Representations of Practice to Support Teacher Instruction: Video Case Mathematics Professional Development

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REPRESENTATIONS OF PRACTICE TO SUPPORT TEACHER INSTRUCTION: VIDEO CASE MATHEMATICS PROFESSIONAL DEVELOPMENT

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What do teachers take up and use from mathematics professional development (PD) focused around video cases as representations of practice? In this chapter we explore what teachers took back to their classrooms based on a video case-based PD experience. Data gathered from focus group interviews and a set of reflection questions on teachers' learning and uptake from the PD form the basis of the analysis for this chapter. Teachers were classified into four different user categories -- Generative, Transformative, Incremental, or Non Users – based on how they carried their PD experiences into their mathematics classrooms. These classifications contribute to our understanding of how, what and why teachers take up information from PD programs, and that they do that in unique ways and to varying degrees.

Key Words: Video case, mathematics professional development, inservice, representations of practice, teacher practice, teacher learning

INTRODUCTION

Video-based professional development (PD) generally relies on selected video clips to serve as representations of practice that support teachers' collaborative discussion and analysis. Video is a tool that brings a slice of the classroom into the PD setting, helping to guide meaningful inquiry, reflection, and learning (Borko et al. 2011, Brophy 2004). Video can be used in a wide range of PD models, to guide teachers' attention and address particular learning goals.

Previously we posited that PD models fall on a continuum from adaptive to specified, and we described the use of video representations in both types of models (Borko et al. 2011, Koellner and Jacobs 2015). On one end of the continuum are *adaptive* models, in which the learning goals and resources are derived from the local context and shared video is generally from the classrooms of the participating teachers. Examples of adaptive, video-based, mathematics PD models are video clubs (Sherin et al. 2009) and the Problem-Solving Cycle (Borko et al. 2015). In these models, video is selected and sequenced by the facilitator and/or the participating teachers, and video viewing and related activities are based on general guidelines that take into account the perceived needs and interests of the group.

On the other end of the continuum, *specified* models of PD typically incorporate published materials that specify in advance teacher learning goals. In video-based specified PD, the video clips are typically pre-selected and come from other teachers' classrooms. For example, Tom Carpenter and colleagues created a specified PD program using video clips from teachers' classrooms that were unknown to PD participants for the *Cognitively Guided Instruction* program. The clips were selected to elicit inquiry and discussion focused on students' mathematical thinking

about arithmetic concepts (Carpenter et al 2000). Another example is the *Learning and Teaching Linear Functions* (Seago et al. 2004), a set of specified PD materials that include video cases to help teachers deepen their understanding of ways to conceptualize and represent algebra content within their classroom practice. Across both adaptive and specified models of video-based PD, authentic video footage can be used as representations of practice that promote productive discussion around targeted content, pedagogical strategies, and/or student thinking (Borko et al. 2008).

Because adaptive models of video-based PD focus primarily on the analysis of the participating teachers' lessons, the experience of viewing video can serve as a reflective mirror into one's own practice (Lundeberg et al. 2008, Tunney and Van Es 2016). By contrast, analyzing video of unfamiliar teachers' practice, as is common in specified models of video-based PD, offers a window into alternative teaching practices (Zhang et al. 2011, Van Es 2012, Calandra and Rich 2015, Givvin et al. 2005). Viewing someone else's classroom can prompt teachers to consider more wide-ranging instructional possibilities, while at the same time the experience can help teachers to see themselves in others and reflect on their own practice.

This chapter contributes to the literature focused on better understanding the use and impact of video cases as representations of authentic instructional practice in specified PD programs. The research questions that guided this work are: What do teachers report learning and using from a specified video case-based PD? What is the nature of the variation across teachers?

NOTICING AS A CONCEPTUAL FRAME

Mathematics teachers come to PD workshops with varying levels of knowledge, much like the students who come to their math classrooms. One unique aspect of teachers' knowledge is their "professional vision," which refers to their ability to notice and analyze features of classroom interactions (Sherin 2007). Van Es and Sherin (2002) defined noticing as a process rather than a static category of knowledge and argued that it includes three components: (1) identifying important features of a classroom situation; (2) making connections between classroom interactions and the broader principles of teaching and learning; and (3) using what one knows about the context to reason about classroom events. 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, Jacobs and Philipp (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 influences where they choose to focus their attention.

