Designing asynchronous video-based professional development for mathematics teacher educators

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The Video in the Middle (VIM) project is creating forty two-hour video-based professional development modules that can be combined in a variety of ways to form personalized pathways that meet the unique needs of a wide range of professional learning settings and contexts. The VIM asynchronous modules are designed to be used in three flexible facilitation formats: locally facilitated, expert facilitated, or independent/non-facilitated. VIM modules aim to support teacher noticing of student thinking and increase their mathematical knowledge for teaching linear functions. Preliminary research results indicate that teachers appreciated the variety of facilitation formats, found the online modules useful and engaging, and noticed, compared, and analyzed a variety of visual and numeric methods for solving linear function problems.

Keywords: Mathematics teacher educators, facilitation, online professional development, video-based learning, teacher noticing, mathematical content knowledge.

Introduction

Incorporating video within a professional learning environment offers great potential for mathematics teacher educators to support teachers in unpacking the relationships among pedagogical decisions and practices, students' thinking, and the disciplinary content (Borko et al., 2011). With video, teachers can observe and study the complexity of classroom life, reflect on their own instructional decisions, and to integrate multiple domains of knowledge to solve problems of practice (Blomberg et al., 2013). Recent reviews of the literature on video use in professional development (PD) point to the value of video as a tool for improving instructional practice (Gaudin & Chaliès, 2015).

As video technology and online video sharing have become more accessible and widespread, video-based PD is well-positioned to leverage the benefits of digital platforms (Teräs & Kartoglu, 2017). Online platforms can allow teachers access to professional learning resources that may not be available to them locally and can also support those who are reluctant to share ideas in face-to-face settings in becoming more comfortable doing so in digitally mediated interaction. Online PD is considerably more scalable than comparable face-to-face PD, and in many cases is subject to fewer monetary and logistical constraints for teachers (Killion, 2013). Research to date on online PD has shown some positive effects for teachers, even compared to face-to-face formats (O'Dwyer et al., 2010). Most research comparing online, and face-to-face versions of PD has found that well-designed online courses utilizing high-quality learning materials intended for individual use can produce learning outcomes that are like or better than face-to-face options (Fishman et al., 2013).

There is a general recognition of the critical role facilitators play in leading PD and the need for knowledgeable PD facilitators, leaders, and coaches (Bates et al., 2011). As PD shifts to address challenges such as COVID-19, facilitators are increasingly engaging with online platforms. To flexibly respond to teachers' complex and rapidly changing circumstances, new types of facilitation roles will become necessary (Koellner et. al., 2022). This paper reports on the design and preliminary findings from a project that is adapting face-to-face mathematics PD materials to an asynchronous digital format that was pilot tested with mathematics teachers in three facilitation conditions (local facilitated, expert facilitated and non-facilitated) to examine the impact on teacher and student knowledge. The paper will focus on findings related to the three facilitation conditions.

The video in the middle project

The Video in the Middle (VIM) project is designing and researching asynchronous PD modules. The asynchronous format allows participants access to PD at any time, in any location, and can potentially eliminate the often-mentioned roadblocks to participation—lack of scheduling flexibility and geographic distance. The VIM project draws upon the face-to-face *Learning and Teaching Linear Functions: Videocases for Mathematics Professional Development* video and ancillary resources (e.g., lesson graphs, transcripts, mathematical and video commentaries) to develop 40 two-hour modules intended to develop teachers' noticing skills and mathematical knowledge for teaching linear functions. These modules offer flexibility by allowing mathematics educators to design a variety of module sequences to fit their professional learning needs.

Conceptual frameworks

The design and development of the VIM asynchronous modules are conceptually grounded in two main bodies of research related to teacher learning in PD. First, the development of professional knowledge that consists of deep and connected mathematical content knowledge, the knowledge of students' thinking and how students learn the content, and knowledge of pedagogical practices and norms to support student learning. Second, the development of a professional vision that consists of teachers' ability to notice, analyze, and reason about features of student thinking and classroom interactions. In this section, we briefly discuss these two research areas with a focus on how they relate to the design and impact of the VIM asynchronous PD.

