ASYNCHRONOUS MATHEMATICS PD: DESIGN AND FACILITATION FORMAT EFFECTS ON TEACHER LEARNING

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In this paper, we share the design and effects on teacher learning of a set of two-hour online mathematics professional development modules adapted from face-to-face video-based materials. The modules are designed to be used in three facilitation formats: project staff- facilitated, district leader-facilitated, or structured independent. The modules aim to impact teachers' mathematical knowledge for teaching linear functions and effective mathematics teaching practices (MTPs; NCTM, 2014). Analysis of teacher learning, as related to evidence of the MTPs in teachers' written reflections, found teachers demonstrated learning of key MTPs, and in particular, there were not significant differences by facilitation format. Results and implications are discussed.

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 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 (Major & Watson, 2018).

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. Asynchronous PD allows participants flexible access to PD, with choice of schedule and location, and teachers report that the ability to access online PD anytime is very or extremely important (Parsons et al., 2019). Online PD may also be more scalable than comparable face-to-face PD and may have fewer monetary and logistical constraints (Killion, 2013). Asynchronous forms of online PD have resulted in positive findings related to teachers' attitude and self-efficacy (An, 2018) as well as high satisfaction and relatively high levels of information sharing (Yoon et al., 2020). In the research reported here, we investigate how asynchronous PD participation can support secondary mathematics teachers' mathematical knowledge for teaching.

THEORETICAL FRAMEWORK

Ball and colleagues have identified and elucidated "mathematical knowledge for teaching" (MKT) as the professional knowledge that mathematics teachers must have

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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. Incorporating video within a professional learning environment supports opportunities for teachers to develop their MKT by designing opportunities for teachers to examine the relationships among pedagogical decisions and practices, students' thinking, and the disciplinary content (Bloomberg et al., 2013). Viewing video clips allows for the complexities of classroom practice to be stopped in time, unpacked, and thoughtfully analyzed, helping to bridge the theory-to-practice divide and support instructional reflection and improvement.

MODULE STRUCTURE AND DESIGN

The Video in the Middle (VIM) project is adapting a face-to-face video-based PD to online 40 two-hour modules asynchronous PD modules designed to expand teachers' MKT. The modules incorporate MKT as a design principle by creating multiple and varied experiences for teachers to examine and compare a variety of mathematical methods and representations, and to analyze the complex relations between content, pedagogy, and student thinking. The bite-sized modules offer flexibility by allowing mathematics educators the opportunity to design a variety of module sequences to fit their learning needs and have the potential to eliminate common roadblocks to participation such as scheduling difficulties and geographic distance.

Each module contains a common set of structured activities, where a video clip is 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 (Seago et al., 2018; Figure 1). This structure is intended to support teachers' professional learning related to mathematical knowledge for teaching (Ball & Bass, 2002) and NCTM's (2014) Mathematical Teaching practices (MTPs), a research-driven "core set of high-leverage practices and essential teaching skills necessary to promote deep learning of mathematics" (p. 9). The VIM modules emphasize six of the eight MTPs, as noted below:

1. Establishing mathematics goals to focus learning
2. Implementing tasks that promote reasoning & problem solving
3. Using and connecting mathematical representations
4. Facilitate meaningful mathematical discourse
5. Pose purposeful questions
8. Elicit and use evidence of student thinking.

Two additional design principles are also reflected: 1) All materials are rooted in the activities and materials of practice—authentic, unedited videos of classroom interactions, representing a *practice-based theory of professional learning* (Ball &

Cohen, 2002), and 2) there are multiple opportunities for teachers to access alternative perspectives from students, peers, mathematicians and educators, following the principle of *promoting multiple perspectives and accessing expert knowledge* (Herrington et al., 2010). While the overall module structure and these design principles may not be new to mathematics teacher PD, we seek to label this structure and investigate how it supports teacher learning in asynchronous teacher PD.