The conceptual frame of noticing is relevant to our consideration of what teachers take up from video-based PD for mathematics teachers and the impact on their classroom practice. It is well established that PD programs that incorporate video representations of practice foster the development of teachers' noticing skills (Roller 2016, Santagata and Yeh 2013). As they attend to and make sense of instructional events viewed during PD workshops, teachers are also likely to consider the implications for own practice (Koh 2015). In other words, what teachers notice appears

directly relevant to how they elect to carry their learning into their classrooms (Sherin and van Es 2009). In addition, participants in video-based PD do not all make sense of the video clips or the classroom situations they depict in the same way; rather individuals bring differing knowledge and beliefs about teaching and learning, students, content, and curriculum to bear on what they notice (Erickson 2011, Van Es 2011). Furthermore, these are important individual differences in terms of what teachers bring to and take from video-based mathematics PD experiences (Kazemi and Hubbard 2008, Kersting et al. 2010, Santagata and Yeh 2014). Teachers bring diverse perspectives on teaching and learning, experiences as classroom teachers, and content knowledge based on their own backgrounds and context. This individual diversity impacts what they notice in the videos, how they engage in the professional development and what they take and use in their own practice. More research is needed to understand and categorize these differences, and connect the use of video to both noticing and uptake.

LTG VIDEO CASE MATERIALS AND DESIGN

The Learning and Teaching Geometry[1] (LTG) materials (Seago et al. 2017) use video as a centerpiece in the professional development designed to improve the teaching and learning of mathematical similarity based on geometric transformations. The authors of the materials conjectured that viewing and discussing video footage, on its own, would be insufficient to meet the LTG materials' learning goals. Therefore, the PD design incorporates pre and post-video viewing tasks, which together constitute a 'video case' and serve as a holistic basis for supporting learning from representations of practice (Seago et al. in press).

The LTG materials engage teachers in learning about similarity, congruence, and transformations and offer access to specific and increasingly complex mathematical concepts that are presented within the dynamics of classroom practice (Seago et al. 2010). The learning goals for the LTG PD were chosen because this content was a critical area of need for teachers—new U.S. Common Core Standards for Mathematics required them to teach transformations-based geometry, which had not previously been part of state standards (Seago et al. 2013). Therefore, it is likely that neither teachers nor their students have had many opportunities to engage with the specific mathematics content covered in the PD materials.

In addition to learning the content, a central goal of the materials was to support teachers' ability to provide classroom experiences to promote their students' learning. Sustained and in-depth engagement with video-cases, led by a knowledgeable facilitator, was hypothesized to be a powerful tool to promote teacher learning, instructional change, and student learning. The representations of practice form the backbone of what constitutes the LTG materials— a specified PD curriculum that is organized into 18, three-hour sessions, intentionally sequenced to follow a mathematical trajectory. In total, the program includes over 50 video clips, selected from real classroom footage of mathematics lessons across the United States. All of the video clips were examples of productive instruction, yet the clips vary in how similarity and congruence are taught.

[1] The National Science Foundation supported both the Learning and Teaching Geometry Study (NSF Award #0732757) and the Learning and Teaching Geometry Efficacy Study (NSF Award #1503399).

Only two teachers' instructional practice display expert content knowledge of transformations-based instruction, however the series of video clips are used purposefully in the sequenced mathematical trajectory. By focusing on classroom video from across multiple and varied contexts, the materials provide insight into what an emerging understanding of similarity looks like as well as a variety of instructional strategies that can foster this understanding.

The professional learning activity that most commonly comes before watching a given video clip in the LTG materials is working on the mathematical task that is in the clip. Solving the same task as the students in the video allows teachers to develop an adequate understanding of the mathematical demands faced by the students, and helps them to better engage with and interpret the student thinking and pedagogical moves captured by the video clip. In some cases, teachers are prompted to make predictions about how students will solve the problem or discuss the types of mistakes they think students might make. The assumption behind this type of pre-video activity is that teachers need a period of time to become sufficiently immersed in and familiar with the mathematics content they are about to see, so that they can readily follow the pertinent issues that arise in the video episodes.

