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Transitioning Face-to-Face Mathematics Professional Development to Synchronous Online Implementation: Design Considerations and Challenges

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Abstract

To make professional learning experiences more accessible to teachers, professional development providers redesigned a face-to-face professional learning experience – a Teaching Lab – for an online platform utilizing synchronous modalities. To design the online version of the Teaching Lab, our team employed design principles derived from research on high-quality professional development and from theories of technology use in education. We describe these design principles, the multiple iterations of the Teaching Lab, and the challenges we faced in the design process. We consider the roles of technology as replacement, amplification, transformation, or hindrance with respect to the online model. We conclude with a discussion of the technology framework to offer suggestions and considerations for mathematics education leaders who design professional learning opportunities.

Providing access for rural teachers to high-quality professional development has been a consistent problem. Challenges such as distance, cost, and availability of substitute teachers have plagued the efforts of professional development providers and rural district leaders alike. Capitalizing on the affordances of technology, our professional development project team designed a fully online professional learning model, providing an in-person experience from a distance. The purpose of this article is to share our experience as professional development designers so that others in similar roles can learn from the challenges we faced moving an existing program to an online format. We describe the design and implementation of online demonstration lessons, which we termed Teaching Labs. We previously used Teaching Labs as a face-to-face professional learning experience in which we worked with small groups of mathematics teachers to plan, implement, and reflect on lessons taught by a facilitator, often in conjunction with a broader set of professional learning experiences. The Teaching Labs encompass features similar to the studio model (e.g. Higgins, 2013; TDG, 2010), lesson study (e.g. Fernandez & Yoshida, 2004) or demonstration lessons (e.g. Barlow & Holbert, 2013; Strayer et al., 2017). These models give teachers an image of high-quality instruction, provide immediate and practical takeaways, deepen their understanding of pedagogical

principles, and orient them to an inquiry stance. Our goals for the Teaching Labs were for teachers to observe how to elicit and build from student thinking about important mathematical ideas.

In prior implementations of face-to-face Teaching Labs, a facilitator from our professional development team worked with a small group of teachers to plan a lesson together, hypothesizing how the lesson would engage students with key mathematical ideas. The facilitator taught the lesson in one of the participating teachers' classrooms while the small group of teachers observed with a particular focus on student reasoning. Afterward, the facilitator and teachers debriefed the lesson experience together focusing on student thinking and learning outcomes. Throughout this article we use the term facilitator to refer to our project personnel who both taught the Teaching Lab lesson and also facilitated the professional learning experience for the participating teachers. We purposefully use the term facilitator instead of coach or instructor to denote the collaborative and mindful way we hoped to guide teachers to develop their own noticing and discourse practices.

Through funding from the National Science Foundation, we created an online version of the Teaching Labs to make them available to middle school mathematics teachers in rural contexts. Although our focus was to support rural teachers, we believe lessons learned about our transition from face-to-face professional development to an online model would be beneficial for educational leaders and professional development designers. This article describes our design rationale and iterative efforts to transform the Teaching Labs into fully online experiences. We articulate the challenges and opportunities entailed by this transformation, with the goal of advancing the conversation of online professional development of mathematics teachers, especially those who are not geographically proximate to sites that offer high-quality professional development. We believe administrators, coaches, and professional development providers have similar struggles. Sharing our story and the considerations and challenges we faced as we transitioned to an online model can help the field continue to explore new ways that technology can support teachers.

Professional Learning Context

In our project, the Teaching Labs were situated within a larger three-part online professional learning model that used both synchronous and asynchronous modalities to provide learning opportunities designed to meet or exceed face-to-face learning opportunities. We designed the model to support teachers to improve their discourse practices and to use their knowledge of student thinking to make instructional decisions (e.g., Jacobs, Lamb, & Philipp, 2010; Smith & Stein, 2011). The three components included: a) online course modules, b) Teaching Labs, and c) online video coaching. The online course modules were designed to support teachers to improve discourse practices in their classrooms based on the work of Smith and Stein (2011). The Teaching Labs, the focus of this paper, were the second component of the three-part model. Coaching, the third component, followed a Content-focused Coaching approach (West & Staub, 2003) transformed into a fully online experience. The three parts of the model overlapped temporally, took place across two academic years, and included multiple Teaching Labs (for a full description of the entire model, see Choppin et al., in press). The teachers in our project were 16 middle grades mathematics teachers from rural contexts.