Mathematical knowledge for teaching

Ball and colleagues have identified and elucidated "mathematical knowledge for teaching" (MKT) as the professional knowledge that mathematics teachers must have to do the mathematical work of teaching effectively (Ball & Bass, 2002). This conception of knowledge of mathematics for teaching is multifaceted and includes both content and pedagogical content knowledge. MKT includes a sophisticated understanding of effective instructional practices and student thinking related to specific mathematical content and comes into play during all phases of teaching. For mathematics teacher educators, incorporating video within the learning environment supports opportunities for teachers to develop their MKT by unpacking the relationships among pedagogical decisions and practices, students' work, and the disciplinary content (Bloomberg et al., 2013). Collectively viewing and discussing video clips allows for the complexities of classroom practice to be stopped in time, unpacked, and thoughtfully analyzed, helping to bridge the ever-present theory-to-practice divide and support instructional reflection and improvement. The VIM module design incorporates MKT by providing multiple and varied experiences to examine and compare a variety of mathematical methods and representations, and to analyze the complex relations between content, pedagogy, and student thinking.

Professional vision and noticing

One unique aspect of mathematics teacher educators' knowledge is their "professional vision", which refers to their ability to notice and analyze features of classroom interactions, make connections to broader principles of teaching and learning, and reason about classroom events (Seidel & Stürmer, 2014). Over the years, diverse conceptions of noticing have emerged in the literature, but in general most discussions of mathematics teacher noticing involve two main processes: (1) *Attending* to particular events in an instructional setting (i.e., teachers choose where to focus their attention and for how long) and (2) *making sense* of events in an instructional setting (i.e., teachers draw on their existing knowledge to interpret what they notice in classrooms) (Sherin et al., 2011). Sherin et al. (2011) argue that these two aspects of noticing are not discrete, but rather interrelated. Teachers attend to events based on their sense-making, and how they interpret classroom interactions and students' thinking influences where they choose to focus their attention. A noticing conceptual frame is used within the VIM asynchronous module design to support the analysis of classroom interactions and reason about teaching and student thinking within the viewing and analysis probes of the video clips embedded within the modules. In addition, the bridge to practice activities that end each module are designed to connect teachers' learning to their classroom practices.

VIM module design and development

Many, but not all, video-based mathematics PD programs have teachers are designed to engage teachers in specific activities before and after watching the focal video (Borko et al., 2011). For example, prior to watching a clip, PD facilitators may ask the teachers to solve and discuss the math problem shown in the video to develop content knowledge, motivate teachers to notice elements of the content contained within the clip, and attend to specified activities such as a unique solution method or teacher questions that prompt extended student reasoning. After viewing the video, facilitators may guide a discussion and in which the teachers relate what they have seen on the video to their own classroom practices. The discussion and follow-up activities extend teachers' thinking and analysis by probing more deeply into topics or issues presented within the video.

We label this intentional sequencing of video viewing such that it occurs between designated activities with specified learning goals a 'video in the middle' design (Seago et al., 2018). In video-based mathematics PD that incorporates this design feature, video is in the middle of the learning experience, sandwiched between activities such as mathematical problem-solving and pedagogical reflection. Our goal is not to argue that this design feature is new to the field of professional development, but simply to highlight and label it, and consider how the design is likely to support pre- and in-service teachers' learning.

Each VIM module contains the same set of activities embedded in the video in the middle design, placing a video clip at the center, or "in the middle," of professional learning as teachers take part in an online experience of mathematical problem solving, video analysis of classroom practice, and pedagogical reflection (Figure 1). The overall structure of this design is consistent across all VIM modules and is intended to support teachers' professional learning opportunities around mathematical knowledge for teaching (Ball & Bass, 2002) and teacher noticing of student thinking and teacher-student interactions (Sherin et al., 2011).

