ABSTRACT

Title of Dissertation: NOTICING TEACHERS' NOTICING: UNDERSTANDING AND SUPPORTING VIDEO CLUB FACILITATION

Margaret Walton, Doctor of Philosophy, 2023

Dissertation directed by: Associate Professor Janet Walkoe, Department of Teaching and Learning, Policy and Leadership

Facilitators of teacher professional development (PD) play an integral role in teacher learning. Facilitators often both plan and implement PD and it is important that they can make these experiences meaningful learning opportunities for teachers. Researchers have only recently delved more deeply into understanding the knowledge and skills facilitators need for their work, and how to support facilitators to learn such knowledge and skills.

This qualitative three-article dissertation is a design-based research project that explores what facilitators do and how they learn to support teachers in developing a particular instructional skill- noticing student mathematical thinking. Noticing student thinking is how teachers center and build on student ideas in the classroom. I designed a facilitator PD (F-PD) that aimed to help six novice facilitators learn to lead video clubs, a type of teacher PD that has been shown to support teachers in learning to notice. I examined how the novice facilitators learned to lead video clubs and how characteristics of F-PD supported or constrained that learning.

In the first study, “A Facilitator Noticing Framework: How Facilitators Notice Teacher Thinking,” I develop a framework for facilitators’ cognitive process as they support teachers to learn to notice in PD, like video clubs. I argue that, like teachers, facilitators also notice. However, facilitators primarily notice *teacher,* rather than student thinking. I explain the different aspects of teacher thinking that a facilitator might notice. I then use the framework as a lens to understand how three experienced facilitators’ interactions with teachers in video clubs support the teachers to notice student thinking.

Study Two, “Novice Facilitators Learning to Lead Video Clubs: A Framing Perspective” is a close examination of how the participants in my F-PD learned to lead video clubs. The analysis included qualitative coding of the participants’ focus related to leading video clubs during discussions with each other and me as the F-PD leader. The findings indicate that participants’ understanding likely shifted. Early in the F-PD, participants appeared to think of leading video clubs as sustaining any general conversation between teachers. Later in the F-PD, the participants likely understood video club facilitation as paying attention and responding to aspects of teachers’ thinking related to noticing student thinking. The interactions between the participants and me, along with the F-PD design, appeared to contribute to this shift, which is also explained.

In Study Three, “Designing to Support Facilitators to Learn to Notice Teacher Thinking,” I zoom out and look at the F-PD as an overall activity. I identify some of the problems that arose during the F-PD that constrained participants' learning. I explore how I changed the F-PD design in response or, how differences in the F-PD design from early to later session mitigated issues. I offer several design suggestions for future F-PDs, based on my findings.

NOTICING TEACHERS NOTICING: UNDERSTANDING AND SUPPORTING VIDEO CLUB FACILITATION

by

Margaret Gee Walton

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2023

Advisory Committee:
Associate Professor Janet Walkoe Chair
Professor Daniel Chazan
Associate Professor Tamara Clegg, Dean's Representative
Associate Clinical Professor Daniel Levin
Professor Megan Peercy

Dedication

To my siblings, Katie Walton and Michael Walton. I love you very much.

Acknowledgments

I extend a sincere thank you to all the faculty in Center for Mathematics Education at the University of Maryland for accepting me to the program and for supporting me as I made my way through it. I would also like to thank the members of my dissertation committee, Janet Walkoe, Dan Levin, Dan Chazan, Megan Peercy, and Tammy Clegg for their time and valuable insights into my work. A special thanks to Dan Levin for all of his feedback on the second article in this dissertation, it made the work much stronger. An extra, extra special thanks to Janet Walkoe, my advisor. I truly appreciate all the opportunities, mentoring, patience, and encouragement you have given to me over the last five years. It has made me a better teacher educator and researcher.

I would also like to thank my graduate school friends and classmates who supported me by giving feedback on papers, joining Zoom writing sessions, taking coffee breaks, hanging out at conferences… the list goes on. Thank you to Kristyn Lue, Alexis Young, Blake Turner, Courtney Douglass, Frances Henderson, Peter Moon, Kelly Ivy, Willy Viviani, Tarik Buli, Dani Steflitsch, Madi Moin, Monica Anthony, and Matt Griffin.

My family and friends deserve many thanks. Thank you to my parents, stepmom, and grandparents, Linda Somers, Jon Walton, Susan Walton, Sis Walton, Jon Walton Sr., Randy Somers, and Lou Somers. Your love and support throughout my life let me follow the path of my choice. Thank you to my siblings and siblings-in-law, Katie Walton, Greg Embree, Michael Walton, and Sarah Elms. Text messages, facetime calls, and visits with all of you (and Elliot and Colin!) have

helped me balance school and fun. My outside-of-school friends also deserve thanks for their support with school-life balance. I especially want to thank Emily Conrad, Julia Eddy, Emily Malkin, Ariel Trahan, Callie Wright, Anne Kopf, Carly Hanna, Sarah Kurtz McKinnon, Lauren Crichton, and Lauren Cabrera.

Finally, I would like to thank my teachers from the K-12 to university levels for educating me and helping shape me as a person. Special recognition goes to Sandy Tenkel, Karen Sullivan, Mary Fodell, Kate Murray, David Cleveland, Fabio Ghironi, Michael Resler, Sasha Rehm, and Susan Mintz. You all not only taught me in classrooms, but you modeled for me how to be an intentional and dedicated educator. Thank you.

Table of Contents

List of Tables

List of Figures

Introduction

Prior to starting my graduate work, I taught high school math at a public charter school in Washington, D.C. Overall, I believe I was a good teacher. There was evidence that many students learned math based on their grades and standardized test scores, but also based on my observations that a number of students became more confident and joyful mathematicians. I attribute my teaching skills and knowledge to the teacher educators who instructed me during my teacher preparation program.

I do not think about my position as math department chair at my school in the same way. My responsibilities included coaching the other teachers in the department and designing and facilitating department-wide professional development (PD). I struggled in this role. I recall having trouble applying my own teaching expertise to supporting other teachers. I remember feeling very uncertain as I stood in front of my colleagues and led PD sessions. I had little idea if what I planned was productive for other teachers or if my leadership during PD supported their learning.

I really learned how to be a teacher educator when I came to the University of Maryland (UMD) and began working with Janet Walkoe and Terrapin Teachers, which is UMD's secondary math and science teacher preparation program. In my two years of teaching Step One, the first class in the Terrapin Teachers course program, I co-planned with experienced teacher educators, including Sarah Henson-Darko, Anita Sanyal, Steve Karig, and Kayla White. I observed how they thought about what teachers need to know and be able to do, and how they translated that thinking into lesson plans and instruction for pre-service teachers (PSTs).

While working with Janet, I occasionally guest taught or facilitated video clubs in her classes with PSTs. We would often meet after my guest appearances and talk about how the lessons or video clubs went, and how they might be helpful for our research. It was also an opportunity for me to get feedback from Janet and reflect on my practice.

My motivation for this dissertation is that I want to better understand my learning process from my time at UMD and the learning process that other teacher educators experience. This understanding is important because it informs the design of meaningful teacher educator PD (Prediger et al., 2022; Shaughnessy, et al., 2016). I hope that such PD produces knowledgeable and skilled teacher educators, who in turn can support teacher learning.

Within the larger field of teacher educator learning, I narrowed my focus to supporting facilitators of video clubs. Video clubs are a type of teacher PD that can help teachers learn to *notice* or pay attention to, reason about, and respond to student mathematical thinking during instruction (Jacobs et al., 2010; Sherin, 2007; Sherin & Han 2004; Luna & Sherin, 2017; Walkoe, 2015). Teachers in a video club watch a clip of classroom instruction and then, with a facilitator, discuss the student thinking from the video. When teachers notice student thinking, they aim to understand students' ideas and how students built on those ideas from prior knowledge (Empson & Jacobs, 2008; Levin & Walkoe, 2022). Teachers also work to incorporate those ideas into their instruction. Students, as a result, often have a deeper understanding of the content and receive a wider range of learning opportunities (Carpenter et al., 1989; Jacobs et al., 2007; Robertson et al., 2016). When a teacher engages with

student mathematical ideas it also demonstrates to students that their ideas are valuable. In sum, teacher noticing is an integral part of instruction. It is important to have teacher PD, like video clubs, led by well-prepared facilitators to help teachers learn to notice. My goal in this dissertation is to support those facilitators.

I plan for this dissertation to be a springboard for me to continue to design learning experiences for teacher educators that helps them teach teachers. I want to do what I can to support the department chairs, math coaches, PST instructors, and other teacher leaders of the world because good PD for teachers often depends on them.

Overview of the Studies

This dissertation examines how facilitators of video clubs think about their work, how novice facilitators learn to lead video clubs, and the types of activities and tools that can support that learning. The project is a designed-based research (DBR) project (Cobb, 2003; Gravemeijer & Cobb, 2013; Plomp & Nieveen, 2013). I designed a facilitator professional development (F-PD) to support the novice facilitators, who I call facilitator participants (FPs), to learn to lead video clubs. My purpose is to understand how FPs' learning about video club facilitation develops, but also how the F-PD contributes or does not contribute to that learning. An important characteristic of DBR is that it works in cycles. Once a researcher has designed and implemented an intervention, they study the relationship between participants' learning and the components of the intervention (Gravemeijer & Cobb, 2013). They then change the intervention as needed. For me, this dissertation is the first cycle of this work. I plan to refine and implement a new F-PD design in the future.

The first study, "A Facilitator Noticing Framework: How Facilitators Notice Teacher Thinking," is theoretical. I aim to understand video club facilitators' process as they lead teachers in discussion. This understanding is important because, in order to support novice facilitators to learn to lead video clubs, it is necessary to know how experienced facilitators think about their work. Three questions guided my analysis: *(1) What and how do video club facilitators notice?*, *(2) How does facilitator noticing compare to teacher noticing?*, and *(3) How does a facilitator's noticing contribute to their interactions with teachers during video clubs?* I assert that, like teachers noticing student thinking, facilitators also notice, but they notice *teacher thinking.* I build on prior literature to develop the Facilitator Noticing Framework (FNF), which details the aspects of teacher thinking on which facilitators focus as they lead teachers. I then demonstrate how the framework can be helpful by using it as a lens to understand how three expert video club facilitators support teachers to learn to notice as they lead video clubs.

The second study, entitled "Novice Facilitators Learning to Lead Video Clubs: A Framing Perspective," is co-authored with Janet Walkoe. We shift away from examining expert facilitators to look at novices. We investigate the learning of six FPs who participated in the F-PD. The FNF from the first study guides much of this work. We argue that, in order for novice facilitators to learn to lead video clubs, they need to learn to notice teacher thinking, as outlined in the FNF.

In addition, we take a framing perspective of learning. Framing is a way to think about human cognition and is often referred to as one's understanding of "what is it that's going on here?" (Goffman, 1974, p.8) in a situation. We look for how the

FPs' framing evolves over the F-PD and take that as evidence of their learning. Our main research question is: *In what ways (if any) does novice video club facilitators' understanding of leading video clubs develop as they participate in the F-PD?* We also have a sub-question: *In what ways (if any) does participants' framing of leading video clubs shift over time?* We perform a qualitative analysis of the F-PD discussions to determine how the FPs likely framed leading a video club at different points in the F-PD. We find that the FPs shifted from framing leading video clubs as working to sustain a general conversation with teachers to, by the end of the F-PD, more consistently framing leading video clubs as noticing teachers' thinking. We discuss the mechanisms that we argue contribute to those framings, particularly in terms of the novice facilitators' interactions with each other and me as the leader of the F-PD, and in terms of the activities of the F-PD.

The third study, "Designing to Support Facilitators to Learn to Notice Teacher Thinking," takes a broader look at the relationships between different components of the F-PD. This study differs from Study 2 because it focuses less on the details of novice facilitators' learning process and more on how the tasks and tools in the F-PD supported or constrained that process. My research question is: *How do tasks and tools in an F-PD support novice facilitators to learn to lead video clubs, if at all?* There is also a sub-question: *How do the F-PD tasks and tools contribute to novice facilitators' focus related to different aspects of facilitation?*

I use activity theory as an analytic framework in this study (Engeström, 1987, 1999). Activity theory has its roots in cultural historical theories of cognition (Vygotsky, 1978; Leontiev, 1974) and offered me a way to map out the different

components of the F-PD. Through this analysis, I identify tensions between some of the design choices I made and the other characteristics of the F-PD, like the goals and the participants (Yamagata-Lynch, 2007). I explain how I resolved these issues with changes that I made to the F-PD or by differences in the tasks and tools between earlier and later sessions. I find that when the tasks and tools of the F-PD specifically focused on teachers and their thinking, the FPs more consistently addressed aspects of teachers' noticing of student thinking. At the end of the article, I offer design implications and discuss how my findings can impact future work in F-PD design.

I conclude the dissertation with a discussion of the three studies' contributions to facilitator learning and PD. I also detail directions for future research.

References

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C.-P., & Loef, M. (1989). Using knowledge of children's mathematics thinking in classroom teaching: An experimental study. *American Educational Research Journal*, *26*(4), 499–531.

Cobb, P., Confrey, J., Disessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, *32*(1), 9–13. https://doi.org/10.3102/0013189X032001009

Empson, S. B., & Jacobs, V. R. (2008). Learning to listen to children's mathematics. In D. Tirosh & T. Wood (Eds.), *International Handbook of Mathematics Teacher Education: Volume 2* (pp. 257–281). Sense Publishers. https://doi.org/10.4324/9780203392621-11

Engeström, Y. (1987). *Learning by Expanding*. Orienta-Konsultit.

Engestrom, Y. (1999). Activity theory and individual and social transformation. In *Perspectives on Activity Thoery* (pp. 19–38).

Gravemeijer, K., & Cobb, P. (2013). Design research from the learning design perspective: Part A. *Educational Design Research*, *2006*, 72–113. http://international.slo.nl/publications/edr/

Jacobs, V. R., Franke, M. L., Carpenter, T. P., Levi, L., & Battey, D. (2007). Professional development focused on children's algebraic reasoning in elementary school. *Journal for Research in Mathematics Education*, *38*(3), 258–288.

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.

Levin, M., & Walkoe, J. (2022). Seeds of algebraic thinking: a Knowledge in Pieces perspective on the development of algebraic thinking. *ZDM - Mathematics Education*, *54*(6), 1303–1314. https://doi.org/10.1007/s11858-022-01374-2

Luna, M. J., & Sherin, M. G. (2017). Using a video club design to promote teacher attention to students' ideas in science. *Teaching and Teacher Education*, *66*, 282–294. https://doi.org/10.1016/j.tate.2017.04.019

Plomp, T., & Nieveen, N. (2013). Educational design research: An introduction. In T. Plomp & N. Nieveen (Eds.), *Educational Design Research: An Introduction* (pp. 11–50). slo.

Prediger, S., Roesken-Winter, B., Stahnke, R., & Pöhler, B. (2022). Conceptualizing content-related PD facilitator expertise. *Journal of Mathematics Teacher Education*, *25*(4), 403–428. https://doi.org/10.1007/s10857-021-09497-1

Robertson, A., Atkins, L., Levin, D., & Richards, J. (2016). What is responsive teaching? In A. Robertson, R. Scherr, & D. Hammer (Eds.), *Responsive Teaching in Science and Mathematics* (pp. 1–31). Routledge.

Shaughnessy, M., Garcia, N., Selling, S. K., & Ball, D. L. (2016). What knowledge and skill do mathematics teacher educators need and (how) can we support its development? *Proceedings of the 38th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, 813–820.

Sherin, M.G, (2007). The develop of teachers' professional vision in video clubs. In Goldman, R., Pea, R., Barron, B., Derry, S.J. (Eds.), *Video research in the learning sciences* (pp 383-395). Mahwah, NJ: Lawrence Earlbaum Associates.

Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, *20*(2), 163–183. https://doi.org/10.1016/j.tate.2003.08.001

Vygotsky, L. (1978). *Mind in Society The Development of Higher Psychological Processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press. https://doi.org/10.2307/3726822

Walkoe, J. (2015). Exploring teacher noticing of student algebraic thinking in a video club. *Journal of Mathematics Teacher Education*, *18*(6), 523–550. https://doi.org/10.1007/s10857-014-9289-0

Yamagata-Lynch, L. C. (2007). Confronting analytical dilemmas for understanding complex human interactions in design-based research from a Cultural - Historical Activity Theory (CHAT) framework. *Journal of the Learning Sciences*, *16*(4), 451–484. https://doi.org/10.1080/10508400701524777

A Facilitator Noticing Framework: How Facilitators Notice Teacher Thinking

Introduction

Research in math education has shown that it is important for teachers to center students' mathematical ideas in the classroom. (Carpenter et al., 1989; Empson & Jacobs, 2008; Fennema et al., 1996; Jacobs et al., 2007; Robertson et al., 2016). This process is often called noticing and it is how teachers attend to, interpret, and respond to student mathematical thinking (Jacobs, et al., 2010; Sherin & van Es, 2009). Teachers often need to learn to notice, and professional development (PD), like video clubs, can support teachers to do so (e.g., Sherin & Han, 2004; Sherin & van Es, 2005; Walkoe, 2015). However, such learning opportunities can only be effective if they have competent teacher educators (who I call facilitators) to lead them (Beisiegel et al., 2018; Borko et al., 2011).

A number of researchers have detailed the types of discussion moves that facilitators take during video-based PD that can support teacher learning (Borko, Jacobs, et al., 2014; Kang & van Es, 2019; Tekkumru-Kisa & Stein, 2017; van es et al., 2014). While this work examines productive facilitator actions, it would also be helpful to know facilitators' process that culminates in such actions. In other words, during video-based PD, how do facilitators know how to respond to teachers in ways that support teachers' ability to learn new skills, like noticing student thinking?

This question is especially important for the development of novice facilitators. Novice facilitators could be teachers who have taken a leadership role in their school, school administrators, researchers, graduate students, among others (Park Rogers et al., 2021). It is often assumed that these types of facilitators have

prior experiences that make them prepared to support teachers, but some researchers have argued that these facilitators need better learning opportunities for leading teacher PD (Borko et al., 2011; Elliot et al., 2009).

I examine video club facilitators' process from a noticing perspective. Like teachers, video club facilitators also need to notice, but they notice *teacher,* rather than student, thinking. In this study, I begin to explore how facilitators notice. I introduce the Facilitator Noticing Framework (FNF) to understand what facilitators notice and how it is different from what teachers notice. I then use the framework as a lens to compare how and what three video club facilitators might notice as they lead teachers through discussions about student thinking.

Background

Teacher Noticing of Student Thinking

At any given moment, classrooms are complex spaces where a variety of events and interactions take place. A large body of research suggests that teachers need to be able to filter this complexity to pay attention to, or *notice*, important moments of student mathematical thinking (e.g., Carpenter et al.,1989; Empson & Jacobs, 2008; Jacobs et al., 2007; Roberston et al., 2016). When teachers focus on student ideas, students can get a better conceptual understanding of the content and can participate in a wider range of learning opportunities. Students also often engage in more authentic disciplinary practices (Roberston et al., 2016).

Teacher noticing has been discussed in different ways, but most definitions include an *attending* and *interpreting* component (Jacobs et al., 2010; van Es & Sherin, 2002; Sherin, 2007; Sherin & van Es, 2009). Sherin (2007) wrote about

attending in terms of teachers' *selective attention* (SA), or the idea that teachers focus on some classroom activities more than others. For example, at any given moment a teacher might concentrate on students' interest in the content, how students talk with each other, or whether students are on task. Amid all this activity, it is essential that teachers can identify and remain engaged with important moments of student mathematical thinking. As teachers develop their SA, they should closely look at student thinking to gain sufficient information to reason about it. That is, teachers should not only focus on students, but be able to sufficiently describe the circumstances and content of student actions or speech to be able to make sense of students' mathematical understanding.

Interpreting is the way that teachers reason about student ideas. Teachers interpret student thinking using what Sherin (2007) called *knowledge-based reasoning* (KBR). When teachers employ their KBR, they call on their knowledge of mathematics, teaching, and students. As teachers make sense of student thinking, it is crucial that they work to understand, rather than only describe student ideas, or evaluate them for correctness. As teachers improve their KBR, they should connect what students say and do to broader concepts of mathematical learning and teaching (van Es, 2011).

Jacobs and colleagues (2010) added a third component, *deciding how to respond*, to their noticing definition. According to Jacobs and colleagues, once teachers have interpreted a moment of student thinking they should formulate a response based on that understanding. That response might be, for example, asking a

student to expand on their idea, asking the class a question, or pointing out a connection between different types of student thinking.

Video Clubs

Many teachers need to learn to notice and video clubs can support teachers to do so. (Sherin & Han, 2004; van Es, 2011). A video club is a meeting of a small group of teachers who watch short video clips of classroom interactions. A facilitator often then leads the teachers in discussing interesting instances of student thinking from the clip. Video clubs and other video-based PD can improve teachers' SA, KBR, and response decisions (Sherin, 2007; Sherin & van Es, 2009; Jacobs et al., 2010; Walkoe, 2015). In terms of SA, teachers who participate in video clubs often shift their focus from different details of the classroom, like teacher actions or student behavior, to the content of student thinking. In terms of knowledge-based reasoning, video clubs have also helped teachers formulate deeper analyses of student ideas. Teachers in early video club meetings often simply describe student actions in the video clip. However, after several video clubs, many teachers move beyond description and work to understand student actions in relation to their mathematical understanding, or to more general concepts in teaching and learning. Fewer video club studies examine if and how teachers improve in deciding how to respond to student thinking (Santagata et al., 2021), though González (2018) found that video clubs can help teachers determine instructional moves that elicit students' prior knowledge. These noticing gains during video clubs are likely in part due to the facilitator, particularly facilitator actions during the discussions (Castro Superfine et al., 2019).

Facilitators and Video-Based PD

Facilitators come from a range of backgrounds and in the past have included teachers who take a leadership role at their school, school district instructional personnel, university researchers, or education graduate students (Borko et al., 2021; Goldsmith & Seago, 2008; Lesseig et al., 2017 Luna & Sherin, 2017; Schwarts et al., 2021; Walkoe, 2015; Walton & Walkoe, in press). Video club facilitators are often tasked with setting learning goals for teachers, choosing video, and leading the post-video discussion, which is the focus of this article (Borko, Jacobs et al., 2014; Cole, 2013; Tekkumru-Kisa & Stein, 2017; van Es, et al., 2014; van Es et al., 2020).

A number of researchers have argued that facilitator actions during teacher discussions matter for supporting teachers in learning to center student thinking (Amador, 2021; Borko, Jacobs et al., 2014; Castro Superfine et al., 2019; van Es et al., 2014). Some of these researchers have explored the types of facilitator practices and talk moves that can lead to productive discussions about classroom video. For example, van Es and colleagues (2014) developed a framework that describes moves like *highlighting* (pointing teachers to interesting moments in a video), *lifting up* (taking up a teacher idea and posing it to the rest of the group), and *pressing* (pushing teachers to explain or expand on their ideas) as actions that support teachers to take an inquiry stance while analyzing classroom video. Castro Superfine and colleagues (2019) found that facilitators who employ actions from van Es and colleagues' framework can support teachers in learning to notice, though they often have to use the moves in sequence with one another.

Other studies have found that teacher practices that support student learning can be applied to leading teachers in video-based discussions (Elliot et al., 2009; Lesseig et al., 2017 Tekkumru-Kisa, Stein, 2017). Some of these studies applied the *Five Practices for Orchestrating Productive Mathematics Discussions with Students* (Stein et al., 2008) to leading discussions with teachers. For example, Tekkumru-Kisa & Stein (2017) found that in video-based PD discussions with high school science teachers facilitators *monitored*, or kept track of teacher ideas, and *selected* teacher comments to share with the group. According to the authors, these actions supported the teachers to notice student thinking.

The Need for a Closer Look at Facilitation

The studies above are helpful to understand the types of actions that facilitators should take to support teacher learning in PD. Yet, these studies do not explore how these facilitators *knew when to take such actions* when working with teachers to help teachers, for example, learn to notice. Understanding why facilitators act in certain ways is particularly important for supporting novice facilitators. Video-based PD has expanded throughout the U.S. (Borko et al., 2011; Gaudin & Chaliès, 2015; Marrongelle et al., 2013), meaning there is a need for facilitators. Consequently, more novice facilitators likely have entered and will enter this space. Novice facilitators can have difficulty leading productive video-based discussions that push teachers to explain their ideas about student thinking and build on one another's thinking (Borko, Koellner et al., 2014; Elliot et al., 2009; Jackson et al., 2015). Borko, Koellner, and colleagues (2014) suggested that part of novices' difficulties might be because they need to have "ideas about particular events in the

video clips that are important to discuss and then listen carefully so they can build on teachers' comments in ways that enable them to explore these events" (p. 164). Said differently, much like teachers need to have ideas about math content and carefully listen to understand, or *notice student thinking*, facilitators need to have ideas about student-teacher interactions and need to carefully listen to understand or *notice teacher thinking*. However, supporting novice facilitators to notice teacher thinking first requires understanding what facilitator noticing entails.

In this study, begin to explore how video club facilitators notice teacher thinking. The framework I develop focuses on *what* facilitators notice as teachers discuss student thinking. I then use that framework as a lens to understand how three different facilitators interact with teachers during video clubs. My research questions are:

- What and how do video club facilitators notice?
- How does facilitator noticing compare to teacher noticing?
- How does a facilitator's noticing contribute to their interactions with teachers during video clubs?

A Framework for Facilitator Noticing

Comparing Teacher and Facilitator Noticing

I developed the Framework for Facilitator Noticing (FNF) by building on research that examines the work of teacher educators and starts to explore how facilitators of video-based PD notice. This work shows some of the parallels between teacher and facilitator noticing. However, it also highlights the distinctions between teacher and facilitator noticing and why researchers need to think about facilitator

noticing differently, particularly if they intend to teach novice facilitators how to notice.

Research related to facilitator noticing emphasizes it is important that facilitators listen to what teachers say as they discuss student thinking, to support important teacher ideas in relation to teacher learning goals, and to give teachers opportunities to build on each other's thinking (Borko, Koellner et al., 2014; Goldsmith & Seago, 2008; Lesseig et al., 2017; van Es, 2010). These findings align with research about teachers' instruction, namely that teachers listening to and building on student ideas promotes learning (Carpenter et al., 1989; Fennema et al., 1996; Empson & Jacobs, 2008). Based on this alignment, I posit that the *process* of facilitator noticing is the same as teacher noticing. That is, facilitators also attend to, interpret, and respond to ideas, though they are teacher, rather than student, ideas.

To understand facilitators' noticing of teacher ideas, it is important to understand how the work of teacher educators is different from the work of teachers. There is a growing body of research that examines the knowledge, skills, and practices that teacher educators need (Castro Superfine & Li; 2014; Prediger et al., 2022; Shaughnessy et al., 2016). This collection highlights the layered nature of teacher educator skills and knowledge. Teacher educators need to understand the work of teaching. They also need to know the best ways of presenting the work of teaching to teachers. Shaughnessy and colleagues (2016) explained this idea by showing interactions between teachers, students, and K-12 content are embedded in teacher educators' instruction with teachers. Consequently, teacher educators need to have knowledge, skills, and practices *that support teaching teachers and that support*

teaching students. Given that facilitator noticing is a specific teacher educator practice, facilitators must keep both teachers and students in mind.

Teachers notice to understand student thinking and improve student mathematics learning (Empson & Jacobs, 2008; Robertson et al., 2016). The goals for facilitator noticing have not been as well documented, though earlier research suggests that some of the goals include improving teachers' specialized content knowledge (SCK) and pedagogical content knowledge (PCK) (Borko, Koellner et al., 2014; Elliott et al., 2009; Kazemi et al., 2011; Lesseig et al., 2017; Prediger et al., 2022; Ball et al., 2008; Shulman, 1986). For example, during a video club a facilitator might attend to the different ways that teachers think about a math problem in hopes of helping teachers see these differences, which they then might be able to use during instruction. This facilitation action might support teachers' SCK. In a different instance, a facilitator might recognize when a teacher brings up a pivotal moment of student thinking. The facilitator might push the teacher to expand on their explanation of the student idea, which could support components of the teacher's PCK, like their knowledge of content and students (Ball et al., 2008). Thus, for a facilitator, student learning is not the direct goal. Instead, facilitators' noticing goals focus on supporting teachers to reason about how to support student learning.

Based on this early work, facilitator and teacher noticing are similar in process, but facilitators' noticing expertise must extend beyond that of teachers. This relationship is similar to the relationship between teachers' and students' expertise. For instance, teachers must have a more multifaceted mathematical knowledge base to successfully instruct students. (Ball et al., 2008). On the facilitator level,

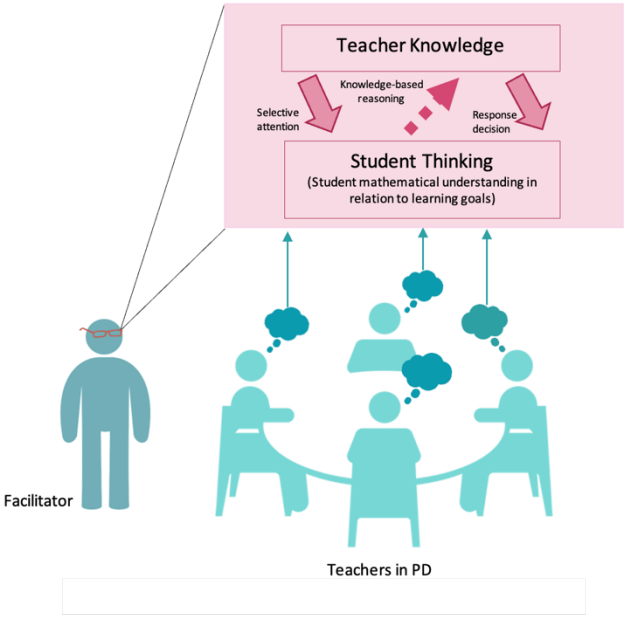
facilitators need a more multifaceted understanding of noticing, which includes accounting for teacher thinking *and* student thinking. The FNF, explained in the next section, addresses this issue.

The Facilitator Noticing Framework

The framework I present in Figure 1 shows *what* facilitators might notice during a teacher video club discussion. As stated above, I argue that the process for facilitator noticing is the same as teacher noticing (i.e., attend to, interpret, and decide to respond to). However, the facilitator in Figure 1 (the figure in the glasses) notices different aspects of teachers' noticing, or what I call teachers' (the seated figures') *noticing process* (the pink box). Teachers' noticing process includes different aspects of the interactions between teachers' knowledge and student thinking. A facilitator looks for (hence, the glasses), makes sense of, and decides to respond to these different aspects, particularly SA, KBR, and teachers' response decisions.

Figure 1

Facilitator Noticing Framework



It is important to zoom in on the pink box– the interaction between teachers' knowledge (TK) and student thinking– to fully understand the components of teachers' noticing process that a facilitator could notice. For the first arrow, labeled SA, teachers work to develop their SA by using their knowledge (which could include their knowledge of mathematics, students, pedagogy, etc.) to identify important moments of student thinking (Sherin, 2007). For example, a teacher might be drawn to the way a student solves a problem because they use an uncommon solution path. In a different instance, a teacher might be curious about a particular student's comment during a discussion and might wonder why they said it. In both examples, the teachers likely use combinations of several types of knowledge, like knowledge of

particular students, knowledge of mathematics, knowledge of pedagogy, etc. to home in on the student thinking.

A facilitator might notice this component of teachers' noticing process for several reasons. If teachers in a video club focus on other aspects of the classroom (e.g., issues of classroom management, how the teacher in the video explains an idea, etc.) the facilitator might try to shift teachers' SA by pointing out student ideas in the video or by asking teachers to identify and better describe moments of student thinking. In addition, a facilitator might also try to broaden teachers' SA in different ways. Teachers of different identities, including race, gender, sexual orientation, and others, are likely to have different types of experiences, which contribute to their teaching knowledge. Consequently, different teachers likely attend to different student ideas. A facilitator can notice the diversity in teachers' SA and ask different teachers to explain their observations to the group, which might expand all teachers' ideas about what productive student thinking looks like.

The second arrow, labeled KBR*,* is dashed because teachers are in a different state at this stage in their noticing process. Rather than acting on student thinking, which occurs with the first and third arrows, the second arrow depicts a state of analysis. As teachers attend to student thinking in terms of what a student says, does, writes, etc., they receive information about student ideas. Teachers then use their KBR to interpret those ideas in terms of students' mathematical understanding, which requires that they employ their teacher knowledge. To continue with an example from above, if a teacher recognizes that a student used an uncommon solution path for a problem, they might connect it back to other solution strategies. In this case, the

teacher might use their knowledge of mathematics, curriculum, pedagogy, etc. to see mathematical relationships. In a different example, a teacher could attend to a student's error and work to understand the student's reasoning behind the error. Here, the teacher might use their knowledge of math and the particular student to interpret to understand how the student thought about the problem.

During a video club, a facilitator might notice opportunities for teachers to better develop their KBR. There could be moments during a video club when teachers attend to student thinking, but simply describe what students say or do, rather than reasoning more deeply about how student thinking relates to mathematical learning (Sherin, 2007; van Es, 2011). A facilitator could notice the teachers' more superficial thinking and push them to connect the student actions to the math at hand. In this instance, the facilitator would focus on teachers' KBR and ask them to take the student ideas they have identified and use their teacher knowledge to make sense of them in terms of mathematical thinking and learning.

The final arrow in the pink box refers to how a teacher decides to respond to student thinking. Once a teacher makes sense of a student idea using their KBR, they determine how to respond to that idea. For the uncommon solution path example above, a teacher might decide to start a full class discussion centered on the unique solution. The teacher might ask questions that help students to see the connection between the one student's more unique solution and solutions from other students.

A video club facilitator might support teachers' response decisions by asking teachers to consider what they would do after making sense of a student idea in the video. For example, a facilitator could ask teachers what questions they might ask the

student, whether they would start a full class discussion, or how they might clarify the student's idea.