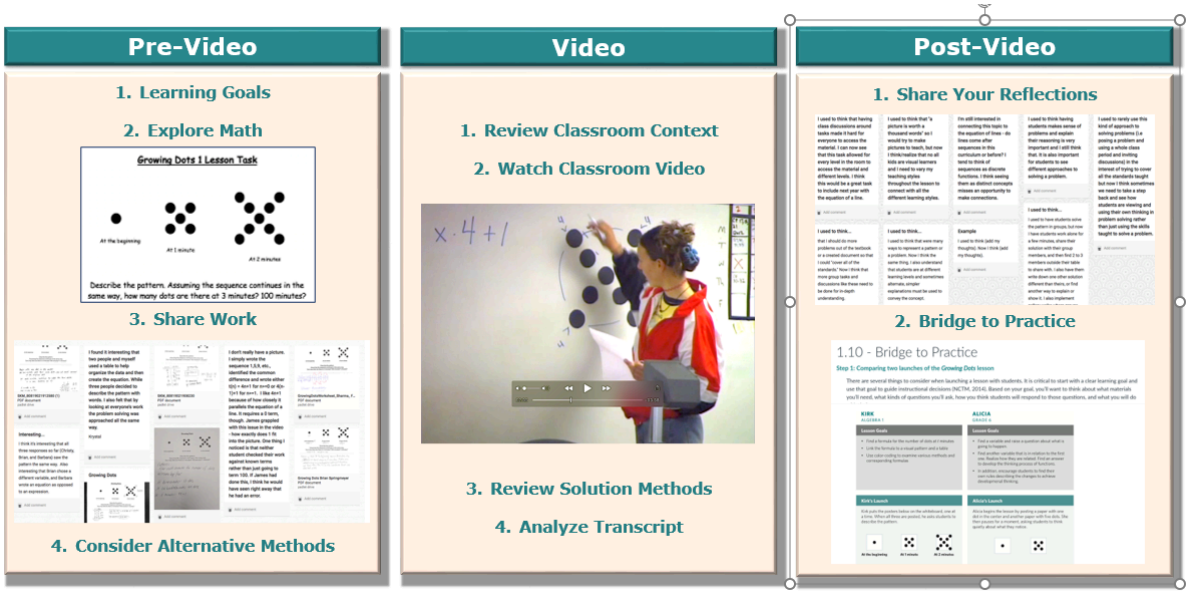

Figure 1: Video in the middle consistent set of activities.

METHODOLOGY

During Spring 2020, middle and high school teachers were recruited across California to participate in a pilot study to address the following research question: *How does VIM participation support teacher learning outcomes related to instructional practice, and how do they differ by facilitation format?*

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). The four modules shared a common set of design principles, structure, and resources. Modules were offered in three formats: (1) project staff-facilitated, (2) district leader-facilitated, and (3) structured independent. Teachers in each of the two district leader-facilitated cohorts were all from the same district, while the other two groups included teachers from many different districts. The study intended to test if and how different facilitation formats impact teacher learning to meet the demand for scalable, high-quality PD (Koellner et al., in press). All three facilitation formats reflect what is known about effective teacher PD (Darling-Hammond et al., 2017) and particularly mathematics PD (Heck et al., 2019). Key features of effective PD were embedded in all conditions (Table 1).

PD feature	Project staff-facilitated	District leader-facilitated	Structured independent
Duration	Four sequenced two-hour modules (a total of eight hours) spread over the course of eight weeks; teachers compete one module per week.		Four sequenced two-hour modules (a total of eight hours); teachers work at their own pace and on their own time schedule.
Content focus	Each module is designed around mathematical content and pedagogical content knowledge goals.		
Coherence	Each module contains a "Bridge to Practice" activity at the end of the module that connects the module goals to instruction and their own teaching context.		
Active & Practice-Based	Participating teachers complete a mathematics task and share their work asynchronously with colleagues, then review a video of the mathematics task as a part of an instructional sequence in a classroom, write reflections on the classroom interactions, and then describe in writing their plan for integrating their learning into their own instructional practice.		
Collective Participation	Teachers share their solution methods and reflections on the classroom video with colleagues by posting them on an online discussion board. Teachers were asked to comment on other teachers' solution methods and engage in dialogue on their written reflections.		
Expert Facilitation	The structure of each nodule and the sequence of the four VIM modules were designed by experts in mathematics content and pedagogy and reflected research on teacher learning, attention to student thinking, and the importance of teacher reflection.		
	A project team member with expertise in mathematics teaching and learning led teacher participation (e.g., encouraged teachers to complete modules, post on their work, and respond to journal reflections) and answered teacher questions during their experiences.	A member of the school district with expertise in mathematics teaching and with knowledge of school and district contexts and goals led teacher participation and answered teacher questions during their experiences.	While the participants in this condition did not have an additional facilitator directing their participation, the structure of each module and the pacing across modules was explained and detailed.

