about the difference between additive and multiplicative approaches, noting that the lesson goal was for students to examine ratios of measurements to one another, regardless of the units used, rather than to subtract the smaller measurement from the larger. Later in the discussion, the group considered the number of femurs needed to measure out one’s height as an example of a ratio they wanted students to understand. This portion of the debriefing session helped clarify the mathematical reasoning goals for the lesson and hence provided a basis for later conversations about the types of pedagogy and content-specific pedagogy that would help students achieve the goals when implementing the lesson in the future.

Discussions about Pedagogy

Both lesson study groups talked about the extent to which their lessons captured students’ attention. Group 1 noticed that most students seemed to be focused and paying attention, but they also discussed how to get all students engaged from the start. One suggestion was to “use an attention-grabbing personal example or an example from well-known Hollywood stars right up front during the lesson.” They conjectured that students would be more motivated to delve into Punnett squares if they were used to predict traits of offspring from actual people rather than abstract entities. As they viewed their lesson video, Group 1 also identified points at which they could have paused to get all students’ attention back before moving on. Like Group 1, Group 2 discussed the opening example for their lesson. It involved having students say what they noticed and wondered about a picture showing a boy’s face with several measurements marked. The group agreed that the opening helped catch students’ attention and helped students understand their later work with ratios. Hence, Group 1 decided to alter the "opening hook" for their lesson, and Group 2 decided to retain theirs in its current form when implementing the lesson again.

Another pedagogical focus for both groups was examining their questioning. Group 1 noticed that their short, general questions such as "what" and "why" and did not get much student response. They became conscious of the need to create more specific questions rather than relying mostly on general ones. Group 1 was also surprised that students did not seem to notice some of the key points from a video about Punnett squares, so they decided to give students focus questions, before the video, when teaching the lesson next time. Specifically, they decided to use the prompt, "In this video, you will be introduced to something called a Punnett Square; write down 3 thoughts or pieces of information that you got from the video and be prepared to share." The preservice teachers in Group 2 noticed they had trouble spontaneously devising questions to engage students during the lesson. The mentor teacher from Group 2 suggested writing some of these questions in advance and embedding them in the lesson plan.

During Group 1's debriefing session, they considered strategies that could be used to help students learn vocabulary. They thought that building a word wall, anchor chart, or word bank could help make vocabulary more visible. Doing so might increase the chance that students would use relevant disciplinary vocabulary in their conversations with one another. The group decided to put the vocabulary for the day on a word wall as each word was introduced during the next implementation of their lesson. Students could then record the new words in their notes in a word bank. The vocabulary in the word bank would then be ready for students to use again during future lessons on Punnett Squares. These strategies could help students become more familiar with the relevant vocabulary for the lesson and increase their usage of it.

At several points during Group 2's debriefing session, there were conversations about how to make parts of the lesson more efficient. These conversations were motivated by their observations that students ran out of time to do all of the planned lesson activities and to complete the exit ticket thoroughly at the end. The inservice mentor teacher for the group suggested putting name cards on the classroom tables ahead of time so students would immediately know where to sit and get started more quickly. Some of the activities for the lesson required students to recall who had taken measurements and what they had measured. Noticing that students took longer than expected to recall this information, one of the preservice teachers in the group suggested having students label things with their names as they worked. Others suggested using colored pencils to help code the information about the person measuring and the object measured.

Another pedagogical consideration voiced during Group 2's debriefing session pertained to teacher modeling. Specifically, the group talked about how to improve their demonstration of the measuring techniques students were to use. During the lesson, they had shown students still pictures of one of the preservice teachers in the group taking measurements. Group 2 decided they could improve this portion of the lesson by creating a 30-second demo video to use instead during their next implementation of the lesson. They believed a video would reduce student confusion about how they were to measure and reduce the number of student questions about how to get started measuring.