Research Base for Design of Teaching Labs

The Teaching Labs were based on *lesson analysis* (Yeh & Santagata, 2015), in which we treated lessons like experiments; teachers conjectured how students would engage with mathematical tasks and how teacher moves would elicit and focus attention on student thinking. To accomplish these goals, we designed and implemented the online Teaching Labs around two principles: increase teacher focus on student thinking and use video effectively.

The first principle, *increase teacher focus on student thinking*, relates to our specific goals for the Teaching Lab. One of the primary purposes was to move teachers away from primarily evaluative reflections on classroom practice to more objective and knowledge-based reflections (e.g., Sherin & van Es, 2009). The goal of the Teaching Labs was similar to the focus on professional noticing described by Sherin and colleagues (Sherin & van Es, 2009; van Es & Sherin, 2008) in which video was used to develop teachers' ability to notice and interpret student thinking and the nature of classroom interactions. Our goal was to have teachers notice how the qualities of the tasks, in conjunction with facilitator's instructional decisions during the lesson, combined to expose student thinking, so they could focus on productively leveraging student thinking to make important connections. We aimed to support teachers to engage

in detailed and complex analyses of student thinking in order to make connections between tasks, facilitator discourse moves, and the productiveness of student thinking. In short, we hoped to initially have participating teachers focus on objective aspects of student thinking (e.g., strategies, use of representations, interactions with others) and features of practice emphasized in our project (e.g., how the facilitator elicited student strategies and organized classroom discussion) as the basis for principled observations of classroom practice (Mason, 2002).

The second principle, *use video effectively*, relates to the structure of the professional conversations and the use of video recordings which researchers describe as having a number of affordances. Video allows educators to reflect on classroom practice without having to observe lessons in real time (Sherin, 2004) as well as allowing for a focus on specific aspects of practice, afforded in part by the ability to pause or replay the video (Borko, Jacobs, Eiteljorg, & Pittman, 2008). Video consequently supports collaborative learning "focused on reflection, analysis, and consideration of alternative pedagogical strategies in the context of a shared common experience" (Borko et al., 2008, p. 419).

Technology Framework Used to Describe Design Processes

To describe the transformation of our Teaching Lab design from face-to-face to online, we turn to the Replacement, Amplification, or Transformation (RAT) framework (Hughes, Thomas, & Scharber, 2006), which builds on longstanding theories in technology education (e.g. Pea, 1985; Reinking, 1997). Replacement refers to technology use that replaces but does not change instructional practices, learning processes, or content goals. Amplification refers to technology use that increases efficiency or productivity in an educational setting but largely maintains the existing form. Transformation builds heavily on the work of Pea (1985) and refers to technology use that leads to or supports instruction, the learning process, or goals in a way that is fundamentally different from what could be accomplished without the technology. The RAT framework is a tool for critical decision-making concerning technology integration in an educational context. Researchers have used the framework in empirical research to explore how prospective or practicing teachers integrate technology in their classrooms (e.g Hsieh & Tsai, 2017; Van Zoest, Stockero, & Kratky, 2010). Within the field of mathematics teacher education, various researchers have used the RAT model to characterize learning opportunities technology provides (e.g. Amador, Weston, Estapa, Kosko, & De Araujo, 2016; Coleman, 2017; Thomas & Edson, 2017, 2018; Van Zoest, Stockero, & Kratky, 2010; van Bommel, & Palmer, 2018). Additionally, Kimmons, Miller, Amador, Dejardines, and Hall (2015) applied the RAT model in a prospective teacher context and added Hindrance (H) to the model, recognizing that the use of technology may hinder learning opportunities. Thus, the RATH (Replacement, Amplification, Transformation, or Hindrance) model was formalized to more holistically capture all potential outcomes of technology integration. We provide this lens to illustrate how we considered technology integration as we moved our face-to-face Teaching Lab to an online version and believe others could apply a similar process in their own context as they consider transitions to online professional development.

