

## ABSTRACT

TAUBER, MONA. Moment-by-Moment Noticing of Professional Development Leaders: A Multi-Case Study on Facilitation of Elementary Mathematics Teacher Professional Development (Under the Direction of Dr. Paola Sztajn).

Research on teacher professional development [PD] has often focused on identifying effective program features for designers (Desimone, 2009) and studying the impact of these opportunities to participating teachers and their learning (Seago, Jacobs, Heck, Nelson, & Malzahn, 2013), but offer little to no direction for the stakeholders tasked with PD implementation. We still know little about what matters to PD leaders and what they learn about facilitation. Literature on teacher noticing provides possible new research avenues to better understand facilitation from the perspectives of PD leaders. This multi-case study extended the use of a professional teachers' noticing framework (Jacobs, Lamb, & Philipp, 2010) to examine PD leaders' noticing. Four purposely-selected PD leaders with varying levels of facilitation experiences specific to the PD program that forms the context of this study participated. One participant analyzed her own past instruction. All participants viewed ten video clips using new video technology. Unlike stationary video, *360 video* permitted participants to continuously alter the viewing angle to choose their focus. A *Think Aloud* protocol permitted participants to express their moment-by-moment noticing around attending, interpreting, and deciding how to respond. Data analyses provided insight into individual participants' noticing and highlighted observed between-group differences. Participants' results support researchers' views of noticing as a back-and-forth process comprised of interrelated components (Jacobs et al., 2010; Thomas, 2017). The findings highlight a need to bridge knowledge between facilitation and noticing to better understand what PD leaders need to know and do during PD instruction. Possible directions for future research efforts regarding facilitation training and supports regarding PD implementation are provided.

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Moment-by-Moment Noticing of Professional Development Leaders: A Multi-Case Study on  
Facilitation of Elementary Mathematics Teacher Professional Development

by  
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A dissertation submitted to the Graduate Faculty of  
North Carolina State University  
in partial fulfillment of the  
requirements for the degree of  
Doctor of Philosophy

Mathematics Education

Raleigh, North Carolina

2019

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## DEDICATION

To my elder sister, Sonal – You may only live on in my heart, but you remain the co-author of my life experiences and accomplishments.

And to my current and future self – Never forget that

*Life is not about being the smartest person in the room, or the strongest or the fastest. Life is about walking through as many doors as you can and learning a new something, seeing a new somewhere and meeting a new someone. Life is about staying intellectually alive.* (Michael Thompson, writer, blogger, and entrepreneur)

This dissertation process was infinitely more challenging than I ever anticipated. I stayed the course, faced new challenges, and learned about areas that required further exploration. I learned the value of placing a premium on my own learning as part of the process of professionally giving back and improving the quality of education for more around me. Self-replenishment transfers to those around me. I strive to remain dedicated to being me and becoming more of me each day by seeking alternative approaches and questioning my own and others' ideas and decisions to find context-based solutions.

## BIOGRAPHY

Mona was born in Jamnagar, India. She migrated to the US with her sister, mom, and dad at a young age and was raised in the suburbs of Milwaukee, Wisconsin. She graduated from Franklin High School and went on to attend the University of Wisconsin, Milwaukee. She earned a bachelor's degree in elementary education and psychology.

Mona pursued a career as an elementary classroom teacher and taught third and fourth graders at an inner-city school within Milwaukee Public Schools. During these two years, she developed cross-curriculum math units that involved launching and running a school-wide bakery business with her diverse learners. She served in other capacities. For example, she led the Building Inclusive Committee Project, other building committees, and inclusive projects seminars.

Mona moved to Germany and began her graduate studies at the Ludwig Maximilians University in Munich, Germany. She worked as the program coordinator assistant and teaching assistant. Her thesis included evaluating a gifted program at a local gymnasium (grades 5-13) and recommending program changes to benefit more students' current and future needs. The school adopted her recommendations, transformed their program, and the state government published her thesis to allow other state schools to study the process. She returned to the United States with a master's degree in educational psychology with a STEM education concentration.

Mona's gifted education focus within her studies led to a new role as a math and reading gifted elementary specialist within the suburban Wheaton-Warrenville Community Unit School District. In her 11-year tenure, she also served on multiple mathematics curriculum committees, multiple building committees, led multiple professional development workshops, collaborated

with colleagues through building and district-level professional learning committees, supervised a student teacher, coached extra-curricular activities, and supported other building initiatives.

While continuing to teach, Mona earned her Certificate of Advanced Study in curriculum and instruction with a concentration in mathematics education from National Louis University. This led to her first adjunct position as a university mathematics education instructor at National Louis University and further mathematics teacher leadership opportunities within her district and building. When her district adopted Common Core, she perceived an alignment to her own past and current NCTM-influenced teaching and learning practices she used since she began teaching. However, many of her colleagues sensed shifting definitions for teaching and learning mathematics and reading and felt unprepared. Mona understood that the new and sometimes rigid rules were part of the growing pains for all as the district was adjusting to new standards and practices. She tried to support her teaching colleagues during the adoption process, but she knew she needed to further her own understanding if she was to help more fellow elementary educators on a long-term basis. So, she resigned from her teaching position and began her full-time doctoral studies in mathematics education at North Carolina State University.

While studying at North Carolina State University, Mona served as a teaching assistant within the STEM department, student teacher supervisor, and research assistant for *Project All Included in Mathematics*. She has learned a great deal about high-leverage mathematics teaching and learning practices and research methods to support pre-and in-service teachers and teacher leaders who lead professional development. She applied many of these same teaching and learning practices while she worked as an adjunct elementary mathematics education instructor at William Peace University. She anxiously anticipates her continued efforts to support teachers

improve their classroom mathematics teaching and learning practices and instruction after she graduates.

## ACKNOWLEDGEMENTS

The path I followed was not the shortest distance between two points and I am thankful to say that, as a result, my journey has been rich in learning experiences and laden with supportive people I have met along the way. There are many people to thank on my professional passage from elementary math educator to educational researcher, and particularly those who sustained me during this dissertation process. That list only grows when I consider all who helped me carve my educational path since childhood. Please know if I didn't mention you by name here, I thank you anyways.

First, I offer my gratitude to my husband and love, Peter. You stimulate my mind and spirit. Fitting to your name, you are my rock and my biggest supporter in life. During this doctoral process, you encouraged me to quench my intellectual curiosity, and maintain a commitment to my health and overall sanity. You also exercised patience and took on extra personal daily duties, including taking the lead with bills, helping with the cooking, and more—all so that I could focus and pursue this degree to further grow professionally. Thank you for not keeping tabs, nor charging me your daily client rate ☺. I promise that this is my last degree!?!  
Ich liebe dich für immer – und einen Tag!

To my family and friends, I offer my appreciation and love. To my parents, you sought to provide us a better life and made the US our permanent home. Your value for education and work ethic instilled in me a sense of hard work, despite having no prior knowledge of the US educational system. Mom, you demonstrated that age, time, gender, and other factors matter less than the ongoing pursuits and skills learned *during* the process. Dad, you taught me the value of hard work and perseverance. You also worked hard to ensure financial burdens did not hinder our path to higher education, allowing us to pursue new avenues and advance professionally. You valued and provided opportunities that supported my intellectual curiosity. My successes

are your successes. To the rest of my family and friends in the US, India, Germany, and elsewhere around the world, you have been my cheerleaders near and far. Thanks for your love and support. And to my F45 and CrossFit communities—thank you for the much-needed stressbuster workouts, mental escape, motivation, acceptance, and progression supports. Together, you all enrich my mind, body, and soul.

To my former students and their families, from whom I learned so much every day we worked together. Your continued wishes and updates regarding your own successes serve as my fuel. You are the reason why I continue to hone my craft. To my former fellow educators, thank you for your professional comradery and being the motivation behind this degree to support other educators. And to all my former principals (like Kathy), administrative bosses (like Kathie), and professors along the way (for example, Edna and Art), I am indebted to you for so many reasons that it would require its own paper to explain. Thank you for providing a myriad of leadership opportunities, unequivocally supporting me as I took risks, and scaffolding my growth over the years. Also, I would be remiss if I did not thank my past and current fellow graduate students (for example, Patricia, Laila, Erin, and more), other professors (like Tina and Cyndi), and my former Project AIM research team for the many ways you prepared me through the collaboration and stimulation along the way. I was fortunate to begin the process under the tutelage of the late Jimmy Scherrer. One word- grateful!

To my committee, who supported me throughout this process and my years here at North Carolina State University. This paragraph does not do justice to all you have done. Dan Heck, as a co-PI on our Project AIM research team, you showed me that one can grow by following new lines of thinking and considering others' ideas, all without losing humility along the way. Your excitement for the field of mathematics teacher education and research is infectious. Temple Walkowiak, your teaching inspired me to think critically and creatively about how to

apply our skills to evolve as individual educators and simultaneously contribute to the field. (Without any needed statistics as evidence) I assert that you are one of the best role models and professors I ever had. Karen Keene, you took time to orient me when I first arrived and remained an advocate for us as graduate students, which showed me that while you work hard and contribute extensively, you still take time to show your genuine care for those you mentor. Academically, you required rigor and helped me broaden my view of the many factors that impact instruction and teaching and learning practices. Angela Wiseman, you embody the very qualitative research and teaching practices you promote to your students. My passion for qualitative research and the desire to seek trustworthiness throughout the research process stems from my initial, positive, and rich learning experiences with you as my guide. Lastly, to Cyndi Edgington. You may listed as a substitute for my final defense on paper, but I dub you an honorary committee member for willingly stepping in at the last minute to make my spring graduation possible. I thank you for all the other ways you helped me advance within mathematics education through the project-and technology-based learning opportunities over the years. All of you together have significantly influenced my journey within mathematics education and research. I owe you all a huge debt of gratitude.

To my chair and advisor, Paola Sztajn, where do I begin? You provided me opportunities and scaffolded my growth as a mathematics teacher educator and researcher through Project AIM. Wearing multiple hats yourself and encouraging us to do the same will have a lasting effect on me. I'll never forget the patience and support you exercised, knowing the path to professional growth is rocky and involves leaps and emotional stumbling. You challenged me to showcase critical thought in our research and my own research pursuits and writing. You listened and help me process my ideas, as well as read and critiqued draft upon draft of these chapters, never showing an unwillingness to help despite your busy schedule. You are my

advisor, my chair, and more. Words just simply cannot describe my gratitude and admiration for you.

To my invaluable confidants, DW, AB, and EH, who volunteered their time to serve as my peer reviewers along the way. Your feedback was truly valuable and not only aided my analysis process, but also influenced how I thought about my ideas regarding my methods and results. Also, to Scott Lennon in the College of Education Information Technology department, who helped me bring my technological ideas to life. Thank you for sharing your expertise and helping me test my ideas so that my data collection process proceeded without a hitch and I could execute my research plan. You, Meimei Davis, and the rest of your team have been instrumental to my behinds-the-scene growth at NCSU.

Finally, to the four professional development leaders who participated in this study. You took time to honestly share your ideas and thoughts. This study would not exist without you! Thank you for making time beyond your other professional responsibilities as educators. You are strong, inspiring women dedicated to our field of education. You work tirelessly and advance yourself as educators to ensure that you do the very best job you can. Thank you for the gift of your time and collegiality as fellow educators on top of all you do every day. I hope my findings do justice in capturing the essence of your noticing regarding facilitation.

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## CHAPTER 1: INTRODUCTION

### Research Problem

School districts throughout the United States have long recognized the pivotal role teacher professional development (PD) plays in ongoing efforts to increase teachers' understanding of mathematics, particularly since the adoption of standards-based mathematics initiatives has altered standards for mathematics proficiency (National Council of Teachers of Mathematics, 2000; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Yet, despite decades-long attempts to alter curriculum implementation, little change occurred in U.S. mathematics instruction (Stigler & Hiebert, 2009). Education stakeholders called for a change in PD approach, only further fueled by the recent issuance of the Common Core State Standards for mathematics content and practices (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

Many mathematics educators and researchers have begun responding to the call by designing PD tied to K-12 teachers' everyday practices and looks to advance participating teachers' mathematical content and pedagogical knowledge and beliefs about how students learn (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Jacobs, Lamb, & Philipp, 2010; Sztajn, 2003). However, while related research provided guidelines on effective PD features for PD designers (Darling-Hammond et al., 2009; Desimone, 2009), it offered little to no direction for the individuals who have the arduous task of implementing the PD. Therefore, attention has turned to facilitation, given its critical role in the successful implementation of mathematics PD programs. Sometimes also referred to as teacher leaders or facilitators, PD leaders serve as resources for participating teachers seeking to advance their own subject and pedagogical knowledge in relation to outlined PD goals.

Researchers acknowledge that high-quality PD leaders make a difference in the effectiveness of supporting teacher learning in mathematics PD (Borko, Jacobs, Seago, & Mangram, 2014a). Yet, PD designers of PD programs are charged with advancing teacher learning. Therefore, there is no surprise that the majority of the research investigating PD environments focused on the impact of such PD opportunities on the participating teachers and their learning (Borko, Jacobs, Eiteljorg, & Pittman, 2008; Goldsmith, Doerr, & Lewis, 2014; Seago, Jacobs, Heck, Nelson, & Malzahn, 2013; van Es & Sherin, 2008). While researchers have begun studying facilitation within mathematics PD to provide insight on how to train PD leaders, there is still little understanding of what and how PD leaders learn (Elliott, Kazemi, Lessig, & Kelley-Peterson, 2009; Even, 2008; Goldsmith & Seago, 2008).

The literature base on facilitating high-quality PD is still emerging. And the PD designers and researchers studying facilitation themselves are extrapolating ideas and activities from literature on teacher learning when designing PD leader preparation programs and supports (Sztajn, Borko, & Smith, 2017). Also emerging from the literature on teacher noticing is that the in-the-moment noticing skills teachers employ do not simply involve activating one's mathematical knowledge for teaching. It is a selective act of deciding what requires further attention and follow-up (Sherin, Jacobs, & Phillip, 2011a). Learning how PD leaders learn involves seeking greater insight into what and why PD leaders do what they do *during* their practice. Filling the knowledge gap on facilitation is essential if aligning teacher learning to current mathematics standards and principles is to be actualized with substance. This study raises dialogue on the topic by examining PD leaders' selective noticing within the elementary mathematics PD setting, namely the selectively noticing process and the knowledge-based reasoning behind their selective thinking.

## **Background of Study**

In mathematics, numerous recent PD program designs engage participating teachers in the analysis of classroom instruction or particularly the analysis of student thinking, often through artifacts of practice (e.g., video-based analysis), as well as the skills to notice teaching and learning behaviors (Borko et al., 2008; Driscoll, Nikula, DiMatteo, & Eagan, 2008; Seago, Mumme, & Branca, 2004; van Es & Sherin, 2008). New research efforts are currently underway to learn more about how PD leaders support teacher learning through promoting teacher noticing of student thinking. Having a deeper understanding of the mathematics content and pedagogy and what PD should entail is only part of the training PD leaders require to effectively lead PD programs (Borko, Koellner, & Jacobs, 2014b). Little is known about how to prepare PD leaders, particularly for those new to facilitation.

To complicate matters, recent research on PD facilitation reveals great variation in the responsive actions PD leaders implement to promote participating teachers' engagement and learning across programs and facilitation (van Es, Tunney, Goldsmith, & Seago, 2014). Such studies are shedding light on what PD designers value and notice based on PD leaders' actions (Borko et al., 2014b). Simultaneously they fail to provide insight into the perspective of a stakeholder who is critical to addressing identified deficiencies in PD practices, namely the PD leaders who are most responsible for implementing effective PD (Park Rogers et al., 2007).

Current efforts by select researchers suggest the field is starting to recognize the needs and challenges of the PD leader in the PD implementation process. This is evidenced by emerging facilitation supports that make explicit and guide the facilitation process in mathematics PD (e.g., Borko et al., 2014a; Elliott et al., 2009; van Es et al., 2014). The current focus on PD leader training within the field also reveals that we currently hold an incomplete picture on how PD leaders can learn and enact effective facilitation skills with integrity and

comfort, particularly since new PD leaders' actions cast doubt on their own abilities (Kazemi et al., 2011). Questions remain regarding facilitation moves both novice and expert PD leaders value and employ during instruction, and their reasoning as a part of their current understandings. Little attention to understanding the level of expertise, knowledge, and skills of PD leaders, including those who are novices, and how best to support them facilitate teacher learning (Even, 2008). Facilitation decision-making occurs during instruction, separate from training and support PD leaders receive from PD designers, necessitating the need for greater insight.

### **Purpose Statement**

This qualitative study adds to past findings on PD leaders by seeking insights into the selective noticing that PD leaders employ as they sieve through the influx of stimuli while viewing the interactive PD teaching and learning instructional process. This study also adds to the literature base on facilitation and noticing by considering the perspective of PD leaders. More particularly, this study examines the noticing and underlying reasoning of PD leaders, who shared a common experience. That is, all were experienced elementary teachers who facilitated the same highly-specified, year-long sustained and content-specific elementary mathematics teacher PD program designed for fellow district primary grades participating teachers.

The purpose of this qualitative multi-case study is twofold. First, the aim is to gain insight into participating PD leaders' professional noticing skill set (i.e. their selective attention, interpretations, and decision-making) and the reasoning behind their noticing. A design decision to focus on qualitative data collection and analysis afforded deeper insight on this timely topic by examining the noticing process from PD leaders' perspectives. Just as educators should determine the current knowledge and skill base of their students as part of responsive instructional planning and implementation, PD designers should understand the current

knowledge and skill set of PD leaders. By studying PD leaders' noticing, this study furthers conversations on the role of PD leaders and offers potential insights into PD leaders' current understandings as part of current efforts to support PD leaders.

### **Research Questions**

Two research questions guide this study. In a mathematics teacher professional development program for elementary teachers designed to promote high quality discourse and mathematics content knowledge and pedagogy:

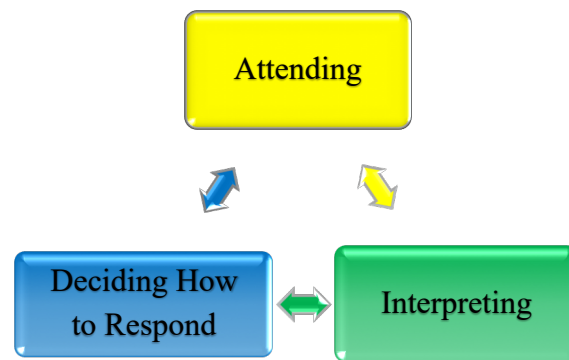
1. What, how, and why do mathematics PD leaders notice during elementary mathematics teacher professional development instruction?
2. What defining noticing characteristics emerge from mathematics professional development leaders' focus within the moment-by-moment professional noticing process?

### **Conceptual Framework**

Researchers are guided by an overall inquiry worldview (DeCuir-Gunby & Schutz, 2016). Through divulging my perspective, I hope to make explicit the lens through which I approach this study. I prescribe to a social-constructivist view. I believe reality as culturally defined. There are some agreed-upon universal truths or constructs that influence individuals within a community and that we belong to multiple communities simultaneously. Therefore, accepted truths can change based on the needs of the community. I also believe that multiple realities coexist, because humans construct their own personal knowledge and view of reality based on their experiences with the environment. This reciprocal nature results in intrapersonal and interpersonal knowledge that is ever-evolving.

Guiding this study is one main theoretical framework. The Jacobs et al. (2010) framework is a widely-accepted guide for studying teacher professional noticing (see Error!

Reference source not found.). Given this study looks to gain insight into elementary mathematics PD leaders' professional noticing, this framework is central to the study. While the three components of attending, interpreting, and deciding how to respond within their model refers to teachers' noticing of children's mathematical thinking within the classroom setting, it can and does relate to PD leaders' noticing of aspects within the elementary mathematics teacher PD setting in this study. PD leaders serve in the role of teaching in a PD setting with participating teachers as adult learners.



**Figure 1.** Jacobs, Lamb, & Phillip's (2010) framework for noticing with components.

I elaborate on how the Jacobs et al. (2010) model served as a guide throughout the research process within the Methods chapter.

## Significance and Limitations

### Significance

On a broader scale, this study draws attention to the inherent complexity of facilitation within mathematics teacher PD instruction. Current recommended mathematics classroom practices and PD approaches have changed and teachers' decisions impact student learning and growth (Stein, Remillard, & Smith, 2007; van Es & Sherin, 2008). Attention to PD leaders' facilitation is crucial. PD designers rely on PD leaders for PD implementation. PD leaders are responsible for responding to participating teachers' mathematical knowledge needs and

scaffolding their growth. It is only natural that PD designers must consider the role of PD leaders within the PD instructional process. Decisions regarding PD design and implementation impact mathematics researchers and educators' abilities to support PD leaders and participating teachers simultaneously. Studies like this promote valuable dialogue on the need to consider PD leaders' current perspectives and needs as part of ongoing mathematics teacher PD implementation quality.

Understanding facilitation from mathematics PD leaders' perspectives is critical. By learning more about what PD leaders notice about the facilitation process, what selective topics they decide deserves further attention and analysis, along with their knowledge-based reasoning, this study draws attention to the role PD leaders' views bear on the decisions they make during implementation. It also brings to light the need to bridge understandings between PD designers and PD leaders. PD leaders' current thinking provide PD designers additional insights on how to support desired noticing and facilitation practices as tandem skill sets needed to promote participating teachers' mathematical knowledge for teaching [MKT] (Ball, Thames, & Phelps, 2008). There is a current dearth of research on PD leader noticing.

The findings about participating PD leaders' current understandings can provide direction for further research regarding potential PD leader training paths. The results continue dialogue about exploring the concordance or discordance between PD leaders' perceptions and previously identified desired facilitation practices. These results also provide insights into the possible challenges, eases, and other issues PD leaders notice and identify about facilitation.

Lastly and more specifically, this study addresses some challenges researchers face in directly studying facilitation and teacher noticing by examining the intersection of these two fields. The data collection method utilizes new video technology that permits PD leaders to notice what matters to them regarding PD instruction. PD leaders' own words provide valuable

insight into the selective noticing they employ as part of facilitating PD. By asking PD leaders to explicitly discuss noteworthy moments within PD instruction we gain additional insight otherwise primarily limited to researchers' observations and inferences. Many noticing studies involving video focused on teacher noticing and occurred within the scope of PD video clubs meant to advance or scaffold teacher noticing. Yet, the noticing that drives facilitation responsiveness occurs in the PD setting during instruction, often without the support of others. This study explores the moment-by-moment noticing of mathematics teacher PD setting interactions salient to PD leaders. Employed new video technology expanded methodological means currently used to understand the ways PD leaders attend, interpret, and decide how to respond regarding facilitation.

### **Limitations and Delimitations**

Despite the evolving nature of qualitative research and the decision to focus on PD leaders' perspectives, limitations and delimitation are inherently a part of the process. The limited context and small, selective sample size itself prevent generalizability. It was a deliberate decision to choose depth over breadth through this multi-case study, because the qualitative richness can contribute to a collective and developing knowledge base on PD in unique ways. It can offer insight on PD leaders' noticing, which is currently lacking.

The choice in the timing of the research methods (namely that interviews did not take place immediately after PD leaders' own facilitation) serves as another limiting factor. This was an intentional decision aligned with the goal of this study. The purpose was not to elicit PD leaders' reflections on their own facilitation, recall or compare their own facilitation, nor try to help them learn from analyzing their own or another's facilitation to support their ongoing PD instruction. This study sought to gain insight on what PD leaders notice to better understand what matters to them and why it matters regarding PD facilitation.

Using emerging technology can pose additional limitations. I chose to use video technology that simultaneously captured the facilitator, all participants, and all their actions and words that occurred during those portions of the PD instruction. This decision permitted participants to define their own subject or focus by rotating or tilting the screen rather than to a pre-defined direction when viewing traditional videos. One can often draw the eye into the frame towards a desired subject or focus using the camera perspective to tell a story with traditional video, but the subject or focus remains ill-defined with this new video technology, thereby allowing the viewer to decide. While simulating what teachers do each day when teaching, navigating an immersive 3-D experience on a 2-D screen may have imposed artificial barriers. For example, when viewing videos with this technology, one could not zoom into select areas of the screen achievable by moving closer in real life. Another limitation may lie in the video clips chosen for analysis. Limited available video clips recorded using this technology resulted in a greater focus on pedagogy than mathematics content. Furthermore, videos using this technology only existed for one facilitator and group of participating teachers. As a result, no other PD leader could view and analyze her own videos in this study. Any results related to these factors are preliminary at best. Efforts undertaken to minimize technological barriers and the choice of video clips and participants are explained in the methods chapter.

Lastly and as with any qualitative research, there is always the possibility and question of consistency within researcher interpretations. Therefore, I acknowledge that I serve as a limitation myself in that I shaped this study. All guiding frameworks and decisions made throughout the design, implementation, and analysis of this study defined and impacted all aspects of the research process. Every researcher makes decisions that limit the scope of their findings. The development and use of a codebook, peer review, and member checks minimized this limitation. Knowing the data intimately as the only coder while seeking input from outside

peers and clarification through member checks partially addressed concern. Furthermore, a transparent design supported the strive for trustworthiness and authenticity.

### **Definition of Terms**

I intentionally chose select terms and consistently applied them within this dissertation to aid readers understand their intended meaning within a context. To help the reader better understand their meaning when referenced in this study, the definitions of terms are as follows:

1. PD designer: an individual (educator and/or researcher) who solely or co-created a professional development meant to advance participating teachers' professional knowledge for teaching within a particular topic or area
2. Mathematical Knowledge for Teaching (MKT): This specialized type of knowledge is comprised of the subject matter knowledge and pedagogical content knowledge teachers require to effectively teach mathematics at their respective level (Ball et al., 2008).  
 Subject matter knowledge refers to the knowledge teachers need to know regarding the mathematics content (that is, the mathematical concepts and skills taught and learned).  
 Pedagogical content knowledge refers to the professional knowledge teachers need to know beyond the mathematics content to guide the learning process clearly and effectively. Researchers sometimes use the term Mathematical Knowledge for Professional Development (MKPD) to name the type of knowledge PD leaders require when facilitating PD (Borko et al., 2014b)
3. PD leaders: teachers of teachers or facilitators who guide teachers as learners in an effort to advance participating teachers' knowledge on a particular topic in relation to specified PD goals within a PD setting (NOTE: The term "*facilitator*" will only be used when referring to the PD leader within the video clips under analysis to distinguish from discussing PD leaders in general or when referring to participants as PD leaders.)

4. Participating Teachers: practicing teachers who participate as learners to advance their own knowledge of a particular topic in relation to specified PD goals within a PD setting
5. Teachers: in-service or practicing teachers who teach K-12 students in a classroom setting and engage in any related teaching duties or activities
6. Students: K-12 learners who learn with a teacher in a classroom setting
7. Classroom (or classroom setting): a school learning environment in which a teacher works with K-12 students to advance students' content knowledge in accordance to specified curricular goals or standards
8. PD setting: a professional learning environment in which a PD leader works with participating teachers to advance participating teachers' specialized knowledge for teaching in accordance to specified PD goals
9. (Professional) Noticing: a selective process involving a set of skills teachers of all levels (including PD leaders) employ by attending, interpreting, and deciding how to respond to aspects within the instructional setting (Jacobs et al., 2010)

## CHAPTER 2: LITERATURE REVIEW

To understand the noticing skill of mathematics PD leaders and its role within facilitation, it is worth examining the literature on both facilitation and teacher noticing within mathematics PD. Most of the research tends to lie in the emerging literature on facilitation. However, the work of PD leaders is similar to that which occurs in classroom instruction. Hence, this study also focused on another emerging area that seeks greater insight into professional mathematics teacher noticing. First, I examine a review of the literature with a focus on facilitation. Specifically, I examine the facilitation moves that support learning, as well as other factors associated with high-quality mathematics PD implementation. Then, I turn my efforts to exploring the research on mathematics teacher noticing. In doing so, I apply the Jacobs et al. (2010) framework to guide the discussion and summary of key emerging findings related to noticing as a skill set. I specifically discuss the construct of teacher noticing and examine a number of studies that offered insight into the components considered to comprise noticing: attending, interpreting, and deciding how to respond. I conclude the literature review by revisiting the construct of mathematics teachers' noticing based on the research findings, in addition to highlighting a few advances and challenges as suggested through the findings.

### **The Backdrop: Challenges and Advances in Mathematics Teacher PD**

Despite decades of PD attempts, researchers noticed a lack of change in classroom practices (Stigler & Hiebert, 2009), which has resulted in calls to transform PD approaches. An such, there is a clear need to understand teachers' context-specific needs as a factor toward advancing their mathematical knowledge. There is still a long way to go to uncover and apply the recommended tenets for effective teacher education. Current researchers generally adhere to four basic, research-based principles for high-quality PD design. These principles are characterized as: (a) intensive, ongoing, and connected to practice; (b) focused on student

learning and addressing a specific content area, (c) aligned with school improvement priorities, and (d) building strong working communities among teachers through collective participation (Darling-Hammond, et al., 2009; Desimone, 2009; Pitoe & Maila, 2012; Sztajn, Marrongelle, & Smith, 2012). These principles are evidenced by such mathematics PD programs now available that utilize artifacts (e.g., videos) of classroom instruction, and particularly student thinking, to engage and focus teachers' skills on noticing and analyzing teaching and learning behaviors (Borko et al., 2008; Driscoll et al., 2008; Seago et al., 2004). These recommended PD features provided guidelines on effective PD features for PD designers, but they offered little to no aid to PD leaders on how to promote productive interactions and implement mathematical activities to create conditions that promote such learning during implementation, nor on how to train PD leaders to enact effective PD (Goldsmith & Seago, 2008).

Perhaps there was no previous need to consider the role of PD leaders, as the mathematics education researchers who designed the PD programs initially implemented most PD efforts themselves. Examples included *Cognitively Guided Instruction* (Carpenter, Fennema, Franke, Levi, & Empson, 2015) and *Count Me In Too* (Bobis, 2009). As select PD designers attempted to scale high-quality PD to train more teachers, the necessity for PD leaders to enter the arena of mathematics teacher PD as a new team of stakeholders became apparent (Borko, 2004; Borko et al., 2014b). These individuals may be teacher leaders, coaches, district leaders, researchers, or other educators but within the PD context, they become teachers of teachers (Tekkumru-Kisa & Stein, 2017). These few efforts to examine the role of facilitation as part of PD scalability efforts have raised new questions on how PD leaders other than the PD designers themselves can learn to facilitate PD programs after initial preparation and support (Borko et al., 2014b).

### **Role of Facilitation within Mathematics Teacher PD Settings**

Akin to other forms of teaching, facilitation is a critical factor in the successful implementation of mathematics PD programs and teacher growth. PD leaders are central to providing opportunities for teachers to gain new understandings of subject matter and pedagogy. Quality of facilitation makes a difference in the effectiveness of supporting mathematics teacher learning (Stein, Smith, & Silver, 1999). It is accepted that PD leaders need to be knowledgeable about both the subject matter and pedagogy as part of their own MKT, as well as enact comparable mathematical beliefs and practices about teaching and learning to the PD programs they facilitate (Remillard, 2005; van Es & Sherin, 2017). There is also a general agreement that PD leaders must hold a deeper, more sophisticated knowledge than their colleagues, whom they guide, because their role is critical in promoting the development of teacher MKT (Borko et al., 2014b). However, possessing specialized and pedagogical content knowledge is only part of the skill set PD leaders need to successfully implement PD (Borko et al., 2014a). This argument is evident in that researchers have investigated and even likened the skillful and disciplined improvisation required by PD leaders *during* PD instruction to that of teachers in classrooms (Borko et al., 2014a; Stein & Smith, 2011).