Discussions about Content-Specific Pedagogy

Group 1's content-specific pedagogy discussions focused on striking an optimal balance between the mathematics and science objectives for their lesson. One of the preservice teachers in the group observed, "Time was too short on Punnett squares and pedigrees - maybe we should just stick with Punnett squares and then explore the mathematics of them to make a stronger connection between mathematics and science." Others agreed that the lesson seemed rushed because it contained too much content to address. For example, one of the preservice teachers who taught Punnett square content during the lesson suggested pausing to help students interpret the probabilities and percentages involved. The group talked about how it would be valuable for students to understand that probability gives a grounded estimate of an outcome's occurrence, but the frequency with which the event occurs may vary slightly from that estimate. Allowing students time to do probability simulations and analyze the data could help illustrate that point. The group felt that mathematical ideas of this nature were largely left unexplored during the lesson, and they thought that going deeper into the mathematics content during the next implementation of the lesson would help students develop better understanding of the scientific content as well.

Group 2's content-specific pedagogy discussions centered on their observations of students' proportional reasoning and teaching strategies they could use to help it develop. This led to a discussion about how U.S. students, in general, tend to struggle with proportional reasoning. The university faculty member for the group suggested explicitly prompting students to write how many times longer one measurement is than another rather than letting students just report how many units longer one object is than another. For example, students who say that a six-unit-long object is two units longer than a four-foot-long object could be prompted to think about how many times larger the first object is than the second. One of the preservice teachers built on this suggestion by saying students could be asked to think about how many head-lengths make up their overall height. Doing so would provide a natural transition to thinking about how many times larger overall height is compared to head height. Others suggested looking at the relationship between arm length and foot length in the same manner. The group decided to start the lesson with these types of prompts the next time they taught it to help students begin to reason proportionally.

Perceptions of the Lesson Study Experience

We administered a three-part survey to collect data on our groups' perceptions of the lesson study experience. The first part of the survey gathered their descriptions of the topic, focus, and goals of the lesson study cycles. The second part asked participants to rate the degree of change in their knowledge and beliefs as a result of participating in lesson study. This part consisted of items developed by Akiba, Murata, Howard, and Wilkinson (2019). We modified some of the items slightly because they were initially developed for lesson study in a mathematics education context and referred to a specific set of state standards. The modified items contained language applicable to STEM more broadly and learning standards for our state. Together, the items in the second part of the survey assessed participants' perceptions of their knowledge growth (e.g., "*I know more about how to develop a student-centered lesson*"), self-efficacy (e.g., "*I believe I can teach my students more effectively if I continue to engage in lesson study*"), and expectations for student learning (e.g., "*I learned the value of giving a challenging problem in order to show what my students are capable of*"). In the final part of the survey, we asked participants to describe ways in which the use of online tools (such as Zoom) facilitated or hindered their ability to engage in effective debriefing. We also asked them to describe strengths of the lesson study cycle and improvements that were needed.

The survey was administered 3-4 weeks after the debriefing sessions. Based on the need to link individuals' responses over time to address ongoing evaluation of our lesson study project, the surveys were not anonymous. For the purposes of the present work, all data were summarized in aggregate rather than being associated with specific individuals' names. Table 3 contains key findings and representative qualitative feedback. Responses to Part I of the survey provided evidence that participants shared clear and consistent goals (e.g., "*…to engage students through [an] integrated math and science lesson*") and lesson foci (e.g., "*Compare different body parts to show proportionality and [determine] the change in scale without magnification*"). Participants' ratings of their growth in knowledge, self-efficacy, and expectations for student learning were strong at the conclusion of the lesson study cycle (Part II); mean scores exceeded the 'Agree' (5) response option, and, in the case of self-efficacy and expectations for student learning, approached the maximum score value on the response scale.