To summarize, like teachers, facilitators engage in the same process to notice, but *what* facilitators notice goes beyond what teachers notice. Teachers primarily notice student thinking, but facilitators must notice more. Facilitators notice interactions between TK and student thinking, which makes teachers' SA, KBR, and response decisions facilitators' primary focus. Finally, it is also notable that student thinking is embedded in teachers' disciplinary content. Thus, it is something that facilitators consider *in service to supporting teachers to notice.*

A New Lens for Video Club Facilitation

I now turn to demonstrating how this framework might be applied to video club facilitation. I describe instances of facilitator noticing in video clubs with three different experienced facilitators from two different projects. I compare the actions of the three facilitators to infer the different teacher thinking the facilitators might notice and how their actions support teachers to develop different components of their noticing process.

Context and Participants

The video club data is of three video clubs from two studies. Video Club 1 (VC1) and Video Club 2 (VC2) come from a study with in-service secondary mathematics teachers during a summer PD. Facilitator 1 in VC1 is a university researcher whose research primarily lies in video clubs and noticing teacher thinking. Facilitator 2 in VC 2 is a veteran high school teacher.

Video Club 3 (VC3) came from a different study that consisted of six video clubs led by one facilitator. The facilitator is a graduate student with experience in leading and participating in video clubs. The study included seven participants (five men and two women) who were pre-service teachers (PSTs) in a year-long accelerated teacher certification program at a mid-sized university in the midwestern United States. The purpose of the study was to expand teachers' ideas about algebraic thinking and to help teachers notice a wider range of student algebraic thinking (Walkoe, 2015). The facilitator developed an algebraic thinking framework and gave it to the PSTs as a tool to help observe and reason about student algebraic thinking as they participated in the video clubs.

Description of the Video Club Classroom Videos

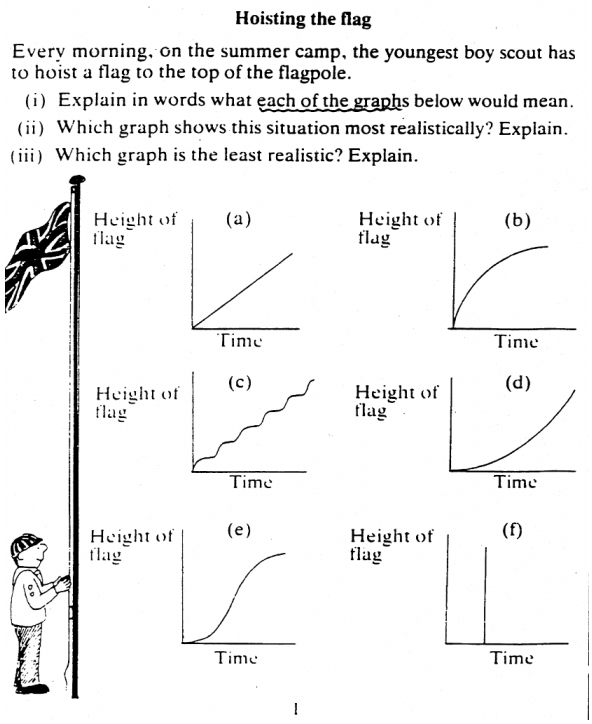
Below are descriptions of the videos from the three video clubs. Table 1 summarizes the key information in each video.

VC1 Summary

The video in VC1 took place in a 6th grade classroom. Students discussed the task below (Figure 2) (Shell Center for Math Education, 1985). One interval of the video showed students talking about various ways to make graph F a possibility. One student, Sal, talked about using a large flag that was the length of the pole. Another student, Billy, said F might be possible if a person jumped from the top of the pole with the flag rope in their hand so that the flag rose very quickly. Several students countered Billy and said jumping would still take time so the graph would not be vertical.

Figure 2

VC1 Task



Note: Used with permission. Original figure at https://www.mathshell.com.

VC2 Summary

The classroom video for this VC2 showed a high school geometry class discussing why when the perimeter of a polygon increases by a factor of n, the area increases by a factor of n^2. Three students in the video had different reasoning and ways of representing their explanations. One of the students, Jasper, seemed to think about the problem algebraically and in terms of the area formula for a square. Jasper spoke and used gestures to express his thinking. The other two students, Rushdee, and Cameron, seemed to take a more geometric approach and thought about how the area of a square expands as the sides expand. Rushdee demonstrated this idea using gestures and a calculator. He used his arm and a calculator to explain what a square

would look like when the sides doubled. Cameron went to the chalkboard and drew a similar scenario, showing how the area of a square would get four times as large.

VC3 Summary

The video from VC3 showed students in an Algebra class discussing the difference between the slopes of horizontal and vertical lines. At one point a student, Peter, said that the slope of the graph y=¾ is 0 because the graph is a horizontal line that never moves up in the y-direction on the graph. Later, Peter said the slope of $x = 0$ is also zero. He invoked the slope formula to support his claim but talked about it as $m = \frac{x_2 - x_1}{y_2 - y_1}$ instead of $m = \frac{y_2 - y_1}{x_2 - x_1}$. A different student, Andrew, thought that the slope of a vertical line is zero because the line does not move over in the x-direction on the graph.

Table 1

Summary of Video Club Videos

Video Club	Task	Focal Students	Description of Video Moments
VC1	Which graph most accurately depicts raising a flag?	Sal Billy	● Sal said that Graph F in the task might work if the flag was the length of the entire pole. ● Billy said Graph F might work if a person jumped from the top of the pole holding the rope for the flag. Several students disagreed saying jumping would still take time.
VC2	Why does the area of a polygon increase by a factor of n^2 when the perimeter increases by a factor of n?	Jasper Rushdee Cameron	● Jasper explained the task in terms of the area formula for a square. ● Rushdee used his arm and a calculator to show how a square would expand when one doubled the sides. ● Cameron drew a square on the chalkboard and then expanded its sides.
VC3	What is the slope of a horizontal line and why? What is the slope of a vertical line and why?	Peter Andrew	● Peter said the slope of $y = \frac{3}{4}$ is 0 because the graph never moves up. ● Peter said the slope of $x = 0$ is zero by plugging in points to $m = \frac{x_2 - x_1}{y_2 - y_1}$. ● Andrew said the slope of $x = 0$ is zero because the graph never moves horizontally.

Analysis

I looked for evidence of facilitators noticing teacher thinking by examining the three facilitators' actions, and how their actions seemed to support different aspects of teachers' noticing process. This is a high-inference analysis. I did not, for example, interview the facilitators, which might result in data more directly connected to the facilitators' thinking. However, I argue it is reasonable to conclude that individuals' actions give some insight into the thinking that culminated in those actions.

I first viewed each of the three video club recordings using the video annotation platform Anotemos (www.anotemos.com) (Herbst et al., 2019). Anotemos allows users to mark and comment at specific timestamps, which can be revisited later. I annotated the video with a set of deductive codes that I derived from the FNF. I annotated a moment of the video with one of the codes when I thought a facilitator acted to support an aspect of teachers' noticing process. My deductive codes included *Teacher Knowledge (TK), Selective Attention (SA), Knowledge Based Reasoning (KBR),* and *Response Decision (RD).*

I then reviewed my codes using both the video recordings and transcripts of each video club and looked for patterns in *how* the facilitators supported aspects of teachers' noticing process. For example, I investigated whether facilitators prioritized one aspect over another. I also looked at whether facilitators supported multiple aspects simultaneously. For each video club, I wrote analytic memos about the patterns I found and supported the patterns with examples from the video clubs.

Findings

I highlight three patterns of facilitator actions during the video clubs that I argue indicate facilitators' noticing of different aspects of teachers' noticing process. I organize this section by discussing each video club separately and providing an example of one of the primary patterns of action each facilitator used. It is notable that there was overlap and differences between the facilitators' actions. However, the purpose of this article is to demonstrate that the FNF can be used to understand how and what video club facilitators notice. Comparing facilitators' approaches to leading video clubs or the frequency at which they noticed in one way over another is beyond the scope of this article.

VC 1: Teachers Pick the Moments, Facilitator Supports SA and KBR

One pattern of action that I observed was when facilitators allowed teachers to select moments from the video to discuss, but then asked the teachers to give a detailed description of what happened in that moment and to reason about the student thinking in that moment more deeply. During these interactions, the facilitators seemed to notice and support teachers' SA and KBR. Facilitator 1 in VC1 often noticed in this way.

For example, Facilitator 1 opened the VC1 conversation by asking, "Um, so um, so what do you think about the, what the kids are saying about the graphs? About their ideas?" The following conversation took place:

> **Joe:** Um, I was impressed with the uh, the one kid who said the giant flag, that the top and the bottom would be the length of the pole basically.
>
> **Facilitator 1:** Okay.

Joe: So that would give F an option, which we ruled out. But.

Facilitator 1: So who is it, who is it that says that? [Teachers start flipping through their transcripts].

Joe: Um. Uh, he, he, he had a hard time describing it, and then they, he went around and had other kids describe it.

Mateo: I think Sal.

Facilitator 1: Is it Sal?

Mateo: I think Sal was the one.

Joe: Sal, yeah...

Mateo: Sal yeah. It's on the first page, "It's possible if you have a really long flag."

The conversation began with Facilitator 1 asking an open-ended question, which allowed the teachers to select an instance of student thinking to discuss. Joe chose the moment when Sal talked about the possibility of a flag that was as long as the flagpole. Joe took an evaluative, approving stance ("I was impressed") toward Sal's idea. Facilitator 1 responded by asking which student had the large flag idea. At this point, the facilitator seemed to be noticing teachers' SA. It seemed that Facilitator 1 noticed that Joe picked a moment of student thinking but did not talk about the moment with enough detail to ultimately understand it. The facilitator responded by prompting teachers to take a closer look at the transcript.

A few turns of talk later, Facilitator 1 appeared to continue to support teachers' SA by prompting them to better describe moments of student thinking in the video. Christina started by saying:

Christina: Yeah I thought that was interesting that… [the students] thought of a way to kind of make F work. I mean I don't, if they're trying to discuss what the most realistic one is, then that's basically not it. But I thought that was pretty interesting that they thought of a way for that one to even be a possibility.

Facilitator 1: So, what's their idea about, right now?

Christina: I thought it was that, I thought one of the students pointed out that basically F wouldn't apply, that [the flag] would have to be, like, instantaneously from top to bottom. Um, and then the one student said, "Well if it was a large enough flag that was touching the top and the bottom at the same time, that would work." That's what my understanding was.

Facilitator 1 asked Christina to better describe the student idea, which prompted her to explain the idea in more detail. The facilitator might have asked Christina for a more detailed description because she knew that if Christina better attended to the idea it would help her interpret and ultimately respond to it. However, at this point Sara changed the focus of the conversation to another idea in the video about jumping from the top of the flagpole:

Sara: You have the idea of jumping from the top of the flagpole is interesting as well. That would make it very steep.

Christina: Yeah.

Sara: Anyways.

Mateo: Right.

Sara: And I just thought they were very creative.

After several other participants agreed and responded to Sara, Facilitator 1 intervened:

Facilitator 1: So, so, this boy has this idea, so you're saying that he's going to stand on top of the flagpole, and jump off and you said it would be really steep then?

Sara: The line.

Facilitator 1: The line. Why, why would it be really steep then?

Sara: Well depending on the units of the, I mean, it depends on how you space out.

Facilitator 1: Sure, sure.

Sara: I mean if this is hours, or something like that. You know. Yeah. [Inaudible]

Lydia: So [the other students in the class] realized it wouldn't just be a vertical line though.

Sara: Yeah.

Mateo: Yeah, yeah.

Facilitator 1: So, you think that's what they're saying when they're responding. Let's look at [the transcript].

Like the other teachers, Sara picked a moment to discuss. Sara was initially evaluative of Billy's idea ("I just thought they were very creative"). Several other teachers agreed with Sara, and then Facilitator 1 clarified the student's idea for the group. Facilitator 1 asked why the graph would be really steep. Facilitator 1 might have acted this way because she noticed that teachers were evaluating, rather than

inquiring about, student thinking. Facilitator 1's question about the steepness of the graph may have been to support teachers' KBR and get the teachers to reason about why students thought graph F was mathematically possible. Indeed, the teachers began to build on each other's thinking. Sara said the steepness of the graph would depend on the unit of time on the x-axis. That comment was followed by Lydia's, who said the other students in the class realized that the line would not be vertical. Here, both Sara and Lydia worked to interpret the students' thinking in terms of the math at hand. Facilitator 1's focus remained on teachers' KBR as she responded by asking teachers to look at the transcript for evidence of Lydia's claim that students knew the line would not be vertical.

In summary, Facilitator 1 noticed the teachers' noticing process in several ways as she let teachers pick moments of the video to discuss. She addressed their SA by asking teachers to explain their chosen moments in more detail. She also supported their KBR by prompting teachers to think about how the jumping-off-the-top-of-the-flagpole idea related to the steepness of the graph.

VC 2: Facilitator Picks the Moments and Interpretations

In other instances during the video clubs, the facilitators still noticed teachers' SA and KBR, but took a more direct role in how the teachers talked about the videos. Facilitator 2 often did this in two ways: (1) by selecting moments from the video for teachers to reason about, and (2) by asking teachers to consider a particular interpretation of students' thinking.

To start VC2, Facilitator 2 asked the group, "Any student ideas you want to talk about right off the bat?" Initially, it seemed that Facilitator 2 took the same

approach as Facilitator 1, she made space for the teachers to pick particular moments to discuss. However, Facilitator 2's actions changed early in the conversation. As the teachers began to compare the thinking of the three students in the video, they agreed that the students all thought in the same way about the relationship between a polygon's area and perimeter and that their explanations became increasingly visual. As Sara put it, "There are different ways of explaining it. So, Jasper was, you know, very verbal explanation and it got more and more visual to help the kids see it as they went from student to student." Two other teachers agreed with Sara. Then, Facilitator 2 said:

> **Facilitator 2:** I kind of wanted to dig a little bit more with Jasper's thoughts there, I guess. Um, I noticed from watching it that, that sort of the whole thing is about, you know, what, when you double the perimeter what happens to the area. Sort of what the general question is. But then in [Jasper's] explanation he doesn't say, I don't think he says the word perimeter.
>
> **Lydia:** Right.
>
> **Facilitator 2:** Which I, I thought was just an interesting like, um, interesting little note there that, um, he somehow manages to make an explanation without using that word perimeter. So, what do we think's going on there?
>
> **Polly:** It seemed like he understood that if you're changing a perimeter, you're really changing the dimensions. He talked about the dimensions.
>
> **Mateo:** Yeah.
>
> **Polly:** So, it seemed like he had that connection between the two. So, if the perimeter changes that means [Jasper is thinking,] "Oh well this is what's

happening to the two dimensions. So now if we need to find the area this is really what we're doing." So, it seemed like he understood that…

Facilitator 2: Yeah.

Polly: …connection there.

Lydia: And he only focused I think on like length and width versus like perimeter.

Facilitator 2: Okay.

Lydia: As far as like [Inaudible] which I think is still okay. I mean I think you could still get it. You know, when you think, well, length and width without the perimeter as they showed.

Here, it is possible that Facilitator 2 noticed that teachers were not attending to and interpreting important moments in the video, like Jasper's focus on the dimensions of the square. As a result, Facilitator 2 modeled how to employ SA. She chose a moment from the video, Jasper's explanation, and exhibited curiosity about it. She also asked teachers to make sense of the moment ("So what do we think's going on there?"), which could have been an attempt to have teachers better employ their KBR. As a result, the teachers attended to Jasper's explanation and began to develop a more sophisticated interpretation of Jasper's ideas that included his emphasis on the dimensions of the square.

Facilitator 2 used this approach several other times. Later in the discussion, Facilitator 2 again directed teachers' attention to Jasper. She brought up a moment when Jessica, another student in the class, asked Jasper to repeat his explanation:

Facilitator 2: Okay. Um, I thought too that, you know, the exchange between, um, Jessica and, and Jasper. So, um, Jasper said something and then I think he said, you know, on the transcript [line] 86, um, it says a student, but I think that was Jessica that says, "Can…

Mateo: Yeah.

Facilitator 2: …we, can we have Jasper say, can we have that again?" And then Jasper goes through [his explanation again]. I think, I don't know, I'd like to, maybe, take a couple minutes to review that again just to tease apart like how deeply do each of them understand what, what, what the concept is? Maybe what the other person is saying too? Any insights there?

Sara: I think it's interesting that Jasper might realize what a misconception might be, that if you, um, take five times the perimeter that that's going to give you five times the area. Um, since he says it's not like you're multiplying the shape by five times, you're multiplying it by five times by, um, five times by five times. So, he seems to even understand what the wrong answer might be and trying to clarify why that wouldn't work.

Facilitator 2: Okay. Okay.

Sara: I thought that was kind of interesting.

Facilitator 2 might have been trying to prompt the teachers to continue to attend to and make sense of Jasper's thinking. She again supported teachers' SA by providing an example of an important moment in the video to which teachers could attend. However, she left the interpretation of that moment to the teachers, which supported their KBR development. Sara began working to understand Jasper's

thinking by claiming that Jasper may have understood that if one multiplied the perimeter of a polygon by 5, each dimension of a polygon would be multiplied by 5. Thus, the area would not be five times bigger, but 25 times bigger.

Facilitator 2 continued by reading more of the transcript:

> **Facilitator 2:** And then Jessica says, "So, you're saying you have to multiply each dimension by five times?" And then Jasper says, "Uh, well, you have to square, square each dimension since there's like," Okay, yeah. And then [Jessica] comes back, "But, it's five times by five times because there are… I get it but I just can't spit it out." So, what, what's Jasper saying in line 102? "Oh, well, you have to square, you have to square each dimension since there's like… something."
>
> **Mateo:** Well, I figure since it's you're doubling you don't just double the length or just double the width but double both of them. And that's when, she was trying to repeat that. So, if you're changing one, if you're changing the length, you also change the width. That, I think that's what he was trying to explain and was trying to get, and she was trying to repeat that also. If you have five times this, then you must multiply five times that. That's where we get 25 times.

Again, Facilitator 2 might have wanted teachers to better attend to and interpret the moment when Jessica and Jake tried to clarify each other's thinking. As a result, Facilitator 2 directed teachers to that moment and questioned it, which again modeled using one's SA. Facilitator 2 did not provide any insight into what she thought about Jasper's thinking. Instead, she left it to the teachers to reason about the

moment, which supported teachers' KBR. As the teachers responded to the facilitator, they continued to focus on how Jasper used the dimensions of a square in his explanation. Like Sara, Mateo tried to make sense of Jasper's explanation and claimed that Jasper understood that when multiplying the perimeter by a factor, be it doubling or multiplying by five, one must multiply both the length and width by the factor, which makes the area increase by n^2. Both Mateo and Sara, at the prompting of Facilitator 2, took a deeper look at Jasper's thinking, which could support the development of their KBR.

In other instances during the video club, Facilitator 2 took a different approach. She presented teachers with an interpretation of student thinking from the video and then asked the teachers to find particular video moments that applied to that interpretation. The following is an example:

> **Facilitator 2:** Mm. Something that I thought, it was pretty noticeable too, sort of switching gears here, is the different ways that, that students like, represented their thinking. You know, or, or displayed their thinking or however you want to say it. They, uh, um, Jasper and Rushdee and Cameron, sort of different interpretations there. Um, anything, you know, anything about that that you find, want to delve into a little more?
>
> **Christina:** I mean the different way that Cameron did it at the end I thought would, was the best for the class because seeing it visually I think kind of got around the fact that some of them weren't saying things right.
>
> **Facilitator 2:** Mm hmm.
>
> **Christina:** And some of them weren't understanding the verbal.

Mateo: And plus the concept of four times, you know they want to take that one area, that one square and you, and multiply by four it creates, that is the area. You double that I think. That shows a pattern, you know, that's, that's visual of those four squares and that's, I think, so I was impressed by that.

Facilitator 2: The class was too. They clapped.

Mateo: Right. And, and more or less I think he probably explained, like he took Jasper's, took Rushdee's idea, and then he showed him how using their idea… this, this, this is created right here.

Facilitator 2 gave the teachers a very general interpretation of the student thinking in the video, that Jasper, Rushdee, and Cameron represented their thinking in different ways. She invited the teachers to bring up moments in the video that highlighted those differences. Facilitator 2 may have prompted the teachers in this way because they originally suggested that the students' thinking was similar. As a result, Facilitator 2 may have seen an opportunity to develop teachers' SA by giving them an interpretation and asking them to find video examples that support the interpretation. This action supported teachers to develop their SA because they had to filter through the video to attend to moments that could support a particular interpretation. As a result, Christina highlighted the end of the video when Cameron presented his drawing. Mateo then built Christina's comment, but he still argued that Jasper's, Rushdee's, and Cameron's ideas were the same. Sara then continued:

Sara: Rushdee started to visualize it. Um, I'm wondering if Jasper had been given the opportunity to go to the board to try to write something down, if it would have helped the class understand it better being, you know, drawn, you

know, some pictures and show them, you know, the factors on each side. You have to multiply this together to get the area, if that would have helped them see it better.

Facilitator 2: So for Jasper? If Jasper would have done that?

Joe: Well, with Jasper, if he had done, Jasper would just drawn like, I thought the key part of Cameron's thing is that he had the four rectangles showing up?

Sara: It, since it would have been…

Joe: Where, where, if Jasper, Jasper had done that…

Sara: …a different explanation.

Joe: …just one bigger rectangle would they have gotten the same…

Sara: Maybe just writing, you know…

Joe: The numbers…

Sara: …two times the two. Right. On the sides and, and helping them see what you're, you're multiplying the dimensions, the word he kept using, together. You know, something like that, if that would have helped or not. A little bit. I mean I still think that it would have, it clicks more with Cameron and, you know, really helping them see it and get an understanding but more students might have understood better if they could have seen Jasper's explanation possibly.

Sara speculated that if Jasper had drawn his explanation for the class, they might have understood it better. Joe then questioned Sara about whether Jasper's drawing would have been the same as Cameron's. Sara said Jasper's explanation would be different, and that he focused more on the dimensions of the shape. Sara's

response is notable, given that at the beginning of the discussion the teachers agreed that the students all thought in the same way.

This part of the discussion started because Facilitator 2 pointed out to teachers that the students represented their thinking differently. Facilitator 2 might have noticed that the teachers were not attending to video moments that exhibited the difference between the students' ideas. Her prompt helped teachers attend to important moments of student thinking (e.g., when Cameron drew squares on the board), which supported teachers' SA. The subsequent conversation also supported teachers' KBR as they began to more deeply consider how the students' explanations were different (e.g., how Jasper's drawing would show the dimensions of a square, unlike Cameron's).

In sum, at times Facilitator 2 picked moments and interpretations of student thinking for teachers to consider. This may have been because Facilitator 2 noticed that teachers were not attending to significant instances of student thinking in the video (which relates to SA) or making distinctions between the different mathematics in student thinking (which relates to KBR). As a result, Facilitator 2 selected particular video instances and asked questions about them. This modeled for teachers how one might use their SA to find important student thinking. Facilitator 2 also posed an interpretation to teachers, which allowed teachers to look for moments in the video that related to that interpretation. This exercise also supported teachers' SA. In both kinds of interactions, teachers' KBR was also supported as teachers worked to make sense of the highlighted video moments.

VC 3: Building Teacher Knowledge to Support SA and KBR

A third type of interaction between the video club facilitators and teachers related to teachers' knowledge, specifically their mathematical content knowledge. During these interactions, facilitators noticed and supported teachers' content knowledge in the context of the video club, which in turn supported teachers' SA and/or KBR.

This type of interaction was most evident in Video Cub 3. A reason for this could be that the goal of VC3 was different from VCs 1 and 2. The primary goal in VCs 1 and 2 was for teachers to generally attend to and reason about student mathematical thinking. VC3 had a more specific goal. Facilitator 3 aimed to expand teachers' ideas of what algebraic thinking could be. Facilitator 3 hypothesized that if teachers had a better understanding of algebraic thinking, they would then notice a wider range of student algebraic thinking (Walkoe, 2015). In order to scaffold teachers' understanding of algebraic thinking, Facilitator 3 developed and gave teachers an algebraic thinking framework, which outlined different types of algebraic ideas.

During the VC3, there were multiple instances when Facilitator 3 asked teachers to consider whether the student thinking they discussed was algebraic. An example is the exchange below when Facilitator 3 invited one of the VC3 teachers to speak about Peter's and Andrew's (the students in the classroom video) thinking:

> **Facilitator 3:** Okay. Okay, good, good ideas. Now let's look at the other point, so Brooks, you had mentioned something as well, so I, and you said, could you mind, do you mind summarizing what your point was?

Brooks first talked about when Peter said that $y = \frac{3}{4}$ has a slope of zero because the graph does not change in the vertical direction. He then talked about Andrew saying that the line $x = 0$ has a slope of zero because the line does change in the horizontal direction.

Brooks: Sure. Well it's sort of with Peter and Andrew, or I don't know which one is more interesting to focus on… but, the conflating of slope and the moving of the line, so Peter says at the bottom of the first page, why is the slope zero "because it's never moving up."

Facilitator 3: M-hm.

Brooks: You know I'm not sure if, I think he thinks moving up and over, whereas Andrew says, "because it's horizontal and if you were doing a zero, zero then it, like up and down and, like move it at all." So, he, the line itself is not moving over.

Facilitator 3: …so, Brooks, earlier when you brought up this point, you said you didn't know if it was algebraic or geometric. Do you think that there's algebraic thinking going on here? When they're talking about slope, the way they're talking about slope?

Brooks: Um, I'm actually inclined to say no. Not when they're talking about moving. I mean when Peter is talking about subtract the change in x and the change in y and look at the difference in the whatever, then that's algebraic…

Facilitator 3: Okay.

Brooks: But…when you're talking about the moving of the line, that doesn't seem to be algebraic to me.

Facilitator 3: Okay, well why is the other one algebraic?

Brooks: Manipulation of numbers, let me look back at [the algebraic thinking framework].

Facilitator 3 asked Brooks if the students' thinking was algebraic. Brooks responded that he did not think it was algebraic when the students talked about the movement of the lines on the graphs. However, Brooks said that Peter's thinking was algebraic when he switched to talking about the slope formula. Several other PSTs voiced similar responses to Brooks. The facilitator then intervened and asked teachers to review the algebraic thinking framework:

Facilitator 3: Okay. Let's go back to this framework for a second. Because I think, so if we look at this, let's, let's use this to talk about some of the other things that, that maybe you noticed in the video. First, let's look at the left-hand side [of the framework]. So did you notice moments in the video where students, so let's just talk about what kinds of algebraic thinking we saw. Did you notice moments where students were generalizing and formalizing? Or generalizing? Maybe you didn't, but I'm just curious.

Kaleb: What do you mean by generalizing? Because you can take "there's a zero in it, in this equation, in this division problem, it has to be zero." That in one sense is generalizing.

Abbi: Okay. I take generalizing, when you're talking about math, a way to generalize the problem, make it apply to all aspects, so I don't know, if you [Facilitator 3] want to clarify.

Facilitator 3: Yeah, yeah, sure. So, generalizing, I think it's just pretty open, so it's kind of what you [Abbi] were saying. And I mean it's looking for, right, looking at specific examples and then applying it to more examples.

Here, Facilitator 3 might have seen an opportunity to press teachers on their conceptions of algebraic thinking and what kind of student thinking is algebraic. Brooks only talked about algebraic thinking in terms of manipulation of formulas. In response, Facilitator 3 pointed teachers to the *generalizing and formalizing* part of the algebraic thinking framework and then answered questions about it. Facilitator 3 might have noticed that Brooks had a narrow view of algebraic thinking, which could limit the moments in the video that he saw as algebraically important, thereby inhibiting his SA. She might have also thought that Brooks was not drawing connections between student thinking and algebra, thereby constraining his KBR. Said differently, Facilitator 3 noticed a limitation of Brook's TK that may have also contributed to his SA and KBR. Facilitator 3 supported Brooks's and the other teachers' knowledge by helping them make sense of a type of algebraic thinking, *generalizing*, with which they may have been less familiar. As the conversation continued, some teachers began to apply generalizing to Peter's ideas about slope:

Jamie: Yeah, I mean, Peter says because, you know the [inaudible] remarks to the slope thing, to the Y coordinate being three-fourths for all input sets.

Facilitator 3: M-hm.

Jamie: He said it's never moving up and that, he made that-- he said because it's never moving up, he said that right after the teacher said, you know, it has to be three-fourths.

Facilitator 3: M-hm.

Jamie: If you put in minus five, I get three-fourths. If I put in minus two…

Facilitator 3: Right, okay.

Jaime: …I get three-fourths.

Facilitator 3: Yeah, interesting, so that sounds...

Heather: I thought, sort of like what they were saying when [Peter] says that, well since the second number is the y, then y equals three-fourths, it has to be three-fourths. Just, it made me think of the fact that when you look at an equation, you're sort of saying, like this is the rule for whatever is happening in the graph. Like, so, yeah, if this is true all the time then no matter what I do… I thought that was, like very algebraic thinking to think of an equation that sort of a description of what is happening in this graph. And so, cause it's confusing to think the y is three-fourths and there's no x and, like how could you have an x value… but sort of thinking of it as the second number is the y, you know this is true all the time. So, this is just like the rule that we have to look at.

Both Jamie and Heather discussed how Peter's ideas could be related to generalizing. For Jamie, Peter's thinking could be considered generalizing because Peter talked about how the y-coordinate would always be ¾, regardless of the x-value. Similarly, Heather said that Peter's idea that the y-value always had to be ¾, would be seen on the graph and in the equation. Jamie and Heather may have attended to and reasoned about Peter's ideas in terms of generalization because they understood it better after referring to the algebraic thinking framework. In this sense,

referring to the algebraic thinking framework seemed to support some teachers' SA and KBR because they were able to interpret a wider range of student thinking as algebraic. Thus, while Facilitator 3's actions seemed to focus on TK, it is possible that she noticed how TK related to SA and KBR and worked to support all three aspects of teachers' noticing process.

To summarize, Facilitator 3 likely noticed teachers' knowledge as she worked to expand teachers' ideas of algebraic thinking. She might have understood that building teachers' understanding of algebraic thinking, as part of their TK, would also improve their SA and KBR. To do this, she clarified teachers' knowledge about the math content in the task, which helped the teachers better reason about student thinking.

Discussion and Conclusion

The purpose of this study was to develop a framework to understand facilitators' process as they interact with teachers to support teachers' noticing of student thinking. I took a noticing perspective and built on research in teacher noticing and studies on facilitation to show that the process of facilitator noticing is similar to teacher noticing. The primary difference is *what* facilitators notice when working with teachers, which is *teachers' noticing process*. The empirical examples above show how video club facilitators might notice various aspects of teachers' noticing process, which contributes to how they interact with teachers.

The framework and empirical examples are helpful in exploring how experienced facilitators support teachers to develop a particular teaching practice-learning to notice student thinking. Other researchers have described how PD

facilitators should generally work with teachers (Shaughnessy et al., 2016 Prediger, 2022) or the types of talk moves that facilitators should employ to have productive discussions with teachers (e.g., van Es et al., 2014). The FNF is aligned with this literature and builds on it in several ways. First, like studies about the knowledge and skills teacher educators need (Castro Superfine & Li, 2014; Prediger, et al., 2022), the FNF captures the layers involved in video club facilitators' work and addresses both teachers and students. In terms of teachers, video club facilitators focus on components of teachers' noticing process, including their TK, SA, KBR, and response decisions.

However, facilitators also need to understand how to instruct students. In the FNF, facilitators' noticing of teacher thinking *includes* noticing student thinking (Amador, 2021). In the empirical examples above it is clear that the facilitators knew how to notice student thinking as they, for example, prompt teachers to make connections between student thinking and the math at hand or select moments of student thinking for teachers to consider.

Understanding the process of facilitator noticing is also important because it shows how facilitators know to act in certain ways to build a specific teaching practice- learning to notice student thinking. Previous literature that details different facilitator talk moves is helpful to understand the characteristics of a productive video-PD teacher discussion (e.g., all teachers' ideas should be included, the focus should be on students and mathematics, etc.) and the actions facilitators can take to maintain these characteristics of the conversation (Borko, Jacobs et al., 2014; Tekkumru-Kisa & Stein, 2017; van Es et al., 2014). The FNF shows how facilitators

know to take these kinds of actions and others to specifically support teacher noticing. In the empirical examples above, there were similarities and differences in the ways that facilitators interacted with teachers during video club discussions. However, all of the facilitators seemed to notice and take steps to support either teachers' SA, KBR, TK or a combination of these. Addressing these aspects of teachers' noticing process shows how facilitators can move beyond sustaining a productive video-based conversation with teachers, in general, to specifically helping teachers learn to notice student thinking.

Understanding facilitator noticing has important implications for the development of math teacher educators. If we want teachers to learn to notice student thinking, then we need facilitators of teacher PD who can attend to, interpret, and decide how to respond to particular aspects of teachers' noticing process, including their SA, KBR, TK, and response decisions. Learning opportunities for novice facilitators should focus on noticing teachers' noticing process. Future studies could investigate PD experiences for facilitators to determine how novice facilitators learn to notice teacher thinking and the kinds of activities that support such learning.

In this article, the FNF focused on how facilitators support teachers' noticing of students' mathematical thinking. However, the FNF could be adapted to understand how facilitators support other teacher practices. It is possible that there are many "pink boxes" that can be substituted for the current version. Such pink boxes might detail other types of teacher thinking that facilitators can notice. For example, depending on the goals of a teacher learning experience, facilitators might notice

teacher thinking related to student affect or issues of equity in the classroom (Louie et al., 2021; Shah & Coles, 2020; van Es et al., 2017).