Teaching Lab Implementation

We describe four iterations in the design of our Teaching Labs. We highlight the challenges we faced in moving the Teaching Labs to an online environment and the design considerations that resulted from the affordances and constraints related to the platforms and tools we used. To illustrate how we made the transition from face-to-face to online Teaching Labs, we share our design decisions and rationales, as well as reflections on each iteration. We had four design iterations: Iteration 1: Face-to-Face Design; Iteration 2: Original Online Design; Iteration 3: Intermediate Online Design; and Iteration 4: Current Online Design.

Iteration 1: Face-to-Face Design

Our face-to-face Teaching Lab engaged teachers in a facilitated day-long professional learning experience that included the following three components: a) pre-lesson discussion, b) lesson observation, and c) debrief discussion. Prior to meeting with the full group of teachers, the facilitator consulted with the teacher in whose class the lesson would be taught to determine a lesson goal, to select or design a high-cognitive demand task, and to craft a lesson plan. On the day of the lesson, the facilitator shared the mathematical learning goals of the lesson and the lesson plan draft with the full group of teachers. The full group then discussed the lesson plan and the mathematical tasks, anticipated student thinking, and proposed possible modifications to the lesson design to better support student learning. Prior to the lesson implementation, each teacher

established a personal focus for their observation to support more productive noticing (e.g. Jacobs et al., 2010; van Es & Sherin, 2008). For example, one teacher may have decided to focus on teacher questioning and student responses, while a second teacher may have decided to focus on student interactions within small groups.

In the second component of the face-to-face Teaching Lab, the facilitator taught the lesson while the participating teachers observed. During the lesson, teachers were encouraged to move about the classroom to collect detailed observation notes about student thinking and instructional moves but not to engage with students. The final component of the Teaching Lab was the facilitated debrief discussion during which teachers shared their observations based on their area of focus and were supported to reflect on implications for their own practice.

Iteration 1 Reflections. Although we found face-to-face Teaching Labs were effective to support teachers' learning, they posed two logistical issues. First, all teachers had to travel to the site of the lesson and spend the full day there which proved burdensome for teachers, particularly those in rural contexts. Second, substitute teacher shortages in the region made it difficult for teachers to be out of their classrooms. In addition to the logistical issues, there was a pedagogical issue in the face-to-face version. It was difficult to control what teachers attended to during the live lesson implementation; some teachers paid attention to aspects that were significant to student learning and some did not. The varied nature of the teachers' areas of focus affected the productivity of teacher noticing with the goal of focusing attention on student thinking.

Iteration 2: Original Online Design

In the first online iteration, we attempted to replace the three components of our face-to-face Teaching Labs in an online space with the primary goal of alleviating the logistical concerns related to travel and the need for substitute teachers. Although we identified the video conferencing technology Zoom as a reasonable replacement to host synchronous pre-lesson and debriefing discussions, it was not possible for us to have a synchronous lesson observation due to scheduling conflicts amongst the teachers. As a result, we separated the three components of the face-to-face Teaching Lab so they occurred on different days. We scheduled a 60-minute synchronous pre-lesson discussion with teachers using Zoom which occurred after the school day. The structure and goals of this pre-lesson discussion directly mirrored those of the face-to-face Teaching Labs. In order to disseminate lesson materials, we set up a shared Google folder in which we uploaded the lesson plan, the task description, and other supporting documents. In addition, because participants' viewing of the enacted lesson was limited to the video recording rather than an in-person observation, we did not require that the participants decide up-front what they were going to focus on for their observation.