<INSERT TABLE 3 HERE>

Table 3. Summary Findings: Participants' Reflections on Lesson Study

Participants also provided meaningful reflections on the effectiveness of online facilitation of debriefing as well the lesson study cycle as a whole. Specifically, participants appreciated the ability to work through lesson planning and initial implementation collaboratively (e.g., "*Being able to go through the cycle of implementing our lesson was an interesting and [effective] teaching experience to see the effectiveness of the lesson and how to best apply it to each and every student*"). They also commented on the logistics, structure, and organization of lesson study (e.g., "*Picking the groups ahead of time and having very clear directions*"). The majority of participants (87.50%) indicated positive views of online facilitation of lesson study debriefing, suggesting that Zoom provided a viable means to support this part of the process. Participants' suggestions for changes and improvements centered on doing an additional cycle to build efficacy in lesson delivery, improving the compilation and dissemination of meeting notes and accomplishments, and developing better connections between science and mathematics content in lesson plans.

To complement our analysis of participants' reflections on lesson study, we also explored differences in learning outcomes based on participation in the two lesson study groups. At the conclusion of the lesson study cycle, Group 1 reported higher expectations for student learning (Group 1: M=5.75, SD=0.50; Group 2: M=5.33, SD=0.47; d=1.39[1]). Group 2 reported greater growth in knowledge (Group 1: M=4.89, SD=0.73; Group 2: M=5.42, SD=0.47; d=0.86) and self-efficacy (Group 1: M=5.38, SD=0.52; Group 2: M=5.94, SD=0.13; d=1.49). Given the small sample sizes, it is difficult to draw firm conclusions about differences between groups, but some conjectures can be made. Expectations for student learning are a general pedagogical issue, and Group 1 dealt with such issues to a greater extent during debriefing. Similarly, Group 2 dealt with both content and content-specific pedagogy to a greater extent during debriefing, perhaps explaining greater knowledge growth. Growth in both types of knowledge have been associated with gains in self-efficacy (Menon & Sadler, 2016; Thomson, DiFrancesca, Carrier, & Lee, 2017), suggesting that finding ways to incorporate such discussions during debriefing could be particularly important. In any case, collectively, these findings suggest preliminary yet promising effects on key learning outcomes for participants after engaging in the types of metacognitive discourse and critical self-reflection supported by the online tools and protocols we used.

Conclusion

Although some of the approaches we have described were designed out of necessity because of COVID-19, they are useful for more than just overcoming barriers imposed by a pandemic. In the U.S., the persistent barrier of lack of time built into school days to engage in

[1] Estimate reflects Cohen's *d* corrected for paired samples; 0.20, 0.50, and 0.80 denote small, moderate, and large effects, respectively.

collaborative reflection can be partially overcome using the asynchronous and synchronous strategies we have described. These strategies sparked collective discourse about pedagogy, content, and content-specific pedagogy, and teachers reported improvements in their knowledge, self-efficacy, and expectations for student learning during the project. The work we report here was done with small groups and focuses mainly on the reflective portions of one lesson study cycle, so it represents a starting point for further investigation rather than a set of definitive conclusions. We invite other teacher educators to experiment with our protocols and tools over multiple lesson study cycles and refine them as they observe their impact on teachers' learning. Just as teachers' practice is continually improved by engaging in multiple cycles of lesson study, tools and protocols like the ones we propose can be refined through multiple iterations of use. As such refinement occurs, the field can progressively develop increasingly more powerful approaches to fostering teachers' learning.

References

Akiba, M., Murata, A., Howard, C. C., & Wilkinson, B. (2019). Lesson study design features for supporting collaborative teacher learning. *Teaching and Teacher Education*, *77*, 352-365. https://doi.org/10.1016/j.tate.2018.10.012

Arias, A., Criswell, B., Ellis, J.A., Escalada, L., Forsythe, M., Johnson, H., Mahar, D., Palmeri, A., Parker, M., & Riccio, J. (2020). The framework for analyzing video in science teacher education and examples of its broad applicability. *Innovations in Science Teacher Education*, *5*(4). https://innovations.theaste.org/the-framework-foranalyzing-video-in-science-teacher-education-and-examples-of-its-broad-applicability/

Author citation. 2011.

Author citation. 2020.