In addition to PD opportunities for novice facilitators, there is still more to be explored about facilitator noticing. One limitation of this article is that the window into facilitator thinking was limited; evidence of what facilitators thought as they lead teachers in video clubs was based on their actions. Future work might be to interview facilitators about their facilitation, or use tools, like point of view cameras (Luna & Sherin, 2017; Sherin & Sherin, 2010), to see what facilitators focus on as they lead video clubs or other PD. Such tools have been used with teachers to get a better sense of what they notice about student thinking in the moment (Luna, 2018). These methods might give insight into facilitator thinking that comes directly from the facilitators.

Also, none of the empirical examples in this article depict video club facilitators noticing how teachers decide to respond to student thinking, the third arrow in teachers' noticing process. This is likely because the studies from which the empirical examples were taken focused on supporting teachers' SA and KBR. Fewer video clubs have explicitly addressed supporting teachers in deciding to respond to student thinking (Santagata et al., 2021). More work is needed to investigate what facilitator-teacher interactions look like when facilitators notice teachers' response decisions.

Despite these limitations, the introduction of the FNF in this article is a promising step in understanding how video club facilitators might think about their

work, and what novice facilitators might focus on to learn how to notice teacher thinking.

References

Amador, J. (2016). Professional noticing practices of novice mathematics teacher educators. *International Journal of Science and Mathematics Education*, *14*(1), 217–241. https://doi.org/10.1007/s10763-014-9570-9

Amador, J. M. (2020). Teacher leaders' mathematical noticing: Eliciting and analyzing. *International Journal of Science and Mathematics Education*, *18*(2), 295–313. https://doi.org/10.1007/s10763-019-09956-5

Amador, J. M. (2021). Mathematics teacher educator noticing: Examining interpretations and evidence of students' thinking. *Journal of Mathematics Teacher Education*. https://doi.org/10.1007/s10857-020-09483-z

Beisiegel, M., Mitchell, R., & Hill, H. C. (2018). The design of video-based professional development: An exploratory experiment intended to identify effective features. *Journal of Teacher Education*, *69*(1), 69–89. https://doi.org/10.1177/0022487117705096

Borko, H., Carlson, J., Deutscher, R., Boles, K. L., Delaney, V., Fong, A., Jarry-Shore, M., Malamut, J., Million, S., Mozenter, S., & Villa, A. M. (2021). Learning to lead: An approach to mathematics teacher leader development. *International Journal of Science and Mathematics Education*, *19*, 121–143. https://doi.org/10.1007/s10763-021-10157-2

Borko, H., Carlson, J., Mangram, C., Anderson, R., Fong, A., Million, S., Mozenter, S., & Villa, A. M. (2017). The role of video-based discussion in model for

preparing professional development leaders. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0090-3

Borko, H., Jacobs, J., Seago, N., & Mangram, C. (2014). Facilitating video-based professional development: planning and orchestrating productive discussions. In Y. Li, E. A. Silver, & S. Li (Eds.), *Transforming Mathematics Instruction Multiple Approaches and Practices* (pp. 259–281). https://doi.org/10.1007/978-3-319-04993-9_16

Borko, H., Koellner, K., & Jacobs, J. (2011). Meeting the challenges of scale: The importance of preparing professional development leaders. *Teachers College Record*, 11–14. https://doi.org/10.1007/s11858-010-0302-5.https

Borko, H., Koellner, K., & Jacobs, J. (2014). Examining novice teacher leaders' facilitation of mathematics professional development. *Journal of Mathematical Behavior*, *33*, 149–167. https://doi.org/10.1016/j.jmathb.2013.11.003

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C.-P., & Loef, M. (1989). Using knowledge of children's mathematics thinking in classroom teaching: An experimental study. *American Educational Research Journal*, *26*(4), 499–531.

Castro Superfine, A., Amador, J., & Bragelman, J. (2019). Facilitating video-based discussions to support prospective teacher noticing. *Journal of Mathematical Behavior*, *54*, 1–18. https://doi.org/10.1016/j.jmathb.2018.11.002

Castro Superfine, A., & Li, W. (2014). Exploring the mathematical knowledge needed for teaching teachers. *Journal of Teacher Education*, *65*(4), 303–314. https://doi.org/10.1177/0022487114534265

Coles, A. (2013). Using video for professional development: The role of the discussion facilitator. *Journal of Mathematics Teacher Education*, *16*(3), 165–184. https://doi.org/10.1007/s10857-012-9225-0

Elliott, R., Kazemi, E., Lesseig, K., Mumme, J., Carroll, C., & Kelley-Petersen, M. (2009). Conceptualizing the work of leading mathematical tasks in professional development. *Journal of Teacher Education*, *60*(4), 364–379. https://doi.org/10.1177/0022487109341150

Empson, S. B., & Jacobs, V. R. (2008). Learning to listen to children's mathematics. In D. Tirosh, & T. Wood, (Eds.), *International Handbook of Mathematics Teacher Education: Volume 2* (pp. 257–281). Sense Publishers. https://doi.org/10.4324/9780203392621-11

Fennema, E., Carpenter, T. P., Franke, M. L., Levi, L., Jacobs, V. R., & Empson, S. B. (1996). A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education*, *27*(4), 403–434. https://doi.org/10.2307/749875

Gaudin, C., & Chaliès, S. (2015). Video viewing in teacher education and professional development: A literature review. *Educational Research Review*, *16*, 41–67. https://doi.org/10.1016/j.edurev.2015.06.001

Goldsmith, L. T., & Seago, N. (2008). Using video cases to unpack the mathematics in students' thinking. In Smith, M. S. & S. N. Friel (Eds.), *Cases in*

Mathematics Teacher Education: Tools for Developing Knowledge Needed for Teaching. Association of Mathematics Teacher Educators.

González, G., & Skultety, L. (2018). Teacher learning in a combined professional development intervention. *Teaching and Teacher Education*, *71*, 341–354. https://doi.org/10.1016/j.tate.2018.02.003

Herbst, P., Chazan, D., & Lavu, S. (2019). *Anotemos*. Web-based collaborative software tool for the annotation of video. Disclosed to the Office of Technology Transfer, University of Michigan.

Jacobs, V. R., Franke, M. L., Carpenter, T. P., Levi, L., & Battey, D. (2007). Professional development focused on children's algebraic reasoning in elementary school. *Journal for Research in Mathematics Education*, *38*(3), 258–288.

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.

Kang, H., & van Es, E. A. (2019). Articulating design principles for productive use of video in preservice education. *Journal of Teacher Education*, *70*(3), 237–250. https://doi.org/10.1177/0022487118778549

Lesseig, K., Elliott, R., Kazemi, E., Kelley-Petersen, M., Campbell, M., Mumme, J., & Carroll, C. (2017). Leader noticing of facilitation in videocases of mathematics professional development. *Journal of Mathematics Teacher Education*, *20*(6), 591–619. https://doi.org/10.1007/s10857-016-9346-y

Loewenberg Ball, D., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59*(5), 389–407. https://doi.org/10.1177/0022487108324554

Louie, N., Adiredja, A. P., & Jessup, N. (2021). Teacher noticing from a sociopolitical perspective: the FAIR framework for anti-deficit noticing. *ZDM - Mathematics Education*, *53*(1), 95–107. https://doi.org/10.1007/s11858-021-01229-2

Luna, M. J. (2018). What does it mean to notice my students' ideas in science today?: An investigation of elementary teachers' practice of noticing their students' thinking in science. *Cognition and Instruction*, *36*(4), 297–329. https://doi.org/10.1080/07370008.2018.1496919

Luna, M. J., & Sherin, M. G. (2017). Using a video club design to promote teacher attention to students' ideas in science. *Teaching and Teacher Education*, *66*, 282–294. https://doi.org/10.1016/j.tate.2017.04.019

Marrongelle, K., Sztajn, P., & Smith, M. (2013). Scaling Up professional development in an era of common state standards. *Journal of Teacher Education*, *64*(3), 202–211. https://doi.org/10.1177/0022487112473838

Park Rogers, M., Berry, A., Krainer, K., & Even, R. (2021). Finding common ground: A synthesis of science and mathematics teacher educators' experiences with professional growth. *International Journal of Science and Mathematics Education*, *19*, 167–180. https://doi.org/10.1007/s10763-021-10188-9

Prediger, S., Roesken-Winter, B., Stahnke, R., & Pöhler, B. (2022). Conceptualizing content-related PD facilitator expertise. *Journal of Mathematics Teacher Education*, *25*(4), 403–428. https://doi.org/10.1007/s10857-021-09497-1

Robertson, A., Atkins, L., Levin, D., & Richards, J. (2016). What is responsive teaching? In A. Robertson, R. Scherr, & D. Hammer (Eds.), *Responsive Teaching in Science and Mathematics* (pp. 1–31). New York: Routledge.

Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A. K., Yang, X., & Kaiser, G. (2021). Mathematics teacher learning to notice: a systematic review of studies of video-based programs. *ZDM Mathematics Education*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z

Shah, N., & Coles, J. A. (2020). Preparing teachers to notice race in classrooms: contextualizing the competencies of preservice teachers with antiracist inclinations. *Journal of Teacher Education*, *71*(5), 584–599. https://doi.org/10.1177/0022487119900204

Sherin, M.G, (2007). The develop of teachers' professional vision in video clubs. In Goldman, R., Pea, R., Barron, B., Derry, S.J. (Eds.), *Video research in the learning sciences* (pp 383-395). Mahwah, NJ: Lawrence Earlbaum Associates.

Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, *20*(2), 163–183. https://doi.org/10.1016/j.tate.2003.08.001

Sherin, M. G., & van Es, E. A. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of Technology and Teacher Education*, *13*(3), 475–491.

Sherin, M. G., & van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education*, *60*(1), 20–37. https://doi.org/10.1177/0022487108328155

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14.

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning*, *10*(4), 313–340. https://doi.org/https://doi.org/10.1080/10986060802229675

Swan, M. (Ed.). (1985). The language of functions and graphs: An examination module for secondary schools. Machester: Joint Matriculation Board, Shell Center for Mathematical Education

Tekkumru-Kisa, M., & Stein, M. K. (2017). A framework for planning and facilitating video-based professional development. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0086-z

van Es A., E. (2010). A framework for facilitating productive discussions in video clubs. *Educational Technology*, *50*(1), 8–12.

van Es, E. A. (2011). A framework for learning to notice student thinking. In M. G. Sherin, V. R. Jacobs, & R. A. Phillip (Eds.), *Mathematics Teacher Noticing Seeing Through Teachers' Eyes* (pp. 134–151). Routledge. https://doi.org/10.4324/9780203832714

van Es, E.A., Hand, V., & Mercado, J. (2017). Making visible the relationship between teachers' noticing for equity and equitable teaching practice. In E. O.

Schack, M. H. Fisher, & J. Wilhelm (Eds.), *Teacher Noticing: Bridging and Broadening Perspectives, Contexts, and Frameworks* (pp. 251–269). Springer. https://doi.org/10.1007/978-3-319-46753-5

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10*(4), 571–596.

van Es, E. A., Tekkumru-Kisa, M., & Seago, N. (2020). Leveraging the power of video for teacher learning. In S. Llinares & O. Chapman (Eds.), *International Handbook of Mathematics Teacher Education: Volume 2* (pp. 23–54). Koninklijke Brill NV. https://doi.org/10.1163/9789004418967_002

van Es, E. A., Tunney, J., Goldsmith, L. T., & Seago, N. (2014). A framework for the facilitation of teachers' analysis of video. *Journal of Teacher Education*, *65*(4), 340–356. https://doi.org/10.1177/0022487114534266

Walkoe, J. (2015). Exploring teacher noticing of student algebraic thinking in a video club. *Journal of Mathematics Teacher Education*, *18*(6), 523–550. https://doi.org/10.1007/s10857-014-9289-0

Walton, M., & Walkoe, J. (in press). Using a video-tagging tool to support facilitators of video-based professional development. *AMTE's Professional Book Series, Volume 5.*

Novice Facilitators Learning to Lead Video Clubs: A Framing Perspective

Margaret Walton and Janet Walkoe

Introduction

A growing research base contends that teacher educators are integral for teacher learning (Beisiegle et al., 2018; Borko et al., 2011; Roth et al., 2017). Teacher educators, including administrators, teacher leaders, university faculty and graduate students, are often responsible for designing and implementing teacher learning experiences (Borko et al., 2021; Kang & van Es 2019, Luna & Sherin, 2017; Tekkumru-Kisa & Stein, 2017; Walton & Walkoe, in press). As demand for teacher PD grows, demand for qualified teacher educators grows as well.

One type of teacher PD that has expanded is video-based PD (Gaudin & Chali és, 2015). Many forms of video-based PD involve convening groups of teachers to watch and analyze videos of instruction to learn about teaching practices or ways of student learning (Santagata et al, 2021). Such PD has been shown to help teachers find new strategies for solving math problems, learn about resources for teaching math, and learn to center student thinking in the classroom (e.g., Koellner et al., 2007; Luna & Sherin, 2017; Stockero et al., 2017; van Zoest & Stockero, 2008; Walkoe et al., 2022). Facilitators of video-based PD often set learning goals for teachers, design the PD activities, and implement the PD (Tekkumru-Kisa & Stein, 2017). It is important for facilitators to have the knowledge and skills to carry out this work so that teachers have quality learning experiences that improve their practice.

Much of the research on facilitation has involved developing frameworks detailing the actions facilitators should take to plan and enact video-based PD (Borko,

Jacobs et al., 2014; Tekummru-Kisa & Stein, 2017 van Es et al., 2014; van Es et al., 2020). These studies are helpful to understand *what* facilitators should do to support teachers, but they do not examine *how facilitators learn to do it*. In addition, studies about facilitator learning have found that novice facilitators can struggle to lead teacher discussions, which is usually an essential component of video-based PD. Understanding how novice facilitators learn to lead teachers, particularly teacher discussions, is important for designing and scaling teacher PD to meet demand and for offering more learning opportunities to teachers (Borko et al., 2011; Elliott et al., 2009; Schwarts, et al., 2021).

The purpose of this study is to understand how facilitators learn to lead a particular type of video-based PD called video clubs. Video clubs have been shown to help teachers learn to *notice* student thinking in the classroom (Luna & Sherin, 2017; Sherin & Han, 2004; Sherin & van Es, 2009; Walkoe, 2015). Noticing student thinking includes attending to student mathematical ideas, working to understand those ideas, and determining how to respond in ways that support student learning (Jacobs et al., 2010; Sherin, 2007). We investigated the learning of six novice facilitators during a facilitator PD (F-PD). The F-PD aimed to teach the facilitators how to lead video clubs. We were particularly interested in how the novice facilitators learned to facilitate video club discussions that could support teachers in learning to notice student thinking.

We take a framing perspective of learning (Goffman, 1974; Hammer et al., 2005) to understand if and how the facilitators learned during the F-PD. Framing is

people's sense of what is taking place in a particular situation, which can contribute to how they think or act. Our research questions are:

In what ways (if any) does novice video club facilitators' understanding of leading video clubs develop as they participate in the F-PD?

- In what ways (if any) does participants' framing of leading video clubs shift over time?
- In what ways (if any) do the FPs' and F-PD leader's interactions during the F-PD and the F-PD design contribute to FPs' framing of leading video clubs?

Background on Video-Based Facilitation

Who Are Facilitators?

People who facilitate teacher PD often come from different areas of the field of education. Video-based PD has been facilitated by researchers who work at universities (e.g., Luna & Sherin, 2017; Goldsmith & Seago, 2008; Schwarts et al., 2021), graduate students (e.g., Walkoe, 2015; Walton & Walkoe, in press), teachers who take on leadership roles (e.g., Borko et al., 2017; Lesseig et al., 2017; Schwarts et al., 2021), and school district instructional support staff (e.g., Jackson, et al., 2015; Lesseig et al., 2017). A number of researchers agree that, regardless of where these facilitators come from, it is important to devote resources to developing their skills and knowledge so that they can provide high-quality PD to teachers (Borko, 2011; Elliot et al., 2009; Margonelle et al., 2013; Schwarts et al., 2021).

What do facilitators do?

A qualified facilitator is integral to implementing video-based PD (Beisiegel et al., 2018; Borko et al., 2011; Roth et al., 2017). Facilitators set goals for teachers and select the video clips that align with those goals (Borko, Jacobs et al., 2014; Coles, 2013; Tekkumru-Kisa & Stein, 2019; van Es et al., 2020). They also guide teacher discussions about video. Facilitators often allow teachers to drive conversations but interject to point out interesting student ideas, clarify teacher contributions, or push teachers to build on their own and each other's thinking (Borko, Jacobs et al., 2014; Coles, 2013; Goldsmith & Seago, 2008; van Es et al., 2014). These actions can help teachers learn new skills, particularly those related to centering student thinking during instruction (Castro Superfine et al., 2019; Goldsmith & Seago, 2008).

For example, during a video-based PD with middle and high school math teachers, Goldsmith & Seago (2008) described early discussions when teachers primarily evaluated student ideas from the video. During these early sessions, the facilitator mostly clarified the mathematical ideas in teachers' comments and asked teachers to support their claims about students' thinking with evidence from the video. By the last PD session, teachers focused on making sense of student ideas, rather than considering correctness. The facilitator's actions also changed in later sessions. She worked to highlight important teacher contributions and prompted teachers to explain their thinking. The authors posited that moves by the facilitator met the evolving needs of the teachers over the course of the PD and helped them develop their ability to attend to and interpret student thinking.

Research on Facilitation

Researchers have more recently begun to study facilitation in greater depth. Much of the research on facilitation has involved developing frameworks that detail the kinds of actions that facilitators should take to plan and enact video-based PD, like selecting video, or the types of talk-moves that lead to productive teacher discussions (Borko, Jacobs et al., 2014; Kang & van Es, 2019; Prediger et al., 2022; Tekkumru-Kisa, & Stein, 2017; van Es et al., 2014; van Es et al., 2020). These frameworks are largely based on observations of experienced facilitators. For example, van Es and colleagues (2014) analyzed data from two different video-based PD studies and developed a framework of talk moves that facilitators can use to lead teacher discussions. The moves include *lifting up*, which is when a facilitator points out an important teacher idea that merits further discussion. Another move is *distributing participation,* which is when a facilitator invites multiple participants to share their thoughts.

These studies are helpful to detail the actions that facilitators should take to support practices, like teacher noticing, but they do not examine how facilitators *learn* these moves. *Even experienced facilitators were once novices who had to develop their facilitation skills*. It is important to understand how facilitators learn to lead teachers to design high-quality F-PD opportunities. Knowing *what* to do to support practices, like teacher noticing, is important, but facilitators also need to learn *how* to do it (Schwarts, et al., 2021).

Researchers have begun to investigate how facilitators learn to lead productive video-based PD, but there is still much to be explored. These studies found that novice facilitators were generally able to perform tasks, like establishing group

culture and selecting meaningful video, but had difficulty with learning to lead teacher discussions (Borko, Koellner et al., 2014; Elliott et al., 2009; Jackson et al., 2015). Although many facilitators were able to moderate discussions that gave teachers a chance to share varying thoughts on math content or student thinking, most of these conversations were a superficial "sharing out." The facilitators did not give teachers the opportunity to delve more deeply into ideas that could help them reason about mathematics and/or student thinking (Borko, Koellner et al., 2014; Elliot et al., 2009; Jackson et al., 2015). Based on this work, it is clear that facilitators need more support in leading substantive video-based teacher discussions.

There have been several studies that show potential for F-PD opportunities to help facilitators lead discussions with teachers (Lesseig et al., 2017; Lewis, 2016; Schwarts, 2021). Schwarts and colleagues (2021) examined changes in the facilitation practices of two novice facilitators, one who was a university researcher and one who was a high school math teacher, as they engaged teachers in conversations aimed at developing productive mathematical discourse with students. The researchers found that more experience with facilitation and an F-PD that supported the novices to reflect on their facilitation practices helped them build discussion leadership skills, like maintaining focus on PD goals and synthesizing participant comments.

In a different study, Lesseig and colleagues (2017) designed a video-based F-PD for 35 novice facilitators. The novice facilitators analyzed videos of facilitators discussing mathematical tasks with teachers. The F-PD prompts asked the novice facilitators to connect the mathematics, goals for teachers, and facilitator moves in the videos. The researchers found that many of the novice facilitators developed noticing

skills related to understanding the facilitator moves in the video and their relationship to the mathematical goals for teachers. The authors argued that such noticing would better prepare novice facilitators to enact moves that would support teacher discussions about mathematical tasks. This finding is promising and is a good springboard to explore whether facilitators can learn to notice not only teachers' mathematical ideas, but also the development of teacher instructional practices, like noticing student thinking.

The findings above are encouraging and show that facilitators can improve their discussion leadership skills with support. We aim to build on these findings to understand how facilitators learn to lead discussions to help teachers develop a particular practice- noticing student thinking. Included in this understanding is identifying how interactions between the F-PD participants and leader contributed to facilitator learning, along with how parts of F-PD design contributed to facilitator learning.

Theoretical Grounding

Teacher Noticing and Video Clubs

The goal of our work with facilitators is to help them lead video clubs so that they can support teachers to learn to center student mathematical thinking during instruction. Given the multitude of events in a mathematics classroom at any given time, it is important that teachers can pick out students' important disciplinary thinking and use it for instruction. This process is often referred to as *teacher noticing* (Jacobs, et al., 2010; Sherin, 2007).

We view teacher noticing as consisting of three components. The first two are *selective attention* (SA) and *knowledge-based reasoning* (KBR) (Sherin, 2007; Sherin & van Es, 2009). Teachers use their SA to determine what to focus on in the classroom at any given moment. For example, a teacher may attend to a student question, a conversation between two students, how many students are engaged in the current task, etc. It is important that teachers focus their attention on expressions of student thinking, like what a student says about a mathematical concept or their written work. Once teachers attend to student thinking, they use their KBR to understand the moment. Teachers might use, for example, their knowledge of the content, their students, and/or pedagogy to reason about a particular moment (Sherin, 2007).

The third component we include is *deciding how to respond* (Jacobs et al., 2010). Teachers determine their response based on their interpretation of the moment at hand. They may try to direct a conversation by asking a student to expand on what they just said, or they may ask a student to clarify an idea. In some instances, the teacher may stand back and let students interact and build on each other's thinking.

Like other teaching practices, many teachers need to learn how to attend to, interpret and decide how to respond to student thinking (Sherin, 2007; van Es, 2011). Video clubs have been shown to help teachers improve their noticing skills in several ways. A video club is made up of a small group of teachers who meet to watch a short video clip (approx. 5-10 minutes) of classroom instruction. After watching the clip, the teachers discuss interesting moments of student thinking that they saw, usually with the guidance of a facilitator. Video clubs can support teachers to develop their

SA. After participation in a video club, some teachers can shift their focus from other aspects of the classroom to students' mathematical ideas (Jacobs et al., 2010; Sherin, 2007; Sherin & Han, 2004; Sherin & van Es, 2005; Sherin & van Es, 2009; Walkoe, 2015).

Video clubs can also help teachers employ their KBR to take a more interpretive stance toward student thinking and use evidence to back their claims about student thinking (Luna & Sherin, 2017; Sherin & Han, 2004; Sherin, 2007; Sherin & van Es, 2005; Sherin & van Es, 2009; Walkoe, 2015). For example, in a video club study with 11 elementary and middle school teachers, Sherin & van Es (2009) found that in early video club meetings, the teachers tended to make general descriptions related to student thinking, like re-stating a student comment. However, by the final video club sessions the teachers focused on the meaning of student responses and tried to connect multiple students' mathematical ideas to better understand student learning.

It should be noted that teachers do not make this progress by watching video and discussing on their own; they need a facilitator to implement the intervention. Indeed, facilitators have been credited with playing an important role in helping teachers learn to notice, primarily through guiding teachers' conversations (Castro Superfine et al., 2019; van Es, 2011).

Facilitator Noticing

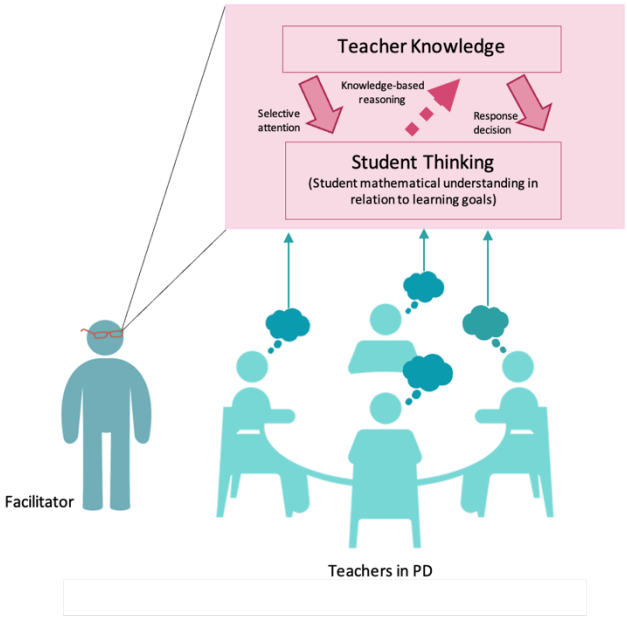
Given that video club facilitators are instrumental for leading discussions, what is their process during these discussions to support teachers to learn to notice? This question is particularly relevant to our study because we aim to teach novice

facilitators to lead video club discussions. In the Background Section, we referred to research that details the types of actions that facilitators take to support teacher learning in video-based PD (Borko, Jacobs et al., 2014; Tekkumru-Kisa & Stein, 2017; van Es et al., 2014; van Es et al., 2020). It is also important to understand *how* the facilitators know to take such actions to help novice facilitators learn to do the same.

We understand how facilitators lead video club discussions with a noticing lens with the Facilitator Noticing Framework (FNF) (Walton, 2023a; Figure 1). Like teachers noticing student thinking, it is important for facilitators to notice *teacher* thinking. Based on the FNF, facilitators' process for noticing is largely the same as it is for teachers. That is, facilitators also attend to, interpret, and determine a response to teachers' ideas. However, *what* facilitators need to notice is different. Facilitators must notice *teachers' noticing process*, which includes how a teacher applies their own knowledge to focus on, make sense of, and determine how to respond to student thinking.

Figure 1

Facilitator Noticing Framework



The figure above depicts how a facilitator notices teacher thinking during teacher conversations, like video club discussions. As teachers talk to one another or interact with artifacts, like video, the facilitator notices (symbolized by the facilitator's glasses) different aspects of teachers' noticing process, which is the pink box. The primary components of teachers' noticing process include teachers' knowledge, SA, KBR, teachers' response decisions, and student thinking. SA, KBR, and the response decisions are represented by the arrows that bounce back and forth between teachers' knowledge and student thinking.

For the first arrow, labeled SA, a teacher uses their knowledge to recognize when a student's utterance, gesture, written work, etc. expresses an important

mathematical idea. From there, a teacher uses their KBR, represented by the second arrow, to understand what the student's idea means in terms of their mathematical understanding. The second arrow is distinct from the other arrows in the pink box because, rather than acting on student thinking, the teacher at this point is in a state of analysis. As the teacher focuses on the student thinking they see, they gain information about what the student is saying or doing. The teacher uses their knowledge of students, content, pedagogy, etc. to analyze that information. Finally, once the teacher has interpreted the student idea, they decide how to respond to it, which is represented by the third arrow in the pink box.

A facilitator might notice any of these arrows and/or the teacher knowledge and student thinking boxes. For example, perhaps during a video club about proportional reasoning, teachers focus on a student's unique solution path. Maybe the teachers merely describe what the student is saying, rather than reasoning about the student's mathematical understanding. In response, the facilitator might ask a question like, "What do you think the student understood about proportions?" In this case, the facilitator attended to the superficial way that teachers talked about the student's idea and concluded that the teachers should better connect what the student did or said to the mathematics of the task. As a result, the facilitator prompted the teachers to use their knowledge to reason about the relationship between the student's thinking and the math, thus focusing on the teachers' KBR.

The FNF gives insight into the different aspects of teachers' thinking that facilitators should be adept at noticing when leading a video club. The question then becomes, how do novice facilitators learn to notice teachers' thinking, and how do the

interactions during the F-PD and the F-PD design support or not support this learning? We explore these questions in this article.

Learning Perspective: Framing and Interaction

We adopt the view that learning is a dynamic process that builds from individuals' prior knowledge and experiences (Cobb & Yackel, 1996; Ernest, 1994; Goldin, 1990). A framing perspective of cognition and learning aligns well with this view. Framing has its roots in anthropology and linguistics and is defined as an individual's sense of "what is it that's going on here?" (Goffman, 1974, p.8) as they engage in a particular situation or activity. Generally, individuals have a range of stored prior experiences that they organize and use to understand a particular moment. These prior experiences set up expectations for the moment at hand, saving individuals from having to uniquely evaluate every life event (Tannen, 1993). These expectations can contribute to what kinds of actions a person finds appropriate in a given situation (Tannen & Wallet, 1987).

An example of framing is how individuals have come to view virtual work meetings during the COVID-19 Pandemic. At the start of the pandemic, co-workers may have been unsure of how to navigate a virtual meeting. As the pandemic endured, individuals developed either explicit or tacit expectations for meeting virtually (e.g., one person will speak at a time, people will mute when not speaking, dress may be more casual, etc.). In this case, people may have developed a new frame, *virtual work meeting*.

An important aspect of framing is that it is contextual, and an individual's sense of an activity can change, even with small cues (Tannen & Wallet, 1987; Elby

& Hammer, 2010; Redish, 2004; Scherr & Hammer, 2009). Continuing with the virtual meeting example, many virtual meetings might begin with the participants engaging in "small talk" (e.g., sharing family news, life outside of work, etc.) However, if someone shares a URL link to a meeting agenda or shares their screen, the participants may quickly reframe the activity from *catching up* to *virtual work meeting*.

In education, framing has often been used in science education research and coupled with a resources perspective of learning (diSessa, 1993; Elby & Hammer, 2010; Hammer, 2000; Hammer et al., 2005; Rosenberg et al., 2006). From a resources lens, cognition involves the activation of fine-grained knowledge elements, or *resources,* based on context. These knowledge elements could originate from a variety of sources, like a person's physical experiences with the world around them, social interactions, and knowledge learned in school. *Frames* develop when a person repeatedly activates that same set of resources together (Hammer et al., 2005; Redish, 2004). These frames can become more stable with repeated activation, but many of them are localized and based on an individual's perception of their current situation (Hammer et al., 2005; Elby & Hammer, 2010). For instance, two students working on the same math problem might have different framings of the event; one might see it as an opportunity for exploration whereas another might view it as a search for the right procedure. The first student might be activating resources related to beliefs about doing math as a meaning-making endeavor, whereas the other student might be activating resources related to beliefs about rote memorization.

Framing has also been employed to understand teacher cognition and learning (e.g., Levin et al., 2009; Watkins et al., 2017; Luna & Sherin, 2017). A number of studies have examined how teachers' framings can contribute to the kinds of student thinking that they notice (Lau, 2010; Levin et al., 2009; Luna, 2018; Russ & Luna, 2013). In terms of teacher learning, teachers' framings during PD meant to support teacher noticing can contribute to how teachers learn to notice (Levin & Richards, 2011, Luna & Sherin, 2017). For example, Luna & Sherin (2017) designed a video club in which teachers recorded and shared moments of student thinking that they found important, rather than the facilitator choosing the video. They found that this activity helped teachers frame video clubs as a time to discuss student thinking, rather than other classroom events, which helped them more quickly improve their SA and KBR. While such studies have focused on teachers, we contend that this work can also inform how facilitators might learn.

For this study, it is helpful to view frames as a coherent set of resources. However, we will not be investigating any fine-grained resources that comprise any particular frame. Rather, we will focus on frames, themselves. We will examine if and how those frames shift and/or become more stable. We argue that there is evidence of learning if a shift in framing takes place and one or more frames becomes more stable than others. Also important to this study are some of the properties of frames, namely: (1) that they help determine how a person "thinks to act" (Hammer et al., 2005, p. 9), and (2) they are context dependent.

In addition, while many researchers look at the framings of individuals, we argue that as people interact they also have a collective framing. For example, when a

stand-up comedian makes an outrageous or sarcastic joke, the audience (assuming the joke is not malicious) laughs. The group understands that they are at a comedy show and should not take the comedian's words literally.

Several studies have examined the framings of groups and have used group discussions to determine such framings (Rosenberg, 2006; Watkins, et al., 2017). Watkins and colleagues (2017) looked at a group of science teachers' framings as an indication of their learning during a PD on attending and responding to student thinking. The authors inferred teachers' collective framings from their conversations. In the first year of the PD, they found that teachers generally framed learning about science as getting knowledge from an authority. By the third year of the PD, a different framing became more stable, learning science by making sense of phenomena. This framing is more productive for being responsive to student thinking. We take a similar approach and examine the collective framings of novice facilitators and how they shift and/or stabilize during the F-PD.

Finally, we combine our collective framing approach with a sociocultural view of cognition and argue that interaction among individuals and with tools is important for learning. From this perspective, knowledge is distributed among individuals, tools/artifacts, and the environment. Thus, interactions between people and tools/artifacts in various contexts can build knowledge (Cobb & Yackel, 1996; Greeno et al., 1996; Lave & Wenger, 1991). In terms of interactions between people, working in groups can enculturate individuals into a community by exposing them to knowledge, ways of discourse, and social practices (Brown et al., 1989; Lave & Wenger, 1991). In addition, as people collaborate, they can build and monitor shared

knowledge (Roschelle, 1992). Group interactions can also expose people to new ideas on a particular topic (Greeno, et al., 1997; Resnick et al., 2010). For tools and artifacts, such objects can serve as a mediator between the cognition occurring within people and the knowledge available in the environment. As a result, the manipulation of tools and artifacts can help people bridge the gap between themselves and the environment to complete cognitive tasks (Engeström, 1999; Hutchins, 1995). These ideas have been used to explain teachers' learning as they discuss with one another during PD sessions, utilize tools to build skills, and/or are immersed in certain environments (Ball & Cohen, 1999; Borko, 2004; Levine, 2010; Levin & Marcus, 2010; Putnam & Borko, 2000). Although this research focuses on teachers, there is some evidence that facilitators learn in similar ways. (Amador, 2021; Borko et al., 2021; Carlson et al., 2017). We combine this perspective of learning with our collective framing lens and argue that F-PD participants will interact with each other and tools in the ways described above (e.g., they will be exposed to each other's ideas and will have access to tools). These interactions can contribute to FPs' collective framing or shifts in their framing.