The facilitator then implemented the lesson in a participating teacher's classroom and project personnel video-recorded the lesson. Our professional development team then viewed the video and created a note-catcher that included prompts to focus teachers' viewing on particular instructional moves or student responses. We then made available the unedited video and note-catcher to the teachers within two to three days of when the lesson was taught. The teachers viewed the recording asynchronously to fit their schedules. Approximately one week later, the teachers and the lesson facilitator met synchronously via Zoom for a 60-minute debrief discussion during which teachers shared their observations, reflected on what they had noticed, and described implications for their own practice—a conversation very similar to the face-to-face debrief discussion.

Iteration 2 Reflections. For this first fully online Teaching Lab, many teachers indicated that they appreciated not having to travel to participate. Many also noted that they appreciated not having to miss school time, as all activities took place outside of the teachers' school day. However, this initial online design presented new challenges. First, feedback from teachers indicated they felt overwhelmed by the process. Instead of attending a one-day professional learning experience, they now had three separate components that they needed to schedule: the synchronous pre-lesson discussion, the asynchronous viewing of the lesson video, and the synchronous debrief discussion. This feedback was of particular concern for the project team because participation in all three components of the Teaching Lab was important. A second challenge was that the process of recording the lesson, sharing it with teachers, and providing ample time to view the lesson created a time lapse between the phases of the Teaching Lab. Teachers commented that it was difficult to remember the conversations from the pre-lesson discussion when watching the video or engaging in the debrief discussion. A third challenge teachers communicated was that watching a full

lesson on video from one vantage point was far less engaging than observing a full lesson in a face-to-face setting.

Iteration 3: Intermediate Online Design

Based on the challenges noted in Iteration 2, we worked to design Iteration 3, in which we moved our thinking to consider how we could use affordances of the technology to re-conceptualize how we implemented Teaching Labs. We wanted technology not to serve simply as a replacement but as an enhancement to the experience (Hughes et al., 2006). The first major design adjustment was to move all three parts of the Teaching Lab into a single, two-hour synchronous session to alleviate the challenges with teacher scheduling and the extended time between components of the Teaching Lab. The resulting Teaching Lab design consisted of a 40-minute pre-lesson conversation, 35 minutes for teachers to watch clips of the lesson video and create notes of their observations, and a 45-minute debrief discussion to share thinking around each clip and reflect on implications for individual practice. This all took place in one synchronous online session using Zoom.

This alteration required the project team to plan, teach, and video-record the lesson prior to the Teaching Lab synchronous session. This decision also required an adjustment to the original intention of the pre-lesson discussion because the lesson was already planned and implemented prior to engaging teachers in the pre-lesson discussion. Like the face-to-face pre-lesson discussion, this online pre-lesson discussion focused on anticipating student thinking in order to prepare teachers to productively notice thinking as they viewed video clips (e.g. Sherin & van Es, 2009; van Es & Sherin, 2008).

In addition to these design changes, we also thought about how to use video for the lesson observation in ways that would create more thoughtful observations and productive conversations. To ameliorate the limitations related to lesson observations inherent when using one camera, we used two cameras, with one focused on the teacher and one on students. We also started to take advantage of the fact that we could determine the aspects of the lesson viewed by teachers. Instead of providing teachers with the complete lesson video, the professional development team carefully selected and organized smaller video clips that strategically highlighted different phases of the complete lesson. For example, the launch phase of a task during a particular Teaching Lab lesson took approximately 15 minutes during the live lesson implementation. We edited out less useful moments during this launch (e.g., passing out papers, private work time), and created an eight-minute clip that provided teachers with an image of this lesson launch that included facilitator moves and student interactions. Through this process, we condensed a full lesson video into four or five clips that totaled approximately 30 minutes, though we still provided a complete image of the lesson—one of our intentions of a Teaching Lab.

To further deepen teacher reflection and foster rich discussion around the lesson images, the project team created a focused set of questions for each clip. These questions were consolidated into a *capture sheet* that was provided to the teachers for the viewing of the video. Figure 1 shows an excerpt from a capture sheet used for a five-minute clip of the opening lesson discussion. This particular example was designed to focus teachers' noticing on the connection between the activity and student engagement in the upcoming task. This type of purposeful focus enhanced the lesson debrief discussion.