Post-video viewing activities in the LTG materials include: careful unpacking of the ideas presented in the video clip, considering how those ideas apply in different mathematical contexts, discussing the pedagogical issues that were brought up by the video clip, and reflecting on how teachers can apply their emerging insights to make improvements in their own lessons. Certainly not all of these topics are discussed after each video, but they are generally part of each session. Facilitators draw on guiding questions provided by the materials, but they are also free to improvise based on their understanding of the teachers' needs and interests (Jacobs et al. in press).

THE LTG EFFICACY STUDY

The LTG Efficacy Study aims to explore the effectiveness of the LTG PD program using a randomized, experimental design. The sample is comprised of 111 mathematics teachers (serving grades 6-12) and their students from two contexts - one in the northeast United States and the other in the western mountain region. All teachers volunteered to participate in the study. Sometimes there were groups of teachers from one school but at times only one teacher represented a school site. Approximately half of the teachers were randomly assigned to take part in the LTG PD in the first intervention year (treatment group) and half will take part in the second intervention year (delayed treatment group/ control group). The treatment group consisted of two sites and included 24 middle and high school teachers in the western mountain region and 25 middle and high school teachers in the northeast. The control group of teachers consisted of 31 teachers in both settings. Treatment teachers in both settings participated in the entire LTG PD program, including a one-week summer institute and four days of academic year follow-up sessions beginning in Summer 2016. Control teachers will participate in the same experiences beginning in Summer 2017. One facilitator led professional development workshops for all groups of teachers. She was one of the expert videotaped teachers found in the video-clips. She had a high level of transformations-based geometry content knowledge. During a pilot, she was found to facilitate with a high degree of fidelity to the LTG PD curriculum goals. The data gathered in this project include focus group interviews, reflection questions, videotape of PD sessions, videotape of teacher's classroom practice, teacher content assessments, teacher pre/post PD assessments, and student content

assessments. Although a large amount of data was collected and used to quantitatively understand the efficacy and impact of the materials, the methodological challenge to understand qualitatively what exactly the teachers learned and took up from the PD and enacted in their classrooms still existed. This is the first step in addressing that challenge. The focus of this chapter is to understand what teachers learned from the PD and what they noticed from the video cases that appeared relevant to their own classrooms, and how they incorporated their learning into their current instructional practice.

DATA COLLECTION AND ANALYSIS

As an exploratory study, the analysis for this chapter is drawn from data gathered in focus group interviews and a set of reflection questions from the treatment teachers in both settings at the last two PD sessions. Focus group interviews allow teachers to collaboratively discuss their experiences and opinions on a selected topic (Vaughn et al. 1996), in this case their uptake of the LTG materials. Structured group conversations have the benefit of sparking memories and experiences a teacher may have forgotten, in contrast to the reflection questions which allowed only for independent thinking. The focus group interviews were conducted by a project staff member with groups of 3-4 participating teachers. A total of 20 teachers were interviewed in this manner. Teachers were encouraged to informally share their learning from the PD, what they had taken up in their practice as a result of participating in the PD, and why they did or did not use tasks, instructional strategies or tools that they experienced/viewed in the LTG PD in their classrooms. The interviewer prompted teachers to talk specifically about the video cases and any other influences from the PD they brought into their classrooms (including student materials and teaching practices), and to describe relevant information about their school or teaching context. Additionally, a set of reflection questions were given to 15 teachers during one of the last PD workshops held in December after the workshop was over. Teachers were asked to think back on the week-long summer PD workshops. They were asked to think about what they learned and what they actually used in their classroom. These questions prompted teachers to describe in writing how they had used content and pedagogical information from the PD in their classrooms. They were also asked what influenced them the most and if they were planning on incorporating any other aspects of the PD during the academic year.