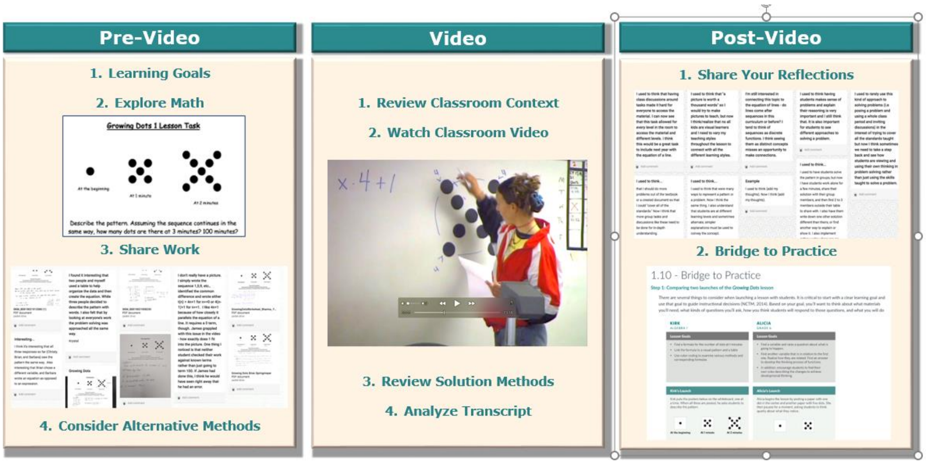

Figure 1: Video in the middle PD activities

The VIM modules are designed to be offered in three asynchronous facilitation formats: (1) locally facilitated, (2) expert facilitated, and (3) independent/non-facilitated. The different formats provide unique affordances for teachers and provides users with both flexibility and choice in their professional learning. Some teachers may prefer to work independently at their own pace and on their own time schedule; others may prefer to work with colleagues at their school with local facilitation from a coach. Or districts may want to offer their teachers the opportunity to participate with other teachers nationally in an expert facilitated experience. VIM's final design will offer a variety of suggested pathways through the modules depending upon goals, grade levels, and mathematics content, with options to personalize a professional learning plan (depending on one's goals) or swap a particular module with another from the bank of VIM modules.

Methodology

During Spring 2020, middle and high school teachers were recruited across the state of California to participate in a pilot efficacy study to address the following research questions:

> *What is the impact of teachers' participation in the three delivery formats on teachers' mathematical knowledge for teaching, their noticing skills, and their teaching practice? What is the impact on their students' performance?*

In this paper, we report on the impact of participation in the three delivery formats on teachers' mathematical knowledge for teaching and noticing skills.

Participants. Mathematics coaches/leaders from two school districts with which researchers had existing relationships were recruited for the locally facilitated condition. The coaches/leaders in each district recruited teachers and then served as the local facilitators for groups in their districts. For the independent /non-facilitated condition and the expert-facilitated condition, teachers were recruited from districts across California and randomized into two groups. Where multiple teachers were recruited from the same district, teachers were split between the two groups. Of the 68 teachers who began the study, 56 (82%) completed all or nearly all study activities, including all four VIM modules

(16 local facilitated, 16 expert facilitated, 24 independent). All three conditions had 80% or higher completion rates—local facilitated (83%), expert facilitated 80%, and non-facilitated 83%.

Intervention. All teachers experienced the same four sequenced, two-hour modules for a total of eight hours of professional development over the course of eight weeks (February-March 2020). While the modules are structured alike and contain a consistent set of activities and resources, each individual module is focused on a set of three unique learning goals (mathematical, pedagogical, and instructional) that are designed around each VIM mathematical task and video clip.

Facilitator training. In January 2020 two project staff designed and facilitated a 90-min zoom facilitator orientation for the two expert and three local facilitators. During the orientation, staff gave an overview of the RCT study and timeline, the VIM module structure, tools (such as Canvas, NowComment and Padlet), and a web-based facilitator guide. Additionally, a video tutorial focused on the journal tool was created for the facilitators to learn how to comment on participants responses and provide feedback to their teacher participants within the asynchronous format.

Measures. A variety of measures were used to gather impact data on teachers and students. Teacher measures included an online pre-post video and student work analysis task, weekly online self-report teacher logs focused on what teachers used in their classroom practice related to the PD, teacher interviews focused on usefulness, engagement and facilitation conditions, classroom observations and PD embedded pre-post community wall posts and comments. A student online quiz was developed to assess shifts in content knowledge. The focus of this paper will be on the analysis and results of the mathematics community wall pre-post data and interview data across the three facilitation conditions.

Analysis and results

COVID's impact on data collection, analysis, and results. Weeks seven and eight of the RCT were impacted by COVID-19. In both facilitated groups there was less interaction among participants in the fourth module than the previous three modules. Typically, there were four-five participants who commented on colleagues' posts. For the fourth module, there were one or two people who completed the module around the same time and interacted with each other. For teachers who completed the fourth module, they completed all the activities and journal entries but didn't comment or interact much with their colleagues. In addition, while ~5000 pre student quiz data was successfully collected, post student quiz data was not able to be collected. Teacher observations were not completed and therefore teaching practice impact data was not collected.

Teacher community walls. Within each of the VIM modules, teachers worked on the mathematical task that the students in the video clip engaged with. After solving the problem, they uploaded an image of their work and colleagues and facilitators commented or asked questions. Two project staff independently examined and categorized the various mathematical methods posted by teachers and analyzed the responses by the teachers on each other's methods. They compared and agreed upon their categories, analysis, and calculations. Community mathematics wall participation was high in all three conditions. In the locally facilitated condition, 80% of participants posted their mathematical work in the first VIM module and 95% posted their work in the final VIM module. In the self-paced group, 88% of the participants posted their mathematical work for the first module and 100% posted in the final module. In the VIM project facilitated group, 100% of the participants posted their work in both the first module and last modules. The VIM project facilitated group had the smallest number of pre-non-facilitator comments, but a similar number of total comments to the other two conditions. The most notable pre-post results emerged in the analysis of the visual versus numerical methods used by teachers. Specifically, by condition:

- *Locally facilitated*: Visual methods increased from 3% of the total methods posted in module 1 to 89% in module 4; numerical methods decreased from 70% of the total methods posted in module 1 to 11% in module 4
- *Expert facilitated:* Visual methods increased from 6% of the total methods posted in module 1 to 94% in module 4; numerical methods decreased from 82% of the total methods posted in module 1 to 6% in module 4
- *Non-facilitated:* visual methods increased from 18% of the total methods posted in module 1 to 85% in module 4; numerical methods decreased from 82% of the total methods posted in module 1 to 6% in module 4

The preliminary results in the analysis pre-post methods not only showed improved MKT with a substantial shift from numerical to visual methods, but their comments indicated an increased appreciation for visual methods in general by mentioning use of color, modeling of expressions, etc.

<u>Teacher interviews</u>. Of the 56 teachers who completed the study, nine were randomly selected for guided interviews in June and July 2020, three from each condition. All interviews were audio-recorded and transcribed. Two project staff identified passages related to teachers' engagement in the PD, the usefulness of module features, the content and resources, their thoughts on the facilitation conditions and the impact on their practice. All nine expressed that they found the VIM PD modules engaging and useful. When asked to comment on features or elements of the VIM modules they found most beneficial, the videos, lesson graphs, and community walls were all mentioned by most teachers. In relation to noticing, many teachers commented that watching a video of a real classroom helped them better understand what teacher moves described in the PD would look like and how 'real' students might respond mathematically. In relation to MKT, teachers mentioned that they learned a variety of ways linear functions tasks can be approached or solved, whether from the analysis of the videos, the solution methods document, or in other participants' work posted on the community walls.

When asked about their experiences, teachers in different conditions described distinctive affordances of each. For example, most teachers in the facilitated groups appreciated receiving feedback from a coach in their district or an expert facilitator, while those in the independent/non-facilitated group enjoyed the flexibility of being able to complete the modules at their own pace. As one independent participant said,

> 'I like this particular experience because I can go at my own pace, and it was still almost like it was facilitated because there were questions that you had to answer.'

Most participants in the facilitated groups felt that the facilitation was supportive and helpful. They appreciated the comments and questions posed on the Padlet wall and said that it helped them reflect on their own learning and perspective of the task. Some shared that it helped them to be accountable and get the work done.

> 'I liked the group I was in because it held me accountable to do a lesson a week, or in the time constraints. I might not have managed my time as efficiently... I wouldn't have gotten as much out of them. I feel I was able to get more out of them by being in the structured setting.'

One person in a facilitated group shared how supportive the facilitator was in helping her understand some of the content of the lesson as well as the postings on the Padlet wall. Almost all the participants in the facilitated groups appreciated being in a facilitated group and said that they would choose that option again. One participant felt ambivalent about the facilitation and said she could be in either a facilitated or independent condition, as the facilitation felt minimal and not very helpful. Participants in the independent condition were divided regarding whether they would prefer having been in a facilitated group instead.

> 'I kind of liked the independent group because I was able to adjust my weekly schedule, but I also like to socialize with colleagues and talk about what we are learning. I would like to have tried the other part, but I don't think I have a preference'.

Discussion and conclusion

The VIM asynchronous video-based PD modules are designed to meet the increasing need for online PD options that include flexibility and choice for teachers and facilitators (Koellner et.al., in press). The preliminary analysis of the community wall and interview data show impact of the three facilitation conditions on teacher noticing and MKT in the teacher's examination of student thinking, classroom interactions, and mathematical representations/methods.

A surprising result was the fact that there were no substantial differences in the RCT study across the three conditions regarding teacher engagement and interaction on the community mathematics task wall. We hypothesized that the facilitated group would be more engaged and post more comments in response to their colleagues' methods and facilitator probes. This did not turn out to be the case, as teachers across all three conditions commented in similar numbers and shifted from numeric to visual methods from pre to post. We wonder if the design of the video in the middle experiences—the opportunities provided to teachers to access multiple perspectives of each other, mathematicians and mathematics educators and engage with their peers within the community wall activities—may have provided teachers with more similar than different experiences across the three conditions. We anticipate learning more as we analyze more data (journals, community wall reflections).

The asynchronous, online nature of the VIM modules makes them highly scalable; unlike many face-to-face and synchronous online PD options, mathematics educators do not need to limit participation due to space or cost concerns. At the same time, the various facilitation options allow for interaction and collaboration among teachers.

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