Iteration 3 Reflections. Based on teachers' feedback, the design changes implemented in Iteration 3 were well received. Teachers appreciated a more limited commitment in terms of the number of sessions and the compactness of the three components in terms of keeping track of the discussions. In addition, facilitators reported this design had positive effects on participation and engagement. The modifications made in this online Teaching Lab design reflected efforts by the project team to use technology to amplify (i.e. Hughes et al, 2006) the learning opportunities for teachers. We shifted our question from, "How can we use online technology tools to best replicate a face-to-face Teaching Lab?" to "How can we leverage online technology

FIGURE 1. *Excerpt from a Capture Sheet.*

Video Clip #1: Initial Lesson Launch and Opening Discussion (0:00 - 5:23)

Focus for Clip #1: This clip contains the teacher's initial launch to the task which includes some small group conversation followed by a whole group discussion. As you watch both components, how might this initial activity support student engagement in the task?

Time Stamp	Thoughts/Ideas/Evidence

tools to transform our Teaching Lab design to something that is not possible in a face-to-face Teaching Lab?" This new question drove our thinking for Iteration 4, described below.

Iteration 4: Current Online Teaching Lab Design

Building on the successes of Iteration 3, the project team worked to address the challenge of how to maximize the affordances of technology for teacher learning in an online Teaching Lab to make the process transformational (i.e. Hughes et al., 2006). Though perhaps obvious in hindsight, we began to think about how the use of video for the lesson observation allowed us to pause the lesson at any time and engage teachers in discussion. Consequently, Iteration 4 intertwined the observation and debrief components, rather than having teachers watch the entire series of video clips without interruption and then engage in a single debrief discussion. As in the previous iteration, we engaged teachers in a pre-lesson discussion, but now we asked them to watch a single clip followed by a shorter debriefing conversation, and repeated this with subsequent lesson clips and focus questions. This allowed us to focus teachers' noticing and to highlight instances of practice.

The ability to pause the video at any time during the lesson also allowed for unique discussions not possible during face-to-face debriefing examples. For example, we edited a video clip in which the facilitator approached a group of three students who appeared to be stuck while working on a cognitively demanding task. The facilitator asked clarifying questions to understand the students' strategies. We paused the video at that moment, provided teachers with the students' strategies, and posed questions that positioned teachers to consider possible instructional moves on the capture sheet, as seen on the capture sheet in Figure 2.

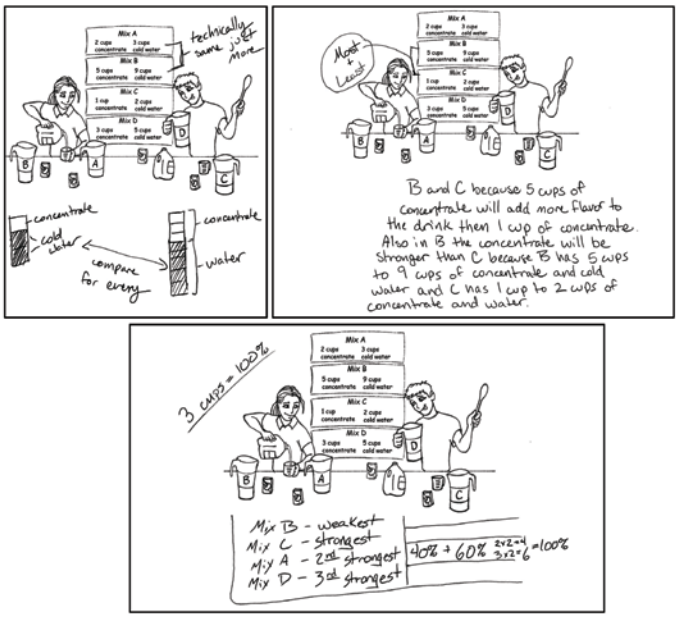
We placed the teachers in breakout rooms within Zoom (which allow for small group conversations) and asked them to examine the student work and determine questions they would use to assess and advance the thinking of the students. After ten minutes, each group shared their questions and strategies for interacting with the group of students. Teachers then watched the next clip, which showed how the facilitator responded to the students. Showing the follow-up clip allowed teachers to reflect on the affordances and drawbacks of the facilitators' actions as well as compare it to the possibilities that they generated (see Figure 3).