Barth-Cohen, L. A., Little, A. J. & Abrahamson, D. (2018). Building reflective practices in a preservice math and science teacher education course that focuses on qualitative video analysis. *Journal of Science Teacher Education*, *29*(2), 83-101. https://doi.org/10.1080/1046560X.2018.1423837

Cajkler, W., Wood, P., Norton, J., & Pedder, D. (2014). Lesson study as a vehicle for collaborative teacher learning in a secondary school. *Professional Development in Education*, *40*, 511–529. https://doi.org/10.1080/19415257.2013.866975

Fernandez, C. (2002). Learning from Japanese approaches to professional development: The case of lesson study. *Journal of Teacher Education*, *53*(5), 393-405. https://doi.org/10.1177/002248702237394

Fischman, D., & Wasserman, K. (2017). Developing assessment through lesson study. *Mathematics Teaching in the Middle School*, *22*(6), 344-351. https://doi.org/10.5951/mathteacmiddscho.22.6.0344

Fujii, T. (2014). Implementing Japanese lesson study in foreign countries: Misconceptions revealed. *Mathematics Teacher Education and Development*, *16*(1), 65-83.

Hamel, C., & Viau-Guay, A. (2019). Using video to support teachers' reflective practice: A literature review. *Cogent Education, 6*, 1673689. https://doi.org/10.1080/2331186X.2019.1673689

Hawkins, S., & Rogers, M. P. (2016). Tools for reflection: Video-based reflection within a preservice community of practice. *Journal of Science Teacher Education*, *27*(4), 415-437. https://doi.org/10.1007/s10972-016-9468-1

Huang, R., & Shimizu, Y. (2016). Improving teaching, developing teachers and teacher educators, and linking theory and practice through lesson study in mathematics: An international perspective. *ZDM Mathematics Education*, *48*, 393-409. https://doi.org/10.1007/s11858-016-0795-7

Jacobs, V. R., Lamb, L. L. C., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, *41*(2), 169-202. https://www.jstor.org/stable/20720130

Lewis, J. (2016). Learning to lead, leading to learn: How facilitators learn to lead lesson study. *ZDM Mathematics Education*, *48*(4), 527-540. https://doi.org/10.1007/s11858-015-0753-9

Lewis, C., & Hurd, J. (2011). *Lesson Study step by step*: *How teacher learning communities improve instruction*. Portsmouth: Heinemann.

Lewis, C. C., Perry, R., & Hurd, J. (2009). Improving mathematics instruction through lesson study: A theoretical model and North American case. *Journal of Mathematics Teacher Education*, *12*, 285–304. https://doi.org/10.1007/s10857-009-9102-7

Menon, D., & Sadler, T. D. (2016). Preservice elementary teachers' science self-efficacy beliefs and science content knowledge. *Journal of Science Teacher Education*, *27*, 649-673. https://doi.org/10.1007/s10972-016-9479-y

Ricks, T. E. (2011). Process reflection during Japanese lesson study experiences by prospective secondary mathematics teachers. *Journal of Mathematics Teacher Education*, *14*, 251-267. https://doi.org/10.1007/s10857-010-9155-7

Santagata, R., & Angelici, G. (2010). Studying the impact of the lesson analysis framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of Teacher Education*, *61*(4), 339–349. https://doi.org/10.1177/0022487110369555

Saucerman, J., Ruis, A. R., & Shaffer, D. W. (2017). Automating the detection of reflection-on-action. *Journal of Learning Analytics*, *4*(2), 212-239. https://doi.org/10.18608/jla.2017.42.15

Schön, D. A. (1987). *Educating the reflective practitioner*: *Toward a new design for teaching and learning in the professions*. San Francisco, CA: Jossey-Bass.