### **Facilitation Moves Considered to Support Teacher Learning**

To better understand the disciplined improvisation PD leaders must undertake, it is important to turn one's attention to what knowledge and skills PD leaders need to utilize during PD instruction. Through the existing education literature, including areas beyond mathematics, many researchers have revealed desired actions or moves that skilled teachers at all levels, including PD leaders, employ to guide and support purposeful conversations within a community of practice that is consistent with the PD goals.

Suggested facilitation moves include creating a climate of respect and establishing collaborative working relationships among participating teachers (Borko et al., 2014b; Linder, 2011) and setting and maintaining explicit social and sociomathematical norms (Elliott et al., 2009). Other studies have identified other moves, such as removing oneself from the center of conversation (Ephratt, 2011), utilizing distinct types of wait time (Ingram & Elliott, 2014), and providing constructive feedback, while avoiding judgmental feedback (Gardiner, 2012; LoCascio, Smeaton, & Waters, 2016). Researchers have even recommended facilitation moves such as asking open-ended questions to elicit and probe participating teachers' thinking (Franke et al., 2009; Ingram & Elliott, 2014; Martino & Maher, 1999), promoting connections between participants' ideas to a larger idea related to their teaching and learning practices or local needs (Bell, Wilson, Higgins, & McCoach, 2010; Koellner, Jacobs, & Borko, 2011; Tekkumru & Stein, 2017), and positioning oneself as a colleague (Odell & Ferraro, 1992).

Through numerous investigations, many researchers have revealed that facilitation moves are an important factor to gaining greater insight into PD implementation. However, they also revealed that the specific facilitation moves PD designers value and PD leaders implemented vary across PD programs (van Es et al., 2014). It is important to understand the other factors influencing facilitation quality.

### **Other Factors that Impact Facilitation**

Those studying facilitation argued that this complex process underlying the construction of mathematics teacher educator's knowledge involves PD leaders interacting and learning from both PD designers and participating teachers (Jacobs, Seago, & Koellner, 2017). This underscores the importance of examining other factors that frame and influence both facilitation quality and PD leaders' ability to engage in the complex facilitation process.

### **The impact of PD program adaptability on facilitation.**

The adaptability of the PD program is one factor considered to influence the role of the PD leader. In *highly-specified* PD programs, PD designers provide the PD leaders with the PD goals and materials (Borko, Koellner, Jacobs, & Seago, 2011). Planning heavily involves understanding the intended goals and materials so that PD leaders can carry out the designers' intended PD visions. In contrast, *highly-adaptive* PD programs are those in which general guidelines are provided to PD leaders with an attention to local context valued. Planning involves identifying goals for teacher learning, selecting tools to support PD activities, and preparing guiding questions for discussions, all of which are usually provided to PD learners in highly-specified PD programs (Sztajn et al., 2017). These two different types of PD programs suggest that the role of a PD leader depends not only on specific PD goals, but also the structure of the PD program. However, a study on highly-specified PD found that PD leaders made improvised decisions after training (Borko et al., 2014a). These findings suggest that PD leaders need to and do employ facilitation moves regardless of PD adaptability.

Researchers who conducted studies on highly-adaptive and highly-specific PD program have also raised two critical issues regarding PD leader training. PD leaders require support like other teachers, and researchers' results on both types of PD programs suggest these skills are trainable. Another study on highly-adaptive PD programs demonstrated that PD leaders can begin as novices, receive extensive training, and advance their skills as a PD leaders (Borko et al., 2011). Therefore, Individuals within education unaffiliated with the PD design can successfully serve as PD leaders with extensive training and support. Regardless of PD type, there seems to be a consensus among researchers that gaining the requisite knowledge to become an effective PD leader is a socially-constructed process that involves in-depth study and

disciplined inquiry, and takes time (Elliott et al. 2009; Jacobs et al., 2017; Jenlink & Kinnucan-Welsch 2001).

However, as PD designers attempt to further scale PD programs, issues of scalability draw into question the feasibility and sustainability that extensive training would demand. More information is necessary to grasp how facilitation looks without extensive training, particularly for novice or less skilled PD leaders. PD designers may need to explore and offer alternative forms of support to help multiple PD leaders employ actions or moves consistent with the PD goals. Therefore, determining the types of facilitation supports that would best serve PD leaders requires an understanding of the background of the PD leaders they are trying to serve.

#### **The impact of PD leader facilitation experience.**

Another identified factor to consider when examining the decisions PD leaders make during PD instruction is PD leader experience level, such as their overall past facilitation experience or level of familiarity with a PD program. Borko et al. (2014b) found that greater variation in enacting characteristics of effective PD exists among PD leaders lacking facilitation experience, particularly in how they interpreted instructional needs. Amador's (2016) study on professional mathematics noticing practices of expert and novice mathematics teacher educators supports Borko et al.'s findings. Amador found novices lacked in-depth interpretative analysis about their teachers' thinking and rarely made connections between the teachers' thinking and the broader instructional principles. Whereas experts were instrumental in drawing conclusions about how to restructure instruction for increased benefits (Amador, 2016).

An exploration of PD adaptability and PD leader experience level indicate that additional factors influence decisions PD leaders make during implementation. It is through these additional factors that we better understand the background context in which PD is situated. Such factors are often choices made prior to PD implementation and require PD leaders to

interact and learn from PD designers and participating teachers as adult learners. These additional factors can afford or constrain PD leaders' range and quality of implementation. The same factors also simultaneously highlight that PD leaders make choices during instruction that in turn afford or constrain teachers' learning towards the PD goals regardless of PD program type. Therefore, more attention is necessary to further understand the decision-making choices PD leaders make during instruction and the reasoning behind their decisions, as done in this study.

### **Facilitation Insights from Different PD Stakeholders' Perspectives**

Studies on highly-specified and high-adaptive PD programs that study facilitation are few, as the literature on facilitation is still emerging. Their budding results provide qualitative insight and raise questions about the role of facilitation from the different stakeholders directly impacted by PD programs (i.e., PD leaders, participating teachers, and PD designers). It is critical to understand the viewpoints of all stakeholders involved in the written and enacted PD process. Multiple perspectives highlight the complex role of facilitation, including what and how PD leaders need to learn to effectively implement mathematics PD.

Research that inform PD implementation focuses on the perspective of PD designers. One study by Park Rogers et al. (2007) also compared outlooks of K-12 teachers and PD leaders on effective PD implementation. The researchers found that participating teachers focused more on PD design components than facilitation moves. Participating teachers' themes included classroom application, teachers as learners, and teacher networking. PD leaders also expressed value for classroom application and teachers as learners, but they additionally voiced needs to develop collegial relationships with participating teachers and improve participating teachers' knowledge. The researchers, who were the PD designers, noticed specific facilitation moves that were absent from either list. The PD designers' list included challenging teachers' subject matter

knowledge and pedagogical content knowledge through learning experiences, encouraging teacher leadership as a means for sustained support, and focusing on student learning by instructing teachers how to use student data as formative assessment for teaching practices. The variation in themes suggests misalignment between different stakeholders regarding critical PD features and facilitation moves that support set PD goals. If PD leaders make decisions during facilitation, what impact do misaligned views on effective PD implementation have on the decisions PD leaders make during facilitation and the PD goals outlined by PD designers? PD designers are in the position to minimize misaligned views by offering effective implementation guidance.

PD designers' insights may provide a starting point on features that could support and hinder effective facilitation. For example, Kazemi et al. (2011) examined PD designers' insights on the PD features that PD leaders need to reason about, act on, and learn. The researchers observed video cases of novice and experienced elementary PD leaders engaged in mathematics PD instruction. The goal was to demonstrate how PD designers' noticing of PD leaders' thinking could offer novel supports for PD leaders in facilitating mathematical tasks. They identified a range of ways PD leaders engaged participating teachers with mathematical tasks and efforts PD leaders took to focus on workshop culture to help teachers feel safe and take risks.

Past findings suggest a connection exists between PD leaders' interpretations and their decision-making skills. Kazemi et al. (2011) also found that PD leaders identified strongly with the role of teacher or colleague while serving in the role of PD leader, so they did not anticipate how participating teachers would engage as adult learners with the mathematical tasks.

Although there were signs PD leaders made inferences about participating teachers, their comments tended to be general and judgmental statements about teachers' engagement or understanding. This was particularly common for novice PD leaders who doubted their own

ability to push participating teachers' understanding. The findings further support the notion that a discrepancy exists between stakeholders when considering the findings from the Park Rogers' et al. (2007) study. The discrepancy raises a greater concern about how to support facilitation, so PD leaders become aware of consequences of their choices and alignment between PD leaders' views and enhancement of the designers' goals.

The concern regarding stakeholder misalignment magnifies when considering PD designers' scaling attempts. For example, Borko et al. (2014b) investigated PD leaders' actions in relation to highly-adaptive PD features across multiple sites from the perspective of the PD designers. Like Park Rogers et al. (2007) and Kazemi et al. (2011), Borko et al. (2014b) also found that PD leaders were successful in establishing trust and a climate of respect for participating teachers' experiences and ideas, while promoting collaborative, collegial working relationships within the group. They observed greater differences among novice PD leaders. Novice PD leaders were uncomfortable when conducting PD with new groups, but they learned ways to encourage greater participation by all teachers and facilitate discussions to explore a variety of representations and solution strategies. Novice PD leaders also had more difficulty engaging teachers in discussions to address the affordances and constraints of examples generated or relationships among them. Similarly, expert PD leaders were more successful in selecting appropriate video clips to use as a springboard for discussions than facilitating discussions that required participating teachers to deeply analyze instructional practices or student thinking shown within those very video clips.

The results from these three studies offer prospective understanding about effective facilitation from PD designers' views. They revealed PD leaders valued and created a climate of respect and trust, as well as established collaborative working relationships among their teacher participants. The joint findings also revealed that PD leaders' relationship with participating

teachers in a PD setting have an added layer of complexity regarding added assumptions, particularly with teachers' level of math knowledge and positioning or status differential.

Findings from the three studies further highlight the disparity between the intended PD visions and the enacted PD implementation, particularly between different stakeholders involved in the process. What is still unclear from these studies is whether PD leaders are cognizant of the desired facilitation moves and moments that support teacher learning and of value to PD designers, as well as the necessary decision-making steps to improve PD instruction. There are still few studies that uncovered PD leaders' current understanding as part of an effort to better comprehend the role of facilitation. A concerted effort is necessary to orient PD leaders not only towards utilizing desired facilitation moves, relative to PD designers' point of view, but also recognizing noteworthy moments that require them to engage in responsive decision-making as a part of disciplined improvisation.

### **Proposed Frameworks to Guide Effective Facilitation Practices**

Recent research reveals a promising effort by select mathematics education researchers and PD designers to offer facilitation supports or training to orient PD leaders towards intended overarching goals and desired facilitation moves. By doing so, it potentially addresses misalignments between PD designers and leaders. These recent efforts take us into a new direction by suggesting systematic PD leader support as part of the desired PD enactment process.

PD designers from two separate middle grades mathematics PD programs proposed a joint facilitation framework based on their research on the adaptability needs and key characteristics of their PD programs (Borko et al., 2014a). The joint guide was meant to communicate three central practices PD leaders should attend to when planning and orchestrating discussions about (a) eliciting teachers' thinking, (b) probing for evidence of their claims, and (c)

supporting teachers' connections between their analyses to key mathematical and pedagogical ideas. The joint framework also highlighted attention to planning and implementation, but also recognized that facilitation involves skilled improvisation. Such a framework explicitly communicates expectations to PD leaders and can serve as a facilitation support during and after training. Yet, these researchers acknowledged that their proposed framework was based solely on observing their knowledgeable and well-prepared PD leaders, thereby highlighting the need to support a range of PD leaders.

Van Es et al. (2014) also recently proposed their own framework of four core facilitation practices for productive PD discourse around video analysis. The researchers used a similar method to Borko et al. (2014b) to analyze videos of PD leaders' in-the-moment moves along with the adaptability needs of two separate mathematics PD programs designed to shift upper elementary and middle grades teachers' noticing within group settings through video clubs. Van Es et al. used their facilitation framework to similarly draw PD leaders' attention to their role in enacting four specific facilitation implementation practices that can support productive dialogue and collective exploration about mathematics teaching and learning during PD instruction on (a) orienting groups in the video analysis task, (b) sustaining an inquiry stance, (c) maintaining a focus on the video and the mathematics, and (d) supporting group collaboration. These PD designers went one step further to outline facilitation moves PD leaders enacted associated with each of the four practices and supported participating teachers in productive discussions of mathematics teaching and learning as a part of video-based PD programs. They also explicitly outlined that PD leaders must make decisions during facilitation and that there is no single approach to engaging teachers in productive exploration with video. In contrast to past research that studied individual facilitation moves (e.g., Bell et al., 2010; Gardiner, 2012; Ingram & Elliott, 2014; Linder, 2011), van Es et al. suggested that it is not that particular moves result in

productive discourse, but the coordination of the four practices and their associated moves that guide more productive discussions. What was unclear is whether and how facilitation evolved over time and which outcomes resulted from enacting the same facilitation practices in less productive discourse. The authors acknowledged that they did not study those factors.

Notably absent in both the van Es et al (2014) and Borko et al (2014b) studies was PD leaders' views and responses to the posited frameworks. Neither study mentioned seeking PD leaders' feedback as part of the process to ensure the framework sought to align both PD leaders' current needs with designed facilitation goals. Together these two studies show researchers' important first efforts to recognize PD leaders' specific needs. Their work also draws greater attention to the understand how frameworks and other facilitation resources serve as PD leaders training supports.

Another study by Elliott et al. (2009) provides initial promise in using frameworks to decompose high-leverage practices as part of PD leader training purposes, so PD leaders can better orient participating teachers to the same desired teaching practices. Not only did PD designers train K-12 PD leaders through leader seminars using two self-designed frameworks on desired social and sociomathematical norms and mathematical discourse, but they designed a follow-up study that included PD leader reflection data and analysis. In the process, the researchers described their own expectations relative to PD leaders' reflections. Elliott et al. found that PD leaders were able to support teachers in advancing mathematical learning by attending to the explicit and implicit social and sociomathematical norms of classroom practice and lead more intentional and focused conversations around rich mathematics tasks during their PD workshops. Their results led the researchers to propose a third framework that specifically supported addressing teachers' specialized content knowledge. The use of frameworks by Elliott et al. shows potential in how to responsively address misalignments between PD designers' and

PD leaders' views. Their facilitation model considered PD leader feedback into account and communicated specific facilitation expectations that support effective PD implementation to provide facilitation support that matched PD leaders' needs.

The development and use of such frameworks in a PD setting showcase undergoing efforts to help PD leaders recognize meaningful patterns and news ways of examining desired facilitation and learning. The use of frameworks as facilitation supports also raise the timely issue of advancing PD leaders' own MKT or what Borko et al. (2014b) propose be termed *mathematical knowledge for professional development* (MKPD) as part of effective PD implementation. Researchers seem to agree that PD leaders need to deeply understand the design and coordination of particular tasks and tools to foster the outlined PD program goals (Remillard, 2005; van Es & Sherin, 2017). The work on facilitation also suggests that PD leaders themselves need to understand and embrace the shifting teaching and learning roles that participating teachers in turn need to employ during facilitation. The use of frameworks with PD leaders during training raises new possibilities for tools that PD designers can usefully use to communicate goals to PD leaders and advance PD leaders' MKPD.

Facilitation guides may help PD leaders decompose effective PD implementation that are aligned to the written and intended goals by defining agreed-upon characteristics of high-leverage facilitation practices. While these frameworks show great strides to address the value of focusing on mathematics discourse, they continuously draw greater attention to the needs of PD leaders as one of the PD stakeholders in the process. More specifically, the frameworks alert us to the vital role PD leaders' own learning plays in the advancement of teachers' professional growth. The variation in researcher-recommended facilitation practices and moves on facilitation begets the need to ensure frameworks are responsive to PD leaders' current needs and seek their feedback in the training process.

The emerging literature on facilitation advocates for seeking greater understanding about PD leaders' current understandings and decision-making process that is a part of disciplined improvisation. While training and facilitation supports offer PD leaders learning through enculturation, PD leaders also learn through processing and making decisions that occurs separate from PD designers during PD instruction. Researchers have argued that learning is both a process of active individual construction and enculturation (Borko, 2004). While the emerging research offers some guidance on what PD leaders need to know and execute to effectively lead productive discourse within a mathematics PD community, the research raises new questions for PD designers on how to support novice PD leaders in improvising responsively and skillfully. The lack of attention given to understanding the current level of expertise and knowledge of PD leaders to lead productive discourse within a community of practice indicates a need for additional research in this area (Even, 2008; Elliott et al., 2009). As with learners at all levels, learning the needs of the individuals from them provides more opportunities to support alignment between stakeholders' views of desired facilitation practices. The consequences for teachers and their students who rely on high-quality PD necessitates a timely response to these questions. While there is little to no literature specific to PD leader noticing that offers answers currently, research on teacher noticing provides insight on how we might begin to seek such answers.

### **Role of Teacher Noticing within Mathematics Classroom Settings**

Teachers at all levels, including PD leaders who teach teachers, notice a myriad of things around them in their own classroom settings, on a daily basis. Everyday teaching requires constantly noticing or observing students' actions and statements, evaluating those actions and statements, and contemplating next steps. Yet, noticing is a selective process and there are many

aspects that teachers do not notice, either because they are not attuned, are desensitized, or are preoccupied by something else (Mason, 2011).

Recent research is becoming interested in a particular type of noticing that is executed by professionals (Sherin, et al., 2011). As a part of developing expertise in one's profession, professional noticing is regarded as a specialized skill set (National Research Council, 2000). For example, teachers at all levels must notice important aspects of different learners' thinking within the instructional process to respond to their students' mathematical thinking. The skill of identifying relevant features within teaching situations and interpreting them from the learner's perspective to make informed decisions is a vital component of the teaching practice and requires training as a part of developing mathematical knowledge (Mason, 2002).

While researchers who study mathematics teacher noticing do not share one common definition of professional noticing, most generally conceptualize the type of noticing teachers employ as involving multiple, interrelated components such as attending and making sense of select information (Stahnke, Schueler, & Roesken-Winter, 2016). Others may use different terms, but also tend to ground the focus of noticing on student thinking and understanding. Jacobs et al. (2010) contend that professional noticing expertise involves a set of three components that are interrelated and co-occur during the instructional process: *attending* to children's strategies, *interpreting* children's understandings, and *deciding how to respond* based on children's understandings.

### **Limitations and Advances in Understanding Teachers' Noticing**

Despite increased efforts to improve teacher knowledge of student thinking, past literature indicates that many teachers face challenges attending to student thinking during the process of teaching, even if they possess knowledge of student thinking (Ball, 2001; Schoenfeld, 1998; Taylan, 2015). This emphasizes that noticing is not as simple as activating one's acumen

of knowledge. Instead, noticing is a specialized skill set, which teachers selectively employ during the complex progression of a lesson, often in response to interactions with students. One could argue that teacher noticing expertise is like the disciplined improvisation of PD leaders discussed in the facilitation literature (Borko et al, 2014a). The noticing process highlights that teachers must sieve through an ever-present influx of classroom stimuli to decide what to notice.

Past research documented specific challenges teachers face while noticing. It can be difficult for teachers to notice the mathematical features of learning tasks (Star, Lynch, & Perova, 2011) or teachers may be distracted by other classroom noticing details that do not enhance mathematical thinking (Ball, 2011; Star & Strickland, 2008). Teachers may also be able to describe specific strategies students use to solve problems, but then be unable to connect these strategies back to the characteristics of the problems of focus (Fernandez, Llinares, & Valls, 2012). Expert teachers attend to more detail and interpret with more insight than novice teachers (Luna, Russ, & Colestock, 2009). Yet, much of what researchers are uncovering about what teachers attend to and interpret is learned within PD environments, where they can decompose the practice to study teacher noticing (p. 169).

Schifter (2011) cautioned that teacher noticing cannot be fully captured in a PD setting, because “in the moment of teaching, noticing is guided by what the teacher is trying to teach and is followed by an action” (p. 218). Despite Schifter’s (2011) caution, few studies have documented mathematics teachers’ noticing during instruction or examined teaching practices independent of a PD setting while studying teacher noticing. There is also a gap in the literature to date on studies examining mathematics PD leaders’ noticing during instruction. The lack of literature on PD leaders’ noticing required turning to the research that almost exclusively studies teacher noticing to understand the current challenges with studying PD leader noticing.

### **Accessing teachers' noticing using video technology.**

Part of the challenge in studying what teachers notice during instruction lies in directly accessing teachers' noticing in the moment (Sherin, Russ, & Colestock, 2011). It is unrealistic to ask teachers to voice what they notice during the act of teaching. Therefore, we must acknowledge that much of what we know about teaching and noticing in the moment draws from researchers' approximation of professional teacher noticing (Jacobs, 2017).

The use of video has served as a pivotal medium to aid researchers studying teacher noticing. Through observing videos researchers have started to characterize critical incidents or potential pivotal teaching moments to which teachers do or should attend (e.g., Choppin, 2011; Stockero & Van Zoest, 2013; Taylan, 2015). For example, Stocker and Van Zoest (2013) identified five potential pivotal teaching moments some beginning secondary teachers attend to based on their responses to actions that revealed student thinking. These included (a) *extending* [students' questions or comments went beyond the planned lesson scope], (b) *incorrect mathematics* [incorrect students' solutions made public], (c) *sense-making* [opportunities to clarify or highlight critical math lesson components to students], (d) *contradiction* [conflicting student answers that resulted in competing mathematical interpretations], and (e) *confusion* [student expression of confusion in response to another's comment or explanation] (p. 134-136).

Employing a similar method to much research on teacher noticing and facilitation, Stockero et al. (2013) identified critical incidents based on observed student actions, teacher responses, and researchers' inferences of opportunities teachers either noticed or missed. No information was sought regarding teacher thinking or reasoning (e.g., using post-observation interviews), to verify the mathematics education researchers' findings. Therefore, researcher approximations on teacher in-the-moment noticing are heavily based on observations.

Observation methods offer a means to gain qualitative access on teachers' noticing and there is promise that methods can extend beyond observations. In one known study, researchers attempted to directly access what teachers notice using innovative video methods (Sherin, Russ, Sherin, & Colestock, 2008; Sherin et al., 2011b). Experienced high school teachers recorded clips whenever they noticed an interesting instructional moment using portable, wearable cameras (Sherin et al., 2008, 2011b). The researchers used follow-up interviews shortly after instruction to understand the teachers' own reasoning(s) for their self-chosen clips. Teachers provided similar reasons to themes Stocker and Van Zoest's (2013) observed and inferred, like student thinking and student discourse (e.g., when students disagreed). Teachers referenced other themes, too, like teacher moves [e.g., choosing to spend more time on a moment to see how it progressed rather than moving on], teacher strategies [e.g., questioning one's own response to a students' question], and student engagement [e.g., lack of participation within a group] (Sherin et al., 2008, p. 38). Together, the findings offer initial insight into what teachers with varying years of teaching experience do and do not notice. The research by Sherin et al. (2008, 2011b) also provides additional promise that technological advances can be coupled with traditional post-teaching interviews to directly access teachers' in-the-moment noticing *during* instruction.

### **View of noticing as adaptive expertise.**

Emerging research about what and how teachers notice suggests that noticing is a type of adaptive expertise that enables teachers to innovate when necessary. Findings indicate that teachers' decision-making responses were connected to how they interpreted, more specifically, whether teachers evaluated student thinking or justified using specific evidence (Choppin, 2011; Choy, 2014; Taylan, 2015). For example, Choppin (2011) examined how middle grades teachers' noticing informed their task adaptations using reform-based mathematics materials. Choppin found that teachers who primarily evaluated student thinking adapted tasks by reducing

the complexity. Those teachers who primarily interpreted details with specific evidence regarding student sense making adapted tasks in ways that either maintained or enhanced their complexity. The primary reason cited by teachers who noticed and interpreted details was that they wanted to provide opportunities for students to make sense of key mathematical ideas or engage with ideas before they became formalized (Choppin, 2011).

Additional research studying experienced K-12 teachers known to engage with student thinking mirrored these findings. Dyer and Sherin (2015) and Taylan (2015) found that teachers who provided specific evidence of their claims about student thinking often went one step further by making connections between what they noticed when they analyzed their own instruction to past or future moments of instruction. Results also revealed that teachers often acted on their past decisions to make such connections and decide how to respond in the moment (Dyer & Sherin, 2015; Taylan, 2015). These results suggested that teachers who systematically engaged with student thinking increased their awareness of students' strategies and continued to transform their instructional practices, thereby resulting in higher rates of responsive teaching.

Additionally, these same researchers and others (e.g., Choppin, 2011), have found that when teachers involved peers and/or mentors in the inquiry process of noticing student thinking, they were able to develop their own knowledge, which helped transform their instructional practices.

### **Insight on Teachers' Mathematics Noticing from PD Settings**

Based on the number of additional research studies involving mathematics teachers' noticing within the scope of PD efforts, researchers seem to agree that teachers' can advance their professional noticing abilities. Evidence spans the K-12 terrain, from work with practicing elementary teachers (e.g., Franke, Carpenter, Levi, & Fennema, 2015; Jacobs et al., 2010) to secondary teachers (e.g., Doerr, 2006; Silver & Suh, 2014), as well as prospective teachers (e.g. Star & Strickland, 2008; Sun & van Es, 2015). One of the most influential earlier elementary

practice-based PD efforts to date that successfully engaged teachers in analyzing children's thinking is the *Cognitively Guided Instruction* (CGI) Project. Studies on CGI include one of the few PD efforts that has evidence of its success to help teachers attend to, interpret, and decide how to respond to children's thinking through longitudinal, experimental research with student achievement data (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989) and follow-up research (Franke et al., 2001). Although this research predates the current gaining traction of studies on mathematics teacher noticing, their seminal work provided initial insight that teachers' noticing can shift towards attending to and interpreting how children think and develop mathematical concepts. Other researchers agree that teachers with greater noticing expertise are able to execute their noticing components as an integrated skill set and able to analyze with greater depth and detail than novices (Superfine, Fisher, Bragelman, & Amador, 2017).

It is important to raise the topic of developing mathematics teachers' noticing. This study did not attempt to *advance* PD leaders' noticing, nor did it study noticing *during* PD instruction. Instead, it examined PD leaders' noticing while viewing PD instruction. However, there is much value in examining the noticing literature beyond the focus of this study to learn more about the noticing process required during instruction. The emerging literature base shows that much of what we are currently learning about noticing comes from research within the mathematics teacher PD settings, including studies that helped teachers learn to notice. Findings within the PD context may also provide insight into shifts researchers have observed in teachers' noticing as they gain experience. To aid and maintain a focus on the process of noticing regarding mathematic instruction, the application of the Jacobs et al. (2010) noticing framework guides the continued discussion of past research on teacher noticing. More specifically, the discussion focuses on what the literature reveals about teachers with varying experience notice within the three components of attending, interpreting, and deciding how to respond.

## **Noticing as Attending, Interpreting, and Deciding How to Respond**

By turning to a growing area of research on professional noticing that decomposes the process of noticing into the separate three components for study, the next section provides a window into what and how teachers learn to notice. Furthermore, by examining different research that has studied novice and expert teachers, summary snapshots of teachers with varying levels of experience are portrayed.

### **Attending to salient features of mathematics classroom instruction.**

As stated before, the first component of Jacob's et al. (2010) framework is *attending* or the focus of a teacher's observations. Past literature that studied classroom instructional features found novice teachers tended to notice surface-level features compared to more expert teachers (Star & Strickland, 2008; Sherin & van Es, 2009). The most extensive work on mathematics teacher noticing likely comes from Sherin and van Es (e.g., Sherin, 2001, 2007; Sherin & Han, 2004; Sherin & Russ, 2014; Sherin & van Es, 2005, 2009; Sun & van Es, 2015; van Es & Sherin, 2002, 2006, 2008; van Es, 2012). Their work through video clubs using videos of classroom instruction revealed that teachers initially focused their attention on themselves or the other teachers and the observed teaching actions, but over time they began to focus their attention on their students and their students' conceptions (Sherin & van Es, 2009; van Es & Sherin, 2008). Through guidance and experience, teachers gained experience attending to salient features of classroom instruction and successfully shifted the focus of their attention in both the actor [who is the focus] and topic [what is the focus] (Sherin & van Es, 2009). Yet, the effects of viewing videos of one's own versus others' teaching on the elements of noticing, such as attention and related reasoning processes, are not straightforward. For example, other studies examining the effects of viewing videos of one's own versus others' teaching found that teachers analyzing their own teaching instruction were less self-reflective with regard to articulating critical

incidents, but noticed more relevant components of teaching and learning (Dick, Sztajn, White, & Heck, 2018; Seidel, Stürmer, Blomberg, Kobarg, & Schwindt, 2011). The evidence does seem to indicate that partially influencing attention is the type of material used to support noticing.

Video is a pivotal medium heavily used in the mathematics teacher noticing research base, but some studies have examined what teachers notice through other tools. It is through student work analysis that we learn other areas or topics teachers attend to as a part of mathematics instruction, and whether they focus on additional information while attending to features of student thinking. Multiple studies that asked teachers to analyze student written work found teachers tended to focus on correctness of student answers, particularly student mistakes (Brodie, 2014; Krebs, 2005; Silver & Suh, 2014; Sun & van Es, 2015). In one study, PD leaders attempted to refocus participating teachers' attention to the same students' work by showing videos of those students discussing their solution process (Krebs, 2005). Krebs (2005) found that over time participating teachers not only began to attend to details about student thinking, but also began to ask questions to seek more information. The results suggested participating teachers did more than solely attend to details in student thinking (Krebs, 2005). Other researchers have also substantiated that video may support teachers' ability to notice, revisit, and investigate desired teaching and learning aspects (Rosaen, Lundeberg, Cooper, Fritzen, & Terpstra, 2008; Sherin & van Es, 2009). Such a finding reifies the complexities of student understanding and a need for flexible, yet greater proficiency on the part of teachers to attend to and pursue their own students' thinking. It also highlights that noticing simultaneously activates other cognitive skills in teachers' minds, like seeking additional information as a part of making sense of aspects teachers notice. For example, in another study on video-based teacher noticing,

researchers realized that teachers began to recount and interpret their own classroom instruction attention based on their selective attending during the noticing process (Sherin & Russ, 2014).

### **Interpreting based on own selective noticing.**

The second component within the noticing process is *interpreting*. The growing body of research on teachers' noticing offers insight into how teachers interpret or make sense of what they notice. More specifically, it offers growing evidence that opportunities to analyze student thinking can be a powerful catalyst to orient teachers to reconsider their own teaching and learning of mathematics in PD settings focused on professional noticing.

A teacher's knowledge of students' mathematical thinking requires determining in what way students' answers are or are not meaningful from their mathematical learning standpoint. Yet, research on teacher noticing revealed that many teachers prematurely evaluated as they inferred about student understanding (Brodie, 2014; Jacobs et al., 2010; Silver & Suh, 2014). Fortunately, these same studies also revealed that teachers broadened their sense-making about what constitutes productive mathematical thinking. Through greater noticing experiences, participating teachers began to consider and discuss different strategies and representations (Brodie, 2014; Jacobs et al., 2010; Silver & Suh, 2014). As a result, teachers discussed student work in deeper ways. For example, Brodie (2014) found participating teachers began to notice errors as learning tools for both them and their students. Other researchers also cite the benefit of repeated opportunities on teachers' attention to multiple sources of information. More specifically, researchers found student written work and videos that revealed students' mathematical thinking helped teachers begin to make sense of details regarding student strategies (Jacobs et al., 2010; Silver & Suh, 2014).