Table 1: How three facilitation formats reflect key features of mathematics PD.

Facilitator training. In January 2020, project and district facilitators participated in a 90-minute video-conference orientation with project staff, including an overview of the study and timeline, VIM module structure, and online tools. Facilitators also had access to a web-based facilitator guide and video tutorial demonstrating how to respond to participants.

Participants. Participating teachers taught middle school math, Algebra 1, or first-year high school math. Teachers in the district leader-facilitated condition were recruited by mathematics leaders from each of two school districts. Each of the two leaders then served as the facilitator for their district group. Additional teachers were recruited from districts across California and randomized into either the structured independent condition or the project staff-facilitated condition. Where multiple teachers were recruited from the same district, teachers were randomly split between the two conditions. Where single teachers were recruited from a site, singleton teachers were matched by similar site location or demographics; matched pairs were then randomized into the two conditions. Of the 68 teachers who began the study, 82% completed all or nearly all study activities across the four modules.

Measures. Multiple measures were used to gather impact data on teachers, including teachers' pre-post analysis of student work, their work on the mathematics tasks,

module reflections, and post-study interviews. The focus of this paper is the analysis of teachers' responses to two end-of-module reflection prompts: *What did you learn from this module? What new ideas do you intend to take/use from this professional learning?* Although the prompts were originally designed as a PD activity to support teacher learning and not a research measure, they offer insights into how teachers made sense of their learning and how the VIM modules supported teachers' MKT.

Analysis. 61 teachers (18 district-leader facilitated, 17 project-staff facilitated, 26 structured independent) responded to at least one of the eight prompts, resulting in 446 end-of-module reflections, and 54 to 59 teachers responding to each prompt. Responses were loaded into MAXQDA in order to organize and facilitate coding. Responses were coded using the MTPs (NCTM, 2014), as in addition to being a valueable set of mathematics teaching practices and skills, the MTPs offer a valuable framework for conceptualizing and identifying teachers' MKT growth and intended shifts in classroom practice. Coding for MTPs was as a means to identify evidence of and differences in teachers' MKT across conditions. Two coders, blind to teacher condition, coded responses in small batches of 10 to 15 teachers, adding details to the coding document and reaching consensus for coding of all responses.

RESULTS

Figure 2 presents the the percent of teachers in each facilitation format that showed evidence of MTPs in their responses, suggesting MKT growth by MTP. As shown in Figure 2, there is overall little difference in evidence of MTPs by teacher condition; for example, the percent of teachers that demonstrated evidence of MTP-4 (facilitate meaningful mathematical discourse), ranged from 30.8 to 41.2%, with 7 or 8 teachers per group respectively. Analyses using chi-square tests were completed when the chi-square test assumption of minimum number of expected values in all cells was met (MTP 2, 3, 4, 5, and 8). Results showed that the differences across groups were not statistically significant for these outcomes (e.g. MTP-2 (implementing tasks that promote problem-solving and reasoning), $X2 = 1.89, p = 0.39$; MTP-8, eliciting and using student thinking, $X2 = 3.38, p = 0.16$). As analyses demonstrate that the differences in MTPs were not significant, we can suggest that the differences by condition for MTPs are not significant at this time and further research is needed before more conclusions can be made.