We analyzed notes from the focus group interviews and teachers' written reflections using a modified grounded theory approach to look for patterns and themes that emerged from the data (Glaser and Strauss 2009). Specifically, we used the data to create and define categories based on teachers' reported use of the LTG materials in their classrooms. The themes identified allowed us to sort teachers into categories that highlighted the differences between them based on what they reported using in their practice as a result of their PD experience. In particular, we noticed that there seemed to be different 'levels of use' related to the content and pedagogy. For instance, we documented what participants reported using from the LTG PD along with their explanations for using (or not using) specific components. In some cases, teachers reported only implementing some pedagogical practices covered in the PD (such as using tracing paper to teach transformations) whereas other teachers reported using almost all of the math problems and applets provided in the materials. We also discovered that some participants reported adapting the given problems and pedagogical strategies in ways that were aligned with but moved beyond the PD curriculum. From

this inductive process, we generated four categories that appear to fit the patterns of use described by all of the interviewed teachers. For instance, when teachers were using the math problems, applets, and pedagogical strategies were originally put these teachers in a category and labeled it transformative because it appeared they changed their teaching of transformation-based geometry. However, then we realized that not only had some teachers used all of the materials but that they generated some new material. For instance, some teachers modified curriculum to make a static problem dynamic or another used the content of the PD and created applets that were dynamic to support student learning. These teachers became a new category. In the next section, we describe the four categories and provide case examples of teachers who are representative of each category, using illustrative quotes and other relevant information related to their experience of the PD.

FINDINGS

Based on qualitative data analyses conducted to date, we found that participants report using information from the LTG video cases in very different ways depending on their experiences during the PD, their school context, and the mathematics courses they currently teach. We identified four categories of teachers that highlight the different ways they describe incorporating the mathematics content and pedagogical strategies learned from the PD in their practice: Generative Users, Transformative Users, Incremental Users, and Non Users.

Generative users are teachers who reported going beyond the scope of the LTG PD by using the knowledge and skills gained from the workshops to generate new and innovative instructional materials for their classrooms. Generative users described incorporating both their own newly developed instructional materials, along with materials and practices taken from the LTG PD program, in order to engage their students in the types of content and pedagogical experiences they noticed and considered beneficial during the PD. *Transformative users* intentionally brought what they learned about content and pedagogy from the LTG PD into their classrooms, using many of the given materials and observed practices in a substantive way to transform their mathematics instruction; however they did not generate any new instructional materials. *Incremental users* took up some of the materials and/or pedagogical strategies from the PD for use in their own classroom, but not to the degree of the transformative users. Lastly, *Non Users* are participants who did not use either the LTG content-based materials or pedagogical strategies in their classrooms. In the next section, we provide examples of each type of user, highlighting what they noticed and took up from the PD program and how particular elements of the PD appeared to influence their learning.

Generative User Example

Teachers were classified as generative users if they not only applied what they learned from the LTG PD, but used that learning to generate new instructional materials that expanded on critical mathematical and instructional components of the PD. For example, Peter, a high school geometry teacher with a strong math background, was classified as a generative user of the LTG materials because he developed new computer-based materials (applets created using Geogrebra software) for his students, building from his viewing, use, and discussions of similar materials during the PD. Peter was heavily influenced by the PD's emphasis on mathematical transformations in understanding geometric similarity, and he noticed that his own learning was deeply impacted by opportunities to explore technology on this topic (both through representations of practice and

connected activities). Peter explained why he was driven to generate innovative classroom materials based on his PD experience:

> "I am someone who has very strong visual-spatial reasoning. I regularly manipulate shapes and objects in my mind. I know that this is not something that everyone else has. So it was very beneficial to get to see something that would allow everyone to have a common dynamic vision of similarity. Using Geogebra applets during the workshops inspired me to develop my own Geogebra applets and also worksheets so my students can self-guide through some of our investigations."

The LTG PD highlights the importance of a visual, transformations-based approach to teaching and learning about congruence and similarity. As part of many of the post video-viewing experiences during the workshops, teachers had opportunities to explore Geogebra applets that supported their visualization of the dynamic relationships among similar figures. Peter was inspired by these experiences to develop his own Geogebra applets and accompanying classroom materials that went beyond the scope of the LTG PD materials.