Similar noticing patterns have been seen in teachers who analyzed their own teaching. Initially, these teachers were less critical (Seidel et al., 2011; Sherin & van Es, 2009), but with

time and guidance they began to interpret using greater evidence (Sherin & van Es, 2009). The collective noticing results suggest a trajectory in interpreting. More specifically, teachers' comments revealed a shift from (a) *evaluating to describing in general* to (b) *describing with details* to (c) eventually *interpreting student thinking using evidence* (Goldsmith & Seago, 2011; Jacobs et al, 2010; Sherin & van Es, 2009).

This research on interpreting underscores another important finding. With experience attending to and interpreting students' own words to describe students' mathematical thinking, teachers became aware that analyzing written work alone offered fewer clues and frames into students' thinking than did students' own descriptions of their solution processes (Goldsmith & Seago, 2011; Krebs, 2005). Such a finding suggests that the process of noticing is not one-directional, but that teachers move back and forth through the components. Specifically, teachers likely attend to additional features within the classroom setting after making sense of their initial ideas, particularly as they gain experience attending to student thinking. It also serves as an important reminder that what teachers attend to and interpret depends on the focus of the noticing as they interact with one or more sources of information (Brophy, 2004).

### **Deciding how to respond based on own noticing and interpreting.**

Fewer mathematics teaching noticing studies have examined how teachers *decide how to respond* in their instructional practices. There is much more to still learn about the third component of the noticing process. One study by Doerr (2006) observed the relationship between interpretations and decision-making. Doerr examined the interpretive focus that teachers employed when analyzing written and verbal student work after attempting to shift their interpretive stance from an *evaluative* orientation [concerned with identifying and correcting student error] to an *interpretive* [listens to students' ideas to access understanding and seek additional information] and *hermeneutic* [interacting with and engaging students in negotiating

meaning and understanding] (Doerr, 2006, p. 6). One case of an experienced teacher revealed that teacher shifted how to interpret aspects within the classroom instruction and how to use interpretations to guide student responses. The teacher listened to the students' ideas and responded by asking more questions, so the teacher could orient students in directions that required them to seek their own answers and use their own ideas as a guide rather than providing answers when students faced challenges.

Another study by Brodie (2014) also found that opportunities to notice can positively impact teachers' decision-making reasoning. Participating teachers began to seek reasoning behind student errors to better make sense of the initial information they attended to as they gained experience attending to student thinking. Together, these two studies by Brodie and Doerr (2006) show promise that decision-making skills can change. Doerr's case study findings highlight an important shift in the locus of control that occurs in the classroom when students rather than teachers serve as evaluators of their own emerging ideas. Both studies revealed that how teachers respond based on their interpretations impacts task difficulty, because teachers' attention to their own interpretations of students' thinking are interrelated to how they respond (Brodie, 2014; Doerr, 2006). Brodie found that the link from interpretations to formulating responses signaled whether teachers simplified tasks or language in response to student errors. Doerr observed that by maintaining the responsibility of learning on the students, the teacher maintained or sometimes increased task complexity. These outcomes support other past findings that how teachers decide to respond impacts the enactments of challenging tasks (e.g., Choppin, 2011).

### **Redefining Teaching Experience Based on Noticing as Adaptive Expertise**

Past research offers evidence that teachers' revised noticing learned in a PD setting can transfer to the classroom setting and applied in the moment (Sherin & van Es, 2009). When

coupled with the overall findings on teacher noticing, there is converging evidence that even more experienced teachers benefitted from opportunities to reorient their noticing towards student thinking and other salient features of classroom instruction. The results of these noticing studies raise a related question about the role of *experiences* in noticing expertise, particularly given that the emerging findings reveal teachers' decisions on how to respond are correlated to the quality of enacted instruction.

One study by Jacobs et al. (2010) specifically investigated the role of experience in noticing by studying practicing teachers with similar average years of teaching experience, but varying years of PD experience focused on children's mathematical thinking. The researchers termed teachers *initial*, *advancing*, and *emerging teacher leaders* accordingly. Prospective teachers served as a comparison group. By applying their own noticing framework, the researchers found significant differences for all 3 pairwise comparison groups regarding attention and interpretation. When examining teachers' decisions on how to respond, all differences were significant again except for prospective versus initial teachers (Jacobs et al., 2010). This last finding suggests that noticing expertise in deciding how to respond based on children's understandings does not develop from teaching experience alone. It also reveals the importance of engaging in multiple, ongoing PD focused on children's mathematical thinking to continue to advance teachers' noticing, particularly this last component.

Findings from another study by Jacobson and Lehrer (2000) support the Jacobs et al. (2010) conclusion and suggest that value may lie in providing different area-specific PD that attunes or orients teachers to specific benchmarks and indicators of student reasoning. The researchers found that all elementary teachers, who had previously participated in PD on student thinking within arithmetic, maintained their attention on student thinking. However, only those participating teachers who advanced their MKT in the particular area of focus within a different

PD on geometry placed more emphasis on elaboration and sustained longer, richer classroom discussions that also included function, not just content, when interpreting and deciding how to respond (Jacobson & Lehrer, 2000). In other words, there was greater depth in their interpretations, which impacted how they responded to their students.

These two studies by Jacobs et al. (2010) and Jacobson and Lehrer (2000) further support the notion that teachers' decision-making and underlying reasoning skills can be advanced, but they also offer cautionary advice. Jacobs et al. found that providing robust reasoning as a part of deciding how to respond was challenging, took years to develop, and that did not simply develop with teaching experience. Jacobson and Lehrer found that teachers should not only participate in multiple, ongoing PD opportunities on student thinking, but also in *multiple* mathematical areas. Their findings indicate that deciding how to respond may be the most complex noticing component and harder to alter. Yet, the lack of studies that are still emerging suggest there is more to learn to better understand this component.

### **Synthesis of the Literature**

In this section, I conclude by summarizing some key insights from the research findings about the construct of mathematics teachers' noticing based on this literature review. I also highlight select advances and challenges the findings suggest.

#### **PD Leader Noticing Provides Insight Beyond an Examination of MKT**

The studies on noticing offer insights into why it is important to understand the noticing and knowledge-based reasoning of PD leaders. PD designers tend to select teachers, teacher leaders, and educators to serve as PD leaders. This tells us that PD leaders are not necessarily novice teachers. Instead, they begin with a range of teaching and facilitation experiences. We can surmise from the research on facilitation and teacher noticing that PD leaders' own MKT and noticing of classroom instruction with their K-12 students does not suffice for their new role

as a PD leader within the PD setting. Recent emerging research on facilitation supports this conjecture. One set of researchers even proposed naming the knowledge needed for facilitation *mathematical knowledge for professional development* or MKPD to distinguish the knowledge PD leaders require from the MKT teachers need to know (Borko et al., 2014).

Research recognizes that scaling PD requires numerous skillful PD leaders, so there is an urgent need to identify the types of knowledge and skills PD leaders draw on during facilitation (Borko, et al., 2014a). Based on findings from the noticing literature, we can infer that teachers and PD leaders' noticing is not simply activating or accessing their MKT or MKPD. Noticing is a selective process. Sherin et al (2011) even emphasized that "it is not helpful to think of teacher noticing as simply another category of teacher knowledge...The word noticing names a process rather than a static category of knowledge" (p. 5). Therefore, simply understanding PD leaders' MKPD and the desired facilitation moves they need to employ is providing an incomplete picture of PD leaders' disciplined improvisation. There is still the need for insight into what and how PD leaders notice, as this study addresses. It is important to note that the current literature on teacher noticing and facilitation does not yet provide such acumen.

Without oversimplifying the complexity of these endeavors or limit the domain, the analysis of the current emerging studies suggests that while teachers activate their mathematical knowledge for teaching during instruction, which includes knowledge of student thinking, this is not what is meant by mathematics teacher noticing. Instead, one could say researchers are referring to the internal, mental act or process that involves teachers' in-the-moment decision-making or responsive set of skills that are inherent to the complexities of teaching mathematics and foundational to current, reform-based mathematics teaching and learning practices when they refer to professional teacher noticing.

Research indicates that the act or process of teacher noticing unfolds differently within different settings, thereby requiring different types of reflections [i.e., reflection *on* action when analyzing *after* instruction versus reflection *in* action when noticing in the moment *during* instruction] (Criswell & McKrall, 2017). We have yet to uncover how the process unfolds for PD leaders regarding the PD setting. Yet, there is a common theme based on past studies. Methodological choices and findings suggest researchers recognize that systematic help and multiple opportunities are critical to shift teachers' current noticing and practices and embrace a role as ongoing, continuous learners to advance their own knowledge of reform-based teaching and learning ideas. Instruction on mathematics teacher noticing promotes this type of teacher inquiry. PD programs take what teachers do almost instantaneously during instruction in their own classrooms, decompose and unpack it, and turn it into a collaborative process to shift participating teachers' noticing towards a focus on and understanding of student thinking. A similar process could describe understanding and supporting PD facilitation. Disciplined improvisation requires PD leaders to notice and act alone, without PD designer assistance. It still involves a social act, but one involving attending to, interpreting, and deciding how to respond to the participating teachers as the learners.

### **The Noticing Process from PD leaders' Perspectives**

The research on noticing is still in its fledgling stage. The noticing research is emerging rapidly, and researchers' initial findings already offer valuable, emerging insights on advances and challenges. The studies reveal that there is no prescribed path to understanding or advancing teachers' in-the-moment noticing, but what we are learning comes from examining decomposed practices within a PD setting and more specifically from researchers' perspectives, who are approximating teachers' noticing. Less research is known outside the PD setting and one of the current challenges to understanding more about noticing lies in accessing the unfolding process

that comprises teachers' noticing. Yet, teachers cannot easily stop and vocalize their thoughts while simultaneously engaged in the interactive teaching process. Work by Sherin et al. (2008, 2011b) offer promise of innovative methods that can and should be further explored that could be used in conjunction with interviews to gain insight from teachers' perspectives. The literature base also reveals the need for more research, particularly on studies of less experienced teachers, as well as novice and expert PD leaders. We also lack research to understand what PD leaders notice during and after PD instruction.

The emerging research on teacher noticing also provides initial insight regarding the three specific components of noticing explored in this chapter. Researchers are uncovering pivotal teaching instances that teachers with varying years of experience do and do not productively notice, which indicates how challenging it is to sieve out critical incidents amongst the wealth of information that is abuzz in classrooms (Stockero & van Zoest, 2013; Sherin et al., 2008). This is not only true for beginning teachers, but also those with years of teaching experience but lacking multiple, ongoing PD experiences focused on student thinking (Jacobs et al., 2010; Jacobson & Lehrer, 2000).

We are also gaining insight into a possible developmental trajectory of interpretative stances used during interpreting. More specifically, teachers appear to progress from evaluating to describing generally to describing with details to eventually interpreting and justifying using specific evidence (Jacobs et al., 2010; Sherin & van Es, 2009). Even less is known about how teachers decide to respond, but there is building evidence that there is a link between interpreting and how teachers decide to respond during instruction. What remains unclear is how PD leaders' noticing looks. Only one known study on PD designer noticing observed PD leaders' stances, in which researchers found that PD leaders tended to make evaluative statements about teachers' engagement and discussed the PD leader's role in general terms (Elliott et al., 2011).

Unfortunately, we cannot infer PD leaders' understandings from one study, nor should we generalize about PD leaders based on findings from teachers' noticing alone. We must continue these lines of inquiry that this emerging body of research on mathematics PD leaders has already cultivated.

Bridging the knowledge between facilitation and noticing is critical to understanding more about the mathematics PD facilitation process, namely what PD leaders need to know and do during instruction. The facilitation studies indicate that researchers recognize that PD leaders require assistance to productively notice how participating teachers engage as adult learners with mathematics tasks (Borko et al., 2014b). By employing desired facilitation moves, PD leaders can anticipate and actively build knowledge about their adult learners. The studies also suggest that while MKPD and noticing are different, part of understanding noticing involves understanding how PD leaders intentionally reason about the events they analyze as they apply their MKPD.

As individuals gain more experience within a specific domain, they become more adept at making sense of situations they encounter, but different people notice different things in the same situation (van Es & Sherin, 2008). Therefore, while prior experiences, knowledge, beliefs, and own agendas shape teachers' or PD leaders' noticing and actions, many unforeseen events play out during instruction that require reprioritization of their attention. It is this selective attention or inattention that determines the direction of instruction. Therefore, understanding the issues that shape PD leaders' decisions to prioritize and reprioritize as events unfold would support efforts to better understanding PD leaders' agendas. Also, it is important to understand why PD leaders propose the ongoing, moment-by-moment choices they do as they face the influx of ever-present stimuli within the PD setting and examine these contextual factors via the lens of PD leaders.

### **Research Questions Revisited**

The following two research questions guide this study, which I now further outline. In a mathematics teacher professional development program for elementary teachers designed to promote high quality discourse and mathematics content knowledge and pedagogy:

1. What, how, and why do leaders notice during elementary mathematics teacher professional development instruction?

More particularly,

- a. (Regarding attending) Who and what aspects during elementary mathematics teacher professional development instruction prompt leaders to take notice?
  - b. (Regarding interpreting) How do professional development leaders reason and make sense of the events to which they selectively attend?
  - c. (Regarding deciding how to respond) What courses of action do professional development leaders propose as next or alternative steps and why?
2. What defining noticing characteristics emerge from mathematics professional development leaders' focus within the moment-by-moment professional noticing process?

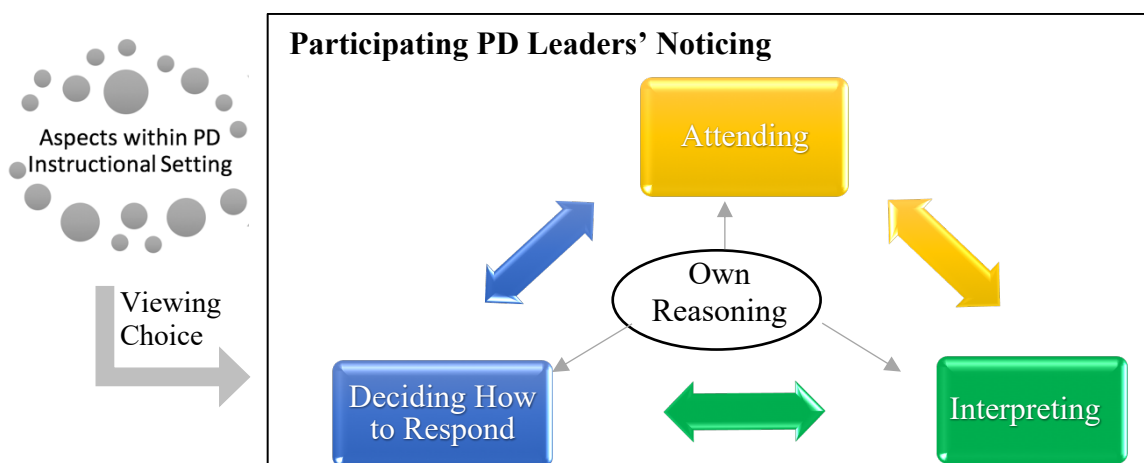
I re-examine the two questions in light of the above literature review here.

#### **Research Question One**

Research Question One centered on the moment-by-moment decision-making components the participating PD leaders employed while analyzing mathematics teacher PD instruction. The Jacobs et al. (2010) framework of teacher noticing offers a lens through which to unpack PD leaders' moment-by-moment noticing within the boundaries of mathematics teacher PD instructional interactions. The motivation for Research Question One rested heavily on the lack of known research to date that has directly studied PD leaders' noticing, let alone

studying it from PD leaders' perspectives. As stated earlier, most of the working knowledge about PD leaders' noticing is approximated by researchers and primarily based on observing PD leaders' actions. Currently we do not fully understand PD leaders' noticing process nor reasoning behind why they notice what they do, as this study addresses.

The emerging literature on teachers' noticing as a selective process suggest a new avenue to bridge the knowledge base between facilitation and noticing of mathematics PD. By understanding how and why mathematics PD leaders attend to incoming stimuli, make sense of the inherently complex and interactive instruction, and decide how to respond, we may begin to uncover more about facilitation and the noticing required during the mathematics PD instructional process. **Figure 2** below provides a visual summary overview of how this study examined PD leaders' noticing, including how the Jacobs et al. (2010) framework guided the research process.



**Figure 2.** Overview of my study.

### Research Question Two

Research Question Two is related to Research Question One and could only be obtained by further analyzing data about elementary mathematics PD leaders' noticing gained from answering Question Two. Through deeper within- and cross-case analyses of participating PD

leaders' interrelated noticing components, I gained greater insight into the foci of their professional noticing that I organized into emerging themes. As in Question One, the focus remained on understanding more about participating PD leaders' noticing process regarding facilitating elementary mathematics teacher PD. Question Two extends the focus to describe converging themes that characterize the overall observed foci within and across participating mathematics PD leaders' individual noticing.

## CHAPTER 3: METHODS

The first two chapters of this dissertation provided justification for my research study. I identified a gap in the literature that supports the need to study PD leader noticing. I also demonstrated that much of the emerging studies on professional noticing is primarily based on researchers' observations. In this chapter, I present the research design in alignment with the research questions. First, I present the rationale for this qualitative multi-case study. Then, I discuss the context in the PD that frames this study and forms the background. Next, I detail the steps of the data collection and analysis. I close by disclosing the trustworthiness and authenticity, and ethical issues associated with this study.

### Research Design and Rationale

The goal of this study is to identify and describe the noticing of PD leaders. The use of a multi-case study approach permitted an interpretive approach to understanding the significance and processes of a particular group within a particular context (Maxwell, 2005). Multiple cases also afford cross-case comparisons (Yin, 2003). The focus of the study remained on PD leaders' noticing and reasoning that undergirds participants' analyses of ongoing actions within an elementary mathematics PD setting—using their words to guide the analysis process. This study does not explore researcher noticing within the PD setting. By employing both emic (insider) and etic (outsider) approaches, the emerging data allows for the portrayal of PD leaders' noticing. Without examining noticing directly from PD leaders' perspectives, we risk building theories on incomplete pictures of the complex social PD setting based only on researchers' perspectives.

Employing a qualitative design supports the intended goals of this study. The use of summary statistics for the cases serves only to support and identify additional emerging qualitative patterns. The focus on qualitative data afforded a finer-grain interpretation of the

participants' understandings. In addition, a multi-case study approach permits an ever-evolving, flexible approach that will be crucial to eliciting PD leaders' noticing with quality needed for depth in analysis (Creswell, 2012; Patton, 2015). Such an approach provides insight into factors that require further investigation and continues dialogue on ways to support effective facilitation due to the complexity facilitation entails.

This study maintained a process-oriented approach that could be classified as falling within a social constructivist philosophy and collaboratively sought to uncover participants' multiple, varied understandings (Patton, 2015). The four purposefully select participants who facilitated the same PD program comprised this multi-case study. This purposeful sample allowed a focus on eliciting select PD leaders' perspectives in this real-life, bounded system. Such depth offered a unique lens into PD facilitation that could not be obtained otherwise (Merriam, 2009). The research design supported collaborative method efforts between the researcher and participants from interviewing to analysis. All findings are the result of this collaborative effort, guided by the research questions and participants' words.

### **Context**

The study is situated within a particular context. Understanding the context, structure, and goals of the PD provides critical insight into this study's background. The *Project AIM* PD program is a highly-specified 40-hour, year-long sustained mathematics NSF-funded PD program for first and second grade teachers. Highly-specified refers to the fact that session goals and plans are highly-scripted to encourage implementation fidelity (Borko et al., 2011). The PD program centers around the topic of subtraction and focuses on supporting teachers to promote productive mathematics discourse in their classrooms. The PD design adheres to the four basic, research-based recommended tenets in the areas of content focus, coherence, duration, and collective participation. The PD has three main goals within the areas of discourse, content

knowledge, and instruction. It attempts to (a) support teachers to promote high quality discourse in the mathematics classroom for all students, (b) develop teachers' level of mathematics knowledge for teaching needed to implement high quality discourse, and (c) provide teachers opportunities to know and use discourse strategies that promote such high-quality discourse. Results from previous analyses have demonstrated teacher growth over the course of the year-long PD program (Sztajn, Heck, & Malzahn, 2013).

Fifty-two primary grades teachers from 11 elementary schools in the same Southeastern US school district participated in school-based teams in two cohorts during the 2016-2017 PD program. According to the most current data from the school district website, the K-12 site location population was over 35,000 K-12 students, with over 16,000 in the 23 elementary schools alone. At the time of the study, students came from over 45 different countries and spoke more than 50 different native languages, including Spanish, Arabic, Chinese, Vietnamese, and Russian. Students' backgrounds were diverse in ethnicity, language, socioeconomic status, and urban versus rural home life.

This 2016-2017 year was the fifth year of PD implementation and the first scaling attempt to a new school district since its inception in the original district context of development in 2011-2012. Scaling altered the previous PD structure, in that PD designers remain off-site this time but were still available for PD leader assistance, if and as requested. Like previous iterations, participating teachers and PD leaders had access to session materials and uploaded completed data via a provided online learning management system. Both teachers and PD leaders received compensation for participation and the completion of their data as part of the research study.

The first six sessions occurred in the summer preceding the school year and the remaining seven sessions took place approximately once per month during the school year,

thereby requiring teachers to apply concepts learned directly in their classrooms, while still participating in the PD program. All 13 sessions for both cohorts were videotaped using a traditional stationary camera. Later sessions for the cohort of focus in this study were also videotaped using a new 360-camera that permits viewers to choose their own focus in subsequent video viewings (i.e., viewers can turn the camera lens and decide where to place their focus within the entire PD setting like they could if they were actually present). The details regarding the selection process of participants and 2016-2017 PD data for this study follows in the description of the participants and pre-data collection procedures.

### **Participants**

Four elementary mathematics PD leaders were purposefully selected to participate in this study: Cecilia, Dina, Lois, and Rosie. All four participants shared the same experience, namely that they led the *Project AIM* PD. A total of 16 different, outside PD leaders who were not the designers previously facilitated the *Project AIM* PD. However, these participants' experiences with this highly-specified PD were most recent compared to other PD leaders and they were the first four PD leaders who worked with both first and second grade participating teachers. To protect their identities, all names are pseudonyms.

The four participants facilitated different iterations of the *Project AIM* PD. Two of these participants, Cecilia and Dina, comprised the entire PD leader population in the 2016-2017 iteration of the PD program. It was the first and only time Cecilia and Dina facilitated the *Project AIM* PD. Both taught in the same Southeastern US school district as the primary grades teachers who participated in the PD of focus. Using video data from one of these cohorts resulted in Cecilia viewing her own videos. The other two participants, Lois and Rosie, comprised the entire PD leader population in the previous iteration of the PD program, which occurred in 2014-2015. They also facilitated the PD in 2012-2013. Both are educators in a

different Southeastern US school district but were also teachers in the same Southeastern US school district as the primary grades teachers who participated in the 2012-2013 and 2014-2015 PD program iterations. Lois and Rosie also facilitated the PD with first and second grade teachers like Cecilia and Dina, but in separate PD iteration years. Furthermore, Lois and Rosie were part of the PD program since its inception in 2011 and provided feedback regarding designer changes made to PD facilitation materials. Therefore, Lois and Rosie were the two PD leaders with the most extensive AIM PD facilitation experience.

The *Project AIM* designers preselected these four and all other PD leaders based on their past experiences. Selection criteria included being an experienced elementary mathematics teacher from the same school district as teachers who engaged in the PD, as well as possessing previous mathematics facilitation experience. All four participants are White females who still taught in their same respective districts. Additional demographic information sought at the start of the study from each participant verified this information and provided additional insight on their backgrounds.

This study was independent of past and current *Project AIM* studies. Therefore, I received institutional review board (IRB) approval prior to seeking formal participant consent (see Appendix A). All four former PD leaders formally agreed to participate in the study and received compensation for their participation through gift cards.

### **Two Known Differences Between Cases**

Purposefully selecting these four participants resulted in two known differences: (a) analyzing one's own facilitation versus analyzing another's facilitation and (b) differences in facilitation experience related to *Project AIM*. Differences in experience level between experts and novices have been established across many fields, including teaching mathematics. For example, past research has shown that expert teachers possess comparatively richer schemata for

ascribing greater meaning to visual classroom information (Carter, Cushing, Sabers, Stein, & Berliner, 1988; Russ & Luna, 2013). Past research has also demonstrated differences in experiences between viewers who analyze their own videos versus others' videos, although professional noticing differences were not straightforward (e.g., Seidel et al., 2011). For these reasons, this study explored both between-group differences during data analysis.

### **Researcher as Human Tool**

As the sole researcher who interviewed and analyzed data, I recognize my role as a human tool. I limited my influence and maintained a focus on the participants' noticing by utilizing a semi-structured interview protocol and systematic analysis process. However, because of my interactions with the participants, I acknowledge that all interview data is co-constructed (Roulston, 2014) and that participants' stories represent an interpretation and presentation of me as the researcher and author of this study, guided by the research questions (Creswell, 2012).

### **Researcher Positionality**

I identify as an Asian-Indian American educator from a middle-class background, with over a decade of US experience at the elementary level and limited US and Germany tertiary-level experience. I have almost exclusively utilized what are often referred to as standards-based mathematics teaching methods throughout my teaching career. Observing and experiencing recent structural challenges when my past district implemented Common Core mathematics standards and practices influenced my decision to pursue a doctoral degree in mathematics education. I hoped that this pursuit would aid learning how to support teachers in understanding and transforming their classroom practices.

Like other fellow school teachers, I held conflicting views of research and practice as guides within education. Significant decisions about teaching and learning were sometimes

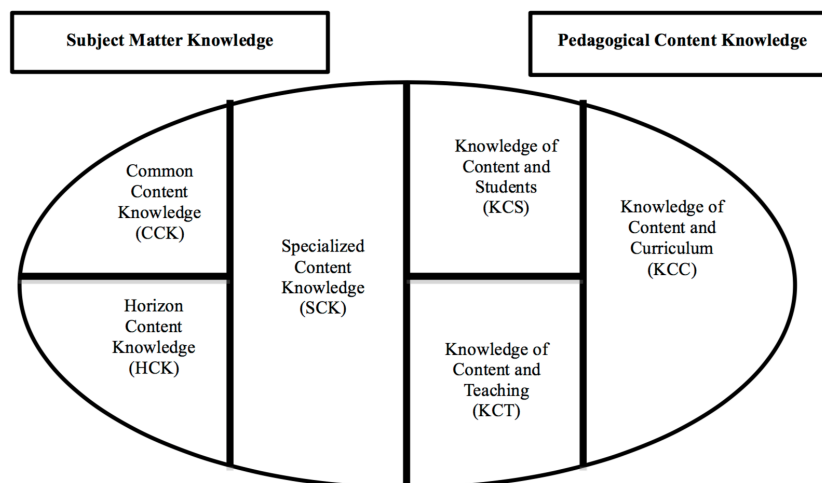
made by policymakers (i.e., lawmakers and researchers) who lacked personal experience regarding the inner workings of a classroom or failed to seek teacher input about teaching and learning needs as part of the implementation process. Yet, there is value in the role of research as part of professional growth. I sought ongoing, research-based PD opportunities to guide my own teaching. The combination of influences likely explains my value for learning about current teachers' and local district practical needs and research findings as part of designing and implementing best research-guided teaching and learning practices. Learning more about a research-practice balance to enhance classroom learning experiences (e.g., the PD program that forms the context for this study) helped minimize internal conflicts.

I recently have come to also identify as a novice researcher in my position as a doctoral student within the mathematics education program. I understand my additional roles place me in a position as an outsider in this study. Yet, I can still relate to my participants' backgrounds as elementary teachers and PD leaders, in that I have experienced first-hand the strengths and limitations of serving in dual roles as a teacher and PD leader involved in the process of changing standards and practices. As a budding researcher, I remained cognizant and negotiated tensions between insider and outsider in this study and in my role as a researcher in my field (Patton, 2015).

Two additional frameworks influenced the underlying philosophical assumptions and supported the design of this research. The first is Simon, Tzur, Heinz, Kinzel, and Smith's (2000) construct of perception-based perspective. In alignment with the social-constructivist perspective to which I subscribe, I accept knowledge as a set of social and cognitive processes that can occur simultaneously and reflexively. The basic principle of perception-based perspective states that individuals' thoughts are coherent, so what they think and do makes sense from their frames of mind. Knowledge is not static; it involves transformations and

reorganizations of the individuals' conceptions (Simon et al., 2000). A focus on PD leaders' perspectives and the meaning behind their noticing defined the research approach undertaken in this study regarding data collection and analysis, thereby impacting the nature of the drawn conclusions. While one cannot know participating PD leaders' perspectives in their entirety, I took efforts to elicit, clarify, and understand their expressed thinking. This study was about their noticing, so I limited the interpretations and discussions to what participants noticed.

Secondly, I subscribe to a broader view of mathematics knowledge for teaching that is applicable to discuss facilitation. According to the Ball et al. (2008) Mathematical Knowledge for Teaching (MKT) model, MKT entails two types of teacher knowledge: teachers' pedagogical content knowledge and subject matter knowledge. This model applied to studying the next level of teaching and learning within a PD setting with the PD leaders serving as teachers and the participating teachers serving as adult learners. Akin to the classroom setting, PD leaders hold a similar position in which they must learn and implement curricular decisions that involve both subject matter mathematics knowledge and pedagogical content knowledge. Subscribing to a broader view of MKT supports the study of elementary PD leaders and the interpretations and understandings of their perspectives. Researchers recognize that PD leaders require similar knowledge to lead professional development. Yet, there are differences from teaching at the classroom level, leading researchers to distinguish and term the knowledge PD leaders require mathematical knowledge for professional development or MKPD (Borko, 2014b). This idea has not yet been further developed, but Ball et al.'s (2008) MKT model is well-known in mathematics education and summarizes my views. See **Figure 3** below for the MKT subcomponents within the model.

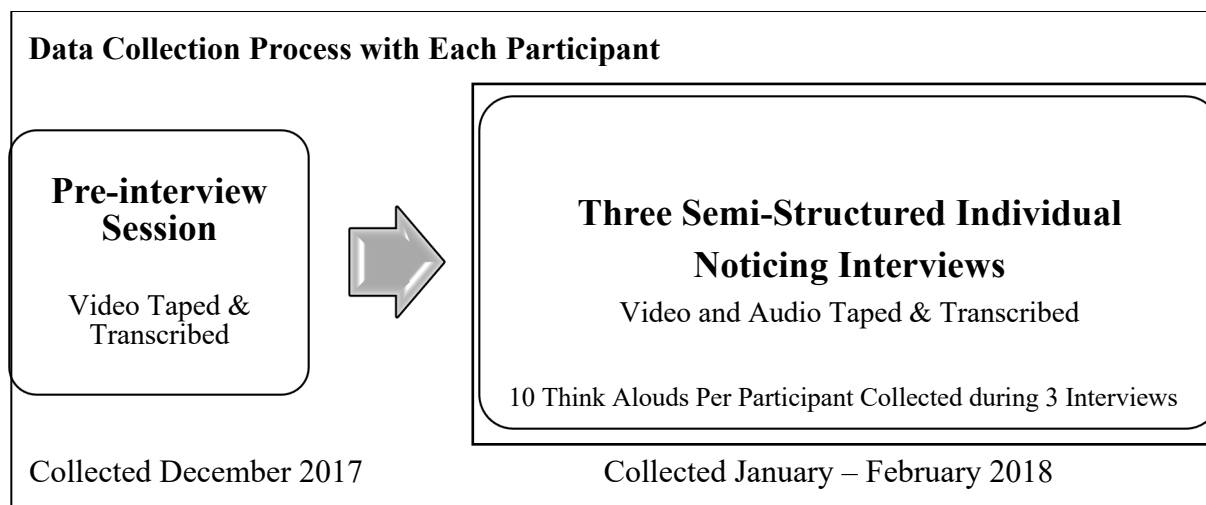


**Figure 3.** Ball, Thames, & Phelps's (2008) mathematical knowledge for teaching model.

By disclosing my positionality, I allow readers to gain insight into the philosophical decisions that influenced the underlying motivations and decisions of this research design and process. My acknowledgements make my values explicit and serve as a guide for understanding how I investigated participating PD leaders' noticing. Revealing value-laden information is never easy when investigating the actions of dedicated PD leaders, who likely desire or strive to make decisions about learners' needs using their own best judgments and data before taking next steps towards helping themselves and their fellow teachers meet their goals. Constructing these realities benefits multiple stakeholders involved in the PD process.