Methods

Context and Participants

This study took place at a large mid-Atlantic university. There were six facilitator participants, whom I call FPs. Nicole and Faith (all names are pseudonyms) both identify as Black women. Libby identifies as a white woman. Todd, Thornton, and Max all identify as white men. All the FPs were doctoral students in mathematics education, teacher education, or urban education, though all studied math education

as part of their program. They also all had prior teaching experience, most of them taught middle or high school math. Libby taught math at a community college. Their prior teaching experience ranged from four to nine years. They were also all instructors of record for undergraduate teacher education courses. Four of the FPs, Faith, Max, Thornton, and Todd previously facilitated in-service teacher PD, but not video clubs. Many of the FPs were preparing for careers in teacher education. As such, facilitation skills could be important for their current and future work.

Design-Based Research

This study employs design-based research (DBR) methods (Cobb et al., 2003; Gravemeijer & Cobb, 2013; Gravmeijer & Van Eerde, 2009; The Design-Based Research Collective, 2003) to explore how FPs' understanding of leading video clubs developed and how the group interactions and the F-PD design contributed to that development. This research paradigm aims to "develop and validate theories about learning processes" (Plomp & Nieveen 2013, p. 11). DBR is a cyclical process of designing and implementing interventions and then analyzing participants' learning. Researchers then refine their conjectures about the learning process and make changes to the design (Engle et al., 2007; Gravemeijer & Van Eerde, 2009).

Our process included designing five F-PD sessions and then reviewing participant data after each session. We made changes to the design of each upcoming session, based on our understanding of FPs' learning from previous sessions. The final designs are described below, though we describe some of our refinements in the results section.

Description of the F-PD

The F-PD took place as an online seminar via Zoom (www.zoom.us). The five sessions occurred once a week for five weeks, were 60-90 minutes, and were led by the first author, Margaret. Table 1 gives a summary of the F-PD activities and data that was used in this study.

Table 1

Overview of F-PD Activities and Data

	Session 1	Session 2	Session 3	Session 4	Session 5
Activities in session	• Video Club 1	• Video Club 2 • Facilitator Debrief 1	• Video Club 3 • Facilitator Debrief 2 • HW: Facilitator Tagging Assignment	• Video Club Goal Brainstorm • Intro to analyzing PST tags • HW: Video Club Lesson Plan	• Video Club Lesson Plan Discussion
Data Used in Study		• Recording of Facilitator Debrief 1	• Recording of Facilitator Debrief 2 • FPs' pins and comments from Facilitator Tagging Assignment	• Recording of Session 4 • List of goals • FPs' lesson plan templates	• Recording of Session 5

The main goal of the F-PD was to support the FPs to learn to lead video club discussions to help teachers improve their noticing of student thinking. As part of this goal, Sessions 1-3 of the F-PD included activities to support FPs to notice *student* thinking. Novice facilitators often need support with noticing student thinking (Amador, 2016, 2020, 2021). Each of these sessions started with a video club in which the FPs took the teacher role, meaning they participated in the video clubs as if they were K-12 teachers. The FPs did not know the teachers or students in the videos that they watched. The video clubs in these sessions were different from traditional

video clubs because, rather than receiving a transcript of the video, the FPs annotated the video using the online video tagging platform *Anotemos* (Herbst et al., 2019; Walton et al., 2020; Walton & Walkoe, in press). Anotemos has a tagging tool where users can mark and comment at different timestamps, which are saved. After the FPs watched and annotated the video, they had a video club discussion, which was led by Margaret. Margaret also had access to FPs' tags and comments and often referred to them during the video club discussion. Besides the video clubs, the different types of activities in Sessions 2-5 focused on learning to notice teacher thinking and are described below.

Reflecting on Facilitation

After the video clubs in Sessions 2 and 3, the FPs participated in facilitator debrief discussions. The facilitator debriefs (Borko et al., 2021) were discussions intended to provide a window for the FPs into how Margaret facilitated the video clubs. To scaffold these conversations, we gave the FPs a framework (van Es et al., 2014, Appendix A), which describes talk moves that facilitators might use during video-based discussions. We called this framework the Talk Moves Framework. Margaret asked the FPs a series of questions like, "Are there places [during the video club] where you remember me doing any of these moves?" The discussions were meant to give FPs an opportunity to think about Margaret's actions and how they supported them as video club participants to notice student thinking.

The final facilitation reflection activity took place after Session 3. The FPs had a homework assignment to complete before Session 4. They were asked to watch a recording of the video club from Session 2 when they were participants. Using

Anotemos, the FPs tagged moments when the facilitator (Margaret) used a talk move. They were then asked to comment in Anotemos and relate the talk move specifically to the work of supporting teachers to learn to notice.

Planning and Implementing Video Clubs

Sessions 4 and 5 focused on planning and implementing video club discussions. During Session 4, FPs watched a video that could be used in a video club and brainstormed noticing goals for a discussion with teachers. The purpose of this activity was to help FPs begin to think about how to break down the process of noticing student thinking for teachers.

The other activity in Session 4 was an introduction to analyzing teacher tagging data for a video club discussion. FPs received a set of sample Anotemos tags and comments that were written by pre-service teachers (PSTs) during a previous video club. The FPs discussed how a facilitator might use these tags to support PSTs during a video club.

For homework after Session 4, FPs planned a video club discussion using a pre-selected video, new sample Anotemos tagging data from different PSTs, and a video club planning template (Appendix B). Finally, Session 5 was a discussion about FPs' experiences planning a video club discussion. The FPs brought their video club discussion plans to Session 5 and discussed how they thought about facilitating a potential conversation, along with the challenges they had in planning.

Data Collection

Data for this study included the video recordings of the facilitation debriefs in Sessions 2 and 3, and all of Sessions 4 and 5. We also collected the FPs' tags and

comments from the Facilitation Tagging Homework Assignment after Session 3. Finally, we collected the video club lesson plans from five participants (one participant did not submit a lesson plan).

Data Analysis

We segmented the transcripts of each video recording into idea units (Jacobs & Morita, 2002) based on the topic of conversation. For example, the FPs might talk about a particular moment in a classroom video that they would want to discuss with teachers. Several FPs might talk about how they would highlight the moment (e.g., they might bring up the moment with teachers and ask them what they think about it) and the reasons they might point it out (e.g., it connects to an important mathematical idea). If the FPs then moved to discuss an interesting PST tag, that would start a new idea unit. Margaret asking new questions was also often the start of a new idea unit. The purpose of dividing into idea units was to compare conversations between different F-PD sessions. Although the idea units were not the same length (they varied from a few seconds to approximately five minutes) and there were a different number of idea units in each discussion, the idea units allowed us to examine *how* the FPs talked about various topics and whether the ways they talked about topics changed over the course of the F-PD.

We then open coded all idea units, paying attention to what the FPs focused on with regard to leading video clubs. We had thoughts about what some of the codes might be, based on the FNF. These codes related to teachers' SA, KBR, response decisions, and teacher knowledge. However, we also looked for ways that FPs discussed leading video clubs that were outside the FNF. We grouped the open codes

into larger categories. These axial codes, along with a description and example are in Table 2. It is important to note that topics of conversation used to separate the idea units were distinct from the codes used to determine how FPs talked about facilitation of video clubs. For example, an idea unit might be about how FPs would use a particular PST tag in a video club discussion. However, within the idea unit, one FP could discuss how they would use the tag to draw attention to a moment that few teachers noticed. Another FP might discuss how that tag could be a valuable connection to the mathematics in the video. As a result, this idea unit might receive two different codes because, as the FPs continued to talk about the same tag, they talked about using it in a video club in different ways.

Some of the key codes included *supporting productive conversation, supporting SA, supporting KBR, supporting responding, and considering teacher knowledge.* An idea unit was coded as *supporting productive conversation* if the FPs' talk focused on aspects of facilitation that could sustain a non-specific conversation, rather than a conversation about noticing student thinking. For example, there were moments when FPs discussed how to include everyone in a conversation or how to validate a teacher's ideas. Such aspects of facilitation are necessary for leading a video club but are not sufficient to help teachers build skills to notice student thinking.

The other codes listed above applied when the FPs talked more substantively about facilitating video club discussions. Each of these codes refers to different aspects of teachers' noticing process. FPs moved beyond only promoting interaction among teachers and specifically focused on improving teachers' noticing process,

which could improve teachers' noticing of student thinking. We coded idea units as *supporting SA*, *supporting KBR,* or *supporting responding* when FPs' discussion related to helping teachers develop their selective attention, their knowledge-based reasoning, or their response decisions, respectively. *Considering teacher knowledge* was used when the FPs discussed how teachers' prior knowledge or experience might impact how they would notice. Once we developed the codes for the F-PD discussions, we applied them to the two homework assignments (the facilitation tagging assignment and the FP lesson plans). Coding the homework assignments was a way to triangulate the data and determine if FPs' thinking was different as they worked individually, rather than in a group.

For this study, we examined how the group of FPs framed leading video clubs. To determine how the FPs framed leading video clubs, we memoed about different patterns that we saw in the codes. We identified two primary framings for how the FPs likely understood leading video clubs, *supporting productive conversation,* and *noticing teachers' noticing*. *Supporting productive conversation* corresponded with the code of the same name. When FPs framed leading video clubs in this way, they seemed to understand the primary goal as supporting a conversation, in general. FPs' focus was on features of a discussion like ensuring teachers felt included, teachers' thoughts were valued, or the conversation was easy to follow.

In contrast, FPs seemed to frame leading video clubs as *noticing teachers' noticing* when they focused on different aspects of teachers' noticing process. For example, an FP might comment about supporting teachers' KBR, while another might consider teachers' SA, while still another might think about how to differentiate

based on teachers' knowledge or experience. While the FPs might focus on varying components of teachers' noticing process, collectively the FPs seemed to understand that addressing these components could improve teachers' noticing and were what they should target as they interacted with teachers in video clubs.

Once we identified FPs' framing related to leading video clubs, we looked for how the interactions between individuals and the F-PD design might have contributed to those framings. We identified several kinds of moments in the F-PD discussions: (1) moments when a framing was initiated and (2) moments when a frame potentially became unstable. For the framing initiation instances, we determined who was responsible for the framing, based on their speech. This determination helped us understand whether the framing started with one of the FPs, or with Margaret as the F-PD leader. We also looked closely at the moments of potential framing instability to determine who initiated the instability and how others (including Margaret) reacted to it. The purpose of this part of the analysis was to determine whether FPs' framing actually shifted and how individuals' interactions maintained or shifted the framing. We now turn to the findings, where we describe how the FPs' framing of leading video clubs developed during the F-PD.

Table 2

Summary of Codes

Code	Description	Example
Support Productive Conversation	FP focused on an aspect of facilitation that would support a productive conversation about video in general without considering how to specifically support teachers' noticing.	"I also thought you did a really nice job of clarifying [my ideas]. I mean, in particular when I was talking about the like, absolute value, because I wasn't exactly sure what I meant. And so you helped me understand what I was trying to say."
Consider teacher knowledge/ experience	FP discussed issues of teachers' knowledge or experience as they thought about helping teachers learn to notice, like differentiating for newer teachers.	"I want to make sure that we don't miss out on some of the things I noticed. Just, like, not because… I'm centering myself, but like, you know, if I'm working with pre-service teachers, for example, like… they're gonna notice particular things. And there are other things that I want them to start, like, being aware of."
Support SA	FPs focused on ways to support teachers' selective attention, like making teachers aware of particular moments in videos or math content expressed by students in the video.	An FP talking about how PSTs should be tagging videos: "And so maybe I'm tagging, like, I think about when the [student] was like making the shape, but she was responding to someone. So maybe I include also who she's responding to."
Support KBR	FPs focused on ways to support teachers' knowledge-based reasoning, like asking teachers to make sense of the connections between student thinking and the broader math context.	"I would want teachers to notice that there are these two ways that students have to move between in order to answer the question…What happens to inputs when it goes into the function and come out? And what does it look like on a graph?"

Support response decision	FPs focused on ways to support teachers in deciding how to respond to student thinking.	"So then like, following up with like, [I would ask teachers] how would you, like, reengage [the student] about that to like, to see if he is, like grasping this? "
Focus on student thinking	FPs reason about student thinking without considering the implications for teacher thinking and learning.	"Because, you know, my thought when, I think [the student's] name is Rushdee, is explaining… is essentially like if you drew a square, and you grab the corner and extended it."
Other	FPs focused on a topic that was very loosely or not connected to helping teachers learn to notice.	"I think [the PST] tags are also a lot shorter than ours [from our video clubs]."

Findings

Over the course of the FP-D, the FPs' focus changed from mostly discussing how to maintain any general conversation between teachers to considering teachers' noticing process, particularly their SA and KBR. Table 3 shows the different areas of focus from the idea units in all the discussion recordings in Sessions 2-5. We argue that this change in focus to teachers' noticing process is evidence that FPs' collective framing shifted away from *supporting a productive conversation* and that *noticing teachers' noticing* became more stable. Below, we present a series of vignettes to gain a more detailed understanding of how the FPs' framing shifted over the F-PD.

Table 3.

Focus of FPs' Discussions During F-PD

	Productive conversation	Support SA	Support KBR	Consider teacher knowledge	Support responding	Focus on student thinking	Other
Debrief 1 (In Session 2) 4 idea units total	3	0	0	0	0	0	1
Debrief 2 (In Session 3) 6 idea units total	3	3	1	1	0	0	1
Session 4 10 idea units total	0	4	5	3	2	1	1
Session 5 17 idea units total	0	9	11	3	1	3	3

Facilitator Debrief 1: FPs Focus on a Productive Conversation

Facilitator Debrief 1 was short in comparison to other discussions in the F-PD, it was approximately 10 minutes. The length was due to time constraints, we over planned our first session, which we corrected as the F-PD progressed. Though the conversation was shorter, three of the four idea units were devoted to discussing aspects of a video club conversation that could support any conversation and not one specifically about noticing student thinking. None of the idea units focused on teachers' noticing process (see Table 3).

Debrief 1 took place right after the FPs participated in a video club, Margaret facilitated. Margaret gave the FPs The Talk Moves Framework (van Es et al., 2014), and some time to familiarize themselves with it. As FPs read through the framework, Margaret asked them to consider the following questions related to her facilitation of the video club in which they just participated:

- Are there places where you remember me doing any of these moves [in the video club that you just participated in]?
- Do you have questions for me on what I did/decisions I made?
- Looking back at yours and other tags, how might have you used these moves?

When the FPs started to discuss the above questions, Todd said (note: “you” refers to Margaret):

> **Todd:** So I thought that the very beginning of [the video club], like, the setup today, we, I think you did a good job of launching, if you did, you did some of the moves for launching, we were able to talk about some of these things, kind of hammer out some of the questions that we had. And, yeah, so we were able to move forward without having to stop and ask more clarifying questions later.

Faith followed Todd’s comments:

> **Faith:** I got you, I have eight things circled on my list thing here. I'm not gonna say all eight, because I definitely want to share the, share the air. One thing I noticed [from the framework] though, for "prompting participants to explain their reasoning more and elaborate on their ideas," is one that really stood out to me. And then "inviting participants to share different ideas," you sort of were like, "Oh, let me go back to the pin. I saw Max that you said this in the pin, like, can we [discuss that]?"
>
> **Margaret:** Yeah. Faith, and to your point, with the, with the pins, like, I really have noticed that that's helpful in sort of bringing people into the

conversation. So yeah, if someone brings something up, and then I'm like, "Oh, someone else pinned something about that, too." Like, and then that can bring them in to talk about that as well. That's definitely something that I was trying to do. Yeah, for sure.

Max responded to Faith and said:

Max: I wonder if that, that latter thing about bringing up people's pins also could fall under the "validating participant ideas" heading as well? Because, because I certainly felt validated when you were like, "Max noticed... blah blah blah."

Margaret: That's, that's a great point, too. And I think, yeah, I think you're right, Max, when like, I've done other sort of, analyses and stuff that comes up where it can serve double purposes. I think the other thing I was trying to do when you did that is sort of a lifting, lifting up, like I was like, "Oh, this comment that Max has kind of gets at one of my goals in the video club. And so like, let me throw this out for the group."

In these instances, the FPs focused on how the talk moves can progress a conversation, in general. Todd discussed how Margaret made the conversation clear by ensuring that everyone understood the focus from the beginning. Faith mentioned talk moves that Margaret used to push participants to explain their ideas and to engage participants. However, Faith did not explain how these moves might specifically support the participants in learning to notice. Max also mentioned that he felt that Margaret validated him during the conversation. While it is important to make people feel validated and included during video clubs, Max did not explain why

Margaret might have highlighted his pin to help him and others learn to notice. He only mentioned that it made him feel as if he had done something right.

Framing and Explanation for Debrief 1

During Debrief 1, the FPs focused on how the talk moves could support a video club conversation that teachers could easily follow and, would allow teachers to share, and would allow teachers to feel they were heard. Given this conversation focus, we argue the FPs framed leading video clubs as *supporting a productive conversation.* That is, FPs understood leading a video club as working to maintain a productive conversation, in general, but not necessarily a conversation that supports teachers to learn to notice.

There are multiple potential reasons for this framing. First, the Talk Moves Framework focuses on actions that can support a discussion in *any* video-based PD. It is not specific to video clubs or supporting teachers to learn to notice. Given this more general purpose, the FPs might have been primed to only look for how the talk moves progress a conversation, and not how they can be used to specifically help teachers notice student thinking. Margaret's prompts also likely contributed to the framing. The prompts were general and largely focused on her as the facilitator. In other words, the FPs were asked to talk about maintaining group conversations, in general, and were given a tool to help them do so. In response, the FPs did what they were asked.

In addition, Margaret missed opportunities to shift FPs' focus to teachers' noticing process. Margaret mostly revoiced and expanded on FPs' comments but did not push them to connect their contributions to teachers' noticing process. Given

these events, we refined the F-PD design prior to Debrief 2, which is described in the next section.

Facilitator Debrief 2: FPs' Discussion Focus was In Flux

FPs' focus on the conversational aspects, rather than the noticing aspects, of leading a video club discussion was not surprising to us. We came to a similar conclusion when we met and reflected on Debrief 1 prior to implementing Debrief 2. For Debrief 2 in Session 3, we changed the activity. We pared down the Talk Moves Framework to focus on moves that we thought best supported noticing student thinking. We also changed the examples in the framework to excerpts from Video Clubs 1 and 2. We reasoned that the FPs would be more familiar with the circumstances of those video clubs since they were participants, which might help them connect the talk moves to noticing student thinking. We also developed more focused discussion questions that explicitly addressed using the talk moves to help teachers learn to notice. At the start of Debrief 2, Margaret gave the FPs the pared-down framework and asked:

> So how do these moves specifically help teachers notice student thinking in the classrooms? Support them to start to shift to do that? Because like I said, I think you could use, you can use these moves for a lot of things with video discussion. You can use them to talk about teachers, you could use them to talk about all sorts of things. So how do these help us specifically try to center students or get teachers to try to center students in the classroom?

At first, the FPs continued to focus on how to sustain a conversation in general. However, by the end of Debrief 2, the FPs more consistently focused on

aspects of teachers' noticing process, including SA, teacher knowledge, and KBR. Several excerpts of the conversation indicate this shift. First, Faith opened the conversation by saying:

> **Faith:** I, I think, you know, there are all these, like, phrases in teaching where they say, "Whoever is doing the talking is doing the learning." And I feel like as a teacher, we might think we understand what somebody means, in some way based, even like our own understanding of something, kind of like what Libby was talking about earlier. And it isn't until students really start to talk that we get a better understanding of what they're thinking. And so I think a lot of these moves- lifting up, pointing to evidence, connecting ideas of students- allows students opportunities to either say more or repeat in a different way, ways that they're thinking or they're conceptualizing what's happening in the classroom.

Here, Faith initially discussed the talk moves in terms of how teachers could use them with students. Margaret clarified that the prompt was about how a facilitator could use the talk moves to support teachers to notice student thinking. Faith's response was:

> **Faith:** So, um, I do think it's similar, though. Same thing, if you get teachers talking, you can understand how they conceptuali-, like, what just happened [between Margaret and me].

While Faith mentioned that getting people to talk helps to understand their thinking, her comments were general and seemed to point to using the talk moves to give individuals opportunities to express themselves or share out. Her comments did not

refer to components of teacher noticing that facilitators should notice when they lead video clubs (e.g., KBR, SA, etc.)

Thornton followed Faith's comments by discussing his difficulty in understanding how the talk moves specifically support teacher noticing. Below is the exchange between Thornton and Margaret:

> **Thornton:** So, I think, thinking about this and kind of this, like, meta way of, as a facilitator, I think the, I think where, I'm struggling is that, and as, [Margaret], you've been very upfront about, like, all of these moves are great. I don't know if any of them particularly helped to notice student thinking as opposed to helping, like, I think, as you said, this is kind of like, a generic framework you can kind of use for if you were looking at teacher questioning techniques, or like, I don't know, like, the best way to crochet a scarf techniques. I mean, like so I think I'm struggling a little bit with the like, I don't know if I exactly see how, um, specific, I don't know if there's specific things that are like, would be particularly helpful for noticing student thinking. But these are all great for just, like, general facilitation.
>
> **Margaret:** Yeah. Yeah. So like, one, great, and that's like, why I want to have this discussion, Thornton, so like, thank you for pointing this out. Um, because yeah, like, I have thought a lot about well, yeah, how does this support [noticing] student thinking specifically? Um, so, like for example, if we take the like that first facilitation move [in the framework], highlighting. So like "directing attention to noteworthy events in the video." So, for example… [in Video Club 2] when I was facilitating, I like pointed out, kind

of, particular instances in the video and then asked you all what you thought of them. Um, and kind of, how, do people have ideas, for example, of how that might support teachers to, like start cent- to like center student thinking?

Thornton stated the challenge he faced when attempting to apply the talk moves to supporting teachers to notice. He did not see how these moves help teachers develop their noticing skills, as opposed to learning about anything else. Margaret responded to Thornton by pointing to a specific talk move and indicating how she used it in a video club with the participants. She also asked a question to encourage the FPs to relate the talk moves to supporting teachers to learn to notice student thinking ("do people have ideas, for example, of how that might support teachers to, like start cent- to like center student thinking?") In addition, Margaret reminded participants of their experiences in a video club. If participants thought about how a talk move impacted their noticing of student thinking, they might be able to apply that thinking to understanding facilitation. Indeed, Libby began to apply her video club experience to facilitation. Her response to Margaret also started to focus on components of teachers' noticing process:

Libby: So I think that, first of all, maybe not highlighting, but what was the one that I was looking at? Uh, or highlighting. It's that there are things that other people notice and tagged in the video that I wouldn't necessarily notice. And having these discussions and these, reinforcing, um, themes, allow me to see more of what I missed. And that's easier to do in a [video] than it is in a [classroom] where you can rewind, and you know, pause.

Libby spoke of her experience in the video club and how Margaret's highlighting moves and the subsequent video club discussion made her more aware of student thinking that she missed. Libby's comment referred to how a facilitator can support SA. Margaret's actions as the video club facilitator contributed to Libby's realization that her SA was limited and could improve. In other words, Libby moved beyond discussing highlighting only as a way to sustain a conversation. Libby's response began to shift the conversation to how talk moves support different aspects of teachers' noticing process, which we argue can support teachers in video clubs to learn to notice.

However, the focus on supporting teachers' noticing did not immediately stabilize during the conversation. A few turns of talk later, Libby returned to Margaret's use of highlighting and linked it to collaboration during video clubs:

> **Libby:** [Highlighting] also sets the stage too for us, like by doing this last time, you set the stage for how we can then, like, using highlighting be like, "Oh, that's a great point, or like, I noticed this," and then it allows us to collaborate in a way that you, you know, built the skeleton for last time as the facilitator.

Libby commented that Margaret's use of highlighting provided a structure for the video club conversation that video club participants could use as a model for subsequent interactions with one another. While Libby still referred to the framework, she shifted back to discussing highlighting as a way to maintain the conversation without a connection to helping teachers learn to notice. Margaret responded by redirecting the conversation back to the original discussion question and Thornton's

challenge with the question. She pointed to another talk move, pressing, which is when facilitators ask teachers to further explain an idea:

> **Margaret:** Yeah, that, that makes sense. What about, I want to look at a couple of these other moves like, pressing, for example, because I think, getting back to like, Thornton's original question, too, is still, like, a good one. And like, how, like for pressing, you could do that with, again, a lot of conversations, right? Like, I could press you on your thinking about, yeah, how to crochet a scarf. But why? And kind of like, what instances does it help teachers, think about student thinking or center student thinking? Any ideas about that? Yeah, Todd go for it.

Todd's response referred to the example that accompanied pressing in the pared-down Talk Moves Framework:

> **Todd:** So I just, you know, this is a really, the example [in the framework], it's really interesting to me, because it's so you know, "Pick apart what the student's thinking about in this moment." And like, like, part of me is like, well, you can't really know what the student's actually thinking. Right? But like, on the other hand like, like, that could be instructive for teachers as well to be like, "Oh, well, I know what the student's thinking." And another teacher might say, "I interpreted that differently."

Todd accepted the redirection from Margaret to focus on how talk moves support teachers to notice student thinking. He said pressing might help teachers discuss their different interpretations of student thinking, which relates to supporting teachers' KBR. For the rest of Debrief 2, the FPs largely continued to discuss how talk moves

could support teachers' noticing of student thinking, particularly in terms of teachers' SA.

Framing and Explanation for Debrief 2

The excerpts above indicate that the FPs' conversation focus was in flux. At first, the FPs continued to focus on surface-level characteristics of any discussion, like making sure everyone can share out. However, by the end of Debrief 2, the FPs more consistently centered components of teachers' noticing process. We suspect that this change indicates that the FPs' framing was unstable and possibly began to shift from *support productive conversation* to *noticing teachers' noticing*.

The framing instability potentially happened in part due to Margaret's efforts to steer the conversation toward supporting teachers to learn to notice. FPs' responses to Margaret likely also contributed. In the excepts above, there are two instances when FPs' focus changes. The first was when Thornton posed his question about whether the talk moves specifically help teachers learn to notice. His statements suggested that he understood facilitation of video clubs should be about more than leading a productive conversation. However, he did not yet know what facilitators look for as they lead teachers in discussions about student thinking. Thornton's framing of leading video clubs could have been unstable, and he might have been moving away from the *support productive conversation* framing to something new.

Margaret responded to Thornton's uncertainty by pointing out a specific talk move, highlighting, and asking the FPs to connect it to helping teachers learn to notice. Libby answered Margaret's question and talked about teachers' SA, which might have served as an example to other FPs, who later discussed other talk moves

and their connection to teachers' noticing process. Here, Libby might have introduced the *noticing teachers' noticing* frame to others, though it lacked stability.

The second moment of instability was when Libby shifted back to talking about how to use talk moves only to support general aspects of a conversation, like collaboration. Margaret responded by referring to Thornton's original question as a bid to refocus the FPs on supporting teachers to notice student thinking. Margaret also posed a new talk move, pressing, to discuss, which Todd took up. This exchange is significant because it shows how the group's framing potentially began to shift. Libby's comments seemed to indicate a *support productive conversation* framing. However, Todd accepted Margaret's redirection and focused on teachers' KBR, suggesting that the *support productive conversation* framing was less stable than it was in Session 2.

Todd's contribution about pressing and teachers' KBR was similar to Libby's initial comments about highlighting. He explained how the talk move could substantively contribute to teachers learning to notice in terms of allowing teachers to share and compare different interpretations of student thinking. Todd's comments might have better stabilized FPs' *noticing teachers' noticing* framing. For the rest of the conversation, the FPs largely discussed how video club facilitators do more than maintain a conversation between teachers and intentionally act to support teachers' noticing process.

In addition, the pared-down Talk Moves Framework and the more focused discussion prompts also likely contributed to FPs' less stable framing. For example, Thornton's confusion was in response to Margaret's prompt "So how do these moves

specifically help teachers notice student thinking in the classrooms?" We contend that the prompt encouraged Thornton, and likely others, to think about why the talk moves could be helpful for supporting teachers to learn to notice, as opposed to helping teachers learn anything else. Thornton tried, with some initial struggle, to do what was asked, as evidenced by his confusion.

In addition, Todd referred to an example in the framework that accompanied pressing. Todd's comment could mean that the pared-down framework was less overwhelming with fewer distractions, which allowed Todd to more easily identify talk moves and their specific connection to leading video clubs. The example was also from a video club in which Todd was a participant, which could have provided a helpful context for Todd to better connect the talk moves with teacher noticing.

In sum, as Margaret was more intentional in foregrounding the connection between the talk moves and teacher noticing, and as we modified the F-PD to do the same, the FPs began to focus on teachers' noticing process and, we posit, began to understand leading video clubs as *noticing teachers noticing.*

Session 4: FPs Primarily Focus on Teachers' Noticing Process

In Session 4 the FPs did not talk about ways to lead a productive conversation and instead largely focused on teachers' noticing process (Table 1). Participants mostly discussed how they might support teachers to develop their KBR, how they would need to consider teacher knowledge or experience while leading video clubs, and how they might support teachers' SA.

An excerpt from early in the first activity in Session 4 is characteristic of the overall discussion for the session. The objectives for F-PD 4 were about planning for

a video club discussion. The first activity was to create goals for a video club. The FPs were asked to identify the important math topics and student mathematical thinking in a pre-selected classroom video and then develop possible goals for a video club. The video was of an Algebra I class discussing whether the graph of $f(x) = \sqrt{x}$ can ever have negative x-values. The students in the class considered the question by looking at what inputs can be plugged into the equation and by predicting what points with negative x-values would look like on the graph.

The FPs shared their goals with one another via a Jamboard (jamboard.google.com), which is an online workspace, and discussed them. Below is an excerpt related to the goal that Faith wrote. Faith's goal was, "Teachers will be able to notice when students are grappling with transition from function thinking to graphical thinking:"

> **Margaret:** Can we go back to Faith's [goal]? A few people have [agreed with] the first one Faith wrote, which is this [one] that says, "Teachers will be able to notice when students are grappling, grappling with transition from function thinking to graphical thinking." Faith, or any of the [people who agreed], do you want to kind of talk to, speak to, kind of, your thinking on that one? And why you think it should be a goal?
>
> **Faith:** Um, yeah, so, so I was thinking about, or I really would like to point to a piece of evidence. And I want to say it was in the beginning of the video, but I'd have to rewatch it to say it specifically. But just hearing students talk about, like one said, like the graph, they talked about the graph being sideways and then it would only be the top part of the graph because of how

the, sort of, rule around square roots work. So like, they're, they're the, to me, I would want teachers to notice that there are these two ways that students have to move between in order to answer the question. And the two ways is thinking about what are the, what happens with the function? What happens to inputs when it goes into the function that come out? And what does it look like on a graph? That's what I thought, that's what I was trying to say.

Margaret: Yeah.

Faith: With my goal.

Here, Faith's focus was on supporting teachers' KBR. She pointed out that the students in the video thought about both the numerical representation ("what happens with the function? What happens to inputs when it goes into the function that come out?") and graphical representation ("And what does it look like on a graph?") of a square root function. Faith wanted teachers to understand how students formulate questions about the different representations and make connections between the two. Said differently, Faith wanted teachers to use their KBR to interpret the ways that students applied their understanding of function representations to find the restrictions on the function's domain.

As the conversation continued, other FPs and Margaret responded to Faith's ideas. Libby made a bid to talk about students' strengths, which could have changed the focus of the conversation to student thinking, without considering teachers. However, Margaret redirected the conversation back to focus on teachers, which Todd accepted:

Libby: I was gonna say, like, Faith mentioned, the two ways that students have to think but also I think, for some students, it is easier to think in one way than it is in another. Like, there's the one girl who, like, traces the graphs repeatedly… And I think for her, it might be easier to visualize it. And then there are other students who were, like, very invested in figuring out, like, this squared versus the square root and that might be easier for them to understand the problem in that way.

Margaret: Max, your question [in the Zoom chat], "Does this fall under a coordinating different representations type of math practice?" What do folks think about that?

Todd: Yeah, actually, I mean, that's something I was thinking about when I [agreed with Faith's goal] was that, you know, I think it really crystal- not crystallizes, but it gives a concrete example of, like, this student's going back and forth between two representations. Like, having teachers make sense of what's going on, I think is [trails off].

Todd thought that teachers should make sense of how students moved between two different function representations, which kept the focus on supporting teachers' KBR. Faith then returned to Libby's idea and said she would want teachers to consider whether students must understand the problem through multiple representations:

Faith: To Libby's point, though, I guess I will, this isn't necessarily a goal. But if I were trying to be a principal, and I was facilitating this, I would want to ask teachers what they think about if students do have to go back and forth

or can they have only one way of thinking and still answer the question, I would probably want them to engage with that.

Faith's focus remained on supporting teachers, but she addressed a different aspect of the noticing process, teachers' knowledge. Faith would ask teachers to engage with their own knowledge of instruction and decide whether the students in the video could depend on just one functional representation to understand the task.

Next, Max continued to focus on teachers' knowledge. Max wanted teachers to recognize the importance of different mathematical representations. To him, they are not simply two ways to express the same mathematical concept, but require students to think in different ways:

Max: That connects to something that I was thinking about, the way that, that Faith put it. So as opposed to talking in terms of, like, different representations, which is, I like the emphasis in Faith's formulation on thinking, and that, it's not just, these are different types of thinking. It's not just going back and forth between different ways of representing the same thing. It's, it's, there's more to it than that. And I think that actually gets at something that I find a little, that's been, like itching me about that phrasing in general, in terms of math practices, which is that there's more to it than just like, "Oh, these are two different thing- two different ways of representing the same thing." You know?