Peter also shared that the video clips helped him to notice the range of student understanding around particular concepts, which then prompted a broad change in his teaching practice. Peter explained:

> "The most significant thing about the video clips was the ability to analyze different "levels" of student understanding. I think understanding these different levels has helped me encourage more students to share their thinking. Understanding students' levels of thinking allows us as teachers to compare between partially correct and correct responses in class discussion. It actually would allow us to make rubrics that are explicitly focused on students thinking."

Nicole is an 8th grade teacher who was also classified as a generative user because she not only used the LTG materials in her classroom but she also generated new, related materials to help her students learn the focal geometric concepts. Nicole, reported,

> "I used most of the materials from the PD. For example, I used all of the dilation problems, the rectangle problem, and I used the transparency paper with markers."

Over the course of the LTG PD workshops, Nicole had multiple opportunities to view a variety of representations of practice that highlighted and contrasted different student approaches to solving similarity problems – in particular, transformations-based student approaches and static-based student approaches. The majority of teachers came into the PD with a strong knowledge of static-based approaches and little knowledge of transformation-based approaches. In fact, most teachers were like Nicole in that they had no experience with using dilation as a tool for solving similarity problems. Nicole explained that she was inspired by her experiences in the PD to modify problems from her mathematics curriculum that encouraged static-based approaches so that they would also allow for transformations-based approaches. Nicole noted that she learned a great deal about both approaches during the workshops, and wanted to make sure she was providing her students with numerous opportunities to explore similarity problems using different methods. Therefore, after the PD, Nicole went carefully through her 8th grade curriculum, identified relevant tasks, and adapted them to be sure her students would become sufficiently proficient with transformations-based geometry.

Transformative User Example

Whereas Peter was particularly attentive to the impact that technology could have on teaching and learning similarity and Nicole was struck by the distinction between static and transformations-based approaches, Nancy was very interested in the use of tracing paper. Nancy found herself learning important content during the LTG workshops by watching videos of students using tracing paper to solve geometry problems. She then decided to transform her teaching by bringing this experience to her own classroom. However, unlike Peter and Nicole, Nancy did not report generating new ways to use tracing paper that were different from those she explored during the PD. Nevertheless, Nancy described the use of tracing paper as supporting a significant shift in her students' learning:

> "I used patty [tracing] paper with transformations, which was helpful because students moved them around and we haven't ever done that before. This definitely helped them learn similarity in more conceptual ways."

Using tracing paper as a tool to solve problems and understand transformations-based geometry is an important focus of the LTG PD materials, and one that is highlighted in multiple representations of practice. During those clips, students use tracing paper in unique and (mostly) mathematically accurate ways, which commonly influences the participating teachers to begin exploring how they can bring tracing paper into their own classrooms. Nancy, like many other teachers, became cognizant of the learning opportunities afforded by this tool and encouraged her students to use it, closely following the examples of the videotaped classrooms and the pre- and post-video activities in which she herself used tracing paper. Nancy is considered a transformative user because she incorporated a new tool, spotlighted by the PD, into her classroom instruction focused on transformations-based geometry, in what appears to be a substantive and appropriate manner.

Incremental User Example

Carol, who is currently teaching Algebra II but no geometry classes, is an example of an incremental user. Although Carol did not mention bringing any of the content focused materials from the LTG PD into her classroom, she described changes in her pedagogy that she attributed to her PD experience. Carol explained that she has not yet had the opportunity to utilize her increased content knowledge due to the fact that she is not currently assigned to teach geometry, however she has intentionally incorporated newly learned instructional practices in her algebra classes. Carol told us,

> "I am trying to incorporate some of the teaching methodologies that we observed in the videos from the workshops. For instance, I am having students present and explain their work to the others and making students defend their positions by further questioning them when they are not clear in their responses."

The video clips that Carol and her colleagues viewed, discussed and analyzed over the course of the LTG PD motivated her to reflect on her own practice and to consider aspects that she could improve on, such as student presentations and teacher questioning. In many of these clips, as Carol noticed, students presented their ideas to their classmates in whole and small groups, questioned each other, disagreed with each other's methods or solutions, or defended and clarified their mathematical arguments. These representations of practice helped Carol to recognize new pedagogical

possibilities, and prompted her to incorporate them into all of her math classes regardless of the content focus.