FIGURE 2. *Excerpt from the Capture Sheet showing student work.*

Video Clip #2 (Part 1): Small Group Discussion (8:31-11:08)

Focus for Clip #2 (Part 1):
Keeping in mind the lesson goals, what might you ask these students to assess and advance their thinking if you were the teacher?

Assessing Questions	Advancing Questions



Iteration 4 Reflections. As in Iteration 3, teachers expressed appreciation that this next iteration allowed them to engage in a Teaching Lab online and in one sitting. In addition, the opportunity to reflect on the lesson video at key moments allowed for new opportunities to deepen teachers' engagement. Of particular importance to this design was the ability to connect key moments in the video to discussion moves (Smith & Stein, 2011); we were able to create and pause video clips in ways that problematized specific practices and allowed teachers to consider their own actions. Teachers were given an opportunity to pause and reflect on how they might respond to these particular students in a way that would both assess and advance student learning in relation to the lesson goals. In addition to these connections, Iteration 4 provided richer discussions about the productiveness of facilitator moves related to student learning than had previously been the case. By pausing and problematizing these key moments,

FIGURE 3. *Excerpt from the Capture Sheet for critical reflection of the teachers' questions.*

Video Clip #2 (Part 2): Small Group Discussions (11:08 - 13:09)

Focus for Clip #2 (Part 2):
What are affordances and drawbacks to the teacher's questions and actions?

Affordances	Drawbacks

the facilitator not only made their practice public, but also made it more vulnerable and open to discussion.

Current Design Challenges and Future Directions

The professional development team identified three areas of challenge for scaling up our design to engage more teachers: a) the preparation time for facilitators, b) expense of the implementation, and c) ability to record lessons in a teacher's classroom. In Iteration 4, we estimated the facilitators spent an average of 70 hours per Teaching Lab in: the planning, implementing, and recording of the lesson; selecting and editing the video clips; developing the capture sheet; and planning for and facilitating the synchronous Teaching Lab sessions. These tasks were costly in terms of compensating the professional development personnel and making the design feasible for future professionals to implement. Furthermore, the logistics of coordinating and teaching a lesson in a teacher's classroom was challenging due to travel logistics, camera operators, and student assent/parent consent requirements because of video recording.

These challenges led us to consider a different possibility for video use in the Teaching Lab and to consider the use of previously recorded videos. However, these changes require consideration of teacher learning and engagement. For example, if the lesson video was no longer from one of the participating teacher's classrooms, would this cause a loss of ownership or authenticity for the teachers? How much impact does the authenticity of the video have on teachers' noticing and reflection on the lesson? Can we use available lesson videos from the Internet, which would reduce the cost but further remove the authenticity of the video? As we move forward with this work involving teachers, we continue to consider these challenges and opportunities.

Technology Characterization and Design Principles

As we consider the challenges and affordances of each of the Teaching Lab iterations, we remain focused on the technological aspects of the process and the affordances of technology use as well as the design principles germane to the project. Table 1 *(next page)* shows our iterations in relation to the RATH framework (Hughes et al., 2006; Kimmons et al., 2015) and the design principles as a means to further describe how we consider the various approaches as related to technology integration.

Through this process, we applied the RATH framework to a professional learning design context, building on the traditional use of this framework (Hughes et al., 2006; Kimmons et al., 2015). We consider this a contribution of this work and suggest other professional development providers coordinate their efforts with the RATH framework to consider how the decisions they make with technology replace, amplify, transform, or hinder the experiences they design for teachers.