Faith: It's a good point.

Margaret: Yeah.

Faith: So we're keeping that as a goal then. Keeping that one [other participants laugh].

Framing and Explanation for Session 4

This excerpt is typical of much of the discussion in Session 4. We argue that FPs' primary framing of leading a video club in Session 4 was as *noticing teachers' noticing*. Overall, the conversation centered around how to support teachers to learn to notice. The FPs largely addressed teachers' noticing process, even if individually they addressed different components of that process.

The FPs appeared to initiate and maintain the *noticing teachers' noticing* framing without Margaret. Faith began the conversation by focusing on teachers' KBR, which was different from when she opened the conversation in Debrief 2. When Faith opened the conversation in Debrief 2, she focused on getting teachers to share out, implying that she framed leading video clubs as *supporting productive conversation.* However, early in Session 4, Faith already focused on teachers' KBR without any direct prompting. Margaret asked a question but did not explicitly refer to supporting teachers' noticing.

In addition, although Libby could have changed the focus to student thinking, rather than teacher thinking (an issue that will be addressed further in the next section), a brief intervention by Margaret kept the focus on teachers. Todd, Faith, and Max then maintained the *noticing teachers' noticing* frame, while building off each other's and Libby's comments. It is also notable that Libby did not protest Margaret's redirection back to a teacher focus, and stayed quiet while Todd, Faith, and Max talked. It is possible that she understood she might be interrupting "what was going

on there" for the group and decided to listen as other FPs talked about supporting teachers to learn to notice. These interactions, mostly independent of Margaret's input, likely indicate that the FPs' framing of facilitating video clubs as *noticing teachers' noticing* had become more stable, and they needed less support from Margaret to perpetuate it.

A possible reason for this more stable *noticing teachers' noticing* framing is that the tasks in Session 4 were: (1) making goals for teachers and (2) practicing how to analyze PST tagging data. Since both tasks already had a teacher focus, it may have been easier for the FPs to immediately frame leading video clubs as the *noticing teachers' noticing.* Thus, the FPs needed less intervention from Margaret and could instead build their understanding of video facilitation by interacting with each other. These sorts of exchanges continued in Session 5 as FPs reflected on planning a video club.

Session 5: FPs Envision Leading a Video Club Discussion

Session 5 was a final discussion during which FPs reflected on the process of video club lesson planning using PST tags. As seen in the first two excerpts below, FPs focused on different aspects of teachers' noticing process in ways that were both similar to and different from Session 4. However, as seen in the third and fourth excerpts below, there were also moments when the FPs primarily focused on student thinking, without considering how they might talk about that thinking with teachers.

The homework assignment from the previous session was to make a video club lesson plan using a pre-selected video, corresponding PST example tagging data, and a lesson planning template (Appendix B). The video featured a high school

geometry class grappling with the question *if the perimeter of a polygon changes by a factor of* n *why does the area change by a factor of* n^2*?*

The first excerpt is like those in Session 4 when the FPs referred to different aspects of teachers' noticing process. At one point in the discussion, the FPs talked about how they found it challenging that the PSTs tagged at a number of timestamps but did not leave comments. Nicole responded to a question from Margaret and said that if she were leading a video club with the PSTs, she would prompt them to explain their tags:

> **Margaret:** I want to, so one thing that Nicole touched on kind of a little bit… and a few other of you sort of touched on when I was looking through your [lesson plans] is yeah, this idea that a lot of [the PSTs'] tags, say nothing, right? Like, like they just tagged there. And so kind of, what do you make of that? And like, how did that work for you in planning? And what would you do with that?
>
> **Nicole:** I think for me, the first question that I would ask [the PSTs] if this is what they tagged is like, "Okay, like, now go back and watch the video again. And like, tell me why you tagged, like, what was important in those moments that you tagged? Other than just like that was when a student was talking…" And then use that to build conversation. Because again, I'm making conjectures about why I think they've tagged things based on conversations that we've had about this video.

Nicole's comments related to supporting PSTs' KBR. Nicole explained that she would ask students to interpret, rather than simply point out, moments of student thinking.

Other FPs built on Nicole's idea. Thornton agreed with Nicole that there were tags with no comments, but also saw an opportunity to push the thinking of PSTs who did comment. Thornton focused on several PST tags about a student in the video who seemed to confuse the meaning of 3^2 and 3^3:

> **Thornton:** I also think that there were the empty tags, which were an issue, but then, like, early on the, the one girl, that was the discussion of three squared versus three cubed, like some of the [PST tag comments] were, like, "Doesn't know the difference between" or like, you know, "Confused about the difference between three squared and three cubed." And it's like, yes, okay. You've summarized the plot… But that doesn't really tell us anything about like, what are you like, sort of like noticing is above and beyond just stating what is happening right now? Because like, a bunch of people tag that little, like, section. And so it's like, okay, so what do we actually take away from this about student thinking? And like, what does this have to do with? Like, how do we connect this to the larger topic at hand about like, areas and scale factors and all this other stuff? Yeah.

Thornton added to Nicole's idea and said he would not only ask the PSTs to comment on their tags, but he would also ask them to interpret student thinking in relation to the mathematics in the problem. Thornton recognized that several PSTs' comments merely stated what happened in the video, the student confused 3^2 and 3^3. Thornton

said he would ask PSTs to make connections to the broader math concepts from the lesson. Thornton noticed an opportunity to develop PSTs' KBR and thought about supporting PSTs to formulate more sophisticated interpretations of student thinking that connect to math teaching and learning.

As the conversation continued, Thornton discussed PSTs' SA and KBR. Margaret asked Thornton a question and he responded by talking about how he would address moments in the video when some PSTs tagged and some did not:

> **Margaret:** So Thornton, is that kind of the, like, is that, kind of, the question you might ask, like? Like, like, how do we connect [the math in the task] to what the students are talking about? Or? What do you think you might like, like, how would you deal with that?
>
> **Thornton:** I would say a lot. Four of you tagged this. What, what about this did you notice? How do you think that, like, what about the student thinking here was interesting? And then I would say for the two of you that didn't tag, why do you think four of your colleagues tagged this? What do you think they might have found interesting?
>
> **Margaret:** Yeah.

Thornton again addressed PSTs' KBR and said he would push them to better explain why they tagged at particular time stamps. He also focused on PSTs' SA by considering the PSTs who may have missed an important moment of student thinking. Thornton said he would ask the PSTs who did not tag a particular moment to think about why other PSTs might have tagged there. This question could draw the

PSTs' attention to the moment and might also support their KBR if they began to interpret how that moment was important for students' math understanding.

Nicole's and Thornton's comments demonstrated a continued focus on teachers' noticing process, particularly as it pertained to the mathematics in the videos. However, the FPs also began to think about other aspects of instruction that contribute to teachers' noticing, like how to equitably notice. This became apparent as FPs discussed another challenge they faced while analyzing the PST tags and planning their video clubs. One of the example PST tags in Anotemos marked a moment in the classroom video when a student, who was white, came to the chalkboard and demonstrated how a square expanded to become four times its original size as the sides doubled. Moments before, another student, who was is not white, gave what could be interpreted as an explanation similar to the white student. The rest of the class and the teacher in the video gave more recognition to the white student by clapping. The PST's corresponding tag said, "not the white student taking credit for the minorities student's idea."

Thornton and Max first addressed this tag and said:

> **Thornton:** I also struggled, because I think the most interesting comment was the very last one, about how the, like, white kid stole the thinking from the student of color. And I was like, okay, that's really interesting. I don't know how, like, what to do with that in the context of student thinking. But like that, if I was just thinking, like, if I was facilitating this, I want to circle back to that, even if it wasn't, like, directly related to kind of whatever the larger goal for this session was, if that makes sense?

> **Max:** I was thinking about that. And I agree that it would be, I think it would be worth definitely worth talking about… I would want to, like, say something like, "Oh, you said something really interesting at the end. I was wondering, would you mind telling us what you know, where that, what you were thinking about that?" Or something where it's not putting that, that pre-service teacher on the spot and giving them the option.

Several other FPs expressed confusion over the PST's tag and what it meant, including Nicole. Then, Nicole said:

> **Nicole:** So [the tag] just it just, it brought my like, got me thinking of like, as a, I would, if I were leading this, I would also want to, like, talk to [PSTs] about like, how we position student's positions, their thinking and like this idea of equity, and who are we noticing and why are we noticing what particular students say over others?

Thornton initially struggled with how he might address the tag but expressed that he knew it would be an important moment for the PSTs to discuss. Max said that he would respond to the tag and would ask the PST to explain further. Nicole was the most explicit in how she would use this tag to support PSTs' noticing. Nicole's comment focused on teachers' SA, but not just from a mathematics perspective. Nicole would ask PSTs to be aware of both to *what and whom* they attend during instruction and to question their noticing practices to ensure inclusivity. She pointed out that issues of equity contribute to teachers' noticing and that video club facilitators need to consider these issues when leading discussions.

Temporary Shifts in Focus

While the FPs primarily focused on teachers' noticing process in Session 5, there were moments when their conversation shifted to other topics. These moments happened when FPs worked to make sense of student thinking in the classroom video for themselves and stopped considering how they would engage with PSTs.

In the first case, Margaret redirected FPs back to focus on leading the video club with PSTs. For example, shortly after Nicole's, comment about student positioning, Faith shifted back to discussing how PSTs might make sense of the mathematics in the video. Faith also referred to the video moment and the PST's tag related to the white student's and the student's of color ideas:

> **Faith:** Also, when I looked at that [moment in the video], I was very confused by the last couple of tags… Because like, when I saw it, I didn't think that [the students' thinking was] exactly the same. I thought one was talking about, like, length and dimension, and the other one was talking about, like area, like constructing more area… then I could use the tag to talk about student thinking if that were the case. But I would need to ask, kind of like Max said.

Here, Faith mentioned her own interpretation of the students' thinking, but she also focused on the PSTs and her concern with how they understood the student ideas in the moment. Margaret then asked Faith what specific questions she would ask and Faith replied:

> **Faith**:… I would like to hear, like, who's, who took whose idea? And what about their ideas mathematically are connected? Like, what, how do you see those two [ideas] as connected? How do we see them as disjoint? And does

anybody see them as disjoint? And I would open that up to everybody. Because the ways in which they're explaining it, yeah, there could be some similarities, but I see them as very different. I would be interested to hear, like, what other people are thinking.

Again, while Faith alluded to her own interpretation of the student ideas, her primary focus was on what she would ask PSTs to support their SA and KBR. However, Libby shifted the focus to the students in the video as she replied to Faith:

> **Libby:** I see where [Faith] says that [the students' thinking is different]. And I completely agree. Because, you know, my thought when, I think his name is Rushdee [the student of color], is explaining… is essentially like if you drew a square, and you grab the corner and extended it. So now you have a square with a larger set of sides… he didn't ever… construct four squares… And so to me, those were very distinct ideas.

Here, Libby gave her interpretation of the student ideas in the video. Her comment did not foreground the PSTs and it was almost as if she was participating in a video club, herself.

Max's response to Libby continued to focus on the students:

> **Max:**… But the more I thought about what was going on with those two students, the more different they seem to me, like Rushdee… I think, like, he was making connections to the area formula. And he was making and he was speaking much more generally, like, he just talked about increasing both, both dimensions by like, multiplying by them by the same number. And then like, he goes back and uses the calculator to give a specific example. But that's

after he stated this very general way of talking. And then what Cameron [the white student] is doing, is, is really just like, it's like a it's a geometric demonstration of one particular application of what Rushdee was saying.

Margaret: And so then, Max, are you sort of saying you, you might question in a similar way that Faith did?

Max: Yes. Sorry. Last point. Yes.

Margaret's question moved Max's focus to leading PSTs in a video club. Afterward, other FPs shifted back to talking about the PSTs.

Margaret had more difficulty redirecting the FPs the second time they shifted their focus to the students in the video. This shift occurred when Margaret asked about a different video moment. In the video, one student, Jasper, explained that the reason the area of a polygon changes by n^2 is because both the length and the width get multiplied by n when the perimeter increases. Another student, Jessica, asked Jasper to repeat his idea. Jessica then tried to repeat Jasper's idea back to him, but Jasper did not completely agree with Jessica's explanation:

Margaret: So in your protocol, Todd, and someone else brought this up too, I think, Libby, you also brought this up. The part, there were tags around the part where Jasper and then [Jessica] are kind of going back and forth. And it seems like, you know, [Jessica] is trying to articulate Jasper's idea. And they're kind of having a discussion. Both of you pointed out that you might ask questions around that. And I'm kind of wondering, yeah, what'd you think of that moment? And what opportunity is there with teachers or pre-service teachers?

After some clarification questions from the FPs, Todd responded:

> **Todd:** So I feel like, you know, [Jessica] seemed like she was trying to like, I don't want to say clarify, but maybe like revoice what he was saying. And, as far as I could tell, like, it was pretty much what [Jasper] was saying. And he like, wasn't like, "Yep, that's what I meant." He like, continued to, like, express something that I think then ended up being a little different. And so it made me wonder, like, what, what actually is his grasp on this concept? You know, he, he described it very well, when he was talking about it in terms of dimensions, and you know, initial description of it. But then when he was like, correcting what Jessica was saying, like, then it sounded like maybe he was a little like, there was a little bit of something that like, he wasn't connecting… So then like, following up with [the PSTs, I would ask] how would you, like, reengage Jasper about that to like, to see if he is, like grasping this? And in like, the way we initially thought that he was?

Todd initially discussed his interpretation of Jake's thinking, which was part of Margaret's prompt. However, he ended by discussing the questions he would have for PSTs, which would ask them to consider how they would respond to the two students' interaction. Todd's questions indicate that he still focused on PSTs and their noticing process, particularly how they might respond to the two students.

Libby then spoke about the students in the video. Margaret responded by asking Libby what she would ask the PSTs:

> **Libby:** Yeah, I mean, I don't know, the dynamics of the class, because I think that definitely plays a role in how students respond to each other's thinking.

So I have no idea what the personality stuff is going on between those two students, but it definitely seemed like as soon as [Jessica] started to revoice… what [Jasper] was saying, it was almost like… the need to just almost, like, justify [his] own idea…

Margaret: Okay, so that makes sense. So, would you, how would you approach that with the pre-service teachers then? Like, what would be, like, your move?

Libby: I think I would ask them what they thought was going on at that point. And then, obviously, everyone sees things differently. So like, that's how I saw it. People could also have seen it as, like, two students collaborating over a complex topic. And that's obviously, like, just as fine of an opinion. Um, I think then you can ask like, how would you handle students, like, discussing their ideas?

Even though Libby initially focused on students, Margaret was able to guide her back to considering how she would lead PSTs in a video club. However, in a few turns of talk the focus again shifted to the students:

Todd: I think the other thing with this situation is now I'm thinking more about it as like, you know, this is a situation where students are, are in the process of negotiating with themselves and with the class and the teacher, like, how they understand what's going on. So, like in Jasper, not like immediately accepting what Jessica, what was her name?

Margaret: We'll call it, I'm pretty sure it's Jessica.

Todd: Okay. Like, like imme- not like immediately accepting it, maybe he's still like, navigating this, this, this thing where he's still trying to make sense. And he doesn't want to, like, immediately say, "Yep, that's exactly what I saying." Because he's like, "Well…" So like, that could be another way to think about it, too, is like, kids who are students who are like, interacting with this for the first time, perhaps, and, you know, so trying to figure out nuances and things like that.

Margaret: Yeah.

Thornton: Yeah. It's like the communication around the math itself. And then the communication between the students. And how do you translate what the one student said into, like, your understanding of the math? I mean, so it can get-

Todd: Totally.

Despite Margaret's intervention with Libby to maintain a focus on the PSTs, Todd and Thornton again turned the conversation to only the students in the video. The difference between Todd's contribution here and his first contribution in this vignette is that he never related his interpretations of student ideas back to working with PSTs during a video club. Likewise, Thornton's response only referred to the students. For these few moments of the conversation, the FPs foregrounded understanding student thinking over considering teachers' noticing process.

Framing and Explanation for Session 5

In Session 5, the FPs primarily focused on teachers and supporting them to learn to notice, though there were instances when the FPs reasoned about the student

thinking in the video club video. Based on this evidence, we argue that the FPs' *noticing teachers' noticing* framing was largely stable, though there were interruptions. Within this framing, FPs seemed to continue to understand their role of leading video clubs as supporting teachers' noticing process and how it related to the mathematics in the video, like in Nicole's and Thorntons' comments about encouraging PSTs to include more detail in the tags.

There was some evidence that the FPs also began to consider how to support PSTs to notice in equitable ways, though many of them appeared to struggle with how to incorporate that aspect of noticing into their *noticing teachers' noticing* framing. Both Thornton and Max seemed to understand that the PSTs' tag about the white student and the student of color would be important to address with teachers, but they were potentially unsure of how it fit into their current understanding of leading video clubs. It is possible that Thornton's and Max's understanding of the *noticing teachers' noticing* framing did not yet include considering issues of noticing equitably. Nicole, on the other hand, thought that the PST's tag was an opportunity to help PSTs become aware of to what and whom they attend in the classroom, which could support PSTs' SA. Nicole seemed to maintain the *noticing teachers' noticing* framing because she understood that SA could apply to more than only attending to content.

Like the activities in Session 4, the lesson planning assignment and Session 5 discussion foregrounded teachers. Thus, the tasks related to Session 5 also likely made it easier for the FPs to understand leading video clubs as *noticing teachers' noticing.* Said differently, in Sessions 4 and 5 the FPs were asked to focus on teachers

and they did. In doing so, they addressed different components of teachers' noticing process, which, we argue, shows that the FPs largely framed video club facilitation as *noticing teachers noticing.*

Finally, while the *noticing teachers' noticing* framing was generally stable in Session 5, there were instances when the frame appeared to get interrupted. Margaret was initially able to redirect the FPs back to considering PSTs, but eventually Todd and Thornton returned to making sense of student thinking. Todd's and Thornton's comments seemed to indicate that, at least for several moments of Session 5, the *noticing teachers' noticing* framing became less stable as FPs worked to understand student thinking in the video. It appeared that the interruptions stemmed from FPs' uncertainty about student thinking. One possibility is that the FPs thought that their own questions about student thinking needed to be addressed before they could consider how to support teachers to notice.

Discussion and Conclusion

Video club PDs have been shown to support teachers in flexibly attending to the disciplinary substance of students' thinking. While there has been much work focused on the effectiveness of video clubs, less has been done to explore facilitation of video clubs. In particular, little work has been done to explore facilitator learning. In this paper, we investigate the process of facilitator learning. We use the Facilitator Noticing Framework to structure the analysis and guide our attention to aspects of facilitator noticing. The FNF illustrates aspects of teacher noticing facilitators might attend to, such as video club participants' selective attention and knowledge-based reasoning. Based on what facilitators notice, they will make decisions about how to

respond while facilitating the video club discussion. Potential responses include facilitator talk moves, as discussed in van Es' framework (van Es et al., 2014).

The F-PD consisted of 5 Sessions. In early sessions, the FPs focused on Margaret's talk moves. In these early sessions, the FPs primarily focused on using the moves with the purpose of keeping the discussion going and drawing people into the discussion. In terms of the FNF, this early focus was on Margaret's attention to the teachers in the PD (the blue characters in the figure) (the FPs in this case). There was less attention on the "pink box," the substance of what the teachers were noticing- what they were noticing and how they were reasoning about it. The FPs appeared to frame the facilitation moves as moves to keep the conversation going, but not to delve into the aspects of noticing student thinking- the relationship between teacher knowledge and student thinking. As the F-PD sessions progressed the tasks shifted from identifying facilitator moves to a focus on designing video club sessions to support teachers' noticing. The session activities and focus shifted from tagging and discussing talk moves to brainstorming goals for a video club and planning a video club experience based on sample teacher tags. In these later sessions, FPs' attention shifted to noticing aspects of teachers' noticing process, such as what they were attending to and how they were reasoning about it. FPs shifted their attention to the "pink box." That is, the FPs discussed talk moves in service of supporting aspects of teacher noticing- selective attention and knowledge-based-reasoning.

In this paper, we looked at these shifts in two ways. The first is through interaction. We looked at how the interaction among the FPs and facilitator impacted the way FPs framed the goals of facilitation and how their framing shifted from

supporting a productive conversation to *noticing teachers' noticing*. This shift in framing was instigated in some cases by FPs and taken up by the group with Margaret's encouragement.

We also contend that the structure of the video clubs primed particular frames (Louca, et al., 2004; Rosenberg, et al., 2006; Berland, et al., 2019). Early on, the activities focus on identifying talk moves. The FPs responded and looked for talk moves, using the talk moves framework. It is possible that the focus on talk moves, and Margaret's prompt to look for talk moves primed FPs to frame the leading video clubs as using talk moves in service of supporting a productive conversation, since that was the focus of talk moves in the provided framework.

In later video clubs, the activity shifted to identifying goals for video clubs and using sample teacher tags to design video clubs for teachers. This activity may have primed FPs to think more about the goals of video clubs- to support teacher noticing, rather than just sustaining a video club conversation. The work of brainstorming goals may have primed FPs to focus on goals, which we saw as their framing shifted to *noticing teachers' noticing*. Additionally, when they FPs had to plan a video club using sample teacher tags may have primed the them to attend to the substance of teacher noticing.

In conclusion, we explored shifts in FPs framing as they participated in the series of facilitator learning sessions. We looked at how the structure of the sessions and the interaction among participants impacted FPs noticing. Implications include the need to specifically design for this type of shift. Perhaps introducing goal setting earlier would support FPs in noticing teacher noticing rather than sustaining a general

conversation. We see our work as an important part of facilitator education. Future work can explore how to build these insights from this study into facilitator education.

References

Amador, J. M. (2021). Mathematics teacher educator noticing: examining interpretations and evidence of students' thinking. *Journal of Mathematics Teacher Education*. https://doi.org/10.1007/s10857-020-09483-z

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In G. Sykes & L. Darling-Hammond (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3–32). Jossey Bass.

Beisiegel, M., Mitchell, R., & Hill, H. C. (2018). The design of video-based professional development: An exploratory experiment intended to identify effective features. *Journal of Teacher Education*, *69*(1), 69–89. https://doi.org/10.1177/0022487117705096

Berland, L. K., Russ, R. S., & West, C. P. (2020). Supporting the scientific practices through epistemologically responsive science teaching. *Journal of Science Teacher Education*, *31*(3), 264–290. https://doi.org/10.1080/1046560X.2019.1692507

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3–15. https://doi.org/10.3102/0013189X033008003

Borko, H., Carlson, J., Deutscher, R., Boles, K. L., Delaney, V., Fong, A., Jarry-Shore, M., Malamut, J., Million, S., Mozenter, S., & Villa, A. M. (2021). Learning to lead: An approach to mathematics teacher leader development. *International Journal of Science and Mathematics Education*, *19*, 121–143. https://doi.org/10.1007/s10763-021-10157-2

Borko, H., Jacobs, J., Seago, N., & Mangram, C. (2014). Facilitating video-based professional development: planning and orchestrating productive discussions. In Y. Li, E. A. Silver, & S. Li (Eds.), *Transforming Mathematics Instruction Multiple Approaches and Practices* (pp. 259–281). https://doi.org/10.1007/978-3-319-04993-9_16

Borko, H., Koellner, K., & Jacobs, J. (2011). Meeting the challenges of scale: The importance of preparing professional development leaders. *Teachers College Record*, 11–14. https://doi.org/10.1007/s11858-010-0302-5.https

Borko, H., Koellner, K., & Jacobs, J. (2014). Examining novice teacher leaders' facilitation of mathematics professional development. *Journal of Mathematical Behavior*, *33*, 149–167. https://doi.org/10.1016/j.jmathb.2013.11.003

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*(1), 32–42.

Cobb, P., & Yackel, E. (1996). Constructivist, emergent, and sociocultural perspectives in the context of development research. *Educational Psychologist*, *31*(3/4), 175–190.

diSessa, A. A. (1993). Toward an epistemology of physics. *Cognition and Instruction*, *10*(2/3), 105–225. https://doi.org/10.1207/s1532690xci1002

Elby, A., & Hammer, D. (2010). *Epistemological resources and framing: A cognitive framework for helping teachers interpret and respond to their students' epistemologies*. *October*, 409–434. https://doi.org/10.1017/CBO9780511691904.013

Elliott, R., Kazemi, E., Lesseig, K., Mumme, J., Carroll, C., & Kelley-Petersen, M. (2009). Conceptualizing the work of leading mathematical tasks in professional development. *Journal of Teacher Education*, *60*(4), 364–379. https://doi.org/10.1177/0022487109341150

Engle, R. A., Conant, F. R., & Greeno, J. G. (2007). Progressive refinement of hypotheses in video-supported research. In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video Research in the Learning Sciences* (pp. 239–254). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203877258

Gaudin, C., & Chaliès, S. (2015). Video viewing in teacher education and professional development: A literature review. *Educational Research Review*, *16*, 41–67. https://doi.org/10.1016/j.edurev.2015.06.001

Goffman, E. (1974). *Frame analysis: An essay on the organization of experience*. Boston, MA: Northeastern University Press.

Gravemeijer, K., & van Eerde, D. (2009). Design research as a means for building a knowledge base for teachers and teaching in mathematics education. *Elementary School Journal*, *109*(5), 510–524. https://doi.org/10.1086/596999

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of Educational Psychology* (pp. 673–708). Macmillan.

Greeno, J. G., & The Middle School Mathematics through Applications Project Group (1997). Theories and practices of thinking and learning to think. *American Journal of Education*, *106*(1), 85–126.

Hammer, D. (2000). Student resources for learning introductory physics. *American Journal of Physics*, *68*(S1), S52–S59. https://doi.org/10.1119/1.19520

Hammer, D., Elby, A., Scherr, R. E., & Redish, E. F. (2005). Resources, framing, and transfer. In J. Mestre (Ed.), *Transfer of Learning: Research and Perspectives* (pp. 1–26). Information Age Publishing.

Herbst, P., Chazan, D., & Lavu, S. (2019). *Anotemos*. Web-based collaborative software tool for the annotation of video. Disclosed to the Office of Technology Transfer, University of Michigan.

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.

Kang, H., & van Es, E. A. (2019). Articulating design principles for productive use of video in preservice education. *Journal of Teacher Education*, *70*(3), 237–250. https://doi.org/10.1177/0022487118778549

Louca, L., Elby, A., Hammer, D., & Kagey, T. (2004). Epistemological resources:Applying a new epistemological framework to science instruction. *Educational Psychologist*, *39*(1), 57–68.

Jacobs, J. K., & Morita, E. (2002). Japanese and American teachers' evaluations of videotaped mathematics lessons. *Journal for Research in Mathematics Education*, *33*(3), 154–175.

Koellner, K., Jacobs, J., Borko, H., Schneider, C., Pittman, M. E., Eiteljorg, E., Bunning, K., & Frykholm, J. (2007). The Problem Solving Cycle: A model to support the development of teachers' professional knowledge. *Mathematical Thinking and Learning*, *9*(3), 273–303.

Lau, M. (2010). Understanding the dynamics of teacher attention: Examples of how high school physics and physical science teachers attend to student ideas (Doctoral dissertation). University of Maryland, College Park, MD.

Lave, J., & Etienne, W. (1991). *Situated learning legitimate peripheral participation* (Cambridge). Cambridge University Press.

Levin, D. M., Hammer, D., & Coffey, J. E. (2009). Novice teachers' attention to student thinking. *Journal of Teacher Education*, *60*(2), 142–154. https://doi.org/10.1177/0022487108330245

Levin, D. M., & Richards, J. (2011). Learning to attend to the substance of students' thinking in science. *Science Educator*, *20*(2), 1–11. https://eric.ed.gov/?id=EJ960631

Luna, M. J. (2018). What does it mean to notice my students' ideas in science today?: An investigation of elementary teachers' practice of noticing their students' thinking in science. *Cognition and Instruction*, *36*(4), 297–329. https://doi.org/10.1080/07370008.2018.1496919

Luna, M. J., & Sherin, M. G. (2017). Using a video club design to promote teacher attention to students' ideas in science. *Teaching and Teacher Education*, *66*, 282–294. https://doi.org/10.1016/j.tate.2017.04.019

Plomp, T., & Nieveen, N. (2013). Educational design research: An introduction. In T. Plomp & N. Nieveen (Eds.), *Educational Design Research: An Introduction* (pp. 11–50). slo.

Prediger, S., Roesken-Winter, B., Stahnke, R., & Pöhler, B. (2022). Conceptualizing content-related PD facilitator expertise. *Journal of Mathematics Teacher Education*, *25*(4), 403–428. https://doi.org/10.1007/s10857-021-09497-1

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, *29*(1), 4–15.

Redish, E. (2004). A theoretical framework for physics education research: Modeling student thinking. In E. Redish & M. Vicentini (Eds.), *Proceedings of the Enrico Fermi Summer School, Course CLVI* (pp. 1-50). Bologna: Italian Physical Society

Resnick, L. B., Michaels, S., & O'Connor, M. (2010). How (well-structured) talk builds the mind. In D. D. Press & R. J. Sternberg (Eds.), *Innovations in educational psychology: Perspectives on learning, teaching, and human development* (pp. 163–194). Springer.

Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change linked. *Journal of the Learning Sciences*, *2*(3), 235–276.

Rosenberg, S., Hammer, D., & Phelan, J. (2006). Multiple epistemological coherences in an eighth-grade discussion of the rock cycle. *The Journal of the Learning Sciences*, *15*(2), 261–292.

Roth, K. J., Bintz, J., Wickler, N. I. Z., Hvidsten, C., Taylor, J., Beardsley, P. M., Caine, A., & Wilson, C. D. (2017). Design principles for effective video-based professional development. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0091-2

Russ, R. S., & Luna, M. J. (2013). Inferring teacher epistemological framing from local patterns in teacher noticing. *Journal of Research in Science Teaching*, *50*(3), 284–314. https://doi.org/10.1002/tea.21063

Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A. K., Yang, X., & Kaiser, G. (2021). Mathematics teacher learning to notice: a systematic review of studies of video-based programs. *ZDM - Mathematics Education*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z

Scherr, R. E., & Hammer, D. (2009). Student behavior and epistemological framing: Examples from collaborative active-learning activities in physics. *Cognition and Instruction*, *27*(2), 147–174. https://doi.org/10.1080/07370000902797379

Schwarts, G., Pöhler, B., Elbaum-Cohen, A., Karsenty, R., Arcavi, A., & Prediger, S. (2021). Novice facilitators' changes in practices: From launching to managing discussions about mathematics teaching. *Journal of Mathematical Behavior*, *64*. https://doi.org/10.1016/j.jmathb.2021.100901

Sherin, M.G, (2007). The develop of teachers' professional vision in video clubs. In Goldman, R., Pea, R., Barron, B., Derry, S.J. (Eds.), *Video research in the learning sciences* (pp 383-395). Mahwah, NJ: Lawrence Earlbaum Associates.

Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, *20*(2), 163–183. https://doi.org/10.1016/j.tate.2003.08.001

Sherin, M. G., & van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education*, *60*(1), 20–37. https://doi.org/10.1177/0022487108328155

Stockero, S. L., Rupnow, R. L., & Pascoe, A. E. (2017). Learning to notice important student mathematical thinking in complex classroom interactions. *Teaching and Teacher Education*, *63*, 384–395. https://doi.org/10.1016/j.tate.2017.01.006

Tannen, D. (1993). What 's in a frame? Surface evidence for underlying expectations. In R. Freedle (Ed.), *New Directions in Discourse Processing* (pp. 137–181). Ablex.

Tannen, D., & Wallat, C. (1987). Interactive frames and knowledge schemas in interaction: Examples from a medical examination/interview. *Social Psychology Quarterly*, *50*(2), 205–216. https://doi.org/10.2307/2786752

Tekkumru-Kisa, M., & Stein, M. K. (2017). A framework for planning and facilitating video-based professional development. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0086-z

van Es, E. A., Tekkumru-Kisa, M., & Seago, N. (2020). Leveraging the power of video for teacher learning. In S. Llinares & O. Chapman (Eds.), *International Handbook of Mathematics Teacher Education: Volume 2* (pp. 23–54). Koninklijke Brill NV. https://doi.org/10.1163/9789004418967_002

van Es, E. A., Tunney, J., Goldsmith, L. T., & Seago, N. (2014). A framework for the facilitation of teachers' analysis of video. *Journal of Teacher Education*, *65*(4), 340–356. https://doi.org/10.1177/0022487114534266

van Zoest, L. R., & Stockero, S. L. (2008). Using a video-case curriculum to develop preservice teachers' knowledge and skills. In M. Smith & S. Friel (Eds.), *AMTE Monograph 4: Cases in mathematics teacher education: Tools for developing knowledge needed for teaching* (pp. 117–132). Association for Mathematics Teacher Educators. https://www.researchgate.net/publication/237432467

Walkoe, J. (2015). Exploring teacher noticing of student algebraic thinking in a video club. *Journal of Mathematics Teacher Education*, *18*(6), 523–550. https://doi.org/10.1007/s10857-014-9289-0

Walkoe, J., Walton, M., & Levin, M. (2022). Supporting Teacher Noticing of Moments of Algebraic Potential. *Journal of Educational Research in Mathematics*, *32*(3), 271–286. https://doi.org/10.29275/jerm.2022.32.3.271

Walton, M., Walkoe, J., Elby, A., Fofang, J., & Weintrop, D. (2020). Teachers' conceptualizations of computational and mathematical Thinking. In M. Gresalfi & I. Horn (Eds.), *The Interdisciplinarity of the Learning Sciences,*

14th International Conference of the Learning Sciences (ICLS) (pp. 2053–2060). International Society of the Learning Sciences.