Shilo, A., & Kramarski, B. (2019). Mathematical-metacognitive discourse: How can it be developed among teachers and their students? Empirical evidence from a videotaped lesson and two case studies. *ZDM Mathematics Education*, 51, 625-640. https://doi.org/10.1007/s11858-018-01016-6

Sibbald, T. (2009). The relationship between lesson study and self-efficacy. *School Science and Mathematics*, *109*(8), 450-460. https://doi.org/10.1111/j.1949-8594.2009.tb18292.x

Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice teachers' ability to notice. *Journal of Mathematics Teacher Education*, *11*, 107-125. https://doi.org/10.1007/s10857-007-9063-7

Stigler, J. W., & Hiebert, J. (2009). Closing the teaching gap. *Phi Delta Kappan*, *91*(3), 32-37. https://doi.org/10.1177/003172170909100307

Thomson, M. M., DiFrancesca, D., Carrier, S., & Lee, C. (2017). Teaching efficacy: Exploring relationships between mathematics and science self-efficacy beliefs, PCK, and domain knowledge among preservice teachers from the United States. *Teacher Development*: *An International Journal of Teachers' Professional Development*, *21*(1), 1-20. https://doi.org/10.1080/13664530.2016.1204355

Tripp, T. R., & Rich, P. J. (2012). The influence of video analysis on the process of teacher change. *Teaching and Teacher Education*, *28*(5), 728-739. https://doi.org/10.1016/j.tate.2012.01.011

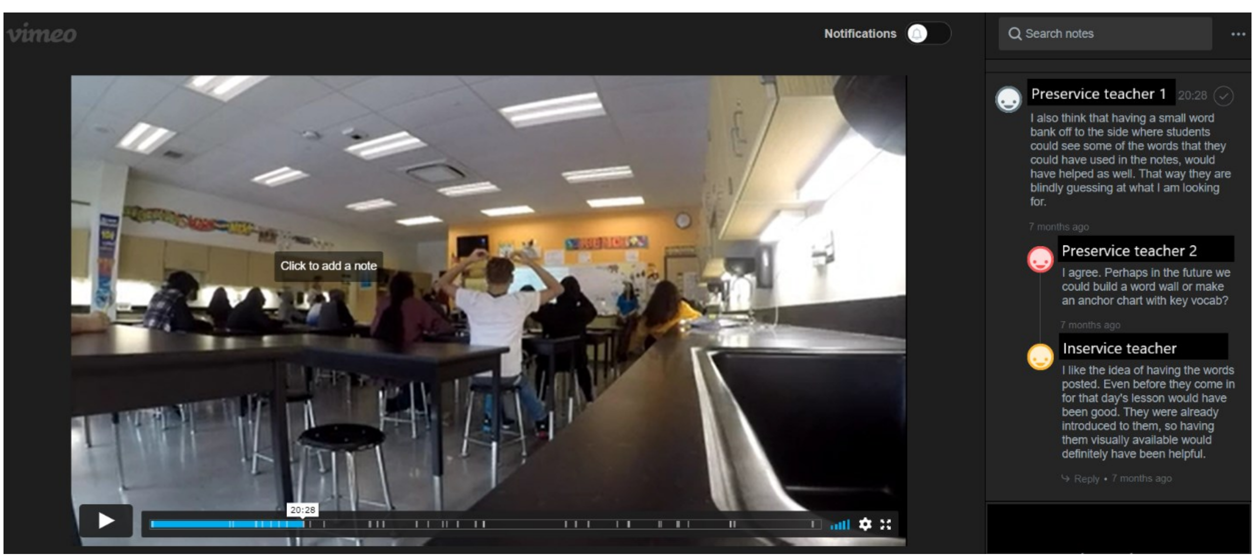
Watanabe, T. (2002). Learning from Japanese lesson study. *Educational Leadership*, *59*(6), 36-39.

Xu, H., & Pedder, D. (2015). Lesson study: An international review of the research. In P. Dudley (Ed.), *Lesson study*: *Professional learning for our time* (pp. 29–58). London and New York: Routledge.

Figures

Figure 1. Placement of synchronous and asynchronous activities within a lesson study cycle.

Figure 2. Online interface used to support asynchronous analysis of videos.



Tables

Table 1. Two Facilitation Protocols for Lesson Study Debriefing Sessions.