Conclusion and Recommendations

The iterative design process of our Teaching Labs provides professional development designers insight about how to transition from face-to-face professional learning to an online space. We were able to recognize the affordances and constraints related to technology and capitalize on the advantages to arrive at a transformational experience that would otherwise not have occurred (i.e. Hughes et al., 2006). We were able to leverage video to hone the focus on specific aspects of teaching practice (Sherin, 2004) and transition teachers from primarily evaluative reflections on classroom practice to knowledge-based interpretations and responses (i.e. Sherin & van Es, 2009). We accomplished this through selecting edited video clips, designing a capture sheet specific to each lesson video, and structuring the learning environment. At the same time, the facilitator purposefully guided the teachers to develop their own noticing and discourse practices (Coles, 2013). An initial review of data collected during this process indicate that learning outcomes from our online version were comparable

Table 1: Overview of iterations of the transformation of Teaching Labs

Iteration	Coordination with RATH Framework (Amador, 2015)	Rationale for RATH Characterization (Replace, Amplify, Transform, Hinder)	Relation to Design Principles (increase teacher focus on students' thinking; use video effectively)
Iteration 1: Face-to-Face Design	No digital technology	This process was void of digital technology	Knowledge-based reflections and noticing were scattered dependent on the teachers' focus during the live lesson; video was not used
Iteration 2: Original Online Design	Replacement with Hindrance	Technology was used to replace aspects of Iteration 1; teachers felt constrained by the limited perspective of the video when having to watch the lesson from one vantage point	Knowledge-based reflections and noticing were from the perspective of one camera angle, which constrained opportunities; video was used to try to replace in-person observation, but actually hindered noticing because of one vantage point
Iteration 3: Intermediate Online Design	Amplification	Edited video with two camera angles provided opportunity for the actual lesson length in the video to be reduced, which focused attention; capture sheets supported video to highlight aspects of video.	Knowledge-based reflections and noticing were more focused with edited videos from two camera angles; edited video was helpful for focus on students' thinking and the capture sheets augmented the use of video for reflection
Iteration 4: Current Online Teaching Lab Design	Transformation	The use of edited clips including two camera angles coupled with stopping and starting video and capture sheets created opportunities to anticipate student thinking and provided an experience that would not otherwise be possible without the technology	Knowledge-based reflections and noticing were focused because of ability to pause video and discuss and the ability to incorporate capture sheets that supported reflection; edited video was helpful for focus

to outcomes from the original face-to-face design for the teachers who participated. This is encouraging for supporting teachers in rural areas who may not otherwise have access to high-quality professional learning opportunities.

We recommend that mathematics education leaders thinking about moving a face-to-face professional learning experience to an online space consider the features of the face-to-face experience that are essential for the intended learning. At the same time, we encourage others to consider design principles that resonate with their intended learning outcomes. As evidenced in our experience, this transition was not straightforward and we faced many challenges along the way. As we move forward with this work, we will continue to explore additional avenues for improvement to our design. We will also consider how new and advancing technologies may also influence our work and perhaps lead to transformative experiences that we have yet to imagine. We encourage others to think about how they can leverage technology to provide learning experiences for teachers that otherwise may not be possible. ✪

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References

Amador, J., Weston, T., Estapa, A., Kosko, K., & De Araujo, Z. (2016). Animations as a transformational approximation of practice for preservice teachers to communicate professional noticing. *Journal of Technology and Teacher Education, 24*(2), 127-151.

Barlow, A., & Holbert, S. (2013). Teachers' perceptions of observing reform-oriented demonstration lessons. *NCSM Journal of Mathematics Education Leadership, 15*, 35-49.

Borko, H., Jacobs, J., Eiteljorg, E., & Pittman, M. E. (2008). Video as a tool for fostering productive discussions in mathematics professional development. *Teaching and Teacher Education, 24*(2), 417–436.

Choppin, J., Amador, J., Callard, C., Carson, C., & Gillespie, R. (in press, 2019). Synchronous online model for mathematics teachers' professional development. *Handbook of Research on Online Pedagogical Models for Mathematics Teacher Education.* IGI Global.

Coleman, T. (2017). *Examining teachers' uses of interactive diagrams in secondary mathematics instruction* (Unpublished doctoral dissertation). University of Maryland, College Park, MD.