### **Data Collection**

This section entails a discussion of the data collection design process. First, I explain the pre-data collection activities and the individual pre-interview session held with each participant prior to the main interviews. Then, I outline the multiple, individual semi-structured interviews conducted with each of the four participants that comprised the main data collection process. See Error! Reference source not found. for an overview of the data collection procedure.



**Figure 4.** Data collection overview with general timeline.

## Procedures

### **Pre-data collection activities.**

Prior to data collection, I selected one set of ten 360 video clips for participants to later view and analyze during the individual noticing interviews. This decision afforded selecting video clips recorded using a new technology, known as 360 video, that only existed for later PD sessions for this one cohort. This decision resulted in one participant, Cecilia, analyzing her own facilitation and the other three participants analyzing another's facilitation. It also explains why no other participant could view and analyze her own videos as a part of this study, nor could video clips from earlier PD sessions be included during data collection purposes.

### ***PD session video clip selection process: Using new 360° video technology.***

Video technology is valuable in studying teacher noticing. The use of videos provides a record of interactions (Sherin et al., 2011). Their use affords multiple viewing opportunities of episodes after they occurred, as well as access to preserved verbal and non-verbal cues that observers might otherwise miss (Kowal & O'Connell, 2014). They also grant PD leaders time to engage in extended analysis and reason on events that took place during a lesson (Sherin et al., 2008).

The 360 videos captured the ongoing, simultaneous actions of the PD leader and participating teachers during the recording. Like other video, 360 video retains the meaningful complexity of the PD events as they unfold. Unlike stationary video footage that limits the perspective of the view to that of the camera lens, this innovative technology afforded participants individual choice regarding viewing focus while watching prior events within the PD setting. Navigation using an iPad allowed participants to simply tilt the screen in line with their eyes or rotate their bodies like they would do in the PD setting rather than using one's fingers on a mouse or track pad that is required to view on a stationary laptop or desktop. Participants could then selectively scan within the PD setting and attend to the actors or events that were of interest to them when viewing 360 video clips of whole-group interactions. Such viewing mimics a feeling of being present in the PD setting, rather than being bounded by the camera lens in stationary video clips. To ensure all participants viewed the same segments, I identified all starting and ending times and automatically played accordingly. All video clips remained otherwise unedited to permit participants to view all unfolding events that occurred during those whole-group interactions.

Utilizing 360 video resolves challenges researchers have previously faced regarding the study of tacit cognitive constructs. I am unaware of studies to date using 360 video or similar technology to study noticing. Its use in this study explores a new way to capture participants' moment-by-moment noticing. While the overall data collection methods used in this study were similar to past studies that relied on post-instruction, video-based interviews of teachers about what they noticed during instruction (e.g., Russ & Luna, 2013), these methods permitted participants to selectively focus their attention and identify anything they noticed, given they could select their own viewing angle and view simultaneously occurring actions during a given whole-group interaction. Providing participants viewing choices reduced the likelihood of

creating inaccurate or constrained accounts of participants' noticing that may be otherwise limited due to the pre-determined focus of a traditional camera lens. Therefore, the use of this technology supported the goal of this study to gain insight what and how PD leaders selectively notice from their perspective.

Employing a systematic process minimized researcher bias when selecting whole-group interactions. Being a new technology, the 360 camera did not record the latter seven PD sessions in their entirety. This factor limited the availability of video clips for selection within this study. To select the video clips, I identified all partial PD sessions recorded using 360 videos and clips that contained whole-group interactions. Whole-group interactions were those that contained at least two participating teacher talk turns and at least two PD leader talk turns (i.e., instances in which only the PD leader spoke classified the clip as a lecture, whereas the inclusion of dialogue between the PD leader and at least two participating teachers classified the clip as a whole-group interaction). Video clip length further narrowed the selection process. I selected video clips ranging four to less than ten minutes in length, per recommended video clip length suggestions (van Es & Sherin, 2008). Past research suggested that surrounding discussions about each video clip usually last about two to three times the video clip length and that individual interviews should not last longer than about one and a half hours (Creswell & Plano Clark, 2011; Patton, 2015). The process yielded 10 video clips for use during this study.

The final set of ten video clips of whole group discussions addressed both pedagogical or mathematics content knowledge but were pedagogical dominant in nature. Appendix B summarizes the ten preselected video clips by interview. Video clip length determined whether participants analyzed three or four video clips per interview. I grouped clips from five consecutive sessions to present multiple clips to participants over three interview sessions.

Preserving the naturally occurring sequence of the video clips within the PD sessions permitted participants to view and analyze clips as they occurred.

***Engagement in researcher noticing.***

As the sole researcher and interviewer, it was important to attune to my own noticing. By engaging in the same process with all ten video clips, I became sensitized to my own noticing prior to conducting interviews (Patton, 2015). This step provided an outlet to voice and become aware of (my own) foci, ideas, opinions, and biases about these interactions. This step also reminded me that the goal was to elicit participants' thinking, not to evaluate or compare their ideas based on any researcher noticing. As a result, I minimized the role to that of an observer during interviews and maintain a focus on participants' ideas rather than awaiting or leading participants towards some predefined ideas regarding what they as PD leaders may or may not notice.

Preparation for the process began by recording background notes on the ten video clips. The first step involved reviewing PD designers' facilitation plans for the five PD sessions, all accompanying handouts surrounding the focus activities, and video clip footage of the implemented focus activities. Studying designers' materials and video footage provided insight on the implemented activity, which verified that all planned activities took place. Then, I summarized and outlined the context of the implemented activity surrounding each video clip. More specifically, I documented and compared the PD focus per activity, goals, and a general summary of the activity per the facilitation guides, including which implemented activities took place during the session for this cohort. I also reviewed and compiled all relevant PD materials (i.e., facilitation notes and handouts) provided for PD facilitation purposes. Together, these outlines described the PD activities the participating teachers and facilitator worked on and what PD goals they addressed. Preparation of these pre-existing PD artifacts provided a context to

understand what transpired prior to viewing individual video clips. After reading the background information for each whole-group interaction, I viewed the respective video clip and recorded my own noticing as the participants later did. Subsequent researcher memos afforded reflections and awareness of potential biases.

***Pilot study.***

A pilot study allowed for the testing of planned data collection methods. Two different former *Project AIM* PD leaders participated in a one-on-one noticing interview. Neither former PD leader participated in the actual study, so no data collected during the pilot served as data within this study. Each interview involved noticing discussions surrounding video clips 1-3.

The pilot study process indicated that the overall data collection process was realistic and viable for this study. The duration of the noticing discussions surrounding individual video clips fell within recommended guidelines, without constraining discussions or scheduling a subsequent session to conclude the interview. I introduced participants to the Jacobs et al. (2010) noticing framework as a guide for the noticing discussions (See Appendix E). Neither former PD leader revisited or requested the noticing framework after its initial introduction. The planned semi-structured interview protocol provided sufficient guiding questions and prompting was only occasionally needed to elicit additional information from either PD leader about their noticing. This was evidenced by individuals' responses. Both voluntarily voiced what they found interesting regarding their selective attention, interpretations, and decision-making ideas and shared ideas that extended beyond the clip, often without prompting. Both also recollected aspects of their own past *Project AIM* PD facilitation, suggesting participants' reflections may include some outside video-based source as part of their reasoning or justification for their noticing, like Sherin and Russ (2014) found. Lastly, the pilot study advanced the necessary researcher experience in listening to participants and tailoring the phrasing of guiding questions

in response to their expressed ideas. Taking brief observation notes raised awareness on what participants did and did not voice or how to seek clarification when needed. Notetaking also helped maintain a focus on the PD leaders' foci and words expressed during their noticing discussions.

### **Individual pre-interview session.**

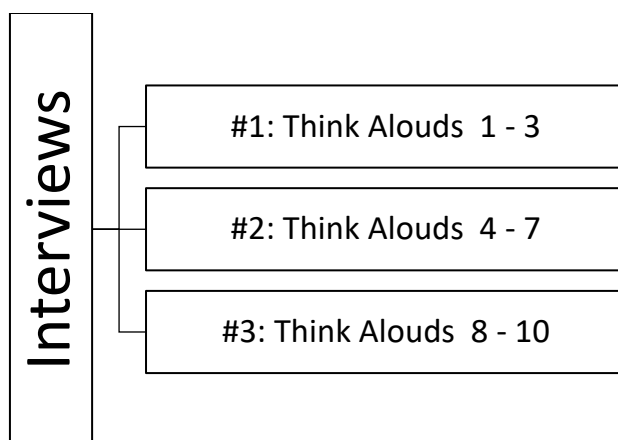
I held a one-on-one pre-interview session with each participant during December 2017. Using the guidelines outlined by Seidman (2013), I created and employed a semi-structured interview protocol across interviews (See Appendix C). Each interview lasted 50-60 minutes, depending on participants' responses. There were four purposes for holding the initial meeting. First, participants' express written consent to participate in the study was necessary. Second, I gained background information about participants' experiences and personal philosophies regarding teaching and learning mathematics. Third, face-to-face meetings provided opportunities to build trust and rapport with each participant. Lastly, participants became familiar navigating the 360-video technology. The start of Appendix D outlines the brief, 10-minute script surrounding the 360-video viewing activity. Providing participants time navigating the innovative technology mitigated potential challenges of using this technology that might have otherwise been unfamiliar to participants.

All four pre-interviews were video-and audio-recorded and later professionally transcribed. Recorded researcher notes served as secondary data for later analysis by providing observations about individual participants' noticing. I confined all subsequent researcher memos and analysis to the scope and lens of this study. It is typical that writing notes are a selective and active process based on researchers' goals, but quality notes can reveal thick descriptions (Corwin & Clemens, 2012).

### Individual video-based noticing interviews.

Interviews with individual participants took place over three different sessions during January and February 2018. Each noticing interview was pre-arranged at an agreed-upon location that permitted privacy and space to play the video clips aloud, as well as record the interviews.

The verbal analysis of each of the ten video clips surrounding the noticing framework involved utilizing participant *Think Alouds* (i.e., the thinking participants voiced aloud regarding their noticing surrounding any one video clip). As used in reading, a Think Aloud generally consists of an individual explaining his or her thinking as it occurs at that moment. Think Alouds have been previously used in research interviews to capture participants' thinking (e.g., Ericsson and Simon, 1993; Fredenberg, 2015), but I do not know of any studies to date that have used Think Alouds or another similar method to directly study PD leaders' noticing from their perspective. Directly studying noticing from PD leaders' perspectives in this multi-case study using Think Alouds explores a possible new methodological avenue. See **Figure 5** below for an overview of the ten Think Alouds over the three noticing interviews (See Appendix B for detail plans and timeline Think Aloud).



**Figure 5.** Overview of individual noticing interviews.

Engaging participants in a Think Aloud was part of the Think Aloud protocol. The same protocol guided all ten Think Alouds in which participants engaged, but the use of the semi-structured protocol varied slightly by participant and video clip (See Appendix D). Each Think Aloud allowed participants to express all they noticed around each given video clip under analysis (all participants noticed regarding each whole group interaction under view at a given time).

Based on the pilot study, the guiding noticing framework was only presented at the start of the first noticing interview (prior to viewing the first video clip) to remind participants about the purpose of the study and help explain how to share their thinking by engaging in a Think Aloud (See Appendix E). The protocol served as a guide based on the noticing components by Jacobs et al. (2010) to elicit any part of the noticing process participants did not express on their own during their Think Alouds. There was no expectation for participants to discuss aspects beyond what they noticed themselves, including how they might respond. For example, they sometimes shared they would do nothing at that time or said they might do what the facilitator did, which equated to their decisions on how to respond. Asking questions around the three noticing components likely influenced participants' viewing behaviors or the focus of their Think Alouds. However, the focus was not on *whether* facilitators noticed, but what they noticed. Follow-up guiding questions allowed differentiating between instances when participants failed to share their thinking versus having no response.

Prior to the start of each video clip, I provided participants the context by briefly summarizing the purpose and goals of the activity under analysis and what occurred in the PD session up to the start of the video clip. Participants then reviewed the facilitation guide and any handouts PD leaders received regarding implementation of that activity to further familiarize themselves with the context before playing the video clip.

Once participants stated they were ready to view the video clip (i.e., they had no further questions), screen-capturing technology recorded their 360 non-verbal viewing behaviors as participants. Participants paused the video when they noticed something that was *interesting* to them. The same generic prompt Russ and Luna (2013) used allowed for a fairly-wide space for participants' ideas. Participants then expressed what they noticed that they found interesting, what that information meant to them or how they interpreted it, what if anything they might do if they were present as the facilitator at that moment, as well as their reasoning. If participants did not pause the video after two minutes, I instructed them to pause the video to discuss what they noticed so far to elicit any thinking participants had up to that point that otherwise may remain unknown. Participants viewed each pre-selected video clip in its entirety, but rewound and reviewed any portion of the video clip, as needed. Permitting participants to review portions of video clips ensured they vocalized what they noticed based on what they understood.

A Think Aloud began when participants paused the video clip and started to express aspects of their noticing and their underlying reasoning. The basic role of the researcher remained the same regardless of participant or video clip, namely, to allow participants to speak (Namey & Trotter, III, 2005). As an active listener, limited questions sought clarification or details regarding participants' thinking as related to the three areas of the noticing framework. While there are multiple ways to elicit participants' ideas through the interview process, this process built trust, avoided judgment, and allowed for listening, while providing a framework within which participants could comfortably and honestly provide their insight through their own voices (Elliott, 2012; Patton, 2015).

The Think Aloud process continued each time participants shared any other aspects they noticed up to the next moment they paused the video and before they continued viewing the same video clip. This cyclical Think Aloud process repeated until the PD leader had no

additional information to add regarding that video clip, thereby ending that Think Aloud. The use of one guiding Think Aloud protocol afforded a faithfully accurate record of each participant's noticing processes in a systematic way as participants analyzed all 10 video clips of PD whole-group interactions.

The data collection process required researcher observation skills that would otherwise result in missing data (Patton, 2015). The use of ongoing, briefly recorded researcher notes provided anchors of key ideas participants expressed and where they placed their focus during their viewing process. More specifically, researcher notes focused on individual participants' responses and non-verbal viewing behaviors regarding who and what was visible as participants used the 360 tool. The use of video recording not only preserved details but also permit researcher focus to remain on the natural bidirectional interview later needed to stimulate researcher's recollections and details of participants' accounts (Elliott, 2012).

Interviewing required a wide range of social, organizational, and academic skills to gain insight from our discourse and produce quality data (Forsey, 2012). The same researcher observation notes informed subsequent researcher memos about ideas participants raised during the Think Alouds, while video recordings preserved data regarding their tracking behavior for later analysis. Researcher memos kept throughout the research process served as written notes about observations, wonderings, as part of the audit trail, and as a check system to ensure consistency with research goals and emerging ideas. The audit trail includes a summary of my data collection steps (See Appendix H).

***Review and reduction of noticing interview data to identify Think Alouds.***

The last step was to prepare noticing interview data for analysis. First, a comparison of the professional transcriptions of all 12 noticing interviews (3 interviews per participant) against original recordings to ensure transcription accuracy. No transcription notation system is

completely accurate and comprehensive, and the level of descriptive details serves as a reflection of my researcher theoretical and ontological beliefs and purposes that form the lens used to see the data and impact the results and conclusions (Kowal & O'Connell, 2014). However, transcription accuracy ensured the accurate capturing of the participants' words.

Then, Seidman's (2013) initial standards guided the process of bracketing passages of interest. The start and end of all 40 Think Alouds (10 per participant for the 10 analyzed video clips) within the comprehensive noticing interview transcripts. Seidman (2013) recommends studying, reducing, and analyzing text to prepare transcripts for analysis, thereby reducing text to "what is of most significant and interest" inductively (Seidman, 2013, p. 119). The text was not further reduced. Instead, all language within the Think Alouds remained verbatim. This step supported the study's goals, because the only pertinent data from these interview transcripts were participants' noticing expressed around each video clip. Retention of the analyzed video clip dialogue in the transcripts served to provide the needed context for understanding participants' expressed ideas, but was excluded from the analysis. Analyzing participants' noticing while considering context improved the trustworthiness of my analysis.

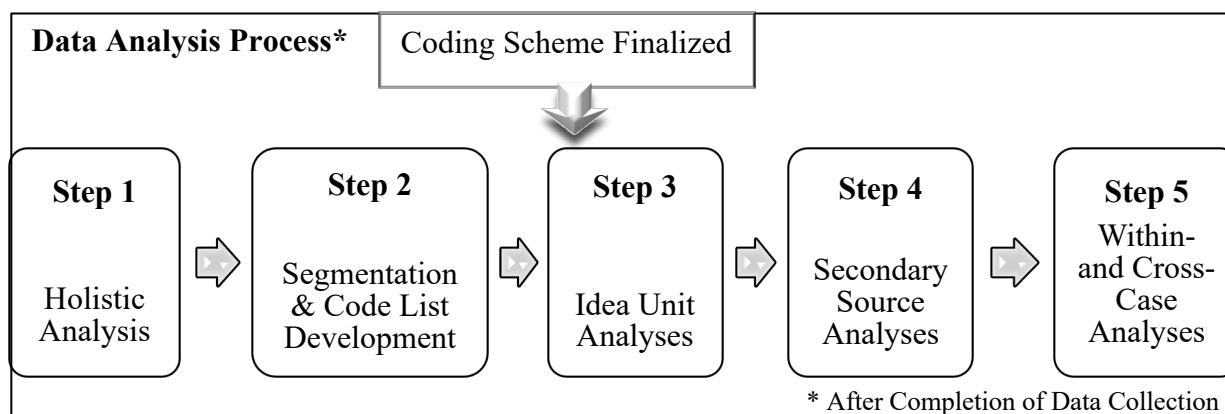
### **Instruments**

The data collection process resulted in rich, qualitative data sources in the form of transcripts and videotapes from the semi-structured, individual Think Alouds, as well as researcher notes. Transcripts from the 40 total Think Alouds served as a primary data source. Researcher observation notes intended to capture non-verbal cues regarding participants' tracking foci while using the 360 tool provided supplementary data on participants' noticing and a summary of participants' Think Alouds, including detailed observation notes that took place (e.g., researcher versus participant prompted pause). Together, the screen recordings of participants' 360 non-verbal viewing behaviors, researcher notes, and transcripts of the four pre-

interviews comprised secondary data sources, because they supported or disputed patterns emerging from the Think Alouds transcripts and provided qualitative details about the participants' noticing.

### Data Analysis

This section focuses on the data analysis process that answered the research questions. In alignment with the process-oriented approach, data analysis began during the main data collection interview and continued in an ongoing, iterative basis after data collection through researcher notes and memos. The data analysis process entailed analyses within and between cases, as advocated by Stake (2006). First, I explain the process for gaining holistic portraits of each participant's noticing (Saldana, 2008). Then, I outline the procedure for developing the coding scheme. Finally, I outlined the multiple steps I employed to analyze participants' data with depth. See **Figure 6** for an overview of the data analysis procedure.



**Figure 6.** Data analysis overview.

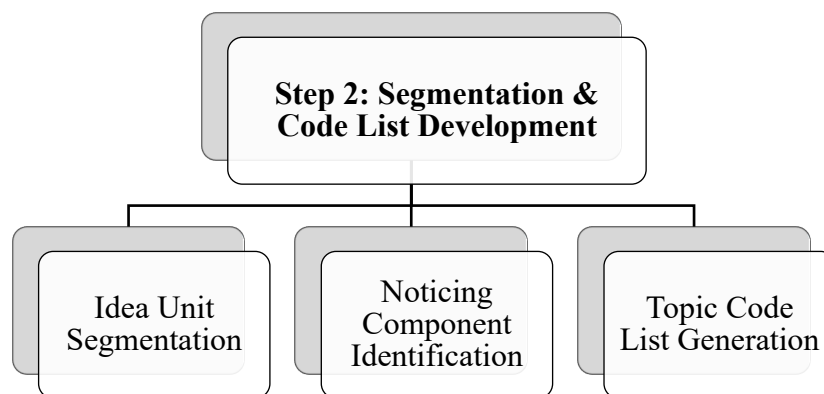
#### Step 1: Holistic Analysis

In alignment with the guiding frameworks and research questions, I employed a holistic analysis approach to the data. The focus remained on constructivist analysis or “how participants create their social worlds using spoken and written words” (Marvasti, 2014, p. 361). Initial holistic analyses permitted becoming intimate with the data and provided initial awareness

of participants' ideas and possible emerging codes (Saldana, 2008). This step entailed reading transcripts from each participant individually and comprehensively, and then recording researcher notes on the main takeaways each participant expressed during individual Think Alouds. Emerging ideas that surfaced during interview observation notes and related memos about participants noticing benefitted this process. Researcher memos taken during this step on main takeaways helped identify tentative themes for later explorations, as well as potential categories that later informed my building coding scheme, including topics that summarized participants' foci within the overall takeaways.

### **Step 2: Segmentation and Topic Code List Development**

This step involved identifying idea units, identifying noticing components within idea units, and generating a stable list of codes for topics participants discussed (see **Figure 7**). All sub-steps involved the use of electronic Think Aloud transcripts within ATLAS.ti (2005), a qualitative analysis software. This step resulted in a finalized coding scheme for subsequent analysis and prepared for coding employed in Step 3.



**Figure 7.** Detailed view of Step 2.

#### **Segmenting into idea units.**

First, segmentation of each Think Aloud into idea units occurred. Idea units are segments of individual participant talk in which discussion centered on a single topic (Jacobs & Morita,

2002). In terms of data for this study that meant an idea unit identified each new area of focus or that a participant found interesting or noticed during the video clip. Usually participants focused on one overall idea when they paused an individual video clip. Step 1 revealed that participants also sometimes revisited the same overall idea when they subsequently paused the video. Less frequently participants expressed another idea during the same pause. Previous researcher memos revealed this pattern across participants, which served as guidelines for idea units. If the participant revisited the same specific idea during a subsequent pause within the same Think Aloud, it remained part of the same idea unit. If the participant progressed to another idea during the same pause, it formed a new idea unit. This decision afforded naturally capturing a participant's noticing cycle within each idea unit (all their attending, interpreting, and deciding how to respond around one overall idea). Therefore, each noticing cycle counted as one idea unit for data analysis purposes within this study.

#### **Identifying noticing components within idea units.**

Next, segmentation of each idea unit to identify the three separate noticing components of attending, interpreting, and deciding how to respond with underlying reasoning within each PD leader's selective noticing cycle occurred. The primary focus was determined by looking at the context in which participants made comments and an effort to gain insight into the noticing process of participants' thinking. Conceptualizing segments at different grain sizes adds value to verbal data analysis, while pointing to the importance of considering the broader context of the conversation (Sherin & van Es, 2009). Dividing idea units by noticing component provided qualitative insights into the noticing process and the different components within each participant's cycle (the order in which they engaged in the process and whether they maintained a focus on the same topics during different noticing components). This sub-step also supported

the identification of present categories that continually emerged, including topics participants expressed. Categorization was essential to informing the overall coding scheme.

### **Generating the topic code list.**

The coding scheme by Sherin and van Es (2009) used to study noticing guided the development of the coding scheme in this study. As stated within the literature review, Sherin and van Es have studied professional noticing extensively and their work dates throughout the 2000s, thereby also offering methodological guidance. For example, they published their coding scheme used to analyze teacher noticing in a 2009 study. The study provided multiple insights, particularly due to their decision to analyze noticing at varying grain sizes. Creating categories within the components of attending, interpreting, and deciding how to respond afforded analyzes at different grain sizes. Part of building a coding scheme entailed identifying the foci of participants' ideas. Emerging codes included capturing participants' focal ideas within the category known as *Topics*. This sub-step of identifying topics within idea units was an integral part of finalizing a full coding scheme and understanding themes that emerged within participants' noticing.

The identification of all topics participants expressed during individual idea units involved employing an inductive approach. An inductive approach is evident within various types of qualitative data analysis and aids an understanding of meaning in complex data through the development of summary themes or categories from the raw data, thereby reducing the data to extract meaning (Miles & Huberman, 1994). The goal of using open, axial coding at this point of the study was to create a stable list of topics and their definitions that captured participants' ideas for later use as part of the coding scheme in Step 3. Generated codes for topics only included ideas participants *explicitly* expressed within idea units when attending, interpreting, and/or deciding how to respond. This sub-step of identifying topics within idea units was an

integral part of developing a full coding scheme and understanding themes that emerged within participants' noticing.

Ongoing comparisons of potentially new topics to the ongoing list of codes and their definitions determined the addition of new codes. The focus remained on analyzing at the idea unit level during this stage but comparing topics across idea units was necessary to generate a stable list of applicable codes for use across instances. Coding each new subset of data began with a different participant and Think Aloud to support a process of identifying topic codes regardless of participant or context. The outcome resulted in code definitions independent of the participants or context of their idea. A systematic coding process also supported an effort to uncover participants' topics of focus, which was one goal of this study. **Table 1** shows a summary list of 16 topic codes that emerged and used within the full coding scheme within Step 3 (See Appendix F, including more detailed definitions and examples).

**Table 1.** Summary list of topic codes.

	<b>Topic Codes</b>	<b>Brief definitions</b>
1.	<i>participating teachers' thinking or understanding</i>	Participating teachers' words or non-verbal communication as an indication of their current thinking or understanding
2.	<i>participating teachers' engagement</i>	Quality or amount of participating teachers' involvement or encouragement to involve them
3.	<i>participating teachers' MKT or readiness to learn</i>	Assessment and inferences of participating teachers' current math knowledge in relation to future mathematical understanding needed
4.	<i>participating teachers' concerns</i>	Expressed participating teacher concern about their own teaching or learning or perceived unease in response to observed participating teachers' comments
5.	<i>anticipation of expected responses</i>	Participant's own expected response on the part of the participating teachers or facilitator
6.	<i>recollection from own past facilitation experience</i>	Participants' recounting of own past facilitation experience or skills used during past facilitation

**Table 1** (continued).

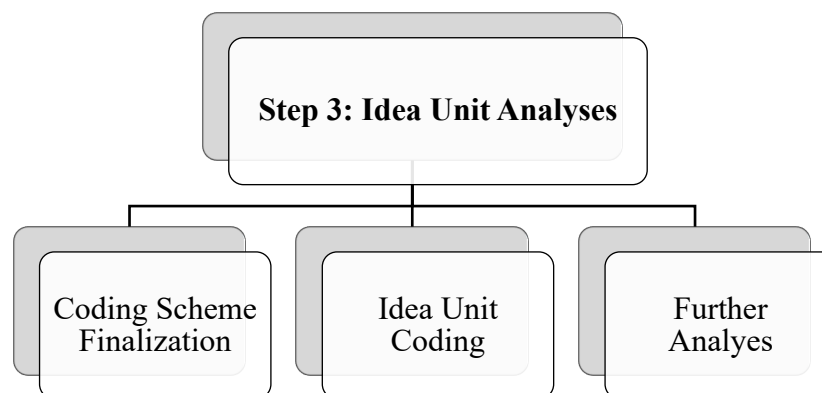
7.	<i>facilitator response or preparedness</i>	Desired or undesired response to observed facilitator decision or perceived readiness or unpreparedness as part of the instructional process
8.	<i>facilitator move suggestion</i>	Proposed facilitator action in response to something unanticipated or part of a commonly-used instructional routine
9.	<i>discourse</i>	Communication or interaction between facilitator and participating teacher or participating teachers
10.	<i>PD Climate</i>	Social environment reference within the PD setting
11.	<i>PD Structural Elements</i>	Any non-human structural element of the PD setting
12.	<i>specific PD activity expectations</i>	Learning outcomes or related purposes and/or reference to underlying purpose(s) of the activity at the activity level
13.	<i>broader PD Goals</i>	<i>Project AIM</i> learning outcomes and/or reference to the underlying purposes of the PD at the session or global level
14.	<i>Project AIM discourse strategies and/or purposes</i>	AIM-specific discourse strategy or its underlying benefits
15.	<i>facilitation or learning needs at PD level</i>	Expressed or perceived PD instructional needs, including a facilitation/adult learning need within the current environment and/or the roles of facilitator and participating teachers
16.	<i>teaching or student learning needs at classroom level</i>	Expressed or perceived teachers' classroom-specific instructional needs, including teaching/learning need during instruction and/or the roles of teacher and students

The process of creating a code list of topics was both etic and emic in nature. While emergent (emic) topics within the data determined all codes, some previously identified topics in past research (etic) guided the naming of emerging topic codes when applicable (van Es & Sherin, 2008). In these instances, a priori names and operationalized definitions served as starting points and modified accordingly. Otherwise, new terms and definitions (emic) were created. In both cases, the focus was on key descriptive phrases participants expressed to characterize and operationalize their ideas and reasons (Sherin et al., 2008). For example, Sherin

et al. (2008) used the term *discourse* to describe how the PD leader and participating teachers “communicated with one another, or on the process by which ideas are articulated and discussed” represented participants’ ideas in this study (p. 38). The highly-specified context of the *Project AIM* PD program also influenced participants’ ideas. Amending the discourse code definition resulted in the inclusion of discourse patterns or talk turns within *Project AIM* that participants discussed (See definitions in Appendix F).

### Step 3: Idea Unit Analyses

This step began with finalizing the coding scheme based on ideas that surfaced through earlier analyses from the previous two steps. The remainder of this step involved employing the coding scheme. **Figure 8** below synthesizes this step.



**Figure 8.** Detailed view of Step 3.

#### **Finalizing the coding scheme.**

As stated earlier, the Sherin and van Es (2009) coding scheme formed the basis of the coding scheme within this study. Their coding scheme provided a starting framework to examine the three components that comprised PD leaders’ noticing in this study. Sherin and van Es did not examine the third component of deciding how to respond. Alignment to the Jacobs et al. (2010) framework necessitated the addition of this component. Ideas within participants’ noticing that emerged through previous analyses informed the needed adaptations to the first two

components of attending and interpreting and new categories and subcategories for the third component of deciding how to respond. **Table 2** summarizes the finalized coding scheme (See Appendix G for details). More specifically, Table 2 includes all changes outlined next. Coding emerging topic listed in **Table 1** within each noticing component are also summarized in **Table 2** and explained next.