George is another example of an incremental user because he has used some of the content pieces and tasks from the PD in his classes, but in a somewhat sporadic way. George explained,

> "For me, I liked the emphasis on transformations to explain rigid motions. I liked the triangle proofs and how we used dilation strategies to determine similarity. I used these approaches in my classroom this fall and I can see the fruit of my labor. I didn't use all of the problems or content that I learned but I used some and it was great."

It appears George appreciated some of the key mathematical ideas from the summer institute that focused on transformation-based approaches. It is not clear why he only chose to use some specific problems and not others, but this type of response led him to be identified as an incremental user. These users up took portions of the mathematics content or pedagogical strategies that resonated well with them, but did not appear to use the content and/or pedagogy from the PD in a holistic or comprehensive way, nor did they generate new materials or practices based on their PD experiences.

Non User Example

Very few participants reported that they had not brought any of the content materials or pedagogical tools from the LTG PD into their classrooms. However, one high school teacher, Barb, who fell into this category explained her non-use by describing the school-imposed barriers she faced in this regard. Barb noted,

> "I haven't used anything so far. We teach 2-hour daily block periods of math, covering one year of material each semester. It is hard to use stuff from this PD with the rapid pace of our math blocks. The pace is harder for me as a teacher than the students. I have so much to do and I can't change my teaching that quickly."

Barb teaches in a high achieving school, and she expressed concern that incorporating the materials and tools from the LTG PD program would cause her to slow down her instruction too much. Although she recognized the benefits of incorporating a transformations-based approach to the study of geometry, she could not see a way to utilize anything from the PD within her own classroom given her school's demands to cover a large amount of information in a short time frame.

CONCLUSIONS

The LTG PD materials, particularly through the use of representations of practice, provide extensive opportunities for teachers to notice and deeply consider the dynamic relationships among mathematics content, pedagogy, and student thinking. Many teachers in our study reported that seeing effective pedagogical strategies in the video clips helped them to envision how certain pedagogical strategies or mathematics content might play out in their own classroom. At the same time, it is clear that the teachers learned not only from the video, but from the activities that supported viewing and discussion of the clips. As we have noted, LTG video cases incorporate not only video clips but pre- and post-video viewing activities. As such, video cases provide teachers with multiple avenues to stimulate content learning and access pedagogical strategies in ways that are aligned with teachers' prior experiences and unique contexts.

Although video cases in specified PD models like LTG target carefully composed content and pedagogical learning goals, individual teachers may find particular components of the video representations of practice to be personally meaningful and relevant to their own classrooms. Individual differences in teachers' knowledge and beliefs impact what they learn from the LTG PD. Teachers will notice and attend to the events in the videos that they connect to, are puzzled by, or concern them. Taking part in a collaborative learning setting, they gain new insights from their colleagues as they notice and discuss a multitude of topics. Their individual and collective noticing impacts what they learn from their PD experience as well as what they choose to use in their own teaching practice.

We found that the purposefully designed LTG video cases anchored teachers' noticing and insights in particular ways, around a variety of issues related to teaching and learning mathematics. We conjecture that teachers' unique experiences in learning from the LTG PD and the specified representations of practice was likely due to differences in their noticing skills and/or their instructional context including grade level, courses taught, and curriculum requirements. We further hypothesize that this combination of differential noticing and variation in instructional context contributed to teachers' classification as different types of users of the PD materials in their classrooms.

It is clear that representations of practice in video based PD serve as a stimuli for reflection and noticing. However, additional research should be undertaken to explore and disentangle this connection between noticing and uptake from the PD as well as the representations of practice. For instance a detailed examination of what individual teachers attended to and brought up during the workshop discussions and whether those PD experiences are correlated with their classroom use categorizations is needed. In addition, objective analyses based on teachers' observed classroom practices is essential to validating data on their self-reported uptake of information from the PD.

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