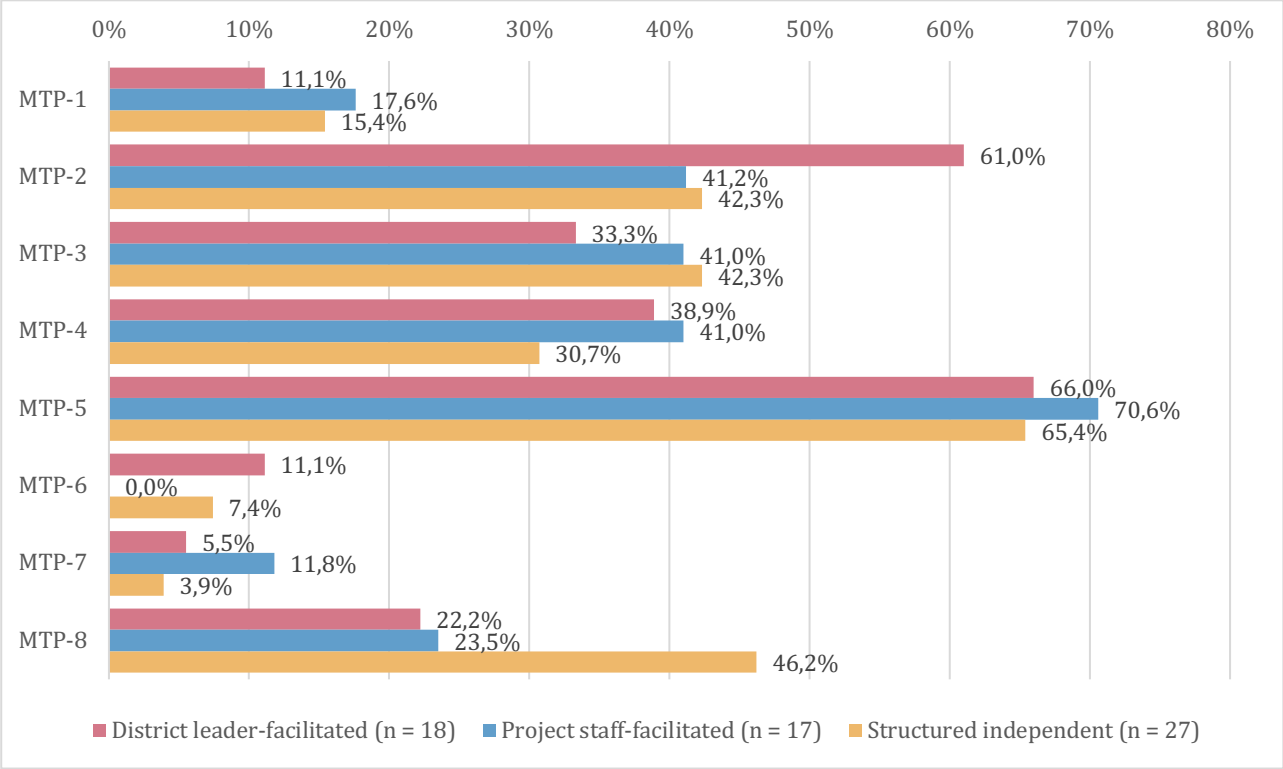

Figure 2. Evidence of MTPs in teachers' refelctions, percent by facilitation format.

DISCUSSION

Across conditions, teachers showed evidence of learning consistent with the VIM modules. Over 92% of the 61 participants who responded to the reflection questions gave at least one response indicating meaningful learning related to an MTP. This is notable given the open-ended nature of the prompts and that they were not written as a research instrument but rather as PD activities. High percentages of teachers across conditions showed evidence of learning related to MTP-2 (46.7%), MTP-3 (39.3%), MTP-5 (67.2%) and MTP-8 (32.8%), areas that were emphasized in the VIM modules.

The evidence of MTP-related learnings after VIM participation, as designed and hypothesized, emphasizes how the VIM modules supported all teachers *across condition,* and particularly statistical analyses do not show differences in evidence of MTPs by condition. That is, while the number of teachers who evidenced learning about a particular MTP did vary across facilitation formats, these differences were not statically significant and thus suggest that at this time there was no differential impact for one facilitation format over another.

CONCLUSION

High-quality professional learning is widely accepted as a core component of meaningful school reform (Borko et al., 2014); however, if schools and districts are to scale quality PD in a cost-effective and widely accessible manner, innovative tools and strategies that do not rely on individual providers spending extensive face-to-face time with small groups of teachers are needed (Cai et al., 2017).

These results support those of Heck et al. (2019), which suggest that the participation format of a PD experience is less critical than the presence of the key design features described in Table 1. As noted above, all three formats of VIM module facilitation were designed and structured following researched-based structure and design principles. The trends in analyses of the MTPs in teachers' written responses show promising preliminary evidence of teacher learning related to MTPs and emphasizes the strength of all three facilitation formats. This analysis also provides initial evidence of impact of independent, asynchronous PD, when it is well designed and structured. Responses also offer opportunities for further analyses of trends and additional themes, as teachers' responses from each condition were detailed, while varied.

There may be a bias towards face-to-face PD and localized PD contexts with an underlying assumption that they are more likely to lead to teacher learning than asynchronous PD. While local and face-to-face experiences may support teacher learning, it may be that they include key features of high-quality PD, and the format itself is less important. The preliminary findings we highlight in this paper suggest that future research is needed to study the relationship between PD design structures, PD format and context, and teacher learning of mathematical teaching practices and further understand the benefits of research-based, structured asynchronous PD.

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