**Table 2.** Coding scheme employed by idea unit within individual cases.

<b>Noticing Component</b>	<b>Category</b>	<b>Brief Definition and Subcategory Codes</b>
<b>Attending</b>	Actor(s)	Individual of focus: <i>participating teachers, facilitator, PD designer, student</i> (at classroom level), and/or <i>other</i>
	Topic(s)	Area(s) or issue(s) of focus (revisit <b>Table 1</b> for list of codes)
<b>Interpreting</b>	Stance(s)	Nature of interpretation: <i>evaluative, literal</i> and/or <i>analytic</i>
	Level of Specificity	Level of details provided: <i>general</i> OR <i>specific</i>
	Source(s) of Inference	Boundary of events examined: <i>within video</i> and/or <i>outside video</i>
	Topic(s)	Area(s) or issue(s) of focus (revisit <b>Table 1</b> for list of codes)
<b>Deciding How to Respond</b>	Response Type	Proposed decision, with level of certainty: <i>new decision, uncertainty/conditional</i> , OR <i>no new response/proceed</i>
	Relative Point(s) of Reasoning	Relative positionality for reasoning: <i>retrospective, prospective</i> , and/or <i>no/vague reasoning</i>
	Topic(s)	Area(s) or issue(s) of focus (revisit <b>Table 1</b> for list of codes)

*Attending* involved coding the same two categories of (a) *actor(s)* and (b) *topic(s)* from Sherin and van Es (2009). See **Table 2** for a brief definition and the subcategory codes that emerged within participants' noticing. See **Table 1** for the list of generated topic codes. Because participants sometimes discussed multiple topics and actors within the same noticing cycle that

formed an idea unit, category codes amendments included *all* actors and topics referenced within the same noticing cycle, not just the one main focus previous researchers inferred.

*Interpreting* involved coding for four categories: (a) *stance(s)*, (b) *level of specificity*, (c) *source(s) of inference*, and (d) *topic(s)*. All categories except source of inference originally used by Sherin and van Es (2009). A later study by Sherin and Russ (2014) informed the inclusion source of inference as a category. Sherin and Russ cited the application of the video-based category as a turning point during their analysis of teacher noticing, when they recognized that some teachers referenced their own classrooms rather than the classroom displayed in the clip to explain what they noticed in the video clip. Broadening their definition permitted capturing participants' references to ideas within the provided curricular materials, which also laid outside the video clip.

Observed references across participants' ideas during the initial holistic analysis and the developing emerging code list informed the four categories included within interpreting. Participants' ideas revealed they sometimes employed more than one stance when inferring about the same overall idea, resulting in the inclusion of *all* referenced stances within a noticing cycle, not just the main one like Sherin and van Es (2009). The same modification applied to other categories, except level of specificity. Original definitions of general versus specific regarding level of specificity were mutually exclusive. Hence, only one applicable level of specificity code per noticing cycle summarized participants' noticing at the idea unit level. See

**Table 2** above for a brief definition and the subcategory codes. See **Table 1** for the list of generated topic codes as well as Appendix F and Appendix G, as needed for details.

Adherence to the subscribed noticing framework by Jacobs et al. (2010) that specified the three components and guided the study goals justified the addition of the component of *deciding how to respond*. Three categories specifically created to code for *deciding how to respond*

included: (a) *type of response*, (b) *relative point(s) of reasoning*, and (c) *topic(s)*. Ideas that emerged during holistic analysis and while building a list of topic codes led to the creation of these three categories and their respective subcategories. For example, coding one response type per noticing cycle was the result of subcategory definitions that were exclusive in nature. Relative point of reasoning sometimes required coding for more than one subcategory within an idea unit, so coding each noticing cycle included all relative points of reasoning.

Like other modifications, wording of the categories and their respective definitions within the component of deciding how to respond were meant to capture the emerging structure of participants' ideas within this noticing component. In the case of decision-making, participants always expressed whether they proposed a new decision or not. So, similar reasoning informed the creation of relative point of reasoning, namely that participants always expressed whether their explanations referenced ideas that already happened or were yet to come.

Participants did not always propose a new decision or sometimes expressed a form of uncertainty that coupled new decisions at select moments. This pattern resulted in expanding subcategories to include level of certainty within response type. Participant responses received the code of *new decision* only if the participant expressed a newly proposed decision with certainty. Responses received the code of *uncertain or conditional* if participants expressed any indecision, regardless of reason (participants' expressed unsureness about a newly proposed decision or specified a future prerequisite that must be met as part of proposing how to proceed next). Responses received a code of *proceed or no response* if participants recommended continuing in accordance to observed actions up to that point in the video clip or no new decision was proposed, regardless of reasoning. Only one response type code applied per noticing cycle, as one subcategory already captured these so-called uncertain moments.

Participants tended to reference events that already happened. While such references were usually within the clip, there were instances when participants referred to ideas outside the clip. Source of inference already captured the boundary of the clip, but failed to capture references to relative point in time, namely that participants sometimes looked ahead to what was yet to come. That led to the creation of the relative point of reasoning category. If participants discussed past events that already occurred, whether they just occurred within the video clip under analysis or occurred in past video clips or PD sessions, the entire response received a code of *retrospective*. If participants referenced a future event, whether planned or unplanned, the response received the code for *prospective*. If participants referenced both types of events, the response received both codes. See

**Table 2** above for a brief definition and the subcategory codes. See **Table 1** for the list of generated topic codes.

The decision to code the topic category as part of each noticing component within individual idea units afforded an opportunity to examine whether participants tended to maintain their focus on the same topic(s) or tended to switch to other topics during a given idea unit or noticing cycle. This represents another modification from Sherin and van Es (2009) original coding scheme, in which they only coded one overall topic per idea unit at the attending level. Avoid confounding grain size analysis with this decision was essential. All calculated frequencies at the idea unit level excluded frequency of topics coded at the noticing component level.

### **Coding idea units.**

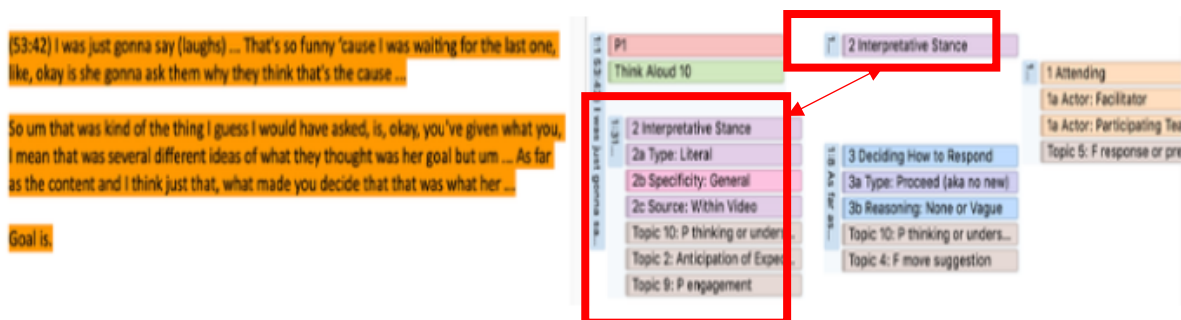
The coding process involved employing the full coding scheme at the idea unit level of analysis, as shown in **Table 2**. The coding process also informed about individual participants' noticing process at the component level. The purpose of pre-segmenting idea units to

participants' naturally occurring noticing cycles around separate overall ideas and further segmenting idea units during Step 2 was to identify when and how participants engaged in each component by noticing cycle. All coding at the idea unit level occurred directly within ATLAS.ti.

Pre-segmented idea units that identified the components of *attending, interpreting, and deciding how to respond* received codes for all categories as outlined in the employed coding scheme. The overall attending component per noticing cycle received one code per actor and topic regardless of frequency of occurrence by subcategory within idea units. That is, if a participant referenced the facilitator within the video multiple times within one idea unit, the noticing cycle received one actor code of facilitator. The same coding rule to exclude frequency of occurrence at the subcategory level within the same idea unit applied to coding at the overall components of interpreting and deciding how to respond per noticing cycle. Interpreting received codes per stance, sources of inference, topic, and level of specificity. Deciding how to respond received codes per response type, relative points of reasoning, and topic. See **Table 2** above for a brief definition and the subcategory codes and Appendix G for details, as needed. See **Table 1** for the list of generated topic codes.

**Figure 9** provides an example of coding at the idea unit level using the coding scheme shown in **Table 2**, which includes topic codes shown in **Table 1**. This example illustrates that while this participant engaged in interpreting twice within this same short idea unit (see two highlighted purple tags), all subcategory codes applied to the overall interpreting component for this idea unit (see second interpreting tag). In this instance, the participant only used a literal stance to describe (first purple code), offered specific details regarding level of specificity (pink code), and only cited aspects within the video as her source of inference (second purple sub-block). During the two times this participant interpreted, the participant discussed the three

topics of participating teachers' thinking or understanding, anticipation of expected response, and participating teachers' engagement (three brown blocks).



**Figure 9.** Employed coding scheme example.

### Further analyses.

After the completion of the coding, a second level of analysis permitted additional explorations into the complexity of participants' noticing. Using coding data within ATLAS.ti, frequencies for all category and subcategory codes were generated and averaged across the total number of noticing cycles per participant. Calculated average total frequencies for each participant conveyed the average occurrence per noticing cycle. For example, if a participant attended to the participating teachers during 38 of her 43 total noticing cycles within the category of actor, that participant attended to participating teachers on average about 0.88 per noticing cycle or in almost 9 out of every 10 noticing cycles (or an average of 88% of all noticing cycles). Similarly generated average frequencies per noticing component within idea unit were calculated to capture the average engagement in the different noticing components per noticing cycle. This was the one use and inclusion of frequency of occurrence within *single* idea units.

Also adopted from Sherin and van Es (2009), this level of analysis included calculating the level of breadth and depth of each category. No modifications regarding breadth or depth categories, definitions, or procedures were necessary. Breadth (*narrow* versus *broad*) referred to whether an individual participant focused on one or more *main* areas across their noticing cycles. Level of depth (*deep* versus *shallow*) involved examining the relative difference between

subcategories. Together breadth and depth summarized each participant's degree of focus. Examining differences within participant foci informed about the breadth and depth across all noticing cycles, as further explained through the two following examples.

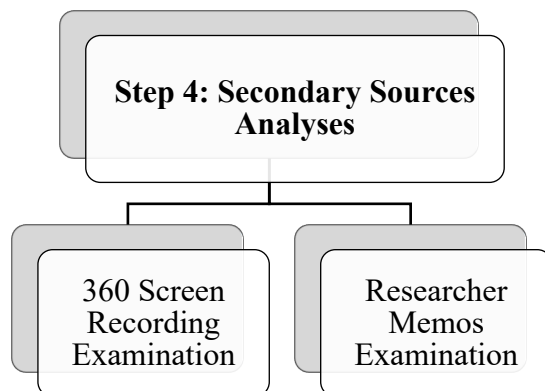
Comparing calculated average unit rates per noticing cycle of subcategories within each category determined if an individual's breadth regarding focus was narrow or broad. An entire category had a *narrow* focus if only one subcategory average unit rate was greater than 0.5 [50% of the noticing cycles per participant] (Sherin & van Es, 2009). For instance, when examining the actor category at the attending level for one participant, the total of average idea unit rates exceeded 1.0 because all actors received codes at the idea unit level, not just the main one. This was typical for other categories when more than one subcategory code was applicable.

Comparisons involved the average occurrences per noticing cycle for all actors. If participating teachers was the focus within 0.90 average occurrence per noticing cycle, the facilitator 0.43, PD designers 0.22, and students at the classroom level 0.08 for one participant, that participant had a narrow focus along the actor category. The same data revealed that this participant's specific attention laid narrowly and heavily on the participating teachers.

Comparing average unit rates between the same subcategories determined the level of depth of participants' noticing. An entire category had *depth* if the difference between the greatest and second greatest subcategory average unit rate was greater than 0.10 (Sherin & van Es, 2009). For example, if the two top subcategory rates within any category were 0.76 and 0.68, then this dimension was *shallow* because the average difference was less than 0.10 or 10%. These analyses drew attention towards participants' individual and comparative qualitative foci.

#### Step 4: Analyses of Secondary Sources

Analyses included secondary sources. More specifically, comparisons included ongoing researcher memos and 360 video screen recordings against the primary coding data to confirm or dispute emerging ideas about participants' noticing (See **Figure 10** below).



**Figure 10.** Detailed view of Step 4.

#### Examining 360 screen recordings.

Examining video data that captured participants' 360 non-verbal viewing habits provided a point of comparison regarding the category of actor within the component of attending. These screen recordings allowed another examination of depth and breadth, using a separate set of data. Recorded time stamps within Think Alouds captured when a participant shifted focus to another actor and who was the focus before observed subsequent attending shifts. If the participant continually scanned the room for any period, its classification depended on whether it remained on participating teachers or also included the facilitator. If it was the former, the actor received a classification as participating teachers. If it was the latter, the actor was classified as a third category of undetermined, because it was unclear whether the participant was looking for someone or if just looking at everyone. Three subcategories were possible: *facilitator*, *participating teachers*, and *undetermined actor*. Calculated and averaged decimals estimated the total relative time each participant spent attending to each actor per Think Aloud. Comparisons

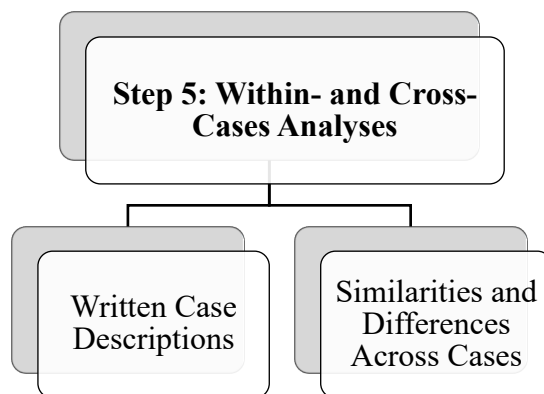
against previously calculated average occurrences within coding results regarding the category of actor and the depth and breadth within the actor category corroborated or disputed the primary data findings.

#### **Examining ongoing researcher notes and memos.**

Ongoing researcher notes and memos suggested possible emerging themes. Comparing emerging themes against primary data identified areas of substantiation and potential conflicts, knowing an examination of secondary data sources may stimulate new ideas later (Gilbert, Jackson, & di Gregorio, 2014). This sub-step also allowed for the resolution of conflicts due to human errors in coding. Therefore, this process distinguished human errors from other conflicting data and emerging patterns. For example, a pattern emerged, revealing that participants sometimes required initial researcher prompting to disclose their ideas around a particular component. As stated earlier, such initial prompting permitted differentiating between instances when participants failed to vocalize ideas they had at that moment versus having no idea around that component. To better understand participants' noticing around this component and the category of decision type, the decision was made to examine instances when the researcher initially prompted participants to share their thinking. Generated frequencies for occurrences, decision type, and type of reasoning and subsequently supported a further exploration of patterns to uncover emerging themes. Using secondary data in conjunction with primary data provided triangulation of the data.

#### **Step 5: Analyses Within and Across Cases**

The analysis of primary and secondary sources also helped build individual case descriptions. Reexamining Think Aloud and pre-interview transcripts along with previous coding data and researcher memos led to case descriptions about individual participants' professional backgrounds and their noticing habits (See **Figure 11** below.).



**Figure 11.** Details of Step 5.

### **Creating case descriptions.**

Creating case introductions by summarizing participants' professional backgrounds preceded the creation of case descriptions. Case introductions involved reading entire transcripts from individual pre-interview sessions and summarizing each participant's educational backgrounds, teaching experience, and years of facilitation experience including the *Project AIM* PD. Case introduction provided greater insight into the two known between-group differences, namely that one participant analyzed her own former facilitation and that two participants had more facilitation experience with the *Project AIM* PD. Specifically, building case introductions helped to better understand individual participants and observed similarities and differences between participants' facilitation experiences.

Writing subsequent individual case descriptions about participants' noticing involved rereading electronic transcripts of entire Think Alouds by participant within ATLAS.ti, generating researcher notes, selecting quotes that summarized tendencies observed within each participant's noticing process, and cross-referencing emerging ideas against previous coding data and ongoing research memos. The goal was to create descriptions that characterized each participant's typical noticing behaviors. The case descriptions also supported the understanding

of later presented cross-case results that included excerpts meant to provide additional insight into the individuals while highlighting similarities and differences across and between cases.

### **Cross-case analyses.**

Cross-case analysis involved examining and comparing multiple sources. Although ongoing researcher memos initiated the process earlier on emerging themes, focused cross-case analyses occurred throughout the duration of Step 5. Coding data formed the primary data in this study and remained the focus of these analyses. An examination of coding results obtained during Step 3 and the Think Aloud transcripts provided qualitative data about individual participants' noticing. The analysis of generated tables of calculated average occurrence per noticing cycle for each component category from coding results revealed similarities and differences between participants' noticing. This sub-step also included reexamining entire Think Aloud transcripts. Rereading Think Alouds by case and across cases again, as done for within-case analyses, captured similarities and differences about the four individuals by component and category. Reexamining participants' words revealed greater depth of thinking around each category. Analyzing transcript data at different grain sizes offered qualitative details that built on summary data to not only describe similarities and differences within participants' noticing, but also further highlight the noticing of each individual participant. Comparisons of secondary data against primary data once again drew into question emerging findings and resulted in the identification of new individual and collective themes.

As the researcher, I recognize the importance of describing the data inductively, as well as noticing both plausibility and lack of plausibility in the data before deducing and interpreting the findings (Miles & Huberman, 1994; Patton, 2015). A back and forth process during this step and the previous one naturally afforded and supported cross-case analyses. Individual emerging patterns or themes in concordance and discordance with past literature revealed additional

qualitative similarities and differences across and between participants. Exploring consistencies and inconsistencies between participants' responses required further investigation about participants' noticing. It also afforded the examination of two known between-group differences: level of PD-specific facilitation experience, as well as analyzing one's own versus others' video. Employing an iterative approach during these two final sub-steps shed light on consistencies and inconsistencies between emerging themes and other data sources, thereby allowing new insights to surface that would have otherwise likely gone unexplored.

### **Trustworthiness & Authenticity**

Ensuring trustworthiness and authenticity was an important, ongoing part of the overall qualitative research design. Through Creswell's (2012) suggestions for trustworthiness and authenticity, a perception-based perspective, and the Jacobs et al. (2010) framework of professional noticing components, the goal was to get as close as possible to the participants' stories that underlie the outlined research goals.

Data triangulation guided the overall qualitative research design and methods through the use of multiple sources. In addition to analyzing secondary data to support and contradict primary data, data dependability came through using various data collection sources and an iterative data analysis process. Following an open-coding approach to create a list of topic codes and finalize a coding scheme improved the authenticity in these methods. Additionally, I was the sole researcher responsible for analyzing the data. Striving for transferable obtained data that involved transparency, thick description, and understanding of the context was an ongoing goal. Creating and implementing a systematic qualitative research process that included the aid of qualitative analysis software and keeping an audit trail improved the credibility of the methods and results (Namey & Trotter, III, 2005). Finally, the analysis process included member checks and peer review at different points and for different purposes, as specifically outlined here.

## Member Check

Member checks provided rigor as part of the trustworthiness and occurred during Step 3 of data analyses. Feedback from participants via email verified or disputed the literal comprehension of their ideas (specifically if the researcher data accurately captured participants' ideas). Participants received select passages of their individual Think Alouds along with a short statements meant to summarize the inferred main ideas they discussed within those passages, along with clarifying questions as needed. While few minor questions or comments surfaced that required no changes to ongoing analyses, potential misinterpretations that could have otherwise impacted the analysis process were minimized through this process. This study sought to learn about participants' noticing from *their* perspective. Accurately capturing their ideas was critical to the trustworthiness of the results.

## Peer Review

Adhering to the qualitative research definition of reliability as response stability across multiple coders (Creswell, 2012) and as the sole researcher who coded and conducted all analysis of the data, the use of peer review at multiple times instead served to broker the process that occurred between participants' ideas and researcher inferences.

The first round of peer review occurred during the second step of the analysis process. An electronic file via Google Drive (2012) provided a peer mathematics education researcher access to a subset of data of pre-segmented idea units from different participants and Think Alouds, coding scheme, and the emerging code list. The shared data eased a videoconferencing dialogue that occurred about holistic takeaways, individual codes, and the segmentation of subunits within individual idea units. The main goal was to compare the researcher inferences against participants' words to determine whether the emerging code list was inclusive in nature (whether a current code list captured a potentially new idea or if another code was necessary). Two

meetings took place. The first meeting began by briefly discussing the research goals, an overview of the methods, the purpose of the coding process, the emerging coding scheme, and the emerging topic code list. Some codes required clarifying, resulting in later modification of their definitions. Next, a brief run through the coding process opened dialogue about the segmentation and coding process. No debate arose when the peer researcher shared thinking and reasoning regarding segmentation (i.e., agreement occurred regarding participant transitions to different noticing components or idea units) during the first meeting. Few questions also arose around coding for subcategories during the second meeting. Therefore, the remaining time within both sessions focused on emerging topics list and the overall coding scheme. The peer independently read a sample idea unit and summarized the overall idea. As needed, the peer sometimes viewed the dialogue about the analyzed video clip for context or asked clarifying questions to understand what the participant was referencing. Continually seeking the peer's thinking and reasoning verified or disputed all the topics the participant was discussing. We identified codes separately before discussing them together. No debate occurred around the overall ideas of idea units, but there was dialogue regarding joint questions, misunderstandings, and reasonings about possible missing codes or redundant codes, as well as modifications needed to further define the boundaries of a particular code. The process continued with other sample idea units from different participants' Think Alouds. Note taking during the meeting and revisions to the coding process and code list made afterwards to ensure continued consistency in my analysis process.

The second round of peer review involved two different educational research peers, who offered counsel during the fourth step of the analysis process. Both had elementary mathematics teaching and PD leadership experiences. Separate, in-person meetings took place with each peer once. The main goal was to substantiate or discredit my researcher interpretations about

emerging themes within individual participants' noticing. Conversations heavily focused on participants' noticing within the component of deciding how to respond. Joint discussions involved presentations and discussions of multiple pre-selected idea units within entire Think Aloud electronic transcripts directly viewed within Atlas. Examinations included dialogue on all four participants. Both peers received a verbal summary of the research goals and the role of coding within the process. Then, each peer independently read and summarized the overall idea within a noticing cycle. The purpose was to provide the peers an overall understanding of that excerpt, but summaries also verified whether we agreed on participants' overall ideas. As needed, peers viewed the video clip context to understand what the participant was referencing. Then, discussion of each select passages within the idea unit occurred one at a time. Both peers began by summarizing participants' ideas at that particular moment around the category of focus. For example, when the participant discussed the category of response type, peers shared which code they would assign it and then why. Follow-up questions then revealed each peer's interpretations of participant decision type and underlying reasoning (e.g. when peers identified that the participant was debating about a decision, they explained why). The process continued with the presentation of additional passages on the same participant to seek the same reasoning before examining excerpts from the other participants. The interpretation process relied on comprehending the actual content of participants' words to identify emerging themes. As done in the previous round of peer review, seeking peer thinking and reasoning preceded sharing researcher thinking and reasoning and dialogue. A few clarifying questions emerged about the context within the idea units, but neither identified any new patterns or inconsistencies. Researcher notes summarized peer ideas that surfaced during each meeting. Both peers confirmed that researcher interpretations captured participants' thinking within the data. Joint

dialogue enriched researcher understanding about participants' noticing. Subsequent written researcher memos supported the continued analysis of data and the results.

All three peers served as human resources to validate or question coding decisions and reasoning. Increased confidence about the research process and trustworthiness of resulting themes and other patterns came from using data triangulation throughout my data analysis process.

### **Ethical Issues**

The ongoing decisions made as the researcher limited the scope of exploring PD leader noticing. The outlined questions guided the direction of this study, so there may be unidentified or unexplored themes and ideas that their Think Aloud transcripts and other data demonstrate. It is impossible to fully bracket the reflexivity, but systematic efforts maintained a focus on participants' experiences. For example, I made the interview process transparent to participants at the start of this study. I shared all guiding conceptual frameworks and methods to make explicit how on data collection and analysis (Corwin & Clemens, 2012; Marvasti, 2014). I questioned and justified choices made before sharing ideas with readers as part of the ethics researchers need to contemplate (Forsey, 2012). Finally, I reflected on the goals on an ongoing basis throughout the research process not only for researcher self-guidance about this study, but also to ensure the participants had a voice to tell their narratives (Patton, 2015).

## CHAPTER 4: CASE DESCRIPTIONS

This chapter presents the four individual cases. First, I summarize participants' professional backgrounds. The introductions provide a context for understanding more about the individual cases of Cecilia, Dina, Lois, and Rosie. Then, I present each case by synthesizing each participant's typical noticing behaviors and foci surrounding the three noticing components of attending, interpreting, and deciding how to respond. This process is meant to offer the reader an opportunity to get to know the participants as individuals and to better understand the similarities and differences discussed across and between cases discussed in the next chapter.

### Introduction of Individual Cases

It is important to remember that this study examined a unique group of elementary mathematics teachers as PD leaders. All four participants facilitated at least one iteration of the *Project AIM* PD program that formed the context of this study prior to its implementation. Also, two participants had more PD-specific experiences regarding the *Project AIM* PD program and that one participant viewed her own videos. However, it was important to better understand their individual elementary mathematics education experiences. Learning about their elementary mathematics teaching and PD experiences, both related and unrelated to *Project AIM*, provided greater insights into the backgrounds of the four participants as individuals.

### Cecilia

Cecilia was the one participant who analyzed her own facilitation as part of this study. She facilitated *Project AIM* once, during the school year that preceded data collection for this study. She participated in a three-day facilitation training directly offered by the PD designers but received no additional ongoing facilitation support aside from the designed written facilitator support materials. She was in her sixth year of teaching and her third year as a fourth-grade classroom teacher of mathematics and science. Cecilia did not have colleagues who taught the

same grade and subject. She previously taught third grade at the same school. Celia had prior facilitation experience at the district level in digital literacy, but *Project AIM* was her first long-term facilitation experience and first within mathematics education. Since facilitating *Project AIM*, she has led a few mathematics PD workshops within her district. Compared to other participants, Cecilia had the least experience teaching and facilitating elementary mathematics.

Cecilia entered elementary education after initially working in the business field. She earned an associate degree and worked in accounting. She then returned to a university to complete her bachelor's degree in elementary education. She has since also earned a gifted certification. Cecilia disclosed that she was comfortable discussing both mathematics content and pedagogy with fellow teachers, but more comfortable conversing about mathematics content. She received PD instruction aligned with current student-centric approaches to teaching mathematics. Her school district adopted a new standards-based curriculum series aligned to Common Core prior to her involvement with *Project AIM* and this study. All of Cecilia's teaching years and PD experiences focused at the elementary level and tied to her school district's and classroom needs, but at the time of this study her specific experience facilitating elementary mathematics teacher education was limited to her one year with *Project AIM*.

### **Dina**

Dina was the other participant in this study who also facilitated *Project AIM* once, during the same year prior to when data collection occurred for this study. She also participated in the same three-day facilitation training offered directly by the PD designers. Dina had the most experience teaching and facilitating elementary math of all participants. She was in her 22<sup>nd</sup> year of teaching at the time of this study, all of which included math instruction across multiple elementary grades. Her prior facilitation experience included involvement with three other PD programs and leading multiple workshops, including mathematics. Her former facilitation

included supporting mathematics teacher instruction. After her involvement with *Project AIM*, she continued offering district-level workshops in mathematics. She was in her first year as a K-5 building-level teaching and learning coach, so her role expanded to also provide fellow classroom teachers mathematics PD on a regular basis in more informal settings. Prior to her new position, she taught all grades from K-5 over the years.

Dina earned a bachelor's degree in early childhood and recently completed a master's degree in elementary education with a math education add-on. Her other certifications include gifted education and digital learning. Dina stated she was more comfortable discussing mathematics content than pedagogy as a facilitator. She continued to work in the same district as Cecilia, using the same student-centric, standards-based mathematics PD curriculum aligned to Common Core. She has also received mathematics PD aligned to her school's district's and classroom needs. Therefore, at the time of this study, she had extensive experience facilitating elementary mathematics teacher education, but her facilitation experience specific to *Project AIM* was also limited to one year.

### **Lois**

Lois was one of two participants in this study who had extensive *Project AIM* PD-specific facilitation experience that included training. She received direct training from the PD designers and shadowed them for one year before she first facilitated herself. She was one of only two PD leaders who taught two iterations of *Project AIM*, the first iteration led by external PD leaders who were not the designers and the second last iteration prior to this study with a different grade level. She even offered feedback to the designers on PD material changes since she last facilitated. Lois also had extensive years of teaching experience, having taught for 12 years. All her teaching years have been within elementary grades and included teaching mathematics like Dina. She is in her sixth year as an elementary gifted specialist for fourth and

fifth grade. Like Cecilia, she does not have colleagues who teach the same grade and subject, so she is not part of an ongoing professional learning team within her school. Prior to her current position, she tutored at the elementary level for two years and then served as an elementary instructional math coach for four years. Prior to facilitating the *Project AIM* PD, she facilitated one other mathematics PD, in which she trained and led a program for her fellow building-level elementary teachers. Since facilitating the *Project AIM* PD, her facilitation experiences have involved offering informal mathematics PD at her building level.

Lois earned her initial bachelor's degree in elementary education and recently earned her master's degree in elementary education with a math education add-on, like Dina. She also held a gifted certification. Like Dina and Cecilia, she mentioned she was more comfortable discussing math content than pedagogy with fellow teachers. She taught in a different school district than Cecilia and Dina, but her district also used a standards-based mathematics curriculum that aligned with Common Core. She has also received mathematics PD that supports student-centric mathematics. Lois' elementary mathematics education facilitation experience primarily involved *Project AIM*, but like Dina, she did facilitate an earlier elementary mathematics PD program at her building level. She also served in an ongoing role in which she supported teachers within mathematics as a math coach after they received mathematics PD training, like the position Dina now holds. Like Cecilia and Dina, her post-*Project AIM* facilitation experiences have been few and less-structured in nature. Lois' knowledge of and facilitation experience specific to *Project AIM* was more extensive than Cecilia's or Dina's.

### **Rosie**

Rosie was the other participant who had extensive *Project AIM* PD-specific facilitation experience and training. Like Lois, she also received direct training and shadowed the PD designers for a year before she facilitated herself. Rosie was the only other PD leader who also

taught two iterations of *Project AIM*, during the two same years as Lois. She offered the same feedback on PD curricular changes as Lois, but also supported PD designers when they trained Cecilia and Dina as PD leaders. Rosie was in her 16<sup>th</sup> year in elementary education and her seventh year as a classroom teacher at the time of this study, teaching fifth grade math and writing. She previously taught third grade. Before teaching in her own classroom, she worked as an elementary interventionist, gifted interim teacher, and a math coach for two years. Like all the other participants, all her teaching years involved teaching mathematics. She had no formal PD program facilitation experience prior to *Project AIM*, but she supported teachers' advancement in mathematics education daily in her former position as a math coach like Lois and now Dina. Since *Project AIM*, she has not facilitated any PD programs within or beyond mathematics but has continued to offer building-level mathematics PD in informal settings for fellow teachers and parents.

Rosie holds a certification to teach elementary education, but she did not earn a degree in elementary education. She earned two bachelor's degree in political science and secondary social studies education. She relied on her teaching experiences and self-directed learning through reading and applying research-based articles to pass the praxis exam and become elementary education-certified. She stated she felt equally comfortable discussing math content and pedagogy with fellow teachers as a PD leader. Rosie's mathematics education facilitation experiences are best summarized as primarily involving *Project AIM* and personalized building offerings as a math coach. She continued to support at her building-level colleagues through within like the other participants. Her knowledge and facilitation experiences specific to *Project AIM* are as far-reaching as Lois.