Coles, A. (2013). Using video for professional development: the role of the discussion facilitator. *Journal of Mathematics Teacher Education, 16*(3), 165-184.

Fernandez, C., & Yoshida, M. (2004). *Lesson study: A Japanese approach to improving mathematics teaching and learning.* Malwah, NJ: Lawrence Erlbaum Associates.

Higgins, K. M. (2013). Building a team of learners. *Teaching Children Mathematics, 19*(8), 490-496.

Hughes, J., Thomas, R. & Scharber, C. (2006). *Assessing technology integration: The RAT – replacement, amplification, and transformation - framework.* In C. Crawford et al. (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference 2006 (pp. 1616-1620). Chesapeake, VA: AACE.

Hsieh, W., & Tsai, C. (2017). Taiwanese high school teachers' conceptions of mobile learning. *Computers & Education, 115*, 82-95.

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.

Kimmons, R., Miller, B., Amador, J., Dejardins, C., & Hall, C. (2015). Technologoy integration coursework and finding meaning in pre-service teachers' reflective practice. *Educational Technology Research and Development, 63*, 809-829.

Mason, J. (2002). *Researching your own practice: From noticing to reflection.* London, England: Routledge Falmer.

Pea, R. D. (1985). Beyond amplification: Using the computer to reorganize mental functioning. *Educational Psychologist, 20*(4), 167-182.

Reinking, D. (1997). Me and my hypertext: A multiple digression analysis of technology and literacy. *The Reading Teacher, 50*, 626-643.

Sherin, M.G. (2004). New perspectives on the role of video in teacher education. In J. Brophy (Eds.), *Using video in teacher education* (pp. 197-217). New York, NY: Elsevier Science.

Sherin, M. G. & van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education, 60*, 20-37.

Smith, M., & Stein, M. K. (2011). *Five practices for orchestrating productive mathematical discourse.* Reston, VA: National Council of Teachers of Mathematics.

Strayer, J., Barlow, A., Lischka, A., Gerstenschlager, N., Stephens, D. C., Willingham, J. C., Hartland, K. S. (2017). Meeting the needs expressed by teachers: Adaptations of the traditional model for demonstration lessons. *NCSM Journal of Mathematics Education Leadership, 16*, 18-26.

Teachers Development Group. (2010). *Mathematics studio program.* Retrieved from: http://www.teachersdg.org/Assets/About%20Studio%20Brochure%20.v.3.0.pdf

Thomas, A. & Edson, A. (2017). A framework for mathematics teachers' evaluation of digital instructional materials: Integrating mathematics teaching practices with technology use in K-8 Classrooms. In P. Resta & S. Smith (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 11-18). Austin, TX, United States: Association for the Advancement of Computing in Education (AACE).

Thomas, A., Edson, A. (2018). Integrating mathematics teaching with digital resources: Where to begin? In H. Weigand, A. Clark-Wilson, A. Donesvska-Tondorova, E. Faggiano, N. Gronbaek, & J. Trgalova (Eds.), *Proceedings of the 5th ERME Topic Conference on Mathematics Education in the Digital Age* (pp. 281-288). Copenhagen, Denmark: European Society for Research in Mathematics Education (ERME).

von Bommel, J. & Palmer, H. (2018). Enhancing young children's understanding of a combinatorial task by using a duo of digital and physical artefacts. *Early Year: An International Research Journal*, online first.

van Es, E. A., & Sherin, M. G. (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education, 24*(2), 244–276.

Van Zoest, L. R., Stockero, S. L., & Kratky, J. L. (2010). Beginning mathematics teachers' purposes for making student thinking public. *Research in Mathematics Education 12*(1), 37-52.

West, L., & Staub, F.C. (2003). *Content-focused coaching: Transforming mathematics lessons.* Portsmouth, NH: Heinemann.

Yeh, C. & Santagata, R. (2015). Preservice teachers' learning to generate evidence-based hypotheses about the impact of mathematics teaching on learning. *Journal of Teacher Education, 66*(1), 21-34.