Walton, M., & Walkoe, J. (in press). Using a video-tagging tool to support facilitators of video-based professional development. *AMTE's Professional Book Series, Volume 5.*

Watkins, J., Coffey, J. E., Maskiewicz, A. C., & Hammer, D. (2017). An account of teachers' epistemological progress in science. In G. Shaw, J. Brownlee, & L. Olafson (Eds.), *Teachers' Personal Epistemologies: Evolving Models for Informing Practice* (pp. 87–111). Information Age Publishing.

Appendix A
Framework for Facilitation of Video Based Discussion (van Es et al., 2014)

	Facilitation move	Definition	Example
Orienting group to the video analysis task	Launching	Pose general prompts to elicit participant ideas	"So, what did you notice? What stood out to you?" "What were interesting mathematical moments or interchanges in the video?"
	Contextualizing	Provide additional information about the classroom context and mathematics lesson	"This was lesson on 2-digit multiplication and you were working the partial products method."
Sustaining an inquiry stance	Highlighting	Direct attention to noteworthy student ideas in the videos	"So it seems like we're all pretty interested in what Tyrone did here. What did he mean by one-fourth equals 25 and one-half is 50?"
	Lifting up	Identify an important idea that a participant raised in the discussion for further discussion	"I think you were bringing up the idea that maybe they understood what met goal exactly meant, but they had this way of thinking that it wasn't each student that got to 50 but rather collectively."
	Pressing	Prompt participants to explain their reasoning and/or elaborate on their ideas	"You said there was a lot she had to do there, can you piece apart for me all the things you think she had to do?"
	Offering an explanation	Provide an interpretation of an event, interaction, or mathematical idea, from a stance of inquiry	"I was thinking that he might have looked at his partner's cards and added the numbers on their two together. That might be why he said 51."
	Countering	Offer an alternative point of view	"You could be right but I was thinking that the sticks and dots weren't really helping Dante. He doesn't arrive at the correct answer . . ."
	Clarifying	Restate and revoice to ensure common understanding of an idea	"So you're saying no, she doesn't really think it's ten?"
Maintaining a focus on the video and the mathematics	Redirecting	Shift the discussion to maintain focus on the task of video analysis	"Can I just bring us back to the video for a second?"
	Pointing to evidence	Contribute substantively to the conversation, using evidence to reason about teaching and learning with video	"Well, what did Jerome say earlier? . . . because I'm wondering if maybe she's using what he said earlier to help her try to figure this out. So, if we look on the page before . . ."
	Connecting ideas	Make connections between ideas raised in the discussion	"So it's similar to what Tom was doing." "Do you have any predictions about what your students would do if they were given this problem?"
Supporting group collaboration	Standing back	Allow the group members time to discuss an issue	Not interjecting when the group is exploring an idea
	Distributing participation	Invite participants to share different ideas based on who is (and is not) participating	"Lisa, it looked like you wanted to say something . . ." "What do others think about that idea?"
	Validating participant ideas	Confirm and support participant contributions	"That's really hard." "That could make sense too. That could be another interpretation."

Note: Used with permission. This table has not been altered.

Appendix B
Hypothetical Video Club Protocol Assignment

Directions: Watch the *Area and Perimeter Video* and then read through the corresponding PST tags and comments about student thinking. Use the tags and comments to develop a video club discussion protocol that supports teachers in noticing student ideas. Your protocol should include the following:

- One or more noticing goals for teachers that relate to the math content in the video.
- An overview of the key moments of student thinking in the video, related to the teacher noticing goals
- At least two questions that you could ask teachers during a video club discussion that relate to the teacher noticing goals and the key moments of student thinking.

The template on the next page is designed to help you complete the necessary components of hypothetical protocol.

Area and Perimeter Video Club

Video Club Overview:
Video Summary: *Include a short summary of the video club here*

Video Club Goal: *Write your video club goal for teacher here.*

Exploring the Math:
Write a description of the math in the video, including the ways that teachers or student might think about the content.

Overview Video Key Moments			
Description of Goal #1:			
Key video moments of multimodal thinking that support goal			
Time Stamp	**Moment Description**	**Visual Cues** (If applicable, feel free to paste screen shots from the video)	**Explanation of Importance** (Including evidence from PST tags, significance of multimodal expressions, different interpretations of student thinking, etc.)

Possible Discussion Questions:

Description of Goal #2:			
Key video moments of multimodal thinking that support goal			
Time Stamp	**Moment Description**	**Visual Cues** **(If applicable, feel free to paste screen shots from the video)**	**Explanation of Importance** **(Including evidence from PST tags, significance of multimodal expressions, different interpretations of student thinking, etc.)**

Possible Discussion Questions:

Designing to Support Facilitators to Learn to Notice Teacher Thinking

Introduction

In recent years, demand for teacher professional development (PD) has increased as schools and school districts aim to support teachers' instructional practices (Gaudin & Chaliès, 2015). An integral part of most PD is the facilitator (Beisiegel et al., 2018; Borko et al., 2011; Roth et al., 2017). The facilitator often designs PD sessions, setting learning goals for teachers and choosing the content. They also typically implement the PD, where they lead teachers in activities and guide discussions (Tekkumru-Kisa & Stein, 2017; van Es et al., 2020). There is a strong research base for *what* facilitators should do when they plan for and lead teachers in PD (Borko, Jacobs, et al., 2014; Kang & van Es, 2019; Tekkumru-Kisa & Stein, 2017; van Es et al., 2014; 2020). However, researchers have only more recently begun to more closely examine *how* facilitators learn to plan and implement teacher PD and how to support novice facilitators in developing these skills (Borko et al., 2021; 2017; Elliott et al., 2009; Jackson, 2015; Lesseig et al., 2017; Schwarts et al., 2021). In particular, more insight is needed into how to design learning experiences for the facilitators. What activities, conversations, tools, etc. help facilitators learn to teach teachers?

One issue that often arises with novice facilitators is engaging teachers in discussions. A number of researchers have found that novice facilitators struggle with this skill (Borko, Koellner et al., 2014; Elliot et al., 2009; Jackson et al., 2015). Novice facilitators' discussions with teachers can often be more superficial and do not delve deeply into, for example, mathematics, student thinking, or instructional

practices. However, the small literature base that examines facilitator PD (F-PD) has found that novice facilitators can learn to lead discussions with support (Castro Superfine & Pitvorec, 2021; Lesseig et al., 2017; Schwarts et al., 2021). Some of these studies adopt pedagogies from teacher education to use with novice facilitators (Elliott et al., 2009; Jackson et al., 2015; Lesseig et al., 2017; Borko et al., 2021).

For this study, I developed an F-PD that also borrows from PD design in teacher education. I explore how the F-PD supported and did not support novice facilitators to learn to lead video clubs- a discussion-heavy type of teacher PD that can help teachers learn to notice students' mathematical thinking. I use activity theory as an analytic lens (Engeström, 1987; Cole & Engeström, 1999; Engeström, 1999; Yamagata-Lynch, 2010) to understand how the F-PD tasks and tools, and changes to the tools and tasks, enhanced or constrained novice facilitators' learning related to leading video club discussions. The results led to several design implications, which I offer for future F-PDs. My research questions are:

How do tasks and tools in an F-PD support novice facilitators to learn to lead video clubs, if at all?

- How do the F-PD tasks and tools contribute to novice facilitators' focus related to different aspects of facilitation?

Background and Conceptual Framework

Facilitators and Their Work

Facilitators come from a variety of backgrounds and can include faculty from universities, graduate students, instructional coaches, school administrators, and teachers who have taken on leadership roles in their schools (Rogers et al., 2021).

Their responsibilities typically include setting learning goals for teachers, planning activities that support those goals, and implementing those activities with teachers (Tekkumru-Kisa & Stein, 2017; van Es et al., 2020; Prediger et al., 2022).

Recently, more researchers have worked to determine the specific knowledge and skills facilitators need to support teacher learning. A number of researchers have argued that facilitators need knowledge of K-12 curriculum and instruction, but also need to be able to present that content to teachers (Castro Superfine & Li, 2014; Prediger et al., 2022; Shaughnessy et al., 2016; Zopf, 2010). For example, facilitators might need knowledge of various classroom instructional strategies, but they also need to know how to break down those strategies so that teachers can learn one component at a time. In another example, a facilitator might need to know how to analyze student mathematical errors and also how to explore those errors with teachers. These types of knowledge and skills can enable facilitators to lead activities with teachers like writing lesson plans, analyses of student work, and discussions about instructional practices (Masingila et al., 2018; Prediger et al., 2022).

A Facilitator Challenge: Leading Discussions

This article primarily focuses on how to support facilitators to learn to lead teacher discussions to foster a particular teacher practice- noticing student thinking. Leading teacher discussions on any topic can be a challenge for many facilitators (Borko, Jacobs, et al., 2014; Elliot et al., 2009; Jackson et al., 2015; Schwarts et al., 2021). Facilitators can struggle to engage in substantive discussions with teachers that align to PD goals and to move beyond superficial understandings to deeper analyses of mathematics, teaching, or student learning. For example, Schwarts et al. (2021)

reported on a case study of two novice facilitators, one who led a teacher PD about the use of mathematical language and another who led a PD to help teachers reflect on instruction and build their mathematical knowledge for teaching (Ball et al., 2008). Despite the different PD aims, both facilitators initially had trouble connecting discussions to PD goals, revoicing teacher comments, and asking teachers to explain their thinking. Other studies have reported similar results (Borko, Jacobs, et al., 2014; Elliot et al., 2009; Jackson et al., 2015).

However, facilitators can learn to engage teachers in substantive discussions with experience and support (Borko et al., 2017; 2021; Lesseig et al., 2017; Schwarts et al., 2021). The facilitators in Schwarts's and colleagues' (2021) study improved their discussion leadership skills. By the end of their respective PDs with teachers, the facilitators improved at building on teacher comments, and at probing teachers to think more deeply about issues of mathematics and teaching. The authors contended that the facilitators improved through a combination of more experience in leading discussions and through F-PD opportunities in which they reflected on their facilitation with peers and received feedback from more expert facilitators.

Borko and colleagues (2017, 2021) also reported that F-PD activities can support novice facilitators in leading teacher discussions. Their F-PD aimed to teach teacher leaders to facilitate the Problem Solving Cycle, a type of teacher PD that involves lesson planning, implementation, and reflection. One of the F-PD goals was to help novice facilitators learn how to lead discussions with teachers about classroom video. The facilitators participated in the "teacher role" in video discussions led by the research team. Afterward, the research team led debriefs where they unpacked

how they thought about leading the video discussions and why they acted in particular ways. The novice facilitators reported that these activities helped to clarify how the research team thought about planning and implementing teacher discussions. The novice facilitators also rehearsed teacher discussions and received feedback from the research team. During these rehearsals, they also observed the facilitation practices of other peers, which they reported as important for their own learning. When the novice facilitators led conversations with actual teachers in the Problem Solving Cycle, their enactment generally aligned with the researchers' goals, though the facilitators tailored discussions to their own school contexts.

This study and others are helpful in beginning to examine F-PD designs that support facilitator learning, particularly designs that support facilitators to lead discussions with teachers. One way to build on this research is to look at the relationship between F-PD activities and novice facilitator learning in more detail. Borko and colleagues primarily looked for evidence of facilitator learning in how the facilitators enacted the Problem Solving Cycle with actual teachers. While this method provides evidence for *what or whether* facilitators learned, it does not necessarily determine *how* the F-PD supported that learning. Other studies take a closer look at the relationship between F-PD activities and novice facilitator learning (Elliott et al., 2009; Lesseig, 2017), but these studies focus on teaching facilitators how to support teachers' content knowledge development. My area of interest, on the other hand, is to teach facilitators how to support teachers to develop their noticing skills.

In the current study, I look at the relationship between the F-PD design and novice facilitator learning. I identify how different components of the F-PD interacted with one another, and how those interactions contributed to facilitator learning about leading video clubs. I aim to understand what F-PD design characteristics are productive for learning to lead a video club discussion.

Teacher and Facilitator Noticing

Teacher Noticing of Student Thinking and Video Clubs

Teacher noticing is one way that researchers understand the process by which teachers center student mathematical thinking in the classroom. Noticing typically consists of three components. The first is attending to student thinking, which requires teachers use their *selective attention* (SA) to filter out other classroom activity and focus on students' mathematical ideas. A teacher must then interpret those ideas using their *knowledge-based reasoning* (KBR) (Sherin, 2007; Sherin & van Es, 2009). Teachers analyze student thinking using their teacher knowledge, which includes their knowledge of students, mathematics, pedagogy, etc. Finally, the teacher decides how to respond to the student idea, based on their analysis (Jacobs et al., 2010).

Video clubs are a form of video-based PD that can help teachers learn to notice (Luna & Sherin, 2017; Jacobs et al., 2010; Sherin, 2007; Sherin & Han, 2004; Sherin & van Es, 2005; Sherin & van Es, 2009; Walkoe, 2015). A video club is a group of teachers that meets to watch short clips of classroom instruction. They then discuss and reason about the student mathematical thinking they see, with the guidance of a facilitator (Sherin, 2007). Video clubs aim to develop teachers' SA,

KBR, and response decisions by giving teachers the opportunity to practice identifying important student thinking and working to make sense of it with the support of other teachers and the facilitator. Indeed, video clubs have been shown to help teachers focus on students and formulate more sophisticated analyses of student thinking that connect to teaching and learning mathematics (Luna & Sherin, 2017; Sherin & Han, 2004; Sherin, 2007; Sherin & van Es, 2005; Sherin & van Es, 2009; Walkoe, 2015). The facilitator can support this development during a video club discussion by taking actions like pointing to video moments that show important student ideas or asking teachers to further explain their claims about student thinking (Castro Superfine et al., 2019; Goldsmith & Seago, 2008)

Facilitator Noticing of Teacher Thinking

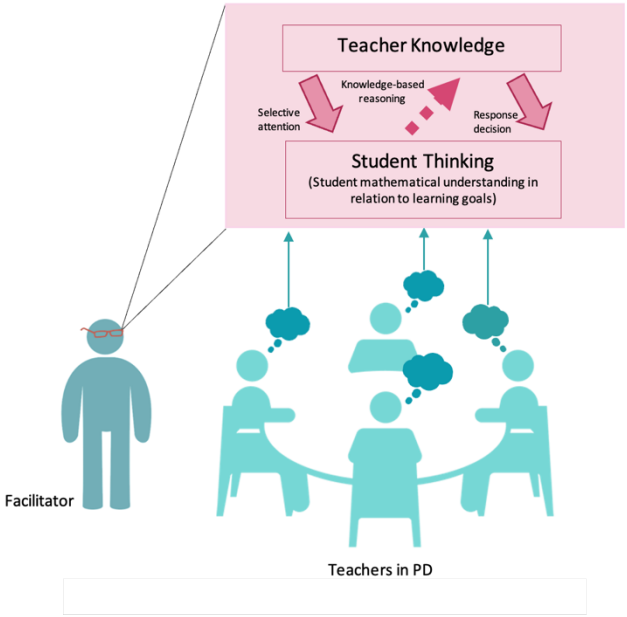
In order to design learning opportunities for novice video club facilitators, it is necessary to understand the cognitive process of an experienced video club facilitator. Such insight can allow F-PD designers to develop activities for novice facilitators that show them ways to think and act in particular situations as they engage with teachers. A number of researchers have argued that, like when teachers center student ideas to promote student learning, facilitators do the same for teachers (Amador, 2021; Borko, Koellner et al., 2014; Lesseig et al., 2017; van Es 2010). In other words, facilitators *notice teacher thinking*.

The framework below, known as the Facilitator Noticing Framework (FNF) (Walton, 2023a) is helpful for understanding how facilitators notice teacher thinking (Figure 1). The facilitator, in glasses, interacts with teachers as they discuss and/or work with PD resources like videos, student work, etc. The glasses represent what a

facilitator looks for, or *notices.* Like when teachers notice student thinking, facilitators also attend to, interpret, and decide how to respond to individuals' ideas. However, facilitators primarily notice teacher ideas. Teacher thinking is represented by the pink box. Called teachers' noticing process, it is essentially how teachers notice student thinking.

Figure 1

The Facilitator Noticing Framework



Teachers' noticing process includes several interrelated components. As stated earlier, teachers use their SA, represented by the leftmost arrow, to discern moments of student thinking that merit further attention. They use their teacher knowledge to find these moments. The middle, dotted, arrow depicts how a teacher interprets a student idea. The interaction between student thinking and teacher knowledge here is

different because, rather than using their knowledge to perform an action (i.e., looking for thinking or responding to thinking), the teacher takes the thinking up for consideration. As the teacher considers a student idea, they use their KBR to understand it in terms of what it means for student mathematics understanding and learning. Finally, as shown by the last arrow in the pink box, the teacher decides how to respond, based on their understanding of student thinking.

In order to support teachers during video clubs, novice facilitators should develop their ability to notice the different components and interactions in the pink box. The purpose of this paper is to explore the kinds of tools and tasks that help novice facilitators learn to notice the different components of teachers' noticing process.

Learning from a Sociocultural Perspective

I adopt a sociocultural lens to understand if and how novice facilitators learn during the F-PD. Sociocultural theorists contend that learning takes place as people interact with one another in communities of practice. As people participate in a community, they learn the rules, practices, discourse, and ways of being in that community. In turn, individuals also contribute to the community as group norms, customs, etc., change with individuals' input (Cobb & Bowers, 1999; Cobb & Yackel, 1996; Lave & Wenger, 1991; Putnam & Borko, 2000).

Tools and artifacts also play an important role in learning with this lens. According to sociocultural theorists, knowledge is spread between people, their environment, and the tools and artifacts that they use to complete tasks (Greeno et al., 1996; Hutchins, 1995; Lave, 1998; Pea, 1993). Tools and artifacts can serve as a

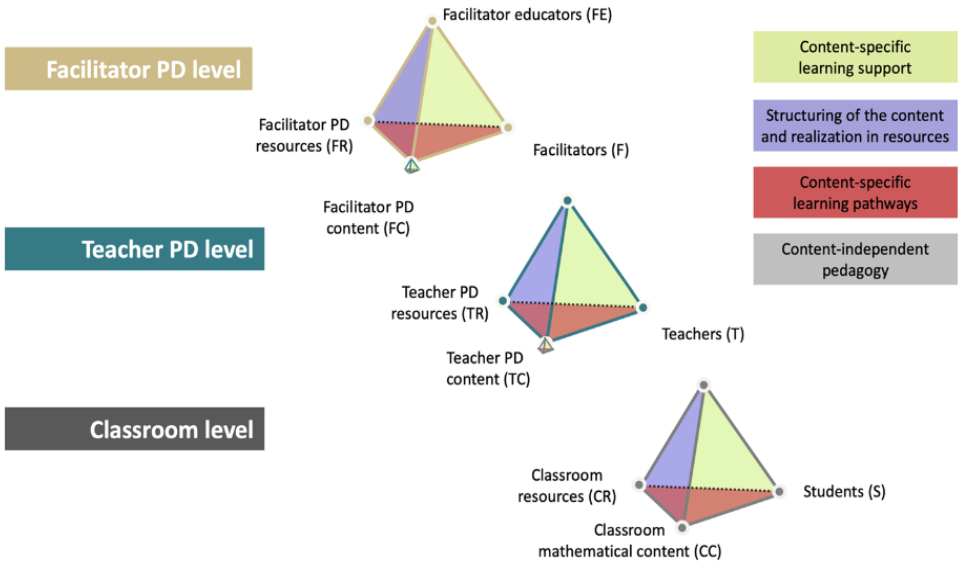
mediator between the cognition occurring within an individual and the knowledge available in a person's environment. As people work with tools or artifacts they can utilize the knowledge stored in them (Lave, 1998; Pea, 1993). A sociocultural perspective is appropriate for this study because I seek to understand how novice facilitators' interactions with others, completion of tasks, and use of tools support them to learn to lead video clubs by noticing teachers' noticing.

Designing F-PDs and Lifting Up Practice Based Teacher Education

Researchers have recently begun to take a closer look at how PD for teacher educators should be designed. A helpful framework comes from Prediger and colleagues (2019). The authors developed a model that outlines the design components for three levels of PD and instruction in education- facilitator PD, teacher PD, and the classroom (Figure 2). The classroom level, at the bottom of the model, shows the various considerations for designing K-12 instruction, including the relationships between teachers, students, and classroom resources. The next level shows a similar structure for designing teacher PD. The classroom level is nested within the teacher level as the teacher PD content. The final level, designing for facilitator PD, again has a similar structure to the teacher PD and classroom levels, except both the teacher PD and classroom levels are nested in the facilitator PD level and make up the facilitator PD content.

Figure 2

The Three Tetrahedron Model for Content Related PD Research (Prediger et al., 2019)



The authors highlight several strategies that designers can use when developing PD at different levels. One of those strategies is called *lifting up* and is when PD designers adapt design approaches used in one of the lower levels to a higher level. For instance, a designer might apply pedagogy common in teacher PD to create PD for facilitators.

Indeed, a number of researchers have used this strategy to design F-PDs (Borko et al., 2021; Elliott et al., 2009; Jackson et al., 2015; Lesseig et al., 2017). One method of instruction that is often lifted up by F-PD designers is Practice Based Teacher Education (PBTE) (Ball & Forzani, 2009; Grossman et al., 2009; McDonald et al., 2013; Lampert, 2010). PBTE prepares teachers and supports their learning by

focusing on practices, often called core practices, that comprise the daily work of teaching. Examples of core practices include eliciting, interpreting and responding to student thinking, leading student group work, and designing assessments (Matsumoto-Royo & Ramírez-Montoya, 2021).

Different pedagogies have been developed to teach core practices (Grossman et al., 2009; Grossman et al., 2018; Grosser-Clarkson & Neel, 2020; McDonald et al., 2013; Matsmoto-Royo & Ramírez-Montoya, 2021). Grossman and colleagues (2009) identified three pedagogical strategies: representations, decompositions, and approximations of practice. Representations usually involve teachers observing a model of a typical teaching activity. For example, middle school math teachers might pretend to be students as a teacher educator leads them in a class discussion about a math problem (McGrew et al., 2018). During this activity, teachers could observe the various moves the teacher educator makes to highlight student comments and make connections between them. The teacher educator might also take time to make the thinking behind their actions explicit for teachers. Decompositions call for breaking down practices into component parts for targeted learning (Grossman et al., 2009). An example might be learning how to select relevant student work while leading a mathematical discussion. Approximations of practice tend to entail some sort of simulation that closely resembles an aspect of teaching (Kelley-Petersen et al., 2018; Schutz et al., 2018). An approximation of practice sometimes used in pre-service teacher (PST) methods classes is when one PST lead a math discussion and their peers act as the students. This opportunity allows PSTs to experiment with different

instructional moves and receive feedback while remaining in a lower stakes situation compared to a real classroom.

One F-PD that lifted up PBTE practices aimed to help novice facilitators learn to lead math tasks with teachers that would support teachers' specialized content knowledge (Lesseig 2017). The authors asked the novice facilitators to analyze a series of videos that showed a facilitator working with teachers on math tasks. The authors found that the novice facilitators learned to better notice the actions of the facilitator and connect those actions to teacher learning of mathematics. These results are promising for my study and I build on them. Like Lesseig and colleagues, I also incorporate video analysis into in my F-PD and I take a noticing perspective. Rather than working with teachers on math tasks, I use similar approaches as I aim to support novice facilitators to learn to lead video clubs so that teachers can better pay attention to and build on student mathematical thinking during instruction.

Borko and colleagues (2021) also lifted up PBTE and used what they called "pedagogies of investigation," which were similar to representations. For example, members of the research team would model leading different activities of the Problem Solving Cycle for facilitators to observe. Research team members also unpacked their thinking about leading these activities. The researchers also developed “pedagogies of enactment,” which were similar to approximations of practice. These activities included role plays or opportunities for facilitators to practice planning for teacher PD. For novice facilitators, the pedagogies of investigation activities were meant to clarify some of the thinking that goes into leading teachers. The pedagogies of

enactment activities were intended to give novice facilitators the opportunity to practice and get feedback on teaching teachers.

The F-PD in the present study also lifted up pedagogies from PBTE to support novice facilitators to lead video clubs. The specifics of the activities will be discussed more in the methods and findings sections. Again, what this study hopes to contribute is a more detailed look at how the characteristics of these activities, which include aspects of PBTE, contributed (or not) to the facilitators' learning to lead video clubs.

Methods

Context and Participants

The F-PD took place with six participants, who I call facilitator participants (FPs). They were math education, teacher education, and/or urban education graduate students at the same large, mid-Atlantic university. Nicole and Faith (all names are pseudonyms) identified as Black women. One of the FPs, Libby, identified as a white woman. Todd, Thornton, and Max all identified as white men. The FPs had between four and nine years of teaching experience prior to going to graduate school. Most of them taught middle or high school math, Libby taught math at the community college level. Faith, Max, Thornton, and Todd all had some experience leading in-service teacher PD, but they had never before led video clubs.

Design-Based Research

I took a design-based research (DBR) approach to understand how the tools and tasks in the F-PD supported the FPs to learn to lead video clubs (Cobb et al., 2003; The Design-Based Research Collective 2003; Plomp & Nieveen, 2013). DBR is typically a way to bring innovative practices to learning experiences. During a

design research study, researchers act as developers, implementers, and evaluators as they build an intervention meant to support a particular learning process. It should be noted that design research is meant to "develop theories, not merely empirically tune 'what works'" (Cobb et al., 2003, p. 9). Thus, researchers not only evaluate the effectiveness of an intervention, but work to gain a greater understanding of some type of learning, why a particular design supports that learning, and how the design might be taken up in new contexts (Cobb et al., 2003; The Design-Based Research Collective 2003; Engle et al., 2007; Gravemeijer & Van Eerde, 2009; Plomp & Nieveen, 2013). The tenets for design research are ideal for my study because I aim to not only evaluate whether my F-PD helps facilitators learn to notice, but also how it helps them to learn.

DBR is a cyclical process in which miniature cycles of experimentation and refinement take place within larger cycles of data collection, analysis, and changes to the intervention design (Gravemeijer & Cobb, 2013; Gravemeijer & Van Eerde, 2009). In terms of the mini-cycles for this study, I reviewed the video recordings and FPs' work from any tasks I collected after each F-PD session. Based on those artifacts, I made conjectures about how I thought the FPs' learning evolved and made changes to plans for upcoming F-PD sessions to support that learning. At the conclusion of the F-PD, I performed a larger data analysis, which is explained in detail below. This was the completion of the larger cycle. I consider the F-PD design and implementation in this article to be the first of what could be multiple F-PD cycles. My analysis is in service to understanding how the F-PD design relates to FPs' process for learning to notice teacher thinking.

F-PD Design

The F-PD took place virtually in five sessions over Zoom (www.zoom.us). Each session was between 60 and 90 minutes. The sessions occurred once a week for five weeks. The overall goal of F-PD was to support FPs to learn to lead video clubs, particularly to learn to facilitate a video club discussion. Two sub-goals were: (1) Learning to notice student thinking and (2) learning to notice teacher thinking. Sub-Goal 2 is the main focus of this article. However, Sub-Goal 1 and its associated activities were necessary because a number of researchers have found that facilitators often need support in noticing student thinking, in addition to teacher thinking (Amador, 2016, 2020, 2021; Borko, Koellner et al, 2014; Lesseig et al., 2017). A summary of the F-PD activities is in Table 1.

The associated activities with Sub-Goal 1 were three video clubs that occurred at the beginning of F-PD Sessions 1-3. During these video clubs, the FPs participated as if they were teachers and I was the facilitator. The video clubs ran largely like traditional video clubs (e.g., Sherin & Han, 2004). The videos came from prior video club projects and the FPs did not know the teachers or students in the videos. One difference was that the FPs watched and annotated the video using the video tagging platform Anotemos (Herbst et al., 2009; Walton et al., 2020; Walton & Walkoe, in press) prior to the video club discussion. Anotemos has a variety of tools to annotate video. The FPs used the "pinning" tool. Users can tag and comment on a video by dropping a pin at a timestamp. The pins and comments are saved by the platform. The facilitator can see all of the users' pins. Note that tag and pin are used interchangeably throughout this article when referring to video annotations. The video clubs can be

considered representations of practice, a PBTE pedagogy, because I was modeling for FPs how they could lead a video club.

Sub-Goal 2 had a number of tasks associated with it (Table 1). The first set of tasks was meant to introduce FPs to actions related to facilitation. This introduction consisted of two kinds of tasks:

- **Facilitation Debriefs-** These occurred after the video clubs in Sessions 2 and 3. During the debriefs, the FPs and I discussed the facilitation actions that I took during the video club that just occurred in the session. The purpose was for FPs to begin to familiarize themselves with the types of facilitator moves that support teachers to notice. I gave the FPs a framework (van Es et al., 2014) as a tool to use during these conversations. The framework is a set of practices and associated facilitator actions that can be helpful for facilitators during video-based discussions with teachers. I referred to the framework as the Talk Moves Framework.
- **Facilitation Tagging Homework Assignment-** This was a homework assignment given after Session 3, to be completed before Session 4. FPs watched a recording of their video club from Session 2 in Anotemos. They were asked to tag different moves from the Talk Moves Framework that I used as I facilitated and explain how those moves could support individuals to learn how to notice student thinking.

I categorize this set of tasks as decomposition tasks, similar to those in PBTE. The aim was for the FPs to break down the actions of a facilitator and connect them to supporting teachers to learn to notice.

The second set of tasks associated with Sub-Goal 2 centered around planning and implementing video clubs. There were several kinds of tasks:

- **Video Club Discussion Goals Brainstorm-** This was the first activity of Session 4. The FPs brainstormed goals for a video club that was based on a classroom video of an algebra class discussion about graphing the square root function. The FPs used a Google Jamboard (www.jamboard.google.com) to write and share ideas for goals.
- **Tasks with Example Tags**- There were two tasks in Session 4 and Session 5 that used example Anotemos tagging data from pre-service teachers (PSTs) who participated in a different series of video clubs. At the end of Session 4, the FPs examined a set of example PST tags so that they could begin to think about how they might use such tags in a video club discussion. The FPs discussed the insights they had about the tags and challenges that they might face in using the tags to facilitate a video club with the PSTs. The FPs then had a homework assignment after Session 4 that was due for Session 5. The assignment was to develop a video club discussion lesson plan, based on a new set of example PST tags. The FPs received a lesson plan template (Appendix A) as support. Session 5 consisted of a discussion during which the FPs were asked how they would use the PST tags during a video club and the challenges they faced while planning for the video club.

These tasks can be regarded as approximations of practice, another PBTE pedagogy. The FPs practiced how to write goals and plan for video clubs, tasks they would also complete while leading real video clubs.

Table 1

Overview of F-PD Activities and Data

	Session 1	Session 2	Session 3	Session 4	Session 5
Activities in session	• Video Club 1	• Video Club 2 • Facilitator Debrief 1	• Video Club 3 • Facilitator Debrief 2 • HW: Facilitator Tagging Assignment	• Video Club Goal Brainstorm • Intro to analyzing PST tags • HW: Video Club Lesson Plan	• Video Club Lesson Plan Discussion
Data Used in Study		• Recording of Facilitator Debrief 1	• Recording of Facilitator Debrief 2 • FPs' pins and comments from Facilitator Tagging Assignment	• Recording of Session 4 • List of goals • FPs' lesson plan templates	• Recording of Session 5

Data Collection

The data collected for this study is summarized in Table 1. It included video recordings of all five F-PD sessions. Transcripts were made of each recording. In addition, data from the two homework assignments was collected, including the FP tags and comments from the Facilitation Tagging Homework Assignment and the FP lesson plans (five of the six FPs turned in their lesson plans). Finally, the F-PD lesson plans and associated online slides that I created were collected.

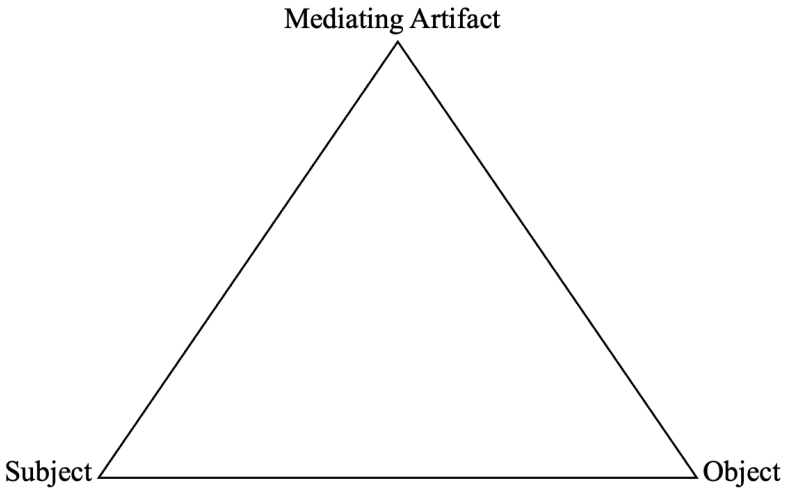
Data Analysis: An Activity Theory Lens

The aim of this study is to understand how the tasks and tools described above supported or did not support FPs to learn to lead video clubs. A helpful lens for examining the relationships between particular environments, interactions among individuals, and tools is activity theory (Cole & Engeström, 1993; Engeström, 1987;

Engeström, 1993 Engeström, 1999; Yamagata-Lynch, 2007; Yamagata-Lynch, 2010). Vygotsky (1978), who was a leader in the foundations of activity theory, argued that learning occurs when individuals make meaning as the result of their interactions with other people and artifacts. He called this process *mediated action* and represented it as a triangle:

Figure 3

Vygotsky's Basic Mediated Triangle



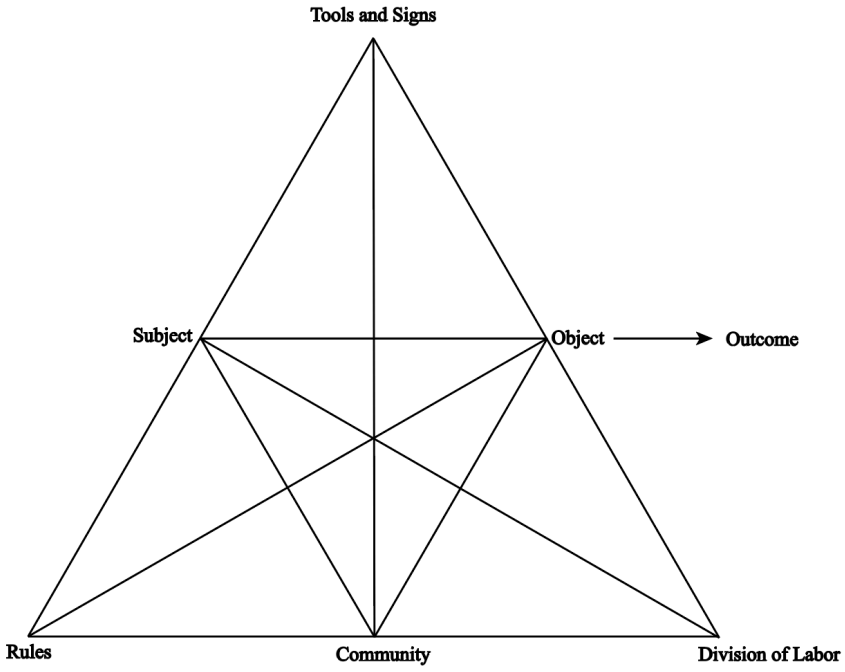
Note: Adapted from Cole & Engeström (1993).