## Two Known Differences Between Cases Reexamined

Learning about participants' elementary mathematics education experiences provided greater insight into similarities across the individuals. For example, all possessed more elementary mathematics education experiences than typical elementary classroom teachers, taught mathematics to elementary students at different grades for multiple years, facilitated at least one other elementary teacher PD, and were teacher leaders in mathematics within their respective schools.

Their backgrounds also revealed additional variation within their teaching and learning experiences, in both the classroom and PD settings. They had different entry paths into elementary education, initial and continuing mathematics education experiences, mathematics teaching experiences, and mathematics facilitation experience. These differences revealed the complexity in defining participants as possessing more or less expertise. Yet, there is a clear difference in the level of experiences specific to *Project AIM* PD that forms the context in this study and led to the purposeful selection of these four participants.

Summarizing the variation in facilitation experiences for purposes of this study lies in considering their level of *PD-specific facilitation experiences*. Using the term *PD-specific facilitation experiences* best describes the differences in the level of *Project AIM* facilitation expertise that forms the context of the participants' noticing. The term also prevents possibly confounding years of total *facilitation experiences* or other terms that otherwise generalize level of *PD expertise* with what is meant by level of facilitation experience within this study. **Table 3** is a summary of participants' professional backgrounds and reveals the similarities and differences mentioned across and between cases. Attention is drawn to the two known between-group differences this study explored of analyzing own versus others' video and those with more or less PD-specific facilitation experiences.

**Table 3.** Summary of participants' professional backgrounds.

<b>Past Professional Experiences</b>	Own		Others	
	Less PD-specific facilitation experiences		More PD-specific facilitation experiences	
	<b>Cecilia</b>	<b>Dina</b>	<b>Lois</b>	<b>Rosie</b>
<i>Years of elementary teaching experience</i>	<ul style="list-style-type: none"> <li>• 6 years</li> </ul>	<ul style="list-style-type: none"> <li>• 22 years</li> </ul>	<ul style="list-style-type: none"> <li>• 12 years</li> </ul>	<ul style="list-style-type: none"> <li>• 16 years</li> </ul>
<i>Grade level and subject teaching experiences</i>	<ul style="list-style-type: none"> <li>• Third – fourth grade, all subjects including mathematics</li> <li>• Current: Grade 4 classroom teacher, science &amp; mathematics</li> </ul>	<ul style="list-style-type: none"> <li>• All grades K-5, all subjects including mathematics</li> <li>• Current: K-5 teaching and learning school building coach, including mathematics</li> </ul>	<ul style="list-style-type: none"> <li>• Elementary grades tutor, all grades, all subjects including mathematics</li> <li>• Elementary instructional mathematics building coach, all grades</li> <li>• Current: elementary grades 4-5 gifted specialist, including mathematics</li> </ul>	<ul style="list-style-type: none"> <li>• Third &amp; fifth grade, all subjects including mathematics</li> <li>• Elementary instructional mathematics building coach, all grades</li> <li>• Current: grade 5 classroom teacher, writing &amp; mathematics</li> </ul>
<i>Initial and continuing education experiences</i>	<ul style="list-style-type: none"> <li>• Associate in business-accounting</li> <li>• Bachelor's in elementary education</li> <li>• Gifted education certification</li> <li>• Within-district mathematics PD learning</li> </ul>	<ul style="list-style-type: none"> <li>• Bachelor's in early childhood</li> <li>• Master's in elementary education, with mathematics education add-on</li> <li>• Gifted education certification</li> <li>• Digital learning certification</li> <li>• Within-district mathematics PD learning</li> </ul>	<ul style="list-style-type: none"> <li>• Bachelor's in elementary education</li> <li>• Master's in elementary education, with mathematics education add-on</li> <li>• Gifted education certification</li> <li>• Within-district mathematics PD learning</li> </ul>	<ul style="list-style-type: none"> <li>• Bachelor's in political science and secondary social studies education</li> <li>• Elementary-education certified</li> <li>• Ongoing PD learning through practitioner elementary mathematics journals</li> </ul>
<i>PD facilitation experience before Project AIM PD</i>	<ul style="list-style-type: none"> <li>• One PD in digital literacy</li> </ul>	<ul style="list-style-type: none"> <li>• Three PD programs, including mathematics</li> <li>• Multiple mathematics workshops</li> </ul>	<ul style="list-style-type: none"> <li>• One PD program in mathematics</li> <li>• Building-level mathematics PD (daily, as building mathematics coach)</li> </ul>	<ul style="list-style-type: none"> <li>• Building-level mathematics PD (daily, as building mathematics coach)</li> </ul>

**Table 3** (continued).

<i>PD facilitation experience after Project AIM PD</i>	<ul style="list-style-type: none"> <li>• Few district-level mathematics PD workshops</li> </ul>	<ul style="list-style-type: none"> <li>• Few district-level mathematics PD workshops</li> <li>• Building-level mathematics PD support (daily, as building coach)</li> </ul>	<ul style="list-style-type: none"> <li>• Building-level mathematics PD support (as needed)</li> </ul>	<ul style="list-style-type: none"> <li>• Building-level mathematics PD support (as needed)</li> </ul>
<i>Prior Project AIM PD Program facilitation experience</i>	<ul style="list-style-type: none"> <li>• 3 day direct facilitation training from PD designers</li> <li>• No ongoing facilitation support</li> <li>• Facilitated one PD iteration</li> <li>• Offered feedback to PD leaders in subsequent facilitation training</li> </ul>	<ul style="list-style-type: none"> <li>• 3 day direct facilitation training from PD designers</li> <li>• No ongoing facilitation support</li> <li>• Facilitated one PD iteration</li> <li>• Offering feedback to PD leaders during subsequent facilitation training</li> </ul>	<ul style="list-style-type: none"> <li>• 1 year direct facilitation training and ongoing shadowing from PD designers</li> <li>• Facilitated two PD iterations (grade 2, then grade 1)</li> <li>• Provided feedback to PD designers regarding recent changes to PD materials</li> </ul>	<ul style="list-style-type: none"> <li>• 1 year direct facilitation training and ongoing shadowing from PD designers</li> <li>• Facilitated two PD iterations (grade 2, then grade 1)</li> <li>• Provided feedback to PD designers regarding recent changes to PD materials</li> <li>• Supported facilitation training efforts for Cecilia and Dina</li> </ul>

### Individual Cases

The previous introductions provide a contextual backdrop for the following individual cases of Cecilia, Dina, Lois, and Rosie. The following cases describe the individual participants' noticing by summarizing their respective typical behaviors during the noticing process and foci.

#### Cecilia

Cecilia showed a willingness to discuss her noticing as she reflected on her own facilitation. When Cecilia paused the video, she quickly and continually engaged in the noticing process. Sometimes she began her noticing cycles by sharing ideas regarding her decision-making, but more often she began by sharing the focus of her attention or interpretations. At times Cecilia attended to her own actions as the facilitator in the video, but she paid more

attention to participating teachers. From the start, she focused on participating teachers' comfort or discomfort with expressing their ideas within the whole group, taking pride if they took risks to share their thinking or whether she felt they were engaged or not. She explicitly stated she was looking for "how engaged [participating teachers] are or not". She initially attended to what she felt was absent from participating teachers' comments after rereading discussion prompts and other information within the PD curriculum materials, but her later attention included more examples of what was present that showed participating teachers were understanding or her own actions as the facilitator in the video. For example, in the following excerpt, she expressed delight with her own decision to employ wait time as a facilitator, even conveying what she interpreted she was thinking at the time.

I'm glad I gave them that wait time, because wait time can be very painful, whether you're working with children or adults. So, it's something you have to get used to, and that's definitely something that I remember doing in this project. That I really tried— 'Cause I can see it in my face that I was like, 'Huuuu', like holding my breath almost. But at the same time, I can tell that I'm wondering if I gave them enough to think about there and respond. Like, did they understand what I was looking for? (Excerpt 1 from Cecilia, January 8, 2018)

The evaluative statement that starts this excerpt was typical of Cecilia's noticing. Sometimes her interpretations only included general, evaluative comments like this instance showed, but it was more common that she shifted from evaluating to analyzing, providing specific evidence. This was particular the case when Cecilia discussed how she formed interpretations about participating teachers' understanding. For example, she once interpreted that the task was "shorted". When asked to clarify what she meant by "shorted", Cecilia went on to explain with greater details and less judgment.

Because the second question, ‘What insights did you gain into your students’ mathematical thinking by using the bet line strategy?’ We didn’t, I don’t remember hearing anything about that. We talked about the successes, we talked about the challenges, we talked about English Learners, but that second bullet point. I mean, I don’t really remember hearing any kind of insights that they gained. But I didn’t cue them, either. Other than that being a part of their discussion that they were supposed to have. They may have talked about it in small group, but that didn’t come out in our whole group (discussion). And looking back, it’s probably me thinking, ‘Okay, I’m at 4:20, this has got to be wrapped up.’ (Excerpt 2 from Cecilia, January 31, 2018)

While the first example highlights how Cecilia typically attended to and evaluated positive moments, she sometimes critically analyzed participating teachers or herself as the facilitator, as seen in the second example. It is the second excerpt that also reveals how Cecilia typically made interpretations about participating teachers’ thinking and understanding. She tended to use participating teachers’ own words or actions and the PD curriculum materials with the included facilitation guidance as a point of comparison. Sometimes Cecilia’s interpretations included trying to learn more about participating teachers’ current thinking, but even in those instances, she remained focused on participating teachers’ responses or her role as the facilitator in relation to the outlined PD goals. When not discussing participating teacher thinking, she often attended to and made interpretations about participating teacher engagement. For example, another time she evaluated and analyzed how her lack of movement in the PD setting likely impacted which participating teachers engaged in the discourse. She attended to and interpreted a pattern she saw based on her physical proximity to them before expressing the need of a PD leader to move.

Cecilia’s noticing involved detailed ideas about her selective attention and interpretations, but she was less critical during her decision-making. Instead, she was quick to

want to return to the video clip. She usually needed prompting to elicit her current decision-making and reasoning. A simple prompt revealed that Cecilia had noticeably clear, specific ideas about whether she wanted to proceed or propose a new decision. She usually offered clear reasoning behind her decision, too, but there were instances when she expressed wanting to wait and see what transpired next in the video clip without much explanation. It was as if she was interested in seeing if she predicted what participating teachers and she would do next in the video clip.

Cecilia's decision-making and rationale focused on understanding more about participating teachers' thinking and the specific PD activity expectations and structural elements, which she often discussed to justify why she wanted to proceed as planned. There were other times she proposed new decisions but with conditional statements, stating she would only implement these actions if she had the flexibility to make adaptations or she had more time. She also spoke about how *every* PD activity was important for the participating teachers. Cecilia directly discussed an internal conflict she faced between her sometimes competing perceptions of participating teachers' current PD instructional needs and adhering to PD curriculum as planned. She declared how "the content of this PD was intense and so you have to pace yourself wisely". These perceived barriers did not stop her from expressing specific questions she would like to ask but as she specified, only in a "not-so-time-constrained session", reiterating that she would've "kept going" if she were given the same materials with the same constraints.

**Summary: Cecilia's overarching views of facilitation.**

Overall, Cecilia's noticing revealed she facilitated using two main approaches: (a) a faithful enactor of the PD curriculum and (b) a cautious guide who leads participating teachers towards the outlined PD content and goals. Cecilia's words indicated she valued supporting and guiding participating teachers as adult learners to reach the outlined PD goals. She recognized

and discussed participating teachers' adult learning needs within the PD instructional environment. Yet, she did not perceive much choice regarding new decisions or adaptations she could or should implement that might deviate from the specified PD activities, because as she said, "it was all important" and she "prioritized" based on outlined activity goals. She still suggested some select moves as a facilitator, like posing a question back to the group instead of validating the first response as she did in the video clip. Her rationale revealed she understood a PD leader's influential role in participating teachers' learning, stating "when a facilitator validates, the participating teachers move on". Yet, she cautiously suggested any such new decisions. It is possible that her internal struggle to first and foremost enact the PD activities within perceived PD constraints, such as time, resulted in the less critical approach observed within her interpretations and decision-making.

### **Dina**

Dina only needed one reminder to pause the video clip and share her noticing. She continuously expressed her thoughts as they occurred, whether she was praising or critiquing what she noticed. Noticeable in Dina's noticing process was her constant abrupt pausing as she discussed her ideas. She was clearly aware that at times she struggled to articulate her ideas during the noticing process. She mentioned how it was "hard sometimes trying to think through it" and apologized. She never paused to state that she had no idea or opinion about what was interesting to her up to that point or how she might respond. Her behavior and own disclosure was evidence that her pausing was simply a reflection of her unfolding noticing process at those moments. That is, she was processing and making sense of her thoughts during her noticing cycles.

Dina's rarely began her noticing cycles by discussing her decision-making and she only sometimes willingly disclosed her decision-making or related reasoning without prompting. She

began discussing her ideas just as quickly as she discussed the other noticing components. This provided further support that Dina had clear decision-making ideas, even though she did not divulge them on her own. Dina instead typically initiated a noticing cycle by sharing what caught her attention or by expressing her interpretations about what she noticed. Her focus was typically on and in response to one or more participating teachers' comments. For example, Dina discussed her desire to better understand a participating teacher's response to a prompt about supporting English language learners (who she called ELL learners) in following excerpt.

I'm not sure if she (the participating teacher) was talking about somebody that was an ELL learner or not, because the original question was about whether it helped the ELL learners. And the first person who was talking sort of dug into that. I don't know if that second one--, if she was talking just about in general or if she was talking about an ELL learner – their misunderstanding about the tickets and the cards and things like that. So – [pause]...I think having to – [pause]... looking at was this helping them with vocabulary or was this helping them with thinking about betting what could happen next with the Bet Line itself... (after prompting about Dina's decision-making) I think even just asking her (the participating teacher), "Was that just in your—with all of your students or did you notice that in particular with your ELL learners?" (after prompting for reasoning) I think so that they, so that they can be able to see what are some ways that you can scaffold and—[pause]... support them (ELLs)... (Excerpt 1 from Dina, January 9, 2018).

While the same example showed Dina also considered participating teachers' thinking in relation to the whole group discussion prompt, she only sometimes attended to the PD materials (i.e., she infrequently referenced the PD materials directly while engaged in the noticing process). Interestingly, this same example draws attention to another actor that she attended to more often the PD materials: students at the classroom level. In this same example, she made

several references to student subgroup and at times English language learners become the subject of her sentences. Even when students were not the main focus, she sometimes discussed students' needs. During another instance, she tried to better understand a participating teachers' understanding of a new discourse strategy. Her focus slowly shifted to students. By the time she explained the reasoning behind her decision, she voiced a student benefit, namely "making sure that the students can tell what they're learning. And not just what they did (on that day)".

Dina's interpretations tended to include more specific details than general comments, as seen above. She often passed judgment through evaluative statements of participating teachers' thinking, but also regularly analyzed their words with details, often during the same noticing cycle. Her evaluative statements were generally positive in nature, often discussing what she was glad to hear. She rarely passed direct judgment on the facilitator, instead analyzing the moves the facilitator employed to support participating teachers or while suggesting new recommended moves to explain how she might decide to respond. Her evaluative statements tended to be more general in nature, whereas her analyses contained more details. Her noticing cycle also revealed that Dina typically noticed and discussed participating teachers' implementation needs within their classrooms and their needs as learners within the PD setting. In the following excerpt, Dina again reacted to a participating teacher's comments who was discussing fear that students would be embarrassed if they were allowed to present incorrect solutions through a discourse strategy they were learning. Dina expressed concern.

Concerned, because if this is Session 10 and talk about – *[pause]*... *the kids being embarrassed if it's wrong. [laughs]* I guess *that's* – *[pause]*... And it's kind of like, "Oh yeah." Yep, there was nothing. I mean I understand why she (the facilitator) didn't – *[pause]*...She may not have wanted to point her (the participating teacher) out. But maybe just the conversation of, "So, what if they do present it and it's wrong?" How can you

help them work through that and be okay with that or that kind of thing? Just felt like a student shouldn't be embarrassed if something's wrong. *[laughs]*... (after seeking clarification what she meant by “concern”) Just that they've had some time to do somethings in their classroom – *[pause]*... that would hopefully promote a little bit more of a growth mindset with – *[pause]*... I did think the other lady's comment about her thinking more of the more purposeful in her conversations with the students was a good talking point.

(after seeking Dina’s decision-making) ... I think just maybe – *[pause]*... And it may come a little bit further, but just why it's okay if it's wrong. What can they learn and what can the class learn – *[pause]*... if it's not correct. I don't know if she's gonna – *[pause]*... end up addressing it, because I stopped it right there. *[laughs]* I think I'd probably try to address it now. I think just there seems to be some group agreement on that. So, I think it may be better to go ahead and address it now or even make some sort of comment to let them think about it. And I noticed that they're kind of getting into this point of it being—*[laughs]* tying it in with the district...(after resuming the clip and seeing that the facilitator addressed this comment)... Well, there was more than one participant that kind of said something about that, as well, so – *[pause]*...*I think that– [pause]*... there's a little bit of agreement there and I think it's good that she (the facilitator) addressed it, because I don't know if they would have said something if she hadn't said something first... (Excerpt 2 from Dina, January 22, 2018).

The excerpt reveals a specific line of thinking seen across Dina’s noticing cycles. Her noticing primarily focused on teachers’ needs to implement the ideas within their classrooms, which included discussing the students’ needs at the classroom level. It appeared that Dina interpreted their needs as adult learners within the PD environment based on their thinking and

understanding of their classroom level needs. Her perceptions of their implementation successes and challenges seemed to guide her decision-making and responses to their needs as adult learners within the PD setting sometimes more than the PD curriculum materials that included guidance regarding facilitation.

As stated earlier, Dina typically provided her decision-making and related rationale only after prompting. In those instances, she still articulated her decision-making. There were times she expressed hesitation, as if she was unsure if her suggestion was the right course of action, but even in those instances, she articulated the specific question or response she had in mind. In other words, she was ready to discuss what she was thinking at that moment, despite not voluntarily disclosing this additional information before prompting. Also, even though her interpretations often began by focusing on participating teachers' classroom level needs, her decisions on how to respond and underlying rationale tended to focus on their needs as adult learners. That was not surprising, given that Dina tended to shift towards discussing her perceptions of their current PD setting needs, as illustrated above. Her suggested decision-making move typically involved proposed posing a new question to the group. For example, Dina shared wanting to ask if "anyone else in the group had that (same) challenge" or "I see some of you are shaking your heads. Did you try that as well"? or "Was it a challenge for you"? Only once did Dina propose engaging participating teachers through a different means when she noticed their lack of participation and involvement during the whole group discussion. She suggested participating teachers first circle select items on a handout before they shared their ideas with the whole group.

**Summary: Dina's overarching views of facilitation.**

Overall, Dina's noticing suggested she facilitated using two main approaches: (a) an opportunistic guide who supports participating teachers towards reaching the outlined PD

content and goals and addressing their own current classroom needs as practitioners, and (b) a knowledge-seeking enactor of the PD curriculum. Dina's noticing revealed she implicitly considered the PD curriculum and goals, even if she did not continually reference the PD materials. It was evident in her ongoing attempts to make sense of what participating teachers were and were not understanding as part of the process of guiding participating teachers towards the outlined goals. Yet, her recommended courses of actions did not deviate from the planned PD activities or goals. Her decision-making indicated she enacted the PD program and guided participating teachers within the outlined PD activity structure. Dina generally limited new facilitation moves to asking additional guiding questions. The primary focus of Dina's questions was on participating teachers' current thinking as related to their understanding about classroom implementation. She sought opportunities within the given PD structure to ask questions that considered participating teachers' and their students' implementation needs at the classroom level. Participating teachers' understanding in relation to their implementation needs and the PD content informed her perceived needs for them as adult learners.

### **Lois**

Lois admitted feeling "judgmental" when critiquing another's facilitation, but she continued to disclose her noticing by simultaneously evaluating and analyzing the facilitator's actions or the participating teachers' thinking and understanding as a part of her interpreting. She held specific ideas regarding what she wanted to see, how to respond, and her underlying reasonings. She even anticipated what would happen at times. While she often identified what she felt was absent and offered her thoughts on how to improve the PD instruction, she also intermittently acknowledged positive instructional moments. For example, she was glad when the participating teachers were able to identify the different structural parts of a lesson within a teaching scenario. She detailed video moments to support what participating teachers

understood as adult learners and potential later benefits for them as practitioners in the classroom, e.g., “they’ll hopefully be able to know how to better a lesson”. In another noticing cycle, she began by stating “the facilitator talked too much”. She then analyzed the discourse and overall lack of participation and expressed facilitator’s decisions that could have shifted the discourse responsibilities. Her attention to the discourse patterns and engagement focus were commonplace and extended to all components of her noticing cycle. While either were typically part of her ideas on participating teachers’ understanding, the following excerpt shows a moment when she focused on these two related issues together:

This clip is further in to the session. They're still not really having a discussion with each other. And that bothers me. I don't know why they're not. I don't know if that's just the kind of day they were having, as we all have bad off days or – I would think, hopefully by session eight, you would be at a comfort level place where you would be having those types of discussions. But at every, almost every comment it keeps coming back to the facilitator. So, I don't know. Maybe she needs to sit down, or—it looks like it's a hard room to move around in. I don't know that for certain, but it looks like it is not necessarily set up for you to be able to freely circulate the tables. But, maybe reposition herself, even if she has to make the comment like, ‘I’m sitting down. You're not talking to me. You're talking to each other’. I feel like they should be talking to each other. I think it's so much more authentic conversation. And if they're talking with one another, I also think it gets more people engaged ... when they're talking and they start to get more freely, actually saying what they're thinking and not waiting to – (to participate) ...

(Excerpt 1 from Lois, January 16, 2018).

Later, Lois advocated that the facilitator model how to promote discourse and discuss it with participating teachers, so they could apply it their classroom instruction.

Whether Lois began by sharing her selective attention, interpretations, or decisions on how to respond, she went back and forth to explain her noticing with reasoning around all three components regularly, usually as a reaction to participating teachers' words and actions. Her selective attention and interpretations showed she considered multiple aspects within the PD instructional process to determine participating teachers current understanding. Excerpt 1 shows from a larger noticing cycle and revealed that Lois considered multiple aspects like participating teachers' engagement, their ongoing classroom implementation needs, discourse, suggested facilitation moves, and her own past facilitation experiences to support the PD instructional process.

Lois' noticing process showed that she also considered her understanding of the PD curriculum content and outlined goals to propose new decisions. For example, when participating teachers expressed possible misunderstandings or shared student misunderstandings about a discourse strategy, she immediately began to wonder and wanted to know more about their thinking to determine how to follow-up. Lois made statements like, "I know this strategy" and "that's not really the point". She described and analyzed the discourse and the purpose of the strategy. She even admitted that at that moment she did not want to stop the video. She wanted to see "what the facilitator's response was gonna be", because she felt it needed addressing then. She had a clear expectation of how she wanted the facilitator to respond. At the end of a different lesson, Lois discussed how participating teachers "missed the boat" about a strategy. She noticed that the facilitator tried to orient participating teachers to the differences in the two scenarios participating teachers were comparing but did not follow through despite "opportunities to point that out". Lois acknowledged the instructional benefits within the other scenario that the participating teachers identified, but that she wanted them to see that scenario

did not lead to the mathematical goal the discourse strategy was meant to support. So, she then shared how she would have guided the conversation:

I think there were a couple moments in there where you could have steered the conversation towards, ‘Okay, even if we like the fact that more kids got to talk in the first one, even if we felt like the teacher was more friendly, you know, what we can we like compare the differences between these two finals and how they could help children the next time or looking back at them or—being the launch for tomorrow’s lesson or whatever.’ I feel like listening to them talk, it would be interesting to ask the question ‘how would either of this help someone solving a different math problem, a different subtraction problem, get started or remind them of what they're supposed to do and see what they thought.’ I don't know what I would do if they still thought the one with specific numbers is the better one to have. (Excerpt 2 from Lois, January 30, 2018).

Despite questioning what she might do if they still did not understand, she had additional ideas and she shared them. It was as if she had a contingency plan for moves to execute.

I would have definitely pointed out the two different questions, because I feel she started to, like she said they both asked that question and then she never went back to it. She was like, ‘Oh, did they both ask it?’ And they were like, ‘Yeah, ddt-ddt-ddt’. And she was never like, ‘Okay, show me those questions, where's your evidence? Where do you see that?’ I would have them look at these two summaries where she has – and Pierre read the summary and talk about like in the classroom they had just written these on the board. ‘In what room would this help them with tomorrow's math-subtraction problem’. Yes, but specifically looking at those. Because you do have a written summary at the end of the LEA strategy and that in theory would be -- I don't think they get the purpose behind it. Do they have an LEA (handout)? – No, right? I was gonna say, maybe it needs to be

passed out and focus – 'Cause doesn't it talk about – (*reading*) like the very first key idea on the LEA strategy sheet is the product of the LEA strategy is a group summary of the target ideas of the mathematics lesson that can later be used as a reference and shared knowledge. I think that having that conversation about the two different summaries and how they would benefit the students by being up and being able to be something you could refer to may help them see the difference in the two and then pointing it out as a key idea of an LEA strategy might help. (Excerpt 2 continued from Lois, January 30, 2018).

Lois' new decisions involved guiding participating teachers towards the goal rather than telling them, because more than once she explicitly mentioned that “any time they can tell you or each other, it's better”. During a different Think Aloud, she proposed taking a moment to employ a Turn and Talk with a neighbor, because she observed little participation. Again, she went into detail about what she would do and why, namely she wanted them to talk a little about the discussion prompt in general and compare their generated list of ideas from analyzing two math tasks to the handout they had in front of them on discourse-promoting task features. She then mentioned that she might ask them to compare the same features handout to a *Project AIM* discourse framework document after, if needed. Lois simultaneously considered participating teachers' current thinking, the understanding needed to apply concepts in their classrooms, and her understanding of the PD curricular content and goals over time to inform how to respond.

**Summary: Lois' overarching views of facilitation.**

Lois' overall noticing indicated she facilitated using three main approaches: (a) a continual assessor of participating teachers current needs and understanding as adult learners, (b) a pressing guide who responsively scaffolds participating teachers towards the outlined PD content and goals, and (c) a live model of desired discourse and related PD teaching and learning

practices that support participating teachers' later needs as practitioners. Lois' attention and interpretations focused on continually assessing and understanding participating teachers' current understanding while keeping the outlined PD goals in mind. Her decision-making involved requiring and pressing participating teachers to further the conversation until they reached the outlined goals. Her decision-making was responsive and included adaptations that considered both participating teachers' current needs as adult learners and the outlined goals. Lois heavily focused on how discourse should scaffold the instructional process. Lois also discussed the role of the PD leader to model and openly dialogue about desired facilitation practices around discourse with participating teachers, so they can later apply the discourse strategies and similar teaching practices in their classrooms as practitioners.

### **Rosie**

Rosie's overall noticing was hallmarked by her repeated engagement in the back-and-forth processes of attending, interpreting, and deciding how to respond. Her extensive back-and-forth process was observed in almost every noticing cycle. She disclosed her thinking with little assistance other than periodic clarification or elaboration. Rosie usually began thinking aloud in response to participating teachers' comments and focused on their current thinking or understanding at that moment. She also often attended to and revisited the PD curriculum guide or handout that detailed PD activities and goals. She then discussed at length the clear ideas she held about what she was looking for in the video clips from both the participating teachers and the facilitator, how to improve the quality of PD instruction, and why. Rosie's noticing revealed she considered different instructional facets that spanned multiple topics during the same noticing cycle. For example, the PD goals and purposes, participating teachers' instructional needs at the PD level including their engagement, and their implementation needs at the classroom level.

The myriad of topics she contemplated seemed to only broaden as Rosie began sharing her interpretations and her reasoning behind her decision-making. Her interpretations about situations included great analytic detail, she also included instinctual evaluative-laden statements. For example, Rosie expressed disappointment in the lack of details she heard, as she hoped that participating teachers' reflections on lessons they recently implemented would have included ideas on the mathematics and discourse they had been learning all year long. Rosie acknowledged that hindsight made reflecting after instruction easier than during instruction. Yet, she proclaimed that it was "the job of the facilitator if things are not being said that you need to have brought out" in the whole group discussion, because that there were different ways to do it based on "personality" or approach. During a later instance, she noticed the lack of participating teachers' engagement and expressed thinking. She knew that she was just seeing some "snippets" from the entire PD instruction, but she said she had observed it earlier and that "there needs to be more challenging of ideas" rather than moving on "when things aren't going in a direction that you don't really want them to go in".

Rosie's interpretations included recollected experiences from her own past *Project AIM* facilitation and the PD curriculum as guides to compare against the whole group interaction she was analyzing before stating she felt "sometimes the discussion was allowed to go away from it". She clarified she meant both what they trying to achieve in the PD setting during that session and its application in participating teachers' classrooms. She explained that a PD leader should engage and lead participating teachers to the main takeaways rather than just "letting them talk" using instructional moves similar to "what you want them to do with their students, too".

Rosie offered several new ideas as part of her decision-making and provided specific questions to support the focus she discussed as part of her interpretations. She even discussed modeling as a part of facilitation and how she felt it would be helpful to talk about some of the

planning and instructional decisions PD leaders make with participating teachers during instruction, because she explicitly saw the parallel to “teaching a class”, stating that “as a teacher in your classroom, you are the facilitator”. Rosie said she still utilized some of the discourse strategies in her classroom and shared stories related to the discourse strategy being discussed. That is likely why when Rosie noticed several participating teachers critiquing the strategy, she talked about facilitator “buy-in” and the importance of validating the PD program and promoting the strategies and concepts. She also outlined a series of specific questions she could ask to orient participating teachers back to the purpose if they were off topic. She admitted she would not ask them all, but rather expressed that how they responded determined how far she needed to go. So, Rosie’s decision-making involved looking multiple steps ahead.

Rosie’s deep, underlying knowledge of the *Project AIM* PD program was evident in her responsive decision-making and underlying reasoning. She saw opportunities to engage in practices that led to the outlined goals that sometimes slightly deviated from the next outlined activity step. For example, she once suggested making connections to *Project AIM* foundational documents like *The Discourse Matrix* that outlines different types of discourse patterns, but she suggested it only when a participating teacher’s comments and the PD activity indicated its applicability. Another time Rosie attended to a participating teacher’s comments about how enlightening it was for her to ask a student questions to get at their mathematical thinking. Rosie interpreted and emphasized that “she used the term ‘why’” and how this was “beyond where she was when she started” the PD program. Rosie then suggested questions to help participating teachers reflect on how they changed in relation to discourse patterns involving *The Discourse Matrix* and further the conversation. Rosie explained that given the prompt, she “wanted them to talk about how they were growing and changing”, which she felt was lacking. In a third instance, Rosie suggested a facilitation move that further showed her use of adaptations and

responsive facilitation. She interpreted that participating teachers were not getting involved in the conversation. Instead of waiting for them to make connections as outlined in the planned activity, she had a different idea.