	Structure 1: Breakout + Large-Group Discussion Mix	Structure 2: Large-Group Discussion for Entire Session
0	Lesson study group views video of lesson online and tags segments they consider to be strengths, weaknesses, areas for improvement, etc.	Lesson study group views video of lesson online and tags segments they consider to be strengths, weaknesses, areas for improvement, etc.
1	Discuss agenda for the session and its purpose.	Discuss agenda for the session and its purpose.
2	Breakout groups are formed to review tags group members have given to the lesson while viewing it online.	Facilitator points out comments related to content, pedagogy, or content-specific pedagogy in the tags participants made to online video.
3	While reviewing tags, breakout groups compile lists of things to change when teaching again, things to keep the same, and any additional notes.	Facilitator invites lesson study group participants to comment on the lesson tags that have been pointed out.
4	The entire group re-assembles and each breakout group shares their notes and observations.	Facilitator encourages group to pursue discussions about content, pedagogy, and content pedagogy that arise.

5	Individuals complete exit ticket: Which specific change to the lesson do you believe will result in the greatest learning gains for students? Why?	Facilitator and lesson group repeat steps 2-4 until the most salient clusters of comments from the entire lesson have been discussed.
6	Individuals share responses to exit ticket prompts	As the group discusses the most salient clusters of comments, the facilitator prompts participants to consider what should change and what should stay the same next time when implementing the lesson.
7	The group is invited to share any other thoughts before the session draws to a close.	The group is invited to share any other thoughts before the session draws to a close.

Table 2. Frequencies of Conversation Tags Related to Content, Pedagogy, and Content-Specific Pedagogy for Each Debriefing Session

	Content	Pedagogy	Content-specific pedagogy
Group 1	0 (0%)	17 (73.9%)	6 (26.1%)
Group 2	6 (15.8%)	21 (55.3%)	11 (28.9%)

Note. Analysis of Group 1's debriefing session resulted in a total of 23 conversation tags; analysis of Group 2's debriefing session resulted in a total of 38 conversation tags.

Table 3. Summary Findings: Participants' Reflections on Lesson Study

Part I: Participant Descriptions of Lesson Study Cycle Topics and Goals		
Lesson Study Goals and Foci: Participant Descriptions:		
"The goal of our lessons was to engage students through [an] integrated math and science lesson."		
"We achieved lessons that incorporated biology, chemistry, and math. Made lessons that were engaging, incorporated hands-on aspects, as well as connecting the lesson to real importance for the students."		
"Compare different body parts to show proportionality and [determine] the change in scale without magnification." [a]		
Part II: Participant Ratings of Their Change in Knowledge and Beliefs	***M*** [b]	***SD***
Knowledge Growth	5.15	0.60
Self-Efficacy	5.66	0.32
Expectations for Student Learning	5.54	0.49
Part III: Participant Evaluations of Lesson Study Facilitation and Effectiveness		
Lesson Study Evaluation: Online Facilitation: Participant Descriptions:		
"It allowed us all to meet together virtually to debrief and communicate our vision for the lesson in the future which we otherwise couldn't have done with everything going on."		
"It was a lot easier to find a time that the whole group could meet when we used Zoom rather than in person."		
"It allowed us to effectively communicate."		
Lesson Study Evaluation: What Worked Well: Participant Descriptions:		
"Engaging students in an integrated lesson and practicing lesson teaching and planning."		
"Everyone worked together and did their part in the lesson."		
"Picking the groups ahead of time and having very clear directions."		
Lesson Study Evaluation: Needed Changes/Improvements: Participant Descriptions:		
"Meeting notes and ideas could be [relayed] more effectively to those that could not always attend the full meeting. "		
"Another practice meeting where we practiced the lesson."		
"[Implement] a way to narrow down ideas given by everyone to find the best activities for students."		

Note. *M*=mean; *SD*=standard deviation.
[a]Reflects a focus of Group 2's lesson study cycle.
[b]Items were administered using a 6-point scale ranging from 1-Strongly disagree to 6-Strongly agree.