Within the triangle, the subject is an individual or group of people participating in an activity to achieve a particular goal, which is the object. The mediating artifact could be tools, exercises, signs (including language), other people who support the activity, etc. The subject, object, and mediating artifact have an interconnected relationship; each component can impact another or impact the entire activity.

Other researchers, including Leontiev (1974), built on Vygotsky's triangle and argued that an activity, like the protocol for children's medical care (Engeström, 2000), a math intervention with 3rd graders, or an F-PD with novice video club facilitators could be understood holistically as a unit of analysis. Engeström (1987, 1999) later argued that models by Vygotsky, Leontiev, and others had more of an individualistic focus and were too restrictive to consider the broader collaborative and societal contexts in which people exist. Engeström developed an expanded model, known as an activity system (Figure 4), that includes components to account for the collective nature of activity.

Figure 4

The Activity System (Engeström, 1987)



Note: Adapted from Cole & Engeström (1993).

The top triangle of the activity system is the same as Vygotsky's mediated triangle. Below that, Engeström added rules, community, and division of labor. The outcome is the end result of the activity. Importantly, the outcome can differ from the object, which can indicate whether the activity functioned as intended. Rules are parameters that can restrict or enhance an activity. Rules could include, for example, social constructs, required procedures for completing a task, or regulations at a workplace. The community represents the larger social group to which the subject belongs while partaking in the activity. Division of labor is how the duties or assignments of the activity get divided among the community.

Another property of activity systems is that they can show tensions. Tensions, which are usually represented by a zig-zag like line, occur when the different triangle components are somehow in conflict with one another (Cole & Engeström, 1993; Engeström, 1993). Tensions can serve to limit the activity or can contribute to progress toward the object.

A final characteristic of activity systems is they can be historical, one can examine the development of an activity over time. Engeström (1999) referred to this development as an *expansive cycle*. As an activity progresses, stakeholders identify internal disruptions, search for solutions, and implement those solutions. The activity eventually stabilizes and, as new challenges arise, the activity will again undergo a period of change.

I chose to adopt an activity system lens to analyze my data because it provides a way to organize, connect, and communicate about the variety of factors that could influence FPs' learning during the F-PD. Design-based studies often produce large

amounts and diverse types of data, which can be overwhelming to analyze (Collins et al., 2004; Yamagata-Lynch 2010). For my study, I had several types of data (e.g., transcripts, FP tagging data, FP lessons plans). Analysis of each could identify a variety of factors related to FPs' learning. Using an activity system framework gave me a way to map out different features of the F-PD and then look for interactions between these features. I was able to visually understand how different parts of the F-PD connected and contributed to the outcome. The activity triangle was also helpful to communicate my findings. It gives the reader a reference as I explain how various features of the F-PD interacted, which can be seen in the findings section.

Analysis of the F-PD

My unit of analysis was the F-PD overall. In general, my analysis involved drafting sets of activity triangles for the F-PD and refining them as I continued to review the data (Yamagata-Lynch, 2003, 2007). I started by determining the object for the F-PD. The primary goal of the F-PD was for FPs to learn to lead video clubs. I contend that much of the process of leading video clubs, particularly video club discussions, is outlined in the FNF. In other words, if FPs are going to learn to lead video clubs, they should learn to notice teacher thinking. Consequently, I assigned *FPs notice teacher thinking of student thinking* as the object.

I then identified the outcome of the F-PD. I assigned the outcome by determining the FPs' focus as they talked and wrote about facilitation during discussions and for assignments. I did this by first open coding the discussion transcripts from Sessions 2-5. I took note of how the FPs talked about facilitation of video clubs. I then grouped those codes into larger categories. Some of the key codes

I identified were *supporting productive conversation*, *supporting SA*, and *supporting KBR*. I coded supporting a productive conversation when the FPs focused on the characteristics of facilitation that sustain any kind of discussion, not one specific to noticing. I coded support SA when FPs focused on helping teachers attend to certain student thinking during video clubs. I coded support KBR when the FPs talked about helping teachers make sense of student thinking. I also coded the other F-PD assignments (e.g., the Facilitator Tagging Homework Assignment, etc.) using these codes. For in-depth descriptions of how I determined the focus codes and for coded examples from the F-PD, see Walton (2023b).

I determined that FPs' attention to different aspects of facilitation could be divided into three distinct stages: (1) FPs mostly focused on aspects of a productive conversation, (2) FPs' focus fluctuated, and (3) FPs mostly focused on teacher and student thinking. I concluded that these shifts represented different outcomes that occurred over the F-PD so I assigned each as an outcome to one of three activity system triangles. Those changes served as significant events in the F-PD and offered a way to divide the F-PD into separate, chronological, time intervals. I treated these time intervals as sub-observations of the F-PD. Given Engeström's (1999) characterization of activity systems as expansive cycles that develop over time, these sub-observations bounded the F-PD into different stages and allowed me to identify components of each activity system, any tensions that arose, and whether and how the tensions were resolved.

I then mapped out the other components of each of the three activity triangles. I first identified the tools and signs that belonged to each of the three triangles based

on the F-PD tasks and discussions that occurred in each stage. I determined the community that the FPs belonged to based on FPs' responsibilities and identities as graduate students. I then identified the rules for each time interval by reviewing the F-PD lesson materials and the F-PD video recordings. I paid particular attention to the prompts I gave. This process helped me determine the parameters that I imposed on FPs to participate in discussions and complete tasks. Finally, I determined the division of labor based on how the FPs' and my participation in the F-PD might contribute to the broader community.

After I mapped out the three triangles, I examined the relationships between each component to identify tensions. I read through transcripts of the video recordings and coded for when different components might be in conflict. For example, if there was an instance when I thought the rules and object might be in conflict I wrote "rules-object tension." I then reviewed the moments in the transcript that received the same codes to gain a better understanding of the circumstances of the tension. I repeated this process for the other F-PD assignments (e.g., the video club lesson plans, etc.)

Results

Overall, the FPs' focus related to facilitating video clubs evolved over three stages during the F-PD: (1) FPs mostly focused on supporting aspects of a productive conversation, (2) FPs' focus fluctuated, and (3) FPs mostly focused on teachers and student thinking. These stages are represented by Activity Systems A, B, and C, respectively (Figures 5-7).

The shifts in FPs' attention were likely due to tensions in the F-PD that emerged or ended based on changes to the tools and signs. Below, I briefly describe how the FPs' focus related to facilitating video clubs in each activity system (i.e., I briefly describe each outcome). I then explain how changes to the tools and signs interacted with the different components of the F-PD to contribute to the different outcomes.

Before exploring the changes in the F-PD, there were several components of the activity system that remained constant. The object, or overall goal, was for FPs to notice teacher noticing of student thinking based on the FNF. The FPs were the subject of the F-PD. They belonged to a larger community of education researchers, facilitators, and teachers (including PSTs). Finally, the FPs worked with the F-PD leader, me, to improve their facilitation practice. Thus, the division of labor was shared among the FPs and me. I posed discussion questions to which the FPs responded and assigned tasks that the FPs completed.

Activity System A: FPs mostly focused on supporting aspects of a productive conversation

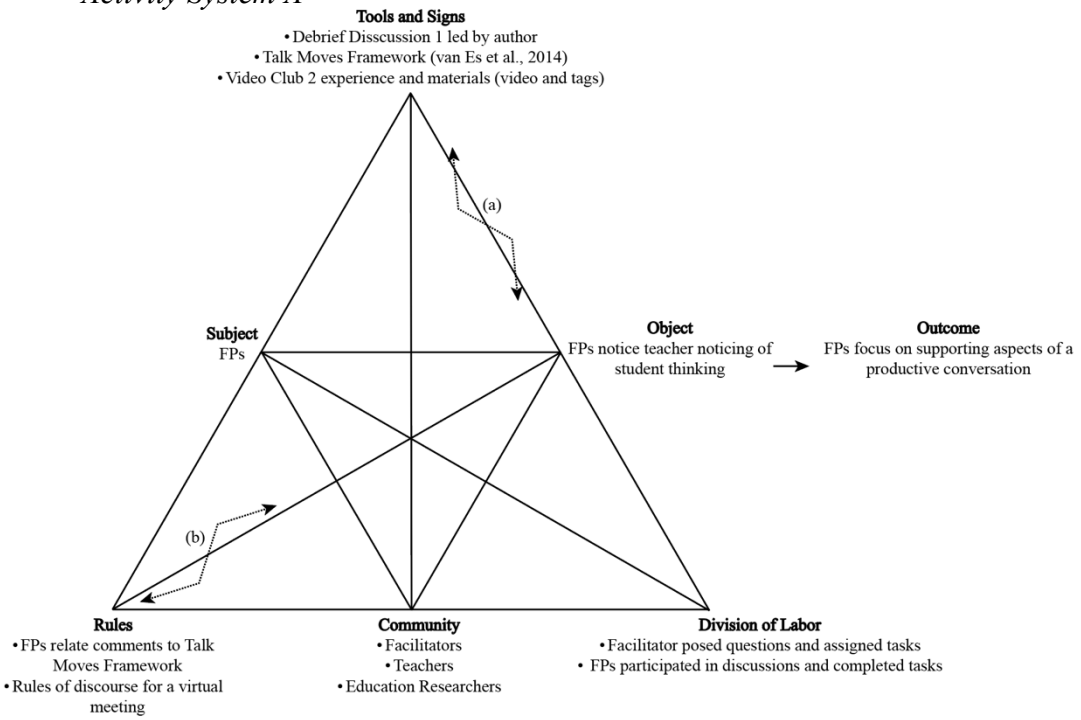
Figure 5 shows Activity Triangle A, which was during Debrief Discussion 1 in Session 2 of the F-PD (see Table 1). The outcome was that FPs focused on leading a video club by supporting aspects of a productive conversation. The discussion prompts for Debrief 1 directed the FPs to identify the different moves from the Talk Moves Framework that I made as their video club facilitator. The FPs primarily paid attention to how I encouraged them to participate, made sure that they all followed

the conversation, and recognized them for their contributions. For example, Todd began Debrief 1 and said:

> You did some of the moves for launching, we were able to talk about some of these things, kind of hammer out some of the questions that we had. And, yeah, so we were able to move forward without having to stop and ask more clarifying questions later. Todd talked as if my video club facilitation, and video club facilitation overall, was about maintaining the flow of the teachers' conversation. While this is part of a facilitator's role, they also need to work to support teachers to learn to notice.

Figure 5

Activity System A



In terms of the other components in Activity System A, the tools and signs in this activity system were Debrief Discussion 1 led by me, the Talk Moves

Framework, and the materials and FPs' experiences from Video Club 2, which FPs could reference as they discussed. The rules were that all participants follow the rules of discourse for a virtual meeting and that the FPs relate their comments to the Talk Moves Framework. The rules of discourse included, for example, letting one person talk at a time, muting when not talking, etc. The FPs were expected to ground their discussion responses in the Talk Moves Framework, based on the prompts that I gave for Debrief 1. For example, two of the prompts were "Are there places where you remember [Margaret] doing any of these moves?" and "Looking back at yours and others' tags, how might have you used these moves?"

Tensions in Activity System A

The object and outcome were not well aligned in Activity System A. In order for FPs to notice teachers noticing student thinking (i.e., the object), their focus (i.e., the outcome) should be conducive to that goal. FPs focused primarily on supporting a productive conversation. Ideally, the object and outcome would be better aligned if FPs addressed specific components of teachers' noticing process. Again, talking about how to sustain any conversation is not an unproductive way to discuss facilitation of video clubs. However, it is important for novice facilitators to move beyond general conversation characteristics so they can specifically support teachers to notice.

There were two tensions that likely contributed to this misalignment. Tension (a) concerned the relationship between the tools and signs and the object. The prompts for the debrief discussion, along with my guidance of FPs' conversation, primarily centered on facilitators. FPs' responses during Debrief 1 mostly referred to

the prompt, “Are there places where you remember [Margaret] doing any of these moves?” This question required FPs to simply remember and identify my facilitator moves during the video club. It did not require FPs to specify how the moves supported teacher noticing. Even when the FPs expanded on what my moves did for them as video club participants, the explanations were too general to fully account for how they would help teachers to notice.

As the leader of Debrief 1, I also contributed to tension (a). Like the FPs, I kept the focus on my facilitation, as opposed to considering teachers. I did not encourage the FPs to relate the moves to teachers and their noticing process. For example, at one point Faith pointed out that I often referred to participants’ Anotemos pins during the video club discussion to invite them to participate. My response was, “Yeah. Faith, and to your point, with the pins... I really have noticed that that's helpful in sort of bringing people into the conversation.” I did not respond to Faith to help her realize how I was strategic when pointing out different pins. In addition to expanding participation, I highlighted pins that could be used to build a conversation around an aspect of teachers' noticing process, like their KBR or SA.

Tension (b) was between the FPs and the rule related to the Talk Moves Framework. The Debrief 1 prompts specified that the FPs should ground their responses in the framework. The framework was meant to help the FPs name the facilitator moves that they remembered from the prior video club and connect them to teacher noticing. However, the Talk Moves Framework is designed for use to lead any video-based PD, not only to lead video clubs to support teacher noticing. As a result, requiring the FPs to use the framework to unpack my video club facilitation

may have turned their attention to how to sustain a general conversation, rather than a conversation specifically focused on noticing student thinking.

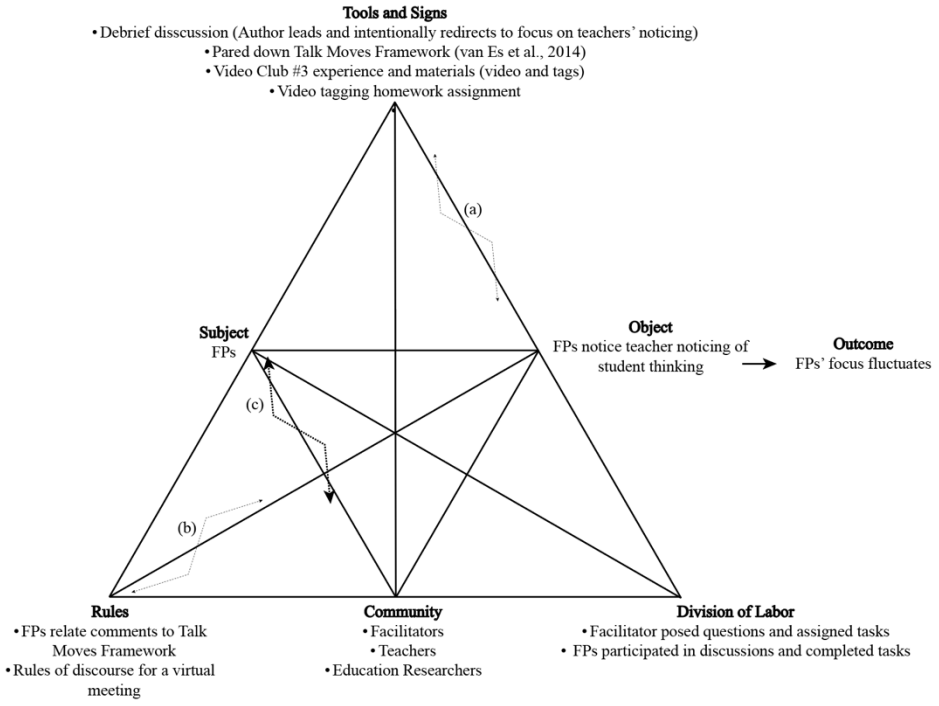
I identified these tensions as I reviewed the video recording of Debrief 1 in preparation for Debrief 2 in Session 3. I made changes to my plan, which contributed to changes in the activity system.

Activity System B: FPs' focus fluctuated

In order to address the tensions from Debrief 1, I made several changes ahead of Debrief 2, which altered the tools and signs from Activity System A to Activity System B (Figure 6). First, I revised the Talk Moves Framework to only include moves that I thought were especially helpful for supporting teachers to learn to notice. I also changed the initial prompt for Debrief 2 to explicitly refer to noticing. The prompt was, “How do you think these moves [in the revised Talk Moves Framework] help teachers to notice student thinking in the classroom?” Finally, I was more intentional during the discussion to press the FPs to move beyond thinking of leading video clubs as facilitating any conversation. I encouraged FPs to focus on how the talk moves related to teachers’ noticing process.

Figure 6

Activity System B



After I made these changes, the outcome of the activity system changed FPs' focus in relation to facilitating video clubs. Their focus fluctuated between supporting aspects of a productive conversation, uncertainty about how to lead a video club discussion, and supporting aspects of teachers' noticing process. For instance, during Debrief 2 Thornton expressed confusion about how to use the talk move to support teachers to learn to notice. He said:

> Where I'm struggling... like, all of these moves are great. I don't know if any of them particularly helped to notice student thinking as opposed to helping, like, I think, as you said, this is kind of like a generic framework you can kind of use for if you were looking at teacher questioning techniques, or like, I don't know, like, the best way to crochet a scarf techniques. I mean, like so I

> think I'm struggling a little bit with the like, I don't know if I exactly see how specific, I don't know if there's specific things that are like, would be particularly helpful for noticing student thinking. These are all great for just like general facilitation.

I responded to Thornton by asking the FPs to consider how a particular talk move, *lifting up*, helped them to notice student thinking during the video club. Libby replied:

> Maybe not highlighting, but what was the one that I was looking at? Or highlighting, it's that there are things that other people notice and tagged in the video that I wouldn't necessarily notice. And having these discussions... allow[s] me to see more of what I missed.

Thornton talked about how he was unsure if he could differentiate between using the talk moves to support teachers to learn to notice student thinking or using them to support teachers to learn other concepts. However, Libby, with my prompting, focused on how *lifting up* could help her see what she missed in the video, which related to her SA. Thus, Libby began to focus on teachers' noticing process. Throughout Debrief 2, as I continued to encourage the FPs to consider teachers' noticing, they became more and more focused on teachers' noticing process (Walton, 2023b).

Changes and Tensions in Activity System B

My changes to the tools and signs appeared to lessen tensions (a) and (b) in Activity System B, which can be seen by the now smaller zig-zag lines in Figure 6. The refined prompt and intentional redirections from me made the task of connecting the talk moves to supporting teachers' noticing more explicit for the FPs. This change

diminished tension (a) because it shifted FPs' focus to teachers instead of facilitators. Tension (b) also weakened because, although the FPs were still required to refer to the talk moves as they discussed, my changes encouraged them to use the framework as a jumping-off point for understanding how one could facilitate a video club. The FPs could use the Talk Moves Framework to identify the actions that I took in the video club, but they still had to consider how the moves specifically related to teacher noticing. As a result, the FPs began to grapple with understanding the talk-moves-to-teacher-noticing connection, as can be seen by Thornton's confusion above.

However, tensions (a) and (b) did not completely cease to exist. There is evidence that these tensions were still present as the FPs completed their Video Tagging Homework Assignment, where their focus in relation to facilitation also varied. As stated in the methods section, the FPs watched a recording of the Session 2 video club in which they participated and I facilitated. They were asked to use Anotemos to tag talk moves that I used and connect them supporting teacher noticing. The directions for the homework assignment read:

> Use the green pins to tag instances where you thought the facilitator (i.e., Margaret) used the different moves in the framework. In the tag comments, write about why you think the facilitator used that move. **In particular, how did that move specifically support the participants (i.e., all of you) in noticing/learning to notice student thinking in the classroom? Another way to look at this question is how do these moves, in this context, go beyond just supporting a conversation? How do they help teachers shift their focus to students and reason about student thinking?**

15 of the 76 FPs tags from that assignment, or nearly 20% of the tags, related to supporting a productive conversation. All 15 tags were written by three of the six FPs. For example, Todd tagged a moment when I used the *pointing to evidence* move with him during the video club discussion. He first wrote what I said and then explained why it was important (note: Todd talks about himself in third person):

> Pointing to Evidence: “Todd, do you have an example of that?"
>
> This opens up a space to allow for Todd to share more about why he was noticing what he saw and why it was important. I think asking for evidence reinforces the need to anchor ideas to something that others can use to follow along with the conversation.

While Todd referred to noticing in his response, he did not explain how the move I made, *pointing to evidence*, helped him to notice. Instead, he wrote about how asking for further explanation can clarify the conversation for others. Again, clarity and other characteristics of a productive conversation are needed in a video club, but are not sufficient to support teacher noticing.

One possible reason for some FPs' continued focus on supporting aspects of a productive conversation during the homework assignment is that I was not a resource at the time. I was not there to redirect FPs’ focus to teachers and to think about how facilitation moves support teachers' noticing process. As a result, tensions (a) and (b) may have interfered with FPs’ focus once again.

In addition, the FPs were a resource to each other during Debrief 2, but not during the homework assignment, which they completed individually. This difference could be another reason that tensions (a) and (b) persisted in Activity System B and

why the FPs' focus varied. The FPs' individual understandings of leading a video club likely impacted the group's focus as they discussed during Debrief 2. For example, Libby's comment above may have helped other FPs start to understand the relationship between the talk moves and supporting teachers to notice. However, when on their own, the FPs could not listen to and build off of each other. As a result, some FPs continued to largely focus on sustaining a general conversation with teachers, instead of moving toward helping teachers learn to notice.

There was also a third tension, tension (c), that surfaced in Activity System B. This tension stemmed from FPs' apparent conflicted feelings over their identity in the broader community of facilitators and teachers. Before continuing, the difference in size between tensions (a), (b), and (c) in Figure 6 does not signify the relative impact of tension (c) compared to (a) and (b). Rather, the smaller size of (a) and (b) represents their likely diminished contribution to Activity System B, compared to their contribution to Activity System A.

Evidence of tension (c) came from a comment Thornton made at the end of Debrief 2. Margaret asked if there were any final thoughts before the session ended. Thornton said:

> This is a really interesting project, but it is really difficult to think about because I'm like... I have to simultaneously sort of keep my attention on three different like, perspectives all at once... I'm like I, I'm going to be thinking about like, how to, how to facilitate and how to think about student thinking to teachers. Like as I've been one- as I've been all of those things at different times in my life...It's like trying to juggle but like, I don't know, I am just, like,

struggling with as soon as I begin to sort of like get a sense of one thing, like, then this other thing over here, like slips away.

Thornton conveyed uneasiness about how to simultaneously account for three different kinds of thinking- the facilitator's, the teacher's, and the student's- particularly because he has at times identified as each of these roles. The potential impact of tension (c) on Activity System B was less clear than tensions (a) and (b), but it is possible that tension (c) also contributed to the FPs' inconsistent focus. Tension (c) had a more prominent role in Activity System C, which I will explain in the next section.

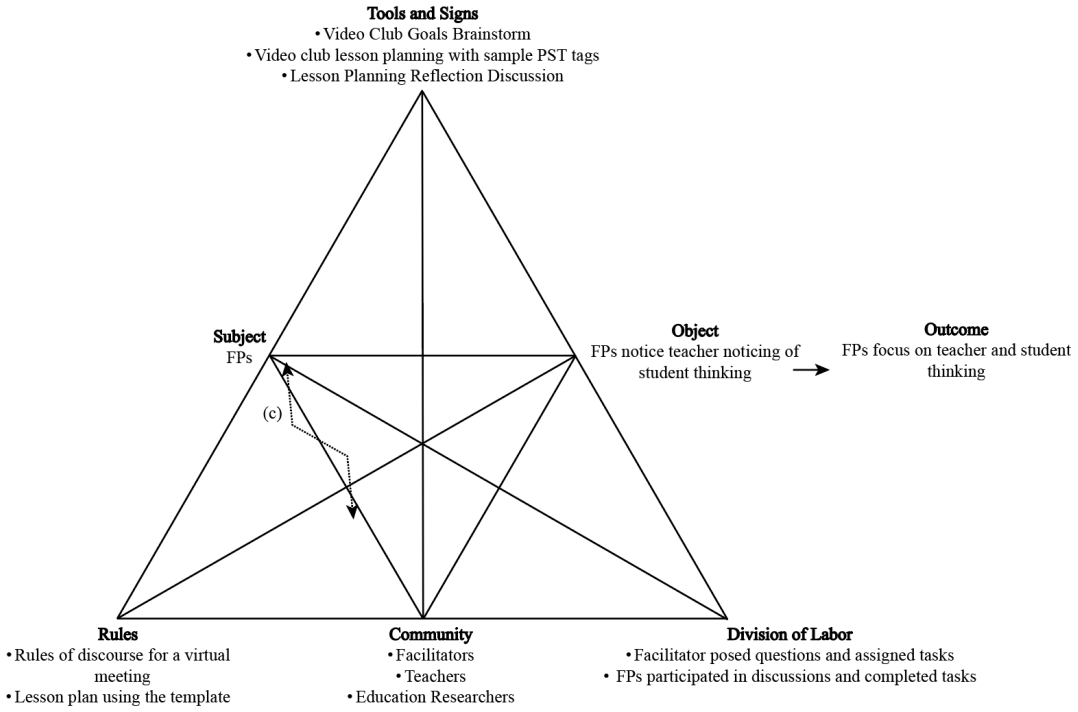
In sum, the changes made to the F-PD after Debrief 1 likely weakened tensions (a) and (b). This was particularly true during Debrief 2 as the FPs interacted with each other and me and began to focus more on teachers' noticing process. However, when FPs individually completed the video tagging homework assignment, these tensions resurfaced without the support of the full group. In addition, Tension (c) also emerged, though its potential impact on the F-PD became clearer in Activity System C.

Activity System C: FPs Focused on Teachers' Noticing Process and Student Thinking

In Sessions 4 and 5, the outcome was that FPs mostly focused on aspects of teachers' noticing process (Figure 7). However, there were several instances when the FPs' focus shifted to student thinking without considering teachers.

Figure 7

Activity System C



An example of FPs' focus on aspects of teachers' noticing process comes from the opening of Session 4 and the Goals Brainstorming Task. During the brainstorming task, the FPs created and shared goals for a video club using a classroom video of an Algebra I class discussing whether it is possible to have negative inputs for the function $f(x) = \sqrt{x}$. The FPs paid attention to aspects of teachers' noticing process from the beginning of the task. Faith talked about her goal, *teachers will be able to notice when students are grappling with transition from function thinking to graphical thinking*, and said:

I would want teachers to notice that there are these two ways that students have to move between in order to answer the question. And the two ways is,

> thinking about what are the, what happens with the function? What happens to inputs when it goes into the function that come out? And what does it look like on a graph?

Faith's explanation referred to how teachers should understand the ways that students connect the numerical and graphical representations of functions to reason about the domain. That is, Faith would want the teachers to connect students' thinking back to the math concepts at hand, which relates to teachers' KBR.

Another example is during the discussion in Session 5 about the video club lesson plans. The video club video that FPs used to develop their lesson plans came from a high school Geometry class. The class tried to understand why, if a polygon's perimeter increases by a factor of n, does its area increase by a factor of n^2? The FPs also had sample PST tags that they analyzed and incorporated into their lesson plans. One of Nicole's comments is representative of much of the conversation. Nicole pointed out that many of the sample PST tags that the FPs did not have comments. She said,

> I would ask [the PSTs] if this is what they tagged is like, "Okay, now go back and watch the video again. And like, tell me why you tagged, like, what was important in those moments that you tagged? Other than just, like, that was when a student was talking."

Here, Nicole addressed teachers' KBR. Nicole would ask teachers to move beyond only pointing out instances of student thinking. She would press them to explain why that thinking was important for student mathematics learning.

However, there were brief moments when the FPs focused only on the student thinking from the video. They did not consider how to support teachers in noticing that thinking. This shift in focus happened when the FPs were unsure of what students in the video were thinking. An example was when the FPs discussed an instance in the video when one student, Jasper, explained that the area of a rectangle would increase by n^2 because two dimensions, the length and the width increase and then get multiplied together. Jasper seemed to think about the rectangle in terms of its area equation $A = lw$. However, when another student in the class restated Japer's idea, Jasper responded with a slightly different explanation. Jasper's response suggested that either he did not understand what the other student said, or he did not fully understand the relationship between the area and perimeter of a rectangle. Todd and Thornton discussed this moment of the video during Session 5 and said:

> **Todd:** This is a situation where students are, are in the process of negotiating with themselves and with the class and the teacher, like, how they understand what's going on....[Jasper's] still like, navigating this, this, this thing where he's still trying to make sense. And he doesn't want to like immediately say, "Yep, that's exactly what I saying. Because he's like, well... So like, that could be another way to think about it, too, is like, kids who are students who are like, interacting with this for the first time, perhaps, and, you know, so trying to figure out nuances and things like that.
>
> **Thornton:** Yeah. It's like the communication around the math itself. And then the communication between the students. And how do you translate what the one student said into, like, your understanding of the math?

Here, Todd and Thornton worked to interpret Jasper's thinking, but they did not then relate their interpretation back to helping teachers understand Jasper. In this moment, it was as if Todd and Thornton assumed a participant role in a video club, rather than working to facilitate one.

Changes and Tensions in Activity System C

The outcome in Activity System C, FPs focus on teacher and student thinking, was more closely aligned with the object, FPs notice teacher thinking of student thinking. In other words, the goal of the F-PD was for FPs to learn to lead video clubs by becoming better at noticing teacher thinking, and their focus on teachers' noticing process indicated that they progressed toward that goal. A reason for this progress could be that changes in the tools and signs removed tensions (a) and (b).

It is notable Faith and Nicole, along with other FPs in Sessions 4 and 5, immediately focused on aspects of teachers' noticing process with no prompting from me. The tools and signs in Activity System C likely better supported this focus because they were about planning for work with teachers, rather than reflecting on the actions of a facilitator. For example, the lesson planning assignment allowed the FPs to envision how they might plan for and work with teachers. In addition, using the PST tags to lesson plan gave FPs an idea of what teachers might think about the video and put teacher thinking at the forefront of their work. As a result, the FPs' attention was directly on teachers and their thinking, which made considering teachers' noticing easier. Said differently, the tasks in Sessions 4 and 5 better aligned with the object of noticing teachers' noticing of student thinking than previous F-PD tasks. The outcome, in turn, was also more in line with the object of the F-PD.

Tension (b) also did not appear in Activity System C, which was likely due to the changes in tools and signs. The tasks of Sessions 4 and 5 did not explicitly require the Talk Moves Framework. Thus, it was no longer a rule for FPs to refer to the framework to participate in the F-PD. As a result, the aspects of leading a general conversation, like distributing participation and validating teachers' responses, became less focal in Sessions 4 and 5. Freedom from this constraint likely allowed the FPs to better focus on the aspects of leading a video club discussion that specifically support teachers' noticing. Although a new rule was imposed, to lesson plan using the lesson planning template, the template was designed to specifically plan for video clubs and support teachers to learn to notice so it did not lead to any further tension.

While tensions (a) and (b) were absent from Activity System C, tension (c) persisted and possibly contributed to interruptions in the FPs' focus on aspects of teachers' noticing process.

In the exchange between Todd and Thornton above, they discussed as if they were participating in a video club. They did not consider PSTs' tags or thinking and instead tried to make sense of the student thinking only for themselves. It appeared that Todd and Thornton assumed the identity of teachers, rather than facilitators, indicating a tension between the FPs and their broader community. In Activity System B, Thornton said he struggled to juggle the different perspectives- facilitator, teacher, and student- that seemed necessary for effective facilitation. Here, Todd and Thornton might have dropped the facilitator identity in favor of the teacher identity as

they made sense of student ideas. Thus, their focus momentarily shifted away from teachers' noticing process as they only considered student thinking.

In sum, in Sessions 4 and 5 the FPs primarily focused on teachers' noticing process and student thinking as they discussed and completed tasks. The nature of the tasks and the tools they used seemed to enhance this focus. The tasks, like the goal brainstorming and lesson planning, focused on teachers. The FPs also did not have to ground their work in the Talk Moves Framework. As a result, tensions (a) and (b) were eliminated and the FPs could more easily focus on teachers' noticing process. However, there were moments when FPs' paid attention only to the student thinking in the classroom video. Tension (c) likely contributed to these shifts. As the FPs tried to understand the student thinking in the video for themselves, they fell into "teacher mode" and acted as if they were the video club participants, rather than the facilitator.

Conclusions and Future Work

Through the lens of activity theory, the results above show how the overall F-PD design constrained and also supported FPs in learning to lead video clubs, and how I made changes to the design to solve issues that arose. As I refined the F-PD tasks and tools, and as the tasks and tools changed in later sessions to foreground teachers, the FPs more consistently focused on teachers' noticing process. This focus better aligned to the object, *noticing teachers noticing student thinking.* The various tools and tasks created or eased tensions that contributed to the FPs' progress toward the F-PD goal and have implications for the design of future F-PDs for supporting teachers to learn to notice, which I describe below.