This is where I just need to make the first connections and speed it up a little bit, and move into talking about the task, instead of waiting for them to make a connect—  
*[pause]*... I mean, it's right in front of them. It's not a hard task they were given, but they're not participating a lot right now. And it just feels heavy. It feels like it's, like I'm losing people [laughs]. I don't know —*[pause]*... So, I think there's time when you ask for their input, and there's times where you might say (picking up the *Project AIM* handout they are discussing), 'Look right here. Y'all said this. A6 says this'. Start making the connections for them, just to kinda speed it up, a little bit, and get them to know what you're wanting them to do, because they're not saying anything. So, maybe – and she's doing that a little bit. She's saying, 'You've mentioned A6, blah blah'. But you might look at what's written on the class pad and say, 'Right here, you said this. Look at A6. Okay. You caught that. Let's look at this, right here. That would be A3. As you're looking at the task or as you're thinking about the task, in a minute, reference the sheet or reference what you said, up here, because a lot of the things are similar or maybe, noticing something they said that wasn't on here, or vice versa. (Excerpt 1 from Rosie, January 11, 2018).

In other words, Rosie wanted to use the list already created of what they learned as a scaffold to orient them to the same outlined goal. She added that she and other PD leaders “were told to use wait time, let people think, but sometimes, it just feels like it’s not going anywhere”. Her adaptation from the plan revealed that she understood that facilitation can and should be responsive to the learning needs of participating teachers as adult learners while still adhering to

the PD design and outlined goals. Even Rosie's moments of uncertainty in her decision-making were responsive in nature. Her conditional statements included waiting to hear more participating teachers' ideas or see if the misunderstanding she anticipated was truly surfacing before deciding how to proceed. She explicitly stated she would not respond "unless I really heard that coming out". During such instances, Rosie still specified the questions she would ask and why.

**Summary: Rosie's overarching views of facilitation.**

Rosie's overall noticing suggested she facilitated using three main approaches: (a) a dual assessor of participating teachers' current understanding and needs as adult learners and practitioners, (b) an adaptive guide that responsively steers participating teachers towards a deeper understanding of the outlined PD content and goals, and (c) a reflective, transparent model of desired PD teaching and learning practices to support participating teachers' current needs as practitioners. Rosie's selective attention and interpretations focused on making sense of participating teachers' current understanding in relation to the outlined PD activity and overall goals. Rosie recognized participating teachers had current needs as both adult learners and practitioners. She considered participating teachers' dual needs while guiding them towards a deeper understanding of the PD curriculum content and PD goals as part of her decision-making. Rosie also reflected on modeling teaching and learning practices that participating teachers needed to experience and use in their own classrooms. She felt that part of her role was to make the use of her facilitation practices transparent. She recommended dialoguing with participating teachers about the practices PD leaders use and how they need to similarly employ as "facilitators" in their own classrooms. Rosie saw supporting participating teachers' personal goals and the collective PD goals within the given PD structure as being simultaneously compatible and she perceived flexibility in the process. This was evident in Rosie's suggested

adaptations to the activities that considered participating teachers' current understandings but still led to the outlined PD goals.

### **Noticing Within Versus Across Cases**

As stated earlier, the goal of this chapter was to summarize the individual cases of Cecilia, Dina, Lois, and Rosie. These presented case descriptions revealed tendencies and features that define noticing behaviors and foci within the individual cases. The collective cases naturally uncover similarities and differences across and between participants' noticing, which are discussed further in the next chapter. Results from cross-case analyses highlight similarities and differences across and between participants' noticing as PD leaders. Results also support and build on these individual cases to provide additional insight into the four participants and their noticing processes.

## CHAPTER 5: RESULTS CONTINUED AND DISCUSSION

This chapter builds on the individual case descriptions and presents results from cross-case analyses to answer the two research questions. The questions guiding this research are as follows. In a mathematics teacher professional development program for elementary teachers designed to promote high quality discourse and mathematics content knowledge and pedagogy:

1. What, how, and why do leaders notice during elementary mathematics teacher professional development instruction?
2. What defining noticing characteristics emerge from mathematics professional development leaders' focus within the moment-by-moment professional noticing process?

I begin this chapter by answering the first research question on PD leaders' moment-by-moment noticing. Then, I turn my attention to answer the second research question. I identify and illustrate collective themes to define characteristics across participants' noticing. Key takeaways from the findings by research question are summarized and discussed.

### Research Question 1: Results

Answering the first research question regarding participating PD leaders' foci when attending, interpreting, and deciding how to respond begins with an exploration of participants' overall noticing trends. Then, an exploration of some primary data continues to separately examine the three noticing components of attending, interpreting, and deciding how to respond across participants. Qualitative excerpts from individuals' noticing cycles interwoven into in this section illustrate participants' ideas, add further insight into the individual cases, and highlight similarities and differences between cases. The discussion includes data results from secondary sources to add insight into the participants' noticing processes as appropriate. Finally, this section concludes with a discussion of key takeaways from the results.

## Overall Noticing

Segmented overall idea units afforded insight into noticing cycles in which PD leaders engaged. Between participants, there was slight variation seen in the total number of times they engaged in their respective noticing cycles, with 45, 43, 37, and 40 for Cecilia, Dina, Lois, and Rosie. Recall that noticing cycles within Think Alouds defined participants' attending, interpreting, and deciding how to respond around one central idea. Therefore noticing cycles served as the idea units. Using the total number of noticing cycles per participant to examine the relative number of average occurrences participants engaged in, each noticing component draws attention to similarities and differences in PD leaders' noticing.

Data in **Table 4** show the average occurrences per noticing cycle of participants' engagement in each of the three noticing components (See **Table 4** below). For example, Cecilia engaged in attending 58 times during her 45 noticing cycles (or an average of 1.29 times per noticing cycle), interpreting 80 times (or an average of 1.78 times per noticing cycle), and deciding how to respond 53 times (or an average of 1.18 times per noticing cycle). All tables in this chapter display the average occurrences per idea unit for each participant. Therefore, all tables permit comparisons regarding how often individual participants engaged in that particular category and relative subcategories on average per noticing cycle.

**Table 4.** Average occurrences per noticing cycle of PD leaders' engagement in each noticing component.

	<b>Attending</b>	<b>Interpreting</b>	<b>Deciding how to respond</b>
<b>Cecilia</b>	1.29	<b>1.78</b>	1.18
<b>Dina</b>	1.42	<b>1.81</b>	1.37
<b>Lois</b>	1.68	<b>2.24</b>	1.51
<b>Rosie</b>	2.28	<b>2.78</b>	2.10

Note that each average occurrences exceeded 1.00 per noticing cycle across participants. This finding conveys that all participants engaged in each component a little more than once per noticing cycle and revisited one or more noticing component regularly during the same noticing



No one, distinct pattern regarding the order in which individual PD leaders engaged in noticing components during their own noticing cycles surfaced (i.e., no PD leader always *attended* first or typically *attended* after they *interpreted*, etc.). Examined individual noticing cycles within and across participants for the same Think Aloud revealed no specific order. A closer examination of all individual noticing cycles by participant revealed patterning tendencies but pointed to a different pattern about noticing that potentially explain these tendencies.

**Table 4** shows that all participants engaged in deciding how to respond least often per noticing cycle and Cecilia and Dina engaged in this noticing component less often than Lois and Rosie. A pattern regarding prompting around the noticing component of *deciding how to respond* emerged, namely that across participants researcher prompting was necessary periodically and specifically access participants' initial ideas around this one component. It is important to remember that this study did not study *whether* PD leaders engaged in all three components within the Jacobs et al. (2010) noticing construct, but the what, how, and why PD leaders noticed. Prompting permitted greater insight into participants' full noticing at those moments beyond whether they immediately disclosed all their own thinking during a given noticing cycle. This decision still permitted the examination of prompting instances. Analysis only included instances when prompting was necessary to elicit participants' *initial* ideas around a given noticing component. Excluded were instances when additional researcher questions sought clarification or elaboration as part of the natural interview process. Calculated average prompting occurrences across noticing cycle for instances when each participant required initial prompting around each noticing component permitted comparisons.

Average prompting percentages across all noticing cycles by PD leader revealed those analyzing another's facilitation required less prompting around deciding how to respond. Those with greater PD-specific facilitation experience required the least prompting. Cecilia required

prompting to share her decision-making and reasoning during 69% of her noticing cycles, Dina needed similar prompting in how she would respond and why during 55% of her noticing cycles, but Lois and Rosie only required prompting regarding this same component during 14% and 5% of their respective noticing cycles. Interestingly, there were occurrences of researcher prompting needed to seek initial thinking around the other two components across all four participants.

Continued explorations examined whether instances of researcher prompting aligned with select decision response types. The specific conjecture was that instances might align to moments when participants suggested no new decision (proceeding based on what they noticed up to that moment) or expressed uncertainty about the next steps in those instances. Yet, an inspection of individual noticing cycles showed that no limitation of prompting existed for these instances. Instead, occurrences also included moments when participants proposed a new decision and provided clear reasoning. Jacobs et al. (2010) found that providing robust reasoning as a part of deciding how to respond was challenging, that it took years to develop, and that it did not simply develop with teaching experience. Therefore, it was foreseeable to find an observed difference by level of PD-specific facilitation experience, with Rosie and Lois requiring relatively less prompting.

### **Overall Topics of Focus**

Expressed topics during participants' moment-by-moment noticing provided insight on the issues that mattered to them and which issues mattered more than others. It was common that all participants discussed multiple topics within the same overall idea unit, which explained the decision to determine frequencies across all noticing cycles using all topics participants discussed within the same idea unit instead of the one main topic. This decision permitted examining the full scope of each participant's focus. **Table 5** shows the average occurrence for each topic per noticing cycle by participant. Only the top four topics individual participants

discussed most often are in **Table 5**. For example, on average Cecilia discussed participating teachers' thinking in more than half of her noticing cycles (0.60). Dina discussed the same topic in about three-fourths of her noticing cycles (0.74), whereas Lois and Rosie discussed this topic most often, given their average occurrence per noticing cycle were 0.84 and 0.85, respectively. This table, like subsequent tables, include the level of breadth and depth for each participant. Recall that breadth summarizes the range of participants' focus, determined by whether the top principal subcategory was the only subcategory greater than half or 50% (0.5). Depth synthesizes the extent that the top principal subcategory exceeds the focus of other topics, determined by whether the difference between the top two subcategories was greater than 10% (0.10).

**Table 5.** Average occurrence per noticing cycle of four principal topics within PD leaders' overall noticing.

<b>Principal Topics of Focus</b>	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	<b>Cecilia</b>	<b>Dina</b>	<b>Lois</b>	<b>Rosie</b>
<b>1.</b>	<i>participating teachers' thinking</i> <b>0.60</b>	<i>participating teachers' thinking</i> <b>0.74</b>	<i>participating teachers' thinking</i> <b>0.84</b>	<i>participating teachers' thinking</i> <b>0.85</b>
<b>2.</b>	<i>discourse or interaction</i> 0.47	<i>teaching or student learning at classroom level</i> 0.67	<i>facilitator move suggestion</i> 0.78	<i>facilitator move suggestion</i> 0.83
<b>3.</b>	<i>PD structural element</i> 0.47	<i>facilitator move suggestion</i> 0.67	<i>discourse or interaction</i> 0.78	<i>facilitation or adult learning needs at PD level</i> 0.78
<b>4.</b>	<i>participating teachers' engagement</i> 0.44	<i>facilitation or adult learning needs at PD level</i> 0.65	<i>facilitation or adult learning needs at PD level</i> 0.73	<i>PD structural element</i> 0.75
<b>Breadth</b> (narrow vs broad)	narrow	broad	broad	broad
<b>Depth</b> (shallow vs deep)	deep	shallow	shallow	shallow

Note in **Table 5** that all participants primarily focused on *participating teachers' thinking*. A closer inspection of individual noticing cycles provide support that all four participants discussed participating teachers' ideas when attending, interpreting, or deciding how to respond. More specifically, they reveal participants explicitly referenced this topic during every Think Aloud and often more than once during the same Think Aloud, as well as when engaged in different noticing components within noticing cycles. For example, when Dina attended to participating teacher's thinking with examples like "she noticed that different problem types can lead to different types of discussions...", her interpretations continued the focus of her attention and shared that she felt the participant's words meant "she has an awareness that if I want the students to be thinking about different types of mathematics, I have to give them different types of problems...". Sometimes her decision-making involved proposing a question in direct response to the same participating teacher's comment, like in this same noticing cycle with "can your problem affect what your goal is or what you're going to get for your discourse?".

Even when PD leaders recommended proceeding without proposing a new decision, it was their reasoning that sometimes clearly revealed they were considering participants' ideas and their interpretations they mentioned within the same noticing cycle. For example, Cecilia said "I feel like it was—that the questions were asked of them and that they fulfilled the purpose of those questions with their responses". It is worth mentioning that the two examples from Dina and Cecilia's noticing are also examples of when participants required prompting to share their decision-making. Like other instances, participants were able to share the thinking behind their decision-making process immediately.

The same data also revealed that other similar principal topics surfaced across multiple participants, namely *facilitator move suggestion* and *facilitation or adult learning needs at PD*

*level*. Two other topics were among the main foci for two different PD leaders: *discourse or interaction* and *PD structural element*. Once again it is evident that a focus on newly suggested facilitation moves and facilitation or adult learning needs at the PD level was more common amongst those analyzing another's PD instruction.

The total average occurrence per participant in **Table 5** also show that participants usually discussed multiple topics within the same noticing cycle. For example, when participants focused on participating teachers' thinking, they typically expressed at least one additional topic that formed the context of participating teachers' thinking as part of their overall idea, as shown in the two examples above. While Cecilia was the only one whose focal topics were narrow and deep in focus, the others' references to multiple topics at high average occurrences raise new questions about additional insights breadth and depth may communicate about noticing. In the case of these participants, it suggested that viewing and analyzing another's video permitted them to sieve through more issues that are part of the facilitation and learning process. **Table 6** further highlights this finding by displaying average occurrence per noticing cycle for *all* topics participants discussed across noticing cycles. Like in previous tables, **Table 6** reveals the average occurrence of each topic per noticing cycle. This table displays all topics participants discussed. Again, the level of breadth and depth are included within the table (See **Table 6** below).

By analyzing and identifying all focal topics participants discussed rather than the one main topic as done in past research by Sherin and van Es (2009), these results reveal *all* the issues participants reflected on when attending, interpreting, and deciding how to respond around individual ideas. The only participant whose focal topics could be narrow and deep is Cecilia. However, given that all participants discussed a total of sixteen topics across their noticing cycles at varying average frequencies, the results disclose that all four participants were

processing a myriad of issues as PD leaders. Further explorations discussed when the noticing process is decomposed to examine the separate noticing components highlights this result.

**Table 6.** Average occurrence per noticing cycle of all topics within PD leaders' noticing.

Topics of Focus	Own	Others		
		Less PD-specific facilitation experience	More PD-specific facilitation experience	
		Cecilia	Dina	Lois
1. <i>participating teachers' thinking or understanding</i>	0.60	0.74	0.84	0.85
2. <i>participating teachers' engagement</i>	0.44	0.28	0.59	0.58
3. <i>participating teachers' MKT or readiness to learn</i>	0.18	0.30	0.38	0.45
4. <i>participating teachers' concerns</i>	0.27	0.35	0.24	0.40
5. <i>anticipation of expected response</i>	0.11	0.09	0.49	0.38
6. <i>recollection from own past facilitation experience</i>	0.13	0.16	0.27	0.33
7. <i>facilitator response or preparedness</i>	0.40	0.37	0.35	0.38
8. <i>facilitator move suggestion</i>	0.16	0.67	0.78	0.83
9. <i>discourse</i>	0.47	0.63	0.78	0.73
10. <i>PD climate</i>	0.16	0.05	0.30	0.40
11. <i>PD structural elements</i>	0.47	0.51	0.68	0.75
12. <i>specific PD activity expectations</i>	0.36	0.37	0.54	0.73
13. <i>broader PD goals</i>	0.09	0.28	0.14	0.45
14. <i>Project AIM discourse strategies and/or purposes</i>	0.13	0.26	0.27	0.55
15. <i>facilitation or learning needs at PD level</i>	0.40	0.65	0.73	0.78
16. <i>teaching or student learning at classroom level</i>	0.33	0.67	0.65	0.65
<b>Breadth (narrow vs broad)</b>	narrow	broad	broad	Broad
<b>Depth (shallow vs deep)</b>	deep	shallow	shallow	shallow

A closer examination of individual noticing cycles across participants provided greater insight into the similarities and differences within the back-and-forth process regarding attending, interpreting, and deciding how to respond. Analyzing noticing cycles within the same Think Alouds across participants revealed participants sometimes noticed similar ideas and proposed similar steps or discussed different ideas and still proposed similar steps in response to same video clips. For example, participants analyzed a whole-group discussion in which the group began the after-school session by debriefing about a discourse strategy they implemented in their classroom. One participating teacher summarized her students mathematical thinking process and shared a challenge she observed. The facilitator revoiced the participating teacher's idea to the group, explaining her decision to revoice was based on observing that the participating teacher eating. Dina and Lois attended to both comments and interpreted that the participating teacher's and facilitator's words did not match, because the facilitator went beyond and added her own ideas. Lois wanted to learn more about the participating teacher's thinking because she perceived a misunderstanding about the strategy and wanted to hear other participating teachers' reactions. Dina also wanted to probe further to seek more details about her thinking to better understand. While their interpretations deviated somewhat, both interpreted the student challenge as a common challenge. Both Dina and Lois also proposed asking other participating teachers if they faced a similar challenge, stating they wanted to hear more participating teachers discuss their students' reactions to this strategy.

Neither Cecilia nor Rosie attended to the differences in the facilitator's revoicing. The following excerpt shows Cecilia's noticing around the same video clip:

I think there would have been an opportune time to ask if any other participant had that same challenge, because I think that's a very common challenge to have. I think because it just immediately resonated, 'Well, yeah, that's what kids do'. Like when you read a

story problem. It's good to see them (students) connect to the context of the story. That's certainly a goal. I think it's just so common in the math class that they want to elaborate or go off on a path that you're kind of constantly trying to get them to get back on the purpose of the task. So, I think to help this group feel more comfortable to participate, 'cause this is only session eight, which, to me is really like, session three in a way, because of the first six were such a condensed, intense two-day session. And then session seven, and session eight. They're still kind of getting used to each other. So, getting comfortable with speaking out. Getting comfortable sharing their challenges. That's not something an educator or anyone, naturally, is going to want to do is to admit their weakness or something that they saw. So, that just would've been an approach that could've helped build that safe zone. (Excerpt 3 from Cecilia, January 8, 2018).

Like the other three participants, Rosie responded to the participating teacher's comments, saw it as a common challenge, and identified the opportunity to see if others experienced a similar challenge. Her interpretations and reasoning were quite different from Cecilia, but there was overlap in the decision-making across all participants. The expectation was that participants' attending and interpretations around the same video clips would diverge and lead to individual observed differences in decision-making. Therefore, it was unexpected to observe an instance when ideas would converge after diverging (i.e., despite the observed differences in participants' attending and interpreting, some similarity in decision-making occurred). There were multiple instances when participants attended to similar initial actors and topics, but their overall noticing diverged. Expected greater divergent thinking made such overlaps across participants' noticing noteworthy.

Collectively, the identified topics also provided initial insight into the different actors participants considered. Participants discussed participating teachers' thinking and the

facilitator's action within the PD setting, participating teachers' and students within their classrooms, as well as the PD curriculum at part of the PD program design. Other results presented later in this chapter support this finding, as well as related emerging themes. However, it is important to further decomposing the overall data on noticing to learn more about participants' noticing by examining each noticing component as part of the first research question.

### Attending: Actor of Focus

Participants' attention was explicitly included as part of the moment-by-moment noticing interview structure. Therefore, participants' noticing allowed analysis of attending by actor. The data in **Table 7** show the average occurrence per noticing cycle of each actor to which the four participants attended (See **Table 7** below). Just as all participants often focused on more than one topic within the same overall noticing cycle, they also focused on multiple actors. So, reported results include all actors participants discussed. This table also includes the level of breadth and depth per participant.

**Table 7.** Average occurrence per noticing cycle of all actors within PD leaders' attending.

Actor(s) of focus	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	Cecilia	Dina	Lois	Rosie
<i>Participating Teachers</i>	<b>0.93</b>	<b>0.88</b>	<b>0.97</b>	<b>0.93</b>
<i>Facilitator</i>	0.47	0.28	0.41	0.33
<i>PD materials</i>	0.33	0.14	0.22	0.35
<i>Classroom Level Student</i>	0.13	0.30	0.08	0.03
<i>Other</i>	0.02	0.02	0.03	0.05
<b>Breadth</b> ( <i>narrow vs broad</i> )	narrow	narrow	narrow	narrow
<b>Depth</b> ( <i>shallow vs deep</i> )	deep	deep	deep	deep

Participating teachers emerged as the principal actor across all four participants. The anticipation of high references to this actor was based on the number of emerging topics that centered on participating teachers. Past research on teacher noticing found that teachers' initial

attention tended to focus on teacher rather than students (Sherin & van Es, 2009). Therefore, the results of this special group of elementary mathematics educators serving PD leaders reveal possible differences may exist in the initial attention between PD leaders and classroom teachers.

An examination of 360-video secondary data revealed the same disproportionate attention participants paid to participating teachers. Recall that data involved calculating elapsed time each participant focused on different actors relative to the total viewing time within the same 360-video non-verbal viewing data and averaging elapsed times across the ten Think Alouds to estimate average individual viewing habits per noticing cycle. Their non-verbal viewing habits showed all four participants primarily attended to participating teachers, at similar average rates. The respective average viewing rates of participating teachers for Cecilia, Dina, Lois, and Rosie were 0.79, 0.75, 0.85, and 0.83 per noticing cycle. Other researcher notes and memos taken during and after the one-on-one noticing interviews also indicated a strong attention to participating teachers across noticing cycles, which the level of breadth and depth within **Table 7** also highlights. The consistency and similarity in viewing habits focused on participating teachers within the 360-video data suggest that viewing using this new 360 video technology supported participants' choice while attending.

An inspection of other secondary data along with the *Project AIM* PD curriculum materials suggested a alignment between PD leaders' instructional views on teaching and learning and those promoted within the *Project AIM* curriculum materials. Initial interviews with all PD leaders indicated that each received continuing PD training on student thinking and that their teaching experiences involved using a standards-based mathematics curriculum during instruction before and after facilitating *Project AIM*. An examination of the whole-group discussion prompts that form the background context of the Think Alouds used in this study support also focus on participating teachers and their thinking. For example, one provided

whole-group discussion prompt asked participating teachers to characterize two math tasks they examined earlier based on discourse-promoting and -limiting features and to share their evidence for their answers (See [Appendix B](#) for other prompts). An examination of other facilitation support materials the PD designers provided PD leaders also revealed a similar learner-centric focus.

Prior to this study the expectation was that if any participant attended to participating teachers at lower average idea unit rates and the facilitator at higher average idea unit rates it would be the participant viewing her own videos based on past findings (e.g., Sherin & van Es, 2009), but the results showed that even Cecilia heavily attended to participating teachers during her typical noticing cycles. Also interesting is that Cecilia attended to the facilitator only slightly more than another participant who had more *Project AIM* PD-specific facilitation experience, Lois (0.47 versus 0.41, respectively). It was Dina, the other PD leader with less PD-specific facilitation experience, who attended to the facilitator at the lowest average idea unit rates (0.28). Unlike past research that suggested teachers required support in their attending to shift from the teacher to the students (Sherin & van Es, 2009), this finding suggests that PD leaders may be different from elementary teachers in this regard. It is unclear whether, how, and why differences might exist from past findings on elementary teachers, but there are plausible explanations. For example, participants' backgrounds suggest the PD leaders in this study may be more similar to teachers with greater PD experience focused on learning thinking that past research identified matters more rather than sole years of teaching experience when examining teachers' noticing (Jacobs et al., 2010). It is also possible that the context of discourse played a role.

Two unexpected actors emerged, namely *PD materials* and *students at the classroom level*. Recall that coding of actors entailed examining who was the subject of participants'

discussion and sentences, meaning participants focused on ideas around a particular subject that can interact with others, whether human or not. PD materials were sometimes the focus of participants' attention and emerged as an extension of PD designers or PD designers' ideas based on participants' language (i.e., participants discussed the PD materials as expressing PD designers' ideas. Therefore, the category included PD materials with other actors. It was the only non-human actor and the context of this study may explain why. For example, facilitating with highly-specified PD materials involves becoming familiar with and using the provided PD materials and activities and all participants received facilitation training directly from PD designers.

It is less clear why participants attended to students at the classroom level. Perhaps it was because classroom connections and artifacts are an explicit part of the *Project AIM* design, all participants teach in school districts, or another reason. That students surfaced as an actor within teacher noticing is not surprising, given teachers work directly with students as learners (Sherin & van Es, 2009). Yet, PD leaders only worked with participating teachers as adult learners in the *Project AIM* PD program, not their students. Therefore, it was interesting that the participants focused on students at any point while analyzing whole group discussions between the facilitator and participating teachers. Even more thought-provoking is that one participant, Dina, attended to students relatively more often than the facilitator or PD materials actors (0.30 versus 0.28 and 0.14, respectively), as was true of other participants.

Participants did have access to the facilitation guide and any PD handouts that formed the context of the whole group discussions they analyzed during the noticing interviews to mirror past access when they facilitated themselves. *Project AIM* is a highly-specified PD and the expectation is that PD leaders closely follow the outlined PD program. So, it was unsurprising that observations included participants reexamining the PD handouts and facilitation guide and

all four often attended to PD designers' words and ideas presented within the materials. More interesting was the extent to which they attended to the PD materials and how they discussed its role during their noticing.

The following partial quote of Lois' attention to PD materials highlights how she and other participants attended to PD materials, including facilitator notes, and continued to use them as a guide against which to compare participants' ideas within a given whole-group discussion: "So, I guess the only thing I'm really noticing right now is what they're talking about matches with what the facilitator notes state...". Sometimes participants' initial attention to a whole-group discussion prompt within the PD materials explicitly preceded their attention to participating teachers as when Rosie referenced the prompt and followed up by saying "they're not talking about the emergent language students". She then went on to share what participants said and continued to compare their comments to the other whole-group discussion prompts within that Think Aloud. Attention to PD materials was clearly important across participants. It was the second or third most common actor for most PD leaders and all often attended to PD materials in tandem with participating teachers for comparison purposes.

### **Attending: Topic of Focus**

Segmenting idea units to further examine noticing cycles afforded a finer grain analysis of noticing such as examining topics specific to the component of *attending* (See **Table 8** below). Calculated decimals estimate average occurrence of all topics per noticing cycle for each participant but contain only instances that occurred during the attending component. **Table 8** shows the four principal topics by participant. This table also includes the level of breadth and depth per participant.

**Table 8.** Average occurrence per noticing cycle of four principal topics within PD leaders' attending.

Principal topics of focus	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	Cecilia	Dina	Lois	Rosie
1.	<i>participating teachers' engagement</i> 0.38	<i>participating teachers' thinking</i> 0.77	<i>participating teachers' thinking</i> 0.68	<i>participating teachers' thinking</i> 0.63
2.	<i>participating teachers' thinking</i> 0.36	<i>teaching or student learning at classroom level</i> 0.40	<i>teaching or student learning needs at classroom level</i> 0.35	<i>teaching or student learning needs at classroom level</i> 0.40
3.	<i>PD structural element</i> 0.27	<i>discourse or interaction</i> 0.30	<i>PD structural element</i> 0.35	<i>participating teachers' engagement</i> 0.40
4.	<i>discourse or interaction</i> 0.24	<i>PD structural element</i> 0.23	<i>discourse or interaction</i> OR <i>participating teachers' engagement</i> 0.30	<i>PD structural element</i> 0.30
<b>Breadth</b> ( <i>narrow vs broad</i> )	broad	narrow	narrow	narrow
<b>Depth</b> ( <i>shallow vs deep</i> )	shallow	deep	deep	deep

Interestingly, this table reveals some overlap in participants' attention when compared to their overall noticing (See **Table 5**). For example, the overall noticing cycle level results in **Table 5** and attending by actor in **Table 7** already revealed that participants focused on participating teachers, so it was no surprise that participants heavily attended to participating teachers' thinking. This table shows that multiple participants also focused heavily on participating teachers' engagement.

Observed differences in attending surfaced for Cecilia, who viewed her own videos. The four principal topics to which Cecilia attended remained the same principal topics across her overall noticing (See **Table 5**). Cecilia's lower and similar average idea unit occurrence across topics in the above table also suggest she divided her attention in multiple directions. In contrast, the average idea unit occurrence of the other three participants indicate their attention was narrow and deep in focus. So, while they also attended to multiple topics simultaneously like Cecilia, they focused heavily on these same select topics across noticing cycles. A comparison of principal topics within **Table 5** and **Table 8** also shows an overlap in focal topics across participants and amplified for those viewing another's video. Only five principal topics emerged across participants: *participating teachers' thinking*, *participating teachers' engagement*, *discourse or interaction*, *PD structural element*, and *teaching or student learning needs at classroom level*.

### **Interpreting: Stance Type**

The moment-by-moment noticing interview structure explicitly included interpreting, like attending. Therefore, segmenting participants' noticing cycles permitted analysis of interpreting by stance type, level of specificity, and source of inference using the same calculations to show their average occurrence per noticing cycle.

Stance type referred to the overall nature of the participants' interpretations, whether *analytic*, *literal*, and/or *evaluative*. It was typical for participants to reference multiple stances within the same idea unit, justifying the decision to include all stances similarly done for the previous categories. Data in **Table 9** show the average occurrences for all interpreting stances used per noticing cycle, along with the level of breadth and depth for each participant. See **Table 9** below for average idea unit occurrence of participating PD leaders' interpretations by stance.

The total average stance occurrences used by each participant well exceeded 1.00 per noticing cycle, exposes the extent to which participants interpreted using more than one stance during the same noticing cycle. For example, Dina employed multiple stances the least often, but her average use of analytic, literal, or evaluative totaled 1.44 per noticing cycle. Even Dina used almost one and a half stances per average noticing cycle. It was unusual that participants interpreted using all three stances but using two was common. An examination of individual noticing cycles revealed that the most common stances participants used jointly to interpret were evaluative and analytic.

**Table 9.** Average occurrence per noticing cycle of all stances within PD leaders' interpreting.

Stance type(s)	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	<b>Cecilia</b>	<b>Dina</b>	<b>Lois</b>	<b>Rosie</b>
<i>Analytic</i>	0.42	0.58	<b>0.78</b>	<b>0.70</b>
<i>Literal</i>	0.29	0.21	0.22	0.33
<i>Evaluative</i>	<b>0.87</b>	<b>0.65</b>	0.68	0.50
<b>Breadth</b> ( <i>narrow vs broad</i> )	narrow	broad	broad	narrow
<b>Depth</b> ( <i>shallow vs deep</i> )	deep	shallow	shallow	deep

The following excerpt was a typical example of participants' use of combined stances to interpret. In this instance, Lois evaluated before she detailed her analytic inferences as a part of her interpretations while viewing the last of multiple clips from one PD session.

...I think the facilitator talked too much. I don't know if she was trying to fill the quiet by talking, but overall, I felt like it was only a few [participants] that you really saw discussing. I think if she had been comfortable with quiet, they would have filled that quiet with their own conversations. Because I think one of the things, especially in something about promoting discourse is that you're trying to help teachers see that they can relinquish control and be more of a facilitator than the teacher, the one with all the

knowledge. And teachers are going to have to be comfortable with silence or figuring out how to get their students to speak. And not just by talking to themselves or students will very easily catch on that 'oh if we're quiet long enough, she won't make us do this'. And so, I think she has to model that more than maybe she did. (Excerpt 3 from Lois, February 12, 2018).

The prevalence of combined stances, particularly the combination of evaluative and analytic stances, was unanticipated. Past research on teacher noticing ascertained a proposed trajectory of stances teachers use to analyze video clips, namely that they often progress from evaluative (judgmental) to literal (retelling) to analytic (detailed inferences) (Sherin & van Es, 2009).

Whether this may be another difference between PD leaders and teachers is unclear, because this study examined all stances used within the same noticing cycle unlike their study that only examined dominant stances. Regardless, these findings suggest PD leaders' interpretations can simultaneously cross stances and that evaluative statements did not preclude other, more detailed inferences of the same overall idea. Considering the same proposed trajectory on stances (Sherin & van Es, 2009), it was also surprising that literal interpretations, not analytic ones, were the least common amongst participants. Literal retellings occurred across all participants' noticing, but it is unclear why literal retellings occurred more sparingly.

Continually comparing individual participants' interpretations other emerging findings and past research revealed other patterns. For example, Cecilia, the participant who viewed her own videos, used evaluative statements at higher than average unit occurrences than the others who viewed another's videos, in accordance with past research (Sherin & van Es, 2009). As mentioned in her case description, Cecilia used both positive and negative evaluations to interpret participating teachers' understanding and her actions as a facilitator. Comparative average unit occurrences show Cecilia's interpretations narrowly and deeply pronounced on

evaluating. Although not narrow and deep, Dina's prominent stance was also evaluative in nature. When Dina evaluated, her evaluations tended to be positive in nature, whereas her analyses involved greater critiques. A past study on PD leaders' noticing also found that PD leaders' interpretations tended to be evaluative despite focusing on participating teachers' understanding or engagement, particularly for novice PD leaders (Kazemi et al., 2011).

While **Table 9** coupled with focal topics show similarities among participants with less PD-specific facilitation experience, the same data reveal a different picture for participants with more PD-specific facilitation experience. Lois and Rosie's primarily interpreted using an analytic stance, but both continued to pass evaluative statements at high average occurrences during the same noticing cycles. This difference draws attention to the topic of how to define experience when discussing expertise in noticing. Past findings by Jacobs et al. (2010) led researchers to suggest distinguishing years of teaching experience from years of other PD and leadership experiences.

As stated earlier, all the participants within this study had experience facilitating the AIM PD that forms the context of this study in addition to other PD and leadership opportunities they received and offered over the years. Yet, similar differences by experience surfaced to those Jacobs et al. (2010) established. The researchers found interpreting not only grew with teaching experience but more so with more years of PD and leadership activities (Jacobs et al., 2010). Lois and Rosie not only had additional *Project AIM* facilitation experience but also received additional AIM training prior to their own facilitation that can be likened to receiving additional PD experiences aligned with the specific PD goals. In fact, data in **Table 9** show an almost reverse tale for Rosie when compared to Cecilia. Rosie's interpretations were also narrowly and deeply focused, but her lens heavily involved detailed analyses albeit coupled with evaluations.

While Lois and Rosie’s detailed analyses may reveal one difference, further analysis by level of specificity magnifies the observed difference by level of PD-specific facilitation experience.

### Interpreting: Level of Specificity

Level of specificity examined the nature of details provided when participants interpreted. Unlike stance, the level of specificity subcategories of *specific* and *general* did not co-occur, due to their reverse meanings. So, each idea unit received one code or the other, but never both, based on whether the participants offered any specific details. Data in **Table 10** show the average occurrence for level of specificity per noticing cycle, along with the level of breadth and depth for each participant.

**Table 10.** Average occurrence per noticing cycle of level of specificity within PD leaders’ interpreting.

Level of specificity	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	Cecilia	Dina	Lois	Rosie
<i>Specific</i>	0.56	0.58	0.84	0.78
<i>General</i>	0.44	0.42	0.16	0.23
<b>Breadth</b> ( <i>narrow vs broad</i> )	narrow	narrow	narrow	narrow
<b>Depth</b> ( <i>shallow vs deep</i> )	deep	deep	deep	deep

The average idea unit occurrences in **Table 10** show that all participants tended to offer more specific interpretations than general interpretations. The following excerpt was a typical example that demonstrated the level of details participants offered when interpreting, including the following in which Cecilia analyzed her own video. Cecilia discussed participants’ understanding and supported her interpretations by referencing specific questions participants were able to answer and what participants were able to identify.

They were able to –when we got down to these guiding questions about them identifying “what does the teacher do to launch the lesson?”, They knew. ‘How did the students explore the task’? They knew. I mean, they—So, that is good because to me that shows

knowledge of the response, *The Discourse Guide* (a *Project AIM* foundation document on discourse types), *The Mathematics Teaching Guide* (another *Project AIM* foundation document on lesson phases). So, that's good that they are able to identify the different parts and what it looks like whenever they see it in a video clip. That stands out to me because it's one thing to learn a process, it's one thing to hear a process we explain to you, but it's a different level to – without prompting. I mean I didn't tell them, 'okay, when we watch this clip, I want you to be able to identify the launch, to explore, to discuss, and then we are gonna talk about what you', - like I didn't set them up for that. So, they were able to do that. So that's just a higher level of comprehension that they've got for this process. (Excerpt 4 from Cecilia, February 14, 2018).

Based on definition alone, the expectation was to observe an alignment between stance and level of specificity, which past research supports. Kazemi et al. (2011) included analysis by inferential stance and level of specificity and found that PD leaders' interpretations tended to make general and evaluative statements. However, the level of specificity revealed a variation by level of PD-specific facilitation experience not already revealed by stance type but seen within earlier excerpts. Dina, who also viewed another's videos provided similar, lower levels of details as Cecilia when interpreting. These results indicate that degree of specificity like an analytic stance may increase with PD-specific facilitation experience, like differences already found in teaching when comparing expert teachers with more novice teachers (Luna et al., 2009). Further examinations by source of inference in this study provided additional support that those with greater expertise interpret with greater insight than their less experienced counterparts and that they could draw upon their own past experiences when interpreting as a part of moment-by-moment noticing.

### Interpreting: Source of Inference

Source of inference allowed for examining the boundary of events, namely whether interpretations involved observations solely within the video clip under examination, outside the video, or both. As with many other categories, participants sometimes referenced ideas within the video and outside within the same noticing cycle, resulting in the coding of all sources.

**Table 11** shows the average occurrences for all source types per noticing cycle, along with the level of breadth and depth for each participant.

**Table 11.** Average occurrence per noticing cycle of all sources types within PD leaders' interpreting.

Source(s)	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	Cecilia	Dina	Lois	Rosie
<i>Within Video</i>	<b>0.98</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>
<i>Outside Video</i>	0.20	0.28	0.41	0.68
<b>Breadth</b> ( <i>narrow vs broad</i> )	narrow	narrow	narrow	broad
<b>Depth</b> ( <i>shallow vs deep</i> )	deep	deep	deep	deep

The data revealed that all participants' interpretations remained heavily within the video clip boundaries, but all participants considered ideas outside the scope of the video clip at times.

Lois and Rosie considered outside sources at relatively much higher average occurrences.

Closer qualitative examinations of individual noticing cycles revealed that outside video sources fell within three overall types. During these instances participants usually referenced a related idea from their own past facilitation experience, like past research demonstrated (Sherin & Russ, 2014). In fewer instances, participants discussed their own MKT or MKPD to some idea under discussion within the video, whether discussing math content or pedagogy at the classroom or PD level. Other lesser instances mentioned a third outside source: the PD scope and sequence (i.e., concepts learned in previous sessions, concepts learned in future sessions, or expectations for participating teacher based on their relative time within the scope of PD program). The following excerpts come from one of Rosie's noticing cycles and provide an

example of interpretations that included multiple outside source types more typically seen as a part of Rosie or Lois' noticing. In this instance, Rosie reflected on her understanding of the pedagogical decisions behind discourse strategies as a part of selecting discourse promoting tasks. She shared what she sought from participating teachers' discussions based on her understanding of the PD goals they learned and her own past facilitation experiences. In between she suggested a new decision as part of her typical back-and-forth noticing process:

Yeah, I think I voiced it, but I know the purpose of *Draft and Final Copy* (a *Project AIM* discourse strategy) is to promote the discourse. So, we talked about whether the final copy looks good, whether it's right—how we could use it. But I wanted to hear them talk about what are the children gonna be doing as they go through *Draft and Final Copy*. And why. Why would they have to talk to each other? Why would they have to engage in collaborative strategies? Why would they have to engage with mathematical thinking? And how it would help English Language Learners... (Excerpt 2 from Rosie, January 24, 2018).

Rosie then suggested a new decision before further elaborating on her reasoning:

It's real easy for the conversation to go over to, 'How are you gonna do that? How are you gonna make it work? What could you do?' And those are valuable things to discuss, but I always want it to come back to why are we doing this anyway? I mean, there are multiple strategies you could use to solve a problem or to assess a student. What is especially important about this one and why? Why would it be effective? Because we used to do that and, oh my goodness, the discussions were amazing because they had to (talk). Especially the independent thinking at the beginning and then the having to come together and pick. (Excerpt 2 from Rosie continued, January 24, 2018).

This excerpt also highlights a theme seen within these instances, that past facilitation experiences served as another gauge against which participants compared current participating teachers' thinking. This was how participants discussed PD curriculum materials or sometimes in tandem with PD curriculum materials, like seen in the example in which Rosie also considered PD goals as part of what she explicitly said she "wanted to hear". Participants' use of PD curriculum materials as a point of comparison was discussed earlier within the individual case studies, including for Dina who referenced PD materials at a lower relative average occurrence.

As **Table 11** shows, Dina and Cecilia referenced outside sources much less often. A detailed examination of their individual noticing cycles did not reveal the same depth observed in the back-and-forth thinking process of Lois and Rosie. Most intriguing were the differences in instances when participants discussed their own MKT or MKPD. Lois and Rosie usually discussed their MKPD of the PD instruction. Sometimes Lois and Rosie also promoted connections for participating teachers at the classroom level during the same or different noticing cycles. Cecilia also discussed her MKPD of the PD instruction in a few instances, but rarely discussed implementation needs or related MKT at the classroom level. On the other hand, Dina heavily discussed the MKT she felt participating teachers needed as practitioners within their classrooms. The following excerpt comes from another of Dina's noticing cycles in which she reacted to a participating teacher's comment about their textbook being scripted. She referenced multiple outside sources with specifics as she pointed to teachers' lack of MKT before explaining what could be learned about anticipating student thinking from the textbook resources and what she expected to hear given the PD program is near the end.

I think there are a lot of teachers that do see it (the textbook series) as scripted. I personally feel that, that maybe due to a lack of content knowledge – [pause]... And so, they're following along with it instead of looking at, because there is a professional

development piece in there. And I think they're doing that without looking at the professional development piece. So, I think maybe they're - I think it's intention is to be there to like show the different examples, which she (the facilitator) pointed out, you know, these are some things that you might see in your students and to give you a 'oh, I hadn't really thought about that, I might see it that way.' But it also becomes some of the teacher's responsibility to be familiar with why and where that conversation can go and it's not a – [pause]... *Say this, say that. Say this, say that [laughs] – [pause]...* It's more just to show you how a conversation could happen. So I think that just giving them a chance to see how this can, all the things they've done, 'cause this is session twelve, 'how all the things you've done can be integrated and supported through that' – [pause]... 'Cause I, I hear a lot of teachers say oh I don't ever, I didn't even know that was back there. (Excerpt 3 from Dina, February 13, 2018).

Participants' individual cases mirror these findings and examples like this one emphasize that all participants focused on participating teachers' current thoughts and understandings, but there was qualitative deviation in depth by level of PD-specific facilitation experience. An examination of focal topics during interpreting reveal further similarities and differences.

### **Interpreting: Topics of Focus**

Segmenting idea units to identify the noticing components within noticing cycles also afforded a finer grain analysis of topics specifically referenced during *interpreting*. **Table 12** shows the four highest ranked principal topics after calculating average occurrence for each topic per noticing cycle. Again, level of breadth and depth are included for each participant (See **Table 12** below).

Seven topics emerged across participants: *participating teachers' thinking, participating teachers' engagement, PD structural element, discourse or interaction, teaching or student*

*learning at classroom level, facilitation or adult learning needs at PD level, and specific PD activity expectations.* Interestingly, the findings show some overlap in participants' interpretations when compared to their overall noticing and even greater overlap with topics participants focused on when *attending* (See **Tables 5** and **8**, respectively).

**Table 12.** Average occurrence per noticing cycle of four principal topics within PD leaders' interpreting.

Principal topics of focus	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	Cecilia	Dina	Lois	Rosie
1.	<i>participating teachers' engagement</i> 0.58	<i>participating teachers' thinking</i> 0.70	<i>participating teachers' thinking</i> 0.59	<i>participating teachers' thinking</i> 0.48
2.	<i>participating teachers' thinking</i> 0.58	<i>teaching or student learning at classroom level</i> 0.49	<i>discourse or interaction</i> 0.59	<i>discourse or interaction</i> 0.45
3.	<i>PD structural element</i> 0.47	<i>PD structural element</i> 0.40	<i>PD structural element</i> 0.43	<i>specific PD activity expectations</i> 0.43
4.	<i>discourse or interaction</i> 0.44	<i>facilitation or adult learning needs at PD level</i> 0.35	<i>participating teachers' engagement</i> OR <i>teaching or student learning at classroom level</i> OR <i>specific PD activity expectations</i> 0.38	<i>teaching or student learning at classroom level</i> 0.25
<b>Breadth</b> (narrow vs broad)	broad	narrow	broad	broad
<b>Depth</b> (shallow vs deep)	deep	deep	deep	shallow

The overlap in topics when interpreting compared to overall noticing was greater for those with less PD-specific facilitation experience. Interestingly, the same four principal topics that appeared within Cecilia's selective attention appear as most often in her interpretations. However, similar principal topics appeared across participants, particularly amongst those viewing another's videos. A closer examination of individual noticing cycles revealed that participants continued to consider topics referenced within their selective attention as part of their interpretations. For example, these findings further highlight a defining feature that appeared in the above excerpt and repeatedly throughout Dina's noticing cycles, namely she heavily focused on participating teachers' needs in the classroom setting as practitioners. Interestingly, Table 12 also supports another point already mentioned within her individual case. She also heavily considered participating teachers' needs as adult learners.

The breadth in **Table 12** highlights that Lois, Rosie, and Cecilia considered a broad range of topics while interpreting across their noticing cycles, but earlier excerpts and findings by level of specificity demonstrated qualitative differences in level depth while interpreting by level of PD-specific facilitation experiences not visible within this one category alone. Yet, **Table 12** draws attention to a theme that reoccurred when examining the individual cases. All participants considered and discussed multiple topics while maintaining a focus on one principal topic. When coupled with other findings presented thus far, this finding highlights the coherence and complexity in participants' noticing and draws attention to the complexity that is facilitation. It is the last topic of deciding how to respond that provided added qualitative insight about participants' noticing and revealed additional observed differences.

### **Deciding How to Respond: Response Type**

Deciding how to respond with reasoning was the third noticing component explicitly included as part of the moment-by-moment noticing interview structure. Participants' noticing

cycles were segmented to identify deciding how to respond like attending and interpreting. Remember that while this noticing component is part of the Jacobs et al. (2010) framework, it was not part of the original coding scheme (Sherin & van Es, 2009) but added for purposes of this study. Qualitative analyses determined the emerging categories and subcategories. Analysis of this component for response type and relative point of reasoning involved calculating average occurrence per respective participant noticing cycle. **Table 13** below shows the average response type occurrence per noticing cycle, along with the level of breadth and depth for each participant. The response types definitions were mutually exclusive, so only one response type appeared per noticing cycle.

**Table 13.** Average occurrence per noticing cycle of response types within PD leaders' deciding how to respond.

Response type	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	Cecilia	Dina*	Lois	Rosie*
<i>New Decision</i>	0.31	<b>0.63</b>	<b>0.70</b>	<b>0.70</b>
<i>Proceed</i>	<b>0.42</b>	0.12	0.16	0.08
<i>Uncertain or Conditional</i>	0.27	0.26	0.14	0.23
<b>Breadth</b> ( <i>narrow vs broad</i> )	broad	narrow	narrow	narrow
<b>Depth</b> ( <i>shallow vs deep</i> )	deep	deep	deep	deep

\*NOTE: Select subcategory sums do not equal 1.00 due to rounding.

Responses coded as *uncertain or conditional* revealed two variations of indecision, as the name implied: true unsureness about carrying out a newly proposed decision, as well as specifying a future prerequisite that needs meeting before determining how to next proceed. Within-case analysis suggested a pattern, so further explorations of individual instances occurred across all cases. Data analyses revealed a pattern seen across participants, namely that participants usually proposed a specific new idea even if they expressed some uncertainty about carrying it out. This was also true for Cecilia, who proposed new decisions less often than other participants. The following excerpt comes from one of Cecilia's noticing cycles after she

reflected on how she did not perceive that participating teachers' takeaways regarding the PD content were as strong as she hoped and shared that she would somehow like to bring something up. When asked if there was something specific, she immediately outlined her ideas while referencing the same PD constraints seen in some of her other excerpts:

Yeah, if I had the liberty, the time, whatever. The flexibility and the content, yeah, I might want- just wanna be like, 'So what did you all think about the strategy? What are some of the negatives you could see? What are some of the positives?' You know? Just expose what they may have been thinking about it. (Excerpt 5 from Cecilia, January 31, 2018).

A closer examination of different participants' uncertainty within individual instances revealed qualitative differences. Like Cecilia, Rosie's instances of uncertainty also involved conditions before she would proceed, but her conditional statement looked quite different. As seen above, Cecilia considered PD design and structure elements like time and flexibility in content, but Rosie's conditionality suggested she was being responsive to how participating teachers responded at that moment. As stated earlier, Rosie also proposed specific ideas and sometimes multiple ideas, but suggested waiting to see what transpired next before deciding how to respond. For example, there were times she coupled her new ideas with conditional statements like "it depends on where the discussion goes" before providing detailed evidence from the video clip about what she saw, what she was looking for, why wait time alone might result in others getting to the point, and then proposed questions she would pose if she did not hear the conversation turn in that direction that supported the goals. At times, she even explained why she would want to wait to hear more ideas from participating teachers before deciding how to respond. For example, another time after she proposed a new decision, she

elaborated on the role of the facilitator to read participating teachers' reactions as part of her reasoning.

I think as facilitator, always looking to see if somebody is making a connection to something that's being said or understands. And that person, too You can look over and say, 'Oh, I saw you nodding. What happened in your room?' Because, and pull them in a little bit. 'You seem to agree with this. What—' I guess it's a way to get more people pulled in if you see that they're having some kind of reaction. There's something in their head, that they could share. (Excerpt 3 from Rosie, January 11, 2018).

Rosie also referred to how teachers come to a PD with experiences and talked about how participating teachers should "learn from each other", not "just the *Project AIM* outlined activities". Although Lois had few uncertain instances, her instances were like Rosie in that she proposed ideas but would also want to wait for how participating teachers reacted before acting. As stated earlier, Dina's uncertainty appeared different, in that she expressed true uncertainty in her newly proposed ideas and were laden with "maybe". While it is unclear if Dina and Cecilia perceived more doubt about their proposed ideas, earlier research also found that novice PD leaders doubted their own ability to push participating teachers' understanding (Kazemi et al., 2011).

**Table 13** reveals that Cecilia was less critical than others when analyzing her own facilitation, which appeared in her decisions on how to respond. Other findings within this study and past research (Seidel et al., 2011) supports this finding. Cecilia had a relatively fewer average occurrence of proposing new facilitator decisions compared to other participants but like in other categories the differences were not straightforward. For example, Lois and Rosie suggested new decisions at only slightly average higher idea unit occurrences than Dina. All participants expressed some uncertainty and Cecilia did not do so at a much higher average idea

unit occurrences than most other participants. Variation surfaced not only among those with less PD-specific facilitation experience, but also with more PD-specific facilitation experience. For example, Lois expressed the least uncertainty and yet recommended proceeding more so than Rosie. Also, those analyzing another's facilitation proposed new decisions more than any other response type, while Cecilia proposed proceeding most often.

### Deciding How to Respond: Relative Point of Reasoning

Relative point of reasoning was another new category that emerged within participants' Think Alouds. This category summarized whether participants' decision-making explanations referenced events that occurred backwards or forward in time or both. Less common were instances when participants looked backwards and forward in time when discussing their decision-making reasoning. In such instances, coding included both relative points of reasonings at the idea unit level. The creation of a third subcategory, *none or vague*, was to capture the moments when participants provided little to no reasoning for their decisions, which also occurred across participants. In these latter instances, only this one subcategory was assigned. Like previous tables, data in **Table 14** show the average occurrence for all relative points of reasoning per noticing cycle and the level of breadth and depth for each participant.

**Table 14.** Average occurrence per noticing cycle of all relative points of reasoning within PD leaders' deciding how to respond.

Relative point(s) of reasoning	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	Cecilia	Dina	Lois	Rosie
<i>Retrospective</i>	<b>0.62</b>	<b>0.70</b>	<b>0.89</b>	<b>0.95</b>
<i>Prospective</i>	0.09	0.02	0.43	0.13
<i>None or Vague</i>	0.31	0.28	0.05	0.05
<b>Breadth</b> ( <i>narrow vs broad</i> )	narrow	narrow	narrow	narrow
<b>Depth</b> ( <i>shallow vs deep</i> )	deep	deep	deep	deep

It was noteworthy to learn that participants sometimes looked ahead in time, which led to the creation of this code. However, the average idea unit occurrences in **Table 14** show that,

apart from Lois, participants rarely discussed future events as part of their reasoning.

Unsurprising but important to mention was that participants rarely made decisions based solely on future instances they anticipated, including Lois whose reasoning included looking ahead more often than other participants. It was more typical that participants considered past events as the basis for future decisions. Together, the relative idea unit occurrences, breadth, and depth across participants in **Table 14** show that all participants narrowly and deeply based their future decisions on past events.

A qualitative examination of participants' reasoning within these individual noticing cycle instances revealed that participants regularly considered events that took place within the video clip. A common observation within participants' decision-making and reasoning included consideration of participating teachers' current thinking before recommending a question to learn more about participating teachers' ideas. The following is a typical example of such type of reasoning. After Dina proposed questions, she would ask the participating teacher in response to student work she was presenting. Dina also briefly explained her genuinely wonderings about desire to learn more about the individual participating teacher's reasoning and purpose for selecting the problem for use with students.

I think just to know if -- [*pause*]... was there scaffolding to build up to that, so that they (the students) were ready? Or was it just more of a let me see what they know, what these students— 'cause it's just kind of 'what's her purpose in that' ... (Excerpt 4 from Dina, February 13, 2018).

Instances heard less often across participants included participants' references to their earlier observations within previously viewed video clips, their own knowledge about concepts or activities from past PD sessions or making connections between what participating teachers' past and current experiences or thinking. When outside earlier references were included as part

of their retrospective reasoning, these references always coupled some event within the video clip being analyzed and participants used these earlier references as support for their decision-making. Such observed instances were a part of Lois' and Rosie's decision-making reasoning. It was as if they considered and promoted connecting ideas over time to inform where to go next. The following is an example of one such instance. This excerpt is part of Lois's noticing cycle in which she attended to a participating teacher's statement about modeling for students and made connections to past PD sessions about scaffolds as she proposed a new idea.

I think that's a great place to have the conversation about what kind of scaffolds or structures can you put in place if you're going to give them (students) high expectations and hold them accountable for their discussions? Like 'what can we do to support the ones who this is hard for? or what kind of supports can we do to start off with?' or – [pause]... I feel like we did (talked about) supports in the first – 'is there something we've learned previously that you've seen has helped your kids, your students?' or 'something you've used from something else that you feel like (would work)? So, I think that's a good – Going along with this idea of high expectations in here, and she's saying, 'Yes if I'm holding my kids accountable, then I have to make sure I'm actually saying it. I have to actually hold them to those high expectations.' But having a conversation about 'well, what can we do to help them get to a place where they're meeting those expectations?' (Excerpt 4 from Lois, January 16, 2018).

The examples above redraw attention to a similar, earlier finding seen within interpreting, namely the difference in level of specificity or depth observed within individual noticing cycles by level of PD-specific facilitation experience. Both Lois and Rosie elaborated and not only discussed the needs of participating teachers but also goals as part of the PD design as part of their reasoning.

The data in **Table 14** and individual instances together highlight another difference by PD-specific facilitation experience level. More specifically, it was more common for those with less PD-specific facilitation experience to provide little to no reasoning when sharing their decisions, regardless of decision type. Cecilia and Dina each provided little to no reasoning about in once in every three noticing cycles (0.31 and 0.28, respectively). Interestingly, Cecilia and Dina are the same two participants who provided fewer details when interpreting, too. As mentioned earlier, Cecilia and Dina also regularly required prompting to elicit their decision-making and reasoning. Dina's instances of little to no reasoning crossed decision types, meaning this occurred whether she recommended proceeding, indicated uncertainty in how to proceed when providing a possible next step, or when she proposed a new decision. Cecilia's instances occurred more so when she recommended proceeding or sometimes when uncertain. But it is important to recall that she typically recommended proceeding based on her observations up that moment in time. In contrast, it was atypical that Lois and Rosie offered little to no reasoning altogether, even when they recommended proceeding.

When looking across participants, lack of reasoning occurred more commonly when participants proposed proceeding. However, that did not mean participants offered less reasoning when they suggested no new course of action. There were more instances in which participants provided retrospective and/or prospective reasoning when they wanted to proceed compared to instances when little to no reasoning given. Examining the specific topics of focus within this last noticing component revealed additional qualitative differences between participants, particularly when considering their level of PD-specific facilitation experience.

### **Deciding How to Respond: Topics of Focus**

Segmenting idea units by noticing component and analyzing topics within the skill of deciding how to respond revealed the greatest qualitative differences so far. **Table 15** provides

calculated average occurrences for all topic per noticing cycle, as well as breadth and depth for each participant. As in **Table 5**, **Table 8**, and **Table 12**, **Table 15** showcases the four principal topics by participant. As expected, some overlap existed in topics when compared to other noticing components, but less overlap existed in deciding how to respond compared to attending or interpreting or participants' overall noticing (see **Table 8** and **Table 12**). This was not surprising given the inherent complexity of decision-making (Jacobs et al., 2010). Nor was it surprising that parallel topics emerged across participants, because of the observed similarities in previous noticing components. Seven areas formed the four principal topics across participants: *facilitator move suggestion, participating teachers' thinking, facilitation or adult learning needs at PD level, teaching or student learning needs at classroom level, specific PD activity expectations, discourse or interaction, and PD structural element* (See **Table 15**).

An examination of breadth and depth exposed differences. Dina focused on fewer topics regarding how to respond, while Cecilia, Lois, and Rosie considered more topics across their respective noticing cycles. However, Lois and Rosie deeply focused on their suggested facilitation moves, like Dina. The same examinations of breadth and depth for Cecilia presented here support earlier findings that Cecilia was less critical or critiqued with less depth when analyzing her own facilitation across the noticing components, revealing her decision-making and reasoning considered multiple topics but without focusing on any specific one across her noticing cycles.

**Table 15.** Average occurrence per noticing cycle of four principal topics within PD leaders' deciding how to respond.

Principal topics of Focus	Own		Others	
	Less PD-specific facilitation experience		More PD-specific facilitation experience	
	Cecilia	Dina	Lois	Rosie
1.	<i>facilitator move suggestion</i> 0.36	<i>facilitator move suggestion</i> 0.65	<i>facilitator move suggestion</i> 0.68	<i>facilitator move suggestion</i> 0.83
2.	<i>participating teachers' thinking</i> 0.31	<i>facilitation or adult learning needs at PD level</i> 0.49	<i>facilitation or adult learning needs at PD level</i> 0.54	<i>facilitation or adult learning needs at PD level</i> 0.63
3.	<i>specific PD activity expectations</i> 0.29	<i>teaching or student learning at classroom level</i> 0.47	<i>discourse or interaction</i> 0.49	<i>participating teachers' thinking</i> 0.58
4.	<i>PD structural element</i> 0.27	<i>discourse or interaction</i> 0.33	<i>participating teachers' thinking</i> 0.43	<i>teaching or student learning at classroom level</i> 0.53
<b>Breadth</b> (narrow vs broad)	broad	narrow	broad	broad
<b>Depth</b> (shallow vs deep)	shallow	deep	deep	deep

The excerpts shared above for response type and relative point of reasoning coupled with data in **Table 15** highlight that participants shifted their focus when deciding how to respond. That is, participants focused on slightly different topics beyond those during their selective attending and interpreting. Individual instances verified the foci of participants' decision-making connected to their attention and interpretations within the same noticing cycles, but a shift occurred to include other topics. For example, one new principal topic across participants involved suggesting a facilitation move, with the most commonly suggested move involving

asking open-ended questions. Questions varied in purpose, but they were almost exclusively in response to participants' thinking or understanding.

Turning to the second through fourth principal topics revealed the contexts of their decision-making and reasoning, including the purpose behind their recommended facilitation moves. More specifically, the content of participants' noticing cycles revealed individual differences in their decision-making thinking and reasoning. For example, Cecilia tended to focus on understanding more about participating teachers' thinking and the specific PD activity expectations and structural elements. There were times Cecilia proposed new decisions, but with caveats. Her conditional statements indicated she would only carry out these actions if she had the flexibility to make adaptations or she had more time. She also spoke about how every PD activity was important for the participating teachers. During a different noticing cycle Cecilia was explicit about this internal struggle, stating that "the content of this PD was intense and so you have to pace yourself wisely". She was very quick to propose specific questions she would have asked in that moment but in a "not-so-time-constrained session", reiterating that if she were given the same materials with the same constraints, she thinks she would've "kept going". Therefore, Cecilia's words indicated she remained focused on her role of supporting participating teachers as learners within the PD setting but within the constraints of delivering the content in a timely fashion so participating teachers reached the outlined goals. She did not perceive choice regarding adaptations she could initiate that might deviate from the specified PD content and activities, because as she said, "it was all important" and she "prioritized" based on outlined activity goals. Her more cautious approach to suggesting new decisions supports she perceived tension and defined her views on facilitation, as stated in her individual case.

The other three participants also focused on participating teachers' thinking, too, but **Table 15** shows that their focus laid more on facilitation or adult learning needs at PD level,

teaching or student learning needs at classroom level, and/or the overall discourse. These topics and participants' words communicated that they recognized their role as facilitators charged with implementing the PD like Cecilia voiced, but each participant's noticing revealed they had different approaches. As the earlier excerpts and ideas across noticing components showed, Dina also remained focused on participating teachers' understanding, but with a primary focus on participating teachers' needs as practitioners at the classroom level. Multiple individual instances, including the examples shared above, showed that Dina concentrated on the needs of both teaching and learning at the classroom level. That does not mean Dina did not discuss participating teachers' needs as adult learners within the PD setting in relation to the PD materials, but that her view of participating teachers differed from Cecilia. More specifically, Dina discussed participating teachers' need as practitioner within their classrooms, which informed her of their current needs as adult learners within the PD setting.

Lois and Rosie were the two PD leaders who also and more regularly discussed participating teachers' needs as adult learners and practitioners, but even their approaches varied. As the examples highlight, Rosie sometimes focused on participating teachers' needs as practitioners and sometimes as adult learners, but many times she considered both within the boundaries set by the PD goals. Like Cecilia, Rosie recognized the need to attend to the PD materials in the process