Design Implication 1: PBTE Pedagogies that Focus on Teachers

Like several other F-PDs in the literature, the F-PD here lifted up PBTE practices, under the assumption that whatever helps teachers learn also likely helps facilitators (Borko et al., 2021; Jackson et al., 2015; Prediger et al., 2019). This study built on the insights of previous work and examined not only whether different tasks and tools rooted in PBTE supported novice facilitator learning, but also *why* they helped the facilitators learn focus on notice teachers' noticing process. An important conclusion that can be drawn from my results is that PBTE pedagogies contribute to facilitator learning, but ,at least for learning to lead video clubs, F-PD content should also center on teachers and their thinking.

Overall, the tasks and tools in the F-PD fell into different categories of PBTE pedagogies. Early in the F-PD, most of the tasks and tools were representations and decompositions of video club facilitation. While engaging in these tasks, FPs focused on aspects of facilitation to support a productive teacher conversation, in general. By Sessions 4 and 5, the tasks and tools were approximations of practice, and FPs' focused more on aspects of teachers' noticing process. Again, understanding how to maintain a conversation with a group of teachers is important and needed for a video club. Thus, it was productive when the FPs worked to understand these facets of facilitation early in the F-PD. However, as other researchers have argued (Borko, Koellner et al., 2014; Elliott et al., 2019; Jackson et al., 2015, Schwarts et al., 2021), facilitators must do more as they lead teachers in discussion for teachers to learn instructional practices, like noticing. Indeed, when the tasks and tools of the F-PD centered on teachers, the FPs then worked to figure out how to support the components of teachers' noticing process, like their SA or KBR.

Given the FPs' shift in focus, a potential takeaway is that approximations of practice provide more valuable learning experiences for novice facilitators than other PBTE pedagogies. However, I contend that the more likely explanation is that the changes in PBTE pedagogies in the F-PD coincided with a shift in the focus of the tasks and tools from the facilitator to teachers. As a result, the FPs paid more attention to teachers' noticing process in Sessions 4 and 5 because the tasks and tools centered teachers. I argue that this means that all PBTE pedagogies likely support facilitator learning, but they should focus on teachers. Like the importance of teachers' attention to students in video clubs (Sherin, 2007), facilitators learning to notice teachers' thinking should attend to teachers.

The decomposition tasks early in the F-PD, like Debrief 1 and the Video Tagging Homework Assignment, largely emphasized the facilitator, which likely made it difficult for FPs to connect facilitator actions to teachers and their noticing. In addition, the tool meant to help FPs identify such connections, the Talk Moves Framework, was not designed to specifically support teacher noticing. Had the tasks early in the F-PD been designed to encourage and remind the FPs to relate facilitation to teachers' noticing process, they might have done so sooner. In fact, there was evidence in Activity System B that such a design could have better supported the FPs in this way. When I changed the prompt for Debrief 2 to explicitly connect to teachers' noticing and then intentionally redirected the FPs to focus on teachers, the FPs moved away from discussing facilitation as a productive conversation. However, when completing the Video Tagging Homework Assignment some FPs shifted back

to concentrating on the characteristics of a general conversation. At this point, they no longer had the support of their peers or me to keep their focus on teachers.

Yet, in Session 4, with no additional feedback from me or anyone else, the FPs immediately focused on different aspects of teachers' noticing process. The first task in Session 4, the Video Club Goals Brainstorming, asked the FPs to consider what they would want teachers to learn in a video club. This emphasis on teachers and the teacher-centered nature of subsequent activities in the F-PD likely made way for the FPs to turn their focus to teachers' noticing process.

In future iterations of this F-PD, and in response to tensions I identified in Activity Systems A and B, I plan to change the decomposition activities so that they better foreground teachers. One idea is instead of introducing the Talk Moves Framework first, have the FPs watch a video club and develop their own conceptions of productive interactions between teachers and the facilitator. The Talk Moves Framework could be introduced later to formalize FPs' ideas. Essentially, this task would be a "video club of a video club" or *lifting up* the video club model to the facilitator level. Other researchers have taken a similar approach (Amador et al., 2022; Elliott et al., 2009; Lesseig, et al., 2017). For example, Amador and colleagues (2022) have had math coaches participate in video clubs where the video is a 1-on-1 meeting between a teacher and a coach to better understand how to support teachers in such meetings.

Design Implication 2: Artifacts that Allow Facilitators to See Teacher Thinking

Based on this study, tools that allow novice facilitators to see teacher thinking are an integral piece of F-PD designs. The example PST tags in Anotemos allowed

the FPs to get a sense of how PSTs thought about the video club video and the state of PSTs' noticing skills. Much like how teachers anticipate student responses during math lessons, the FPs could use the tags to envision how they might respond to PST ideas during a video club. Nicole's comment during Activity System C, which is in the Results section above, is good evidence of this. Through PSTs' tags, Nicole was able to identify a learning need related to PSTs' KBR and make a plan to address it during the video club. Nicole potentially now knows that such a tagging pattern is a possibility for future PSTs, meaning she could anticipate it while planning and implementing future video clubs. Other studies have suggested that there could be other tools, besides video tags, like teacher brain dumps or small group teacher discussions before the full video club, that could also give facilitators access to teacher thinking during video clubs (Walton & Walkoe, in press). Any of these tools could be helpful to novice facilitators as they learn to notice teacher thinking.

In future work, I plan to explore how to better utilize such tools to support video club facilitator learning. For instance, an analogous idea to providing facilitators access to teacher artifacts that show teacher thinking is providing teachers with access to student artifacts. In particular, the *Five Practices for Orchestrating Productive Mathematics Discussions* was developed as a framework to guide teachers to use student work as a foundation for mathematics discussions (Stein et al., 2008). There is potential to use sample PST or in-service teacher video tags as an artifact for facilitators to plan and enact the five practices in video clubs and other teacher PD. These ideas would build on other research on facilitators that has already lifted up the five practices to support facilitators to work with teachers on math tasks (Elliot et al.,

2009; Lesseig, 2017), in facilitating science teacher PD (Tekkumru-Kisa & Stein, 2017), and other video-based PD (Borko, Koellner et al., 2014; Borko, Carlson, et al., 2017).

Other Future Work

This study was an initial exploration of the kinds of tasks and tools that can help facilitators learn to lead video clubs. One limitation is that this study was with a small number of participants. Future iterations of the F-PD could yield more data, which might give more and better insights into how FPs learn to notice teacher thinking and lead video clubs.

In addition, I did not examine whether different F-PD tasks and tools supported FPs to notice different aspects of teachers' noticing process more or less. For example, are some F-PD tasks more appropriate for helping novice facilitators notice teachers' KBR? What types of tasks help facilitators learn to support teachers to better respond to students? Other studies could build on the work here to answer such questions.

Another question left unanswered is the importance of tension (c)'s relationship to facilitators learning to lead video clubs. Thornton had a point when he talked about facilitation as a juggling act; it can be difficult to know what perspective to take (e.g., facilitator or teacher) because video club facilitators must account for the student thinking in the video, what the teachers say about the student thinking, and whatever video club goals the facilitator had in the first place. Given this challenge, I argue that FPs' momentary shifts to reasoning about student thinking in Activity System C were productive. Much like when teachers in video clubs learn content

when they reason about the mathematics in videos (Walkoe, 2015), facilitators stand to learn about student thinking when they work to make sense of the student ideas in a video.

However, like a focus on generally productive conversations is helpful but not adequate for learning to facilitate video clubs, novice facilitators must also learn to do more than notice student thinking (Amador, 2021; van Es, 2010). The question becomes, what is the best way to support novice facilitators in noticing student thinking while simultaneously learning to lead video clubs? Is it with the video clubs that I did in the first three sessions of the F-PD? Or should more activities explicitly about student thinking be woven throughout the F-PD? Again, these are questions for future work.

Finally, this study aims to understand how the F-PD supports novice facilitators as they participate in the F-PD. It gives no indication that individual FPs would be able to transfer their learning to effectively lead video clubs with real teachers or PSTs. I eventually plan to follow novice facilitators from the F-PD into leading real video clubs to understand if and how the facilitators apply what they learned to their work with teachers.

References

Amador, J. (2016). Professional noticing practices of novice mathematics teacher educators. *International Journal of Science and Mathematics Education*, *14*(1), 217–241. https://doi.org/10.1007/s10763-014-9570-9

Amador, J., Choppin, J., Callard, C., Carson, C., Kruger, J., Gillespie, R., Martin, S., Hanan, A., & Heaton, R. (2022). Coaches' noticing before, after, and during

video clubs. In A. E. Lischka, E. B. Dyer, R. S. Jones, J. N. Lovett, J. Strayer, & S. Drown (Eds.), *Proceedings of the forty-fourth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Vol. 6, Issue 1, pp. 1521–1522). Middle Tennessee University. https://doi.org/10.5951/mathteaceduc.6.1.0027

Amador, J. M. (2020). Teacher leaders' mathematical noticing: eliciting and analyzing. *International Journal of Science and Mathematics Education*, *18*(2), 295–313. https://doi.org/10.1007/s10763-019-09956-5

Amador, J. M. (2021). Mathematics teacher educator noticing: examining interpretations and evidence of students' thinking. *Journal of Mathematics Teacher Education*. https://doi.org/10.1007/s10857-020-09483-z

Ball, D. L., & Forzani, F. M. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education*, *60*(5), 497–511. https://doi.org/10.1177/0022487109348479

Beisiegel, M., Mitchell, R., & Hill, H. C. (2018). The design of video-based professional development: An exploratory experiment intended to identify effective features. *Journal of Teacher Education*, *69*(1), 69–89. https://doi.org/10.1177/0022487117705096

Borko, H., Carlson, J., Deutscher, R., Boles, K. L., Delaney, V., Fong, A., Jarry-Shore, M., Malamut, J., Million, S., Mozenter, S., & Villa, A. M. (2021). Learning to lead: An approach to mathematics teacher leader development. *International Journal of Science and Mathematics Education*, *19*, 121–143. https://doi.org/10.1007/s10763-021-10157-2

Borko, H., Carlson, J., Mangram, C., Anderson, R., Fong, A., Million, S., Mozenter, S., & Villa, A. M. (2017). The role of video-based discussion in model for preparing professional development leaders. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0090-3

Borko, H., Jacobs, J., Seago, N., & Mangram, C. (2014). Facilitating video-based professional development: Planning and orchestrating productive discussions. In Y. Li, E. A. Silver, & S. Li (Eds.), *Transforming Mathematics Instruction Multiple Approaches and Practices* (pp. 259–281). https://doi.org/10.1007/978-3-319-04993-9_16

Borko, H., Koellner, K., & Jacobs, J. (2011). Meeting the challenges of scale: The importance of preparing professional development leaders. *Teachers College Record*, 11–14. https://doi.org/10.1007/s11858-010-0302-5.https

Borko, H., Koellner, K., & Jacobs, J. (2014). Examining novice teacher leaders' facilitation of mathematics professional development. *Journal of Mathematical Behavior*, *33*, 149–167. https://doi.org/10.1016/j.jmathb.2013.11.003

Castro Superfine, A., Amador, J., & Bragelman, J. (2019). Facilitating video-based discussions to support prospective teacher noticing. *Journal of Mathematical Behavior*, *54*, 1–18. https://doi.org/10.1016/j.jmathb.2018.11.002

Castro Superfine, A., & Li, W. (2014). Exploring the mathematical knowledge needed for teaching teachers. *Journal of Teacher Education*, *65*(4), 303–314. https://doi.org/10.1177/0022487114534265

Castro Superfine, A., & Pitvorec, K. (2021). Using Community Artifacts to Support Novice Math Teacher Educators in Teaching Prospective Teachers. *International Journal of Science and Mathematics Education*, *19*, 59–75. https://doi.org/10.1007/s10763-021-10152-7

Cobb, P., & Bowers, J. (1999). Cognitive and situated learning perspectives in theory and practice. *Educational Researcher*, *28*(2), 4–15. https://doi.org/10.3102/0013189X028002004

Cobb, P., Confrey, J., Disessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, *32*(1), 9–13. https://doi.org/10.3102/0013189X032001009

Cobb, P., & Yackel, E. (1996). Constructivist, emergent, and sociocultural perspectives in the context of development research. *Educational Psychologist*, *31*(3/4), 175–190.

Cole, M & Engeström, Y. (1993). A cultural-historical approach to distributed cognition. In G. Salamon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 1–46). Cambridge University Press.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. In *Source: The Journal of the Learning Sciences* (Vol. 13, Issue 1).

The Design-Based Research Collective (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, *32*(1), 5–8. https://doi.org/10.3102/0013189X032001005

Elliott, R., Kazemi, E., Lesseig, K., Mumme, J., Carroll, C., & Kelley-Petersen, M. (2009). Conceptualizing the work of leading mathematical tasks in professional development. *Journal of Teacher Education*, *60*(4), 364–379. https://doi.org/10.1177/0022487109341150

Engeström, Y. (1987). *Learning by expanding*. Orienta-Konsultit.

Engestrom, Y. (1993). *Understanding practice perspectives on activity and context*. Cambridge University Press.

Engestrom, Y. (1999). Activity theory and individual and social transformation. In *Perspectives on Activity Theory* (pp. 19–38).

Engestrom, Y. (2000). Activity theory as a framework for analyzing and redesigning work. *Ergonomics*, *43*(7), 960–974.

Engle, R. A., Conant, F. R., & Greeno, J. G. (2007). Progressive refinement of hypotheses in video-supported research. In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video Research in the Learning Sciences* (pp. 239–254). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203877258

Gaudin, C., & Chaliès, S. (2015). Video viewing in teacher education and professional development: A literature review. *Educational Research Review*, *16*, 41–67. https://doi.org/10.1016/j.edurev.2015.06.001

Gravemeijer, K., & Cobb, P. (2013). Design research from the learning design perspective: Part A. *Educational Design Research*, *2006*, 72–113.

Gravemeijer, K., & Van Eerde, D. (2009). Design research as a means for building a knowledge base for teachers and teaching in mathematics education. *Elementary School Journal*, *109*(5), 510–524. https://doi.org/10.1086/596999

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of Educational Psychology* (pp. 673–708). Macmillan.

Grosser-Clarkson, D., & Neel, M. A. (2020). Contrast, commonality, and a call for clarity: A review of the use of core practices in teacher education. *Journal of Teacher Education*, *71*(4), 464–476. https://doi.org/10.1177/0022487119880162

Grossman, P. (Ed.)(2018). *Teaching core practices in teacher education.* Harvard Education Press.

Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. W. (2009). Teaching practice: A cross-professional perspective. *Teachers College Record*, *111*(9), 2055–2100.

Herbst, P., Chazan, D., & Lavu, S. (2019). *Anotemos*. Web-based collaborative software tool for the annotation of video. Disclosed to the Office of Technology Transfer, University of Michigan.

Hutchins, E. (1995). Cultural cognition. In *Cognition in the Wild* (pp. 353–374). The MIT Press.

Jackson, K., Cobb, P., Wilson, J., Webster, M., Dunlap, C., & Appelgate, M. (2015). Investigating the development of mathematics leaders' capacity to support teachers' learning on a large scale. *ZDM Mathematics Education*, *47*(1), 93–104. https://doi.org/10.1007/s11858-014-0652-5

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.

Kang, H., & van Es, E. A. (2019). Articulating design principles for productive use of video in preservice education. *Journal of Teacher Education*, *70*(3), 237–250. https://doi.org/10.1177/0022487118778549

Kelley-Petersen, M., Davis, E.A., Ghousseini. M.K., Kloser, M., & Monte-Sans, C. (2018). Rehearsals as examples of approximation. In P. Grossman (Ed.), *Teaching core practices in teacher education* (pp. 35-55). Harvard Education Press.

Lampert, M. (2010). Learning teaching in, from, and for practice: What do we mean? *Journal of Teacher Education*, *61*(1–2), 21–34. https://doi.org/10.1177/0022487109347321

Lave, J. (1988). Cognition in practice: Mind, Mathematics and Culture in Everyday Life. Cambridge University Press.

Lave, J., & Weger, E. (1991). *Situated learning legitimate peripheral participation* (Cambridge). Cambridge University Press.

Leontiev, A. N. (1974). The problem of activity in psychology. *Soviet Psychology,* 13(2), 4–33.

Lesseig, K., Elliott, R., Kazemi, E., Kelley-Petersen, M., Campbell, M., Mumme, J., & Carroll, C. (2017). Leader noticing of facilitation in videocases of mathematics professional development. *Journal of Mathematics Teacher Education*, *20*(6), 591–619. https://doi.org/10.1007/s10857-016-9346-y

Loewenberg Ball, D., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59*(5), 389–407. https://doi.org/10.1177/0022487108324554

Luna, M. J., & Sherin, M. G. (2017). Using a video club design to promote teacher attention to students' ideas in science. *Teaching and Teacher Education*, *66*, 282–294. https://doi.org/10.1016/j.tate.2017.04.019

Masingila, J. O., Olanoff, D., & Kimani, P. M. (2018). Mathematical knowledge for teaching teachers: knowledge used and developed by mathematics teacher educators in learning to teach via problem solving. *Journal of Mathematics Teacher Education*, *21*(5), 429–450. https://doi.org/10.1007/s10857-017-9389-8

Matsumoto-Royo, K., & Ramírez-Montoya, M. S. (2021). Core practices in practice-based teacher education: A systematic literature review of its teaching and assessment process. In *Studies in Educational Evaluation* (Vol. 70). Elsevier Ltd. https://doi.org/10.1016/j.stueduc.2021.101047

McDonald, M., Kazemi, E., & Kavanagh, S. S. (2013). Core practices and pedagogies of teacher education: A call for a common language and collective activity. *Journal of Teacher Education*, *64*(5), 378–386. https://doi.org/10.1177/0022487113493807

McGrew, S., Alston, C.L., & Fogo, B. (2018). Modeling as an example of representation. In P. Grossman (Ed.), *Teaching core practices in teacher education* (pp. 35-55). Harvard Education Press.

Park Rogers, M., Berry, A., Krainer, K., & Even, R. (2021). Finding common ground: A synthesis of science and mathematics teacher educators' experiences with professional growth. *International Journal of Science and Mathematics Education*, *19*, 167–180. https://doi.org/10.1007/s10763-021-10188-9

Pea, R. (1993). Practice of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 47–87). Cambridge University Press.

Plomp, T., & Nieveen, N. (2013). Educational design research: An introduction. In T. Plomp & N. Nieveen (Eds.), *Educational Design Research: An Introduction* (pp. 11–50). slo.

Prediger, S., Roesken-Winter, B., & Leuders, T. (2019). Which research can support PD facilitators? Strategies for content-related PD research in the Three-Tetrahedron Model. *Journal of Mathematics Teacher Education*, *22*(4), 407–425. https://doi.org/10.1007/s10857-019-09434-3

Prediger, S., Roesken-Winter, B., Stahnke, R., & Pöhler, B. (2022). Conceptualizing content-related PD facilitator expertise. *Journal of Mathematics Teacher Education*, *25*(4), 403–428. https://doi.org/10.1007/s10857-021-09497-1

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, *29*(1), 4–15.

Roth, K. J., Bintz, J., Wickler, N. I. Z., Hvidsten, C., Taylor, J., Beardsley, P. M., Caine, A., & Wilson, C. D. (2017). Design principles for effective video-

based professional development. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0091-2

Schutz, K.M., Grossman, P., Shaughnessy, M. (2018). Approximations of practice in teacher education. In P. Grossman (Ed.), *Teaching core practices in teacher education* (pp. 35-55). Harvard Education Press.

Schwarts, G., Pöhler, B., Elbaum-Cohen, A., Karsenty, R., Arcavi, A., & Prediger, S. (2021). Novice facilitators' changes in practices: From launching to managing discussions about mathematics teaching. *Journal of Mathematical Behavior*, *64*. https://doi.org/10.1016/j.jmathb.2021.100901

Shaughnessy, M., Garcia, N., Selling, S. K., & Ball, D. L. (2016). What knowledge and skill do mathematics teacher educators need and (how) can we support its development? *Proceedings of the 38th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, 813–820.

Sherin, M.G, (2007). The develop of teachers' professional vision in video clubs. In Goldman, R., Pea, R., Barron, B., Derry, S.J. (Eds.), *Video research in the learning sciences* (pp 383-395). Mahwah, NJ: Lawrence Earlbaum Associates.

Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, *20*(2), 163–183. https://doi.org/10.1016/j.tate.2003.08.001

Sherin, M. G., & Van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education*, *60*(1), 20–37. https://doi.org/10.1177/0022487108328155

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning*, *10*(4), 313–340. https://doi.org/https://doi.org/10.1080/10986060802229675

Tekkumru-Kisa, M., & Stein, M. K. (2017). A framework for planning and facilitating video-based professional development. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0086-z

van Es, E. A., Tekkumru-Kisa, M., & Seago, N. (2020). Leveraging the power of video for teacher learning. In S. Llinares & O. Chapman (Eds.), *International Handbook of Mathematics Teacher Education: Volume 2* (pp. 23–54). Koninklijke Brill NV. https://doi.org/10.1163/9789004418967_002

van Es, E. A., Tunney, J., Goldsmith, L. T., & Seago, N. (2014). A framework for the facilitation of teachers' analysis of video. *Journal of Teacher Education*, *65*(4), 340–356. https://doi.org/10.1177/0022487114534266

Vygotsky, L. (1978). *Mind in Society the Development of Higher Psychological Processes.* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press. https://doi.org/10.2307/3726822

Walkoe, J. (2015). Exploring teacher noticing of student algebraic thinking in a video club. *Journal of Mathematics Teacher Education*, *18*(6), 523–550. https://doi.org/10.1007/s10857-014-9289-0

Walton, M. (2023a). A facilitator noticing framework: How facilitators notice teacher thinking. Manuscript in preparation.

Walton, M. (2023b). Novice facilitators learning to lead video clubs: A framing perspective. Manuscript in preparation.

Walton, M., Walkoe, J., Elby, A., Fofang, J., & Weintrop, D. (2020). Teachers' conceptualizations of computational and mathematical Thinking. In M. Gresalfi & I. Horn (Eds.), *The Interdisciplinarity of the Learning Sciences, 14th International Conference of the Learning Sciences (ICLS)* (pp. 2053–2060). International Society of the Learning Sciences. https://www.anotemos.com

Yamagata-Lynch, L. C. (2003). Using activity theory as an analytic lens for examining technology professional development in schools. *Mind, Culture, and Activity*, *10*(2), 100–119. https://doi.org/10.1207/S1532-7884MCA1002_2

Yamagata-Lynch, L. C. (2007). Confronting analytical dilemmas for understanding complex human interactions in design-based research from a Cultural - Historical Activity Theory (CHAT) framework. *Journal of the Learning Sciences*, *16*(4), 451–484. https://doi.org/10.1080/10508400701524777

Yamagata-Lynch, L. C. (2010). *Activity Systems Analysis Methods: Understanding Complex Learning Environments*. Springer.

Zopf, D. (2010). Mathematical knowledge for teaching teachers: The mathematical work of and knowledge entailed by teacher education. Unpublished doctoral dissertation. Retrieved from http://deepblue.lib. umich.edu/bitstream/handle/2027.42/77702/dzopf_1.pdf.

Appendix A
Hypothetical Video Club Protocol Assignment

Directions: Watch the *Area and Perimeter Video* and then read through the corresponding PST tags and comments about student thinking. Use the tags and comments to develop a video club discussion protocol that supports teachers in noticing student ideas. Your protocol should include the following:

- One or more noticing goals for teachers that relate to the math content in the video.
- An overview of the key moments of student thinking in the video, related to the teacher noticing goals
- At least two questions that you could ask teachers during a video club discussion that relate to the teacher noticing goals and the key moments of student thinking.

The template on the next page is designed to help you complete the necessary components of hypothetical protocol.

Area and Perimeter Video Club

Video Club Overview:
Video Summary: *Include a short summary of the video club here*

Video Club Goal: *Write your video club goal for teacher here.*

Exploring the Math:
Write a description of the math in the video, including the ways that teachers or student might think about the content.

Overview Video Key Moments			
Description of Goal #1:			
Key video moments of multimodal thinking that support goal			
Time Stamp	**Moment Description**	**Visual Cues** (If applicable, feel free to paste screen shots from the video)	**Explanation of Importance** (Including evidence from PST tags, significance of multimodal expressions, different interpretations of student thinking, etc.)

Possible Discussion Questions:

Description of Goal #2:			
Key video moments of multimodal thinking that support goal			
Time Stamp	**Moment Description**	**Visual Cues** **(If applicable, feel free to paste screen shots from the video)**	**Explanation of Importance** **(Including evidence from PST tags, significance of multimodal expressions, different interpretations of student thinking, etc.)**

Possible Discussion Questions:

Conclusion

High quality PD is important for pre-service and in-service teachers to improve their instruction (Beisiegel et al., 2018; Borko et al., 2011; Roth et al., 2017). PD facilitators are an integral part of PD and are often responsible for both the PD planning and implementation. High quality PD requires well-prepared facilitators.

One of the practices essential for good mathematics teaching is *noticing* (Empson & Jacobs, 2008; Fennema et al., 1996; Robertson et al., 2016). Many teachers need support to learn how to notice student thinking, but PD, like video clubs, has been shown to help teachers develop this practice (Luna & Sherin, 2017; Sherin & Han, 2004; van Es, 2011; Walkoe, 2015). The video club facilitator is a key factor for teachers to learn to notice. One of the ways that the facilitator contributes to teachers' noticing development is through their interactions with teachers during video club discussions (Castro Superfine et al., 2019; Goldsmith & Seago, 2008). Thus, video club facilitators need to be equipped to lead meaningful discussions that focus on attending to, interpreting, and deciding how to respond to students' mathematical thinking.

This dissertation investigated how novice facilitators learn to lead video clubs and how an F-PD can support their learning. In Study One, I first worked to understand experienced facilitators' process for leading video clubs so that I knew what novices should be learning. I developed the Facilitator Noticing Framework and argued that facilitator noticing and teacher noticing are a similar process. However, facilitators notice teacher, not student, thinking, which I outlined in the framework. I

concluded that effective video club facilitation is based on noticing teachers' thinking.

Study Two was a close examination of FPs' process in learning to lead video clubs. Janet and I looked for evidence of FP learning by zooming in on FPs' interactions with each other, me as the F-PD leader, and with tools like the Talk Moves Framework. The framing perspective helped us understand the changes in interactions that we saw. We argued that FPs first framed leading video clubs as facilitating a conversation that teachers could follow and in which they could participate. This type of facilitation is not enough to support teachers to learn to notice. By the end of the F-PD, we argued that the FPs more consistently framed leading video clubs as noticing aspects of teachers' noticing process, as outlined in the FNF.

Study 3 took a bird's eye view of the F-PD. I adopted activity theory to explain the difficulties that arose in achieving the goal, *FPs noticing teachers' noticing of student thinking,* and to explain the reasons for those issues. I discussed the design decisions I made to solve the problems, and how differences in the F-PD design between the earlier and later sessions also contributed to solutions. My design implications, that F-PD tasks and tools should center teachers and their thinking, are hopefully helpful to future F-PD designers.

An important connection between Study One and Study Two is that Study Two underscores the importance of the FNF. My initial intention with giving the Talk Moves Framework to the FPs was that it would be a helpful scaffold for them. I thought the Talk Moves Framework would help the FPs determine the actions they

should take while leading a video club and understand why those actions would be productive to support teachers to learn to notice. In reality, the Talk Moves Framework was helpful for FPs to have a list of different moves they could use, but it may have primed them to focus on leading a conversation with teachers in general. It did not help FPs connect those moves to supporting teachers to learn to notice. I had to make changes to the F-PD tasks and be more intentional in my own facilitation of FP discussions from them to connect the talk moves to teacher noticing. I made these changes using the FNF as a guide. Thus, general facilitation frameworks may not be enough to help facilitators learn how to pursue specific teacher goals for improving mathematics instruction, like learning to notice. The moves are helpful but need to be more intentionally connected to the goals of an F-PD. This aligns with other F-PD work in teaching facilitators to lead teachers in mathematical tasks (Lesseig et al., 2017).

Another contribution of Studies 2 and 3 is the efficacy of lifting up (Prediger et al., 2019) theoretical and analytical frameworks to the facilitator level of PD and learning. Other researchers have also lifted up theories of learning and analysis used in teacher and K-12 education, so I followed a strong foundation (Borko et al., 2021; Jackson et al., 2015; Lesseig et al., 2017; Tekkumru-Kisa & Stein, 2017). However, I argue that I have shown how framing and activity theory, in particular, can be valuable tools to understand facilitator learning and education.

This dissertation was the first large cycle in a DBR project that could have multiple iterations to come. During implementation, I made some changes to the F-PD design as I engaged in smaller cycles of reflection (Gravemeijer & Cobb, 2013).

Based on my findings here, I plan to do a comprehensive overhaul for a large new cycle that I hope to implement in the near future. A path I am particularly interested in is implementing an improved F-PD design with facilitators who work with in-service teachers, like teacher leaders or department chairs. I look forward to understanding if and how working with these types of facilitators differs from working with graduate students. In addition, although I saw evidence that the FPs learned to lead video clubs over the F-PD, I do not know whether that learning transfers to facilitating real video clubs. I plan to investigate this question by following future FPs into their video clubs with teachers. Such a project would give an even deeper understanding of facilitator learning and inform how to better support them.

References

Beisiegel, M., Mitchell, R., & Hill, H. C. (2018). The design of video-based professional development: An exploratory experiment intended to identify effective features. *Journal of Teacher Education*, *69*(1), 69–89. https://doi.org/10.1177/0022487117705096

Borko, H., Carlson, J., Deutscher, R., Boles, K. L., Delaney, V., Fong, A., Jarry-Shore, M., Malamut, J., Million, S., Mozenter, S., & Villa, A. M. (2021). Learning to lead: an approach to mathematics teacher leader development. *International Journal of Science and Mathematics Education*, *19*, 121–143. https://doi.org/10.1007/s10763-021-10157-2

Borko, H., Koellner, K., & Jacobs, J. (2011). Meeting the challenges of scale: The importance of preparing professional development leaders. *Teachers College Record*, 11–14. https://doi.org/10.1007/s11858-010-0302-5.https

Castro Superfine, A., Amador, J., & Bragelman, J. (2019). Facilitating video-based discussions to support prospective teacher noticing. *Journal of Mathematical Behavior*, *54*, 1–18. https://doi.org/10.1016/j.jmathb.2018.11.002

Empson, S. B., & Jacobs, V. R. (2008). Learning to Listen to Children's Mathematics. In D. Tirosh & T. Wood (Eds.), *International Handbook of Mathematics Teacher Education: Volume 2* (pp. 257–281). Sense Publishers. https://doi.org/10.4324/9780203392621-11

Fennema, E., Carpenter, T. P., Franke, M. L., Levi, L., Jacobs, V. R., & Empson, S. B. (1996). A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education*, *27*(4), 403–434. https://doi.org/10.2307/749875

Goldsmith, L. T., & Seago, N. (2008). Using Video Cases to Unpack the Mathematics in Students ' Thinking. In M. S. Smith & S. N. Friel (Eds.), *Cases in Mathematics Teacher Education: Tools for Developing Knowledge Needed for Teaching*. Association of Mathematics Teacher Educators.

Gravemeijer, K., & Cobb, P. (2013). Design research from the learning design perspective: part A. *Educational Design Research*, *2006*, 72–113. http://international.slo.nl/publications/edr/

Jackson, K., Cobb, P., Wilson, J., Webster, M., Dunlap, C., & Appelgate, M. (2015). Investigating the development of mathematics leaders' capacity to support

teachers' learning on a large scale. *ZDM Mathematics Education*, *47*(1), 93–104. https://doi.org/10.1007/s11858-014-0652-5

Lesseig, K., Elliott, R., Kazemi, E., Kelley-Petersen, M., Campbell, M., Mumme, J., & Carroll, C. (2017). Leader noticing of facilitation in videocases of mathematics professional development. *Journal of Mathematics Teacher Education*, *20*(6), 591–619. https://doi.org/10.1007/s10857-016-9346-y

Luna, M. J., & Sherin, M. G. (2017). Using a video club design to promote teacher attention to students' ideas in science. *Teaching and Teacher Education*, *66*, 282–294. https://doi.org/10.1016/j.tate.2017.04.019

Prediger, S., Roesken-Winter, B., & Leuders, T. (2019). Which research can support PD facilitators? Strategies for content-related PD research in the Three-Tetrahedron Model. *Journal of Mathematics Teacher Education*, *22*(4), 407–425. https://doi.org/10.1007/s10857-019-09434-3

Robertson, A., Atkins, L., Levin, D., & Richards, J. (2016). What is Responsive Teaching? In A. Robertson, R. Scherr, & D. Hammer (Eds.), *Responsive Teaching in Science and Mathematics* (pp. 1–31). Routledge.

Roth, K. J., Bintz, J., Wickler, N. I. Z., Hvidsten, C., Taylor, J., Beardsley, P. M., Caine, A., & Wilson, C. D. (2017). Design principles for effective video-based professional development. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0091-2

Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, *20*(2), 163–183. https://doi.org/10.1016/j.tate.2003.08.001

Tekkumru-Kisa, M., & Stein, M. K. (2017). A framework for planning and facilitating video-based professional development. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0086-z

van Es, E. A. (2011). A framework for learning to notice student thinking. In M. G. Sherin, V. R. Jacobs, & R. A. Phillip (Eds.), *Mathematics Teacher Noticing Seeing Through Teachers' Eyes* (pp. 134–151). Routledge. https://doi.org/10.4324/9780203832714

Walkoe, J. (2015). Exploring teacher noticing of student algebraic thinking in a video club. *Journal of Mathematics Teacher Education*, *18*(6), 523–550. https://doi.org/10.1007/s10857-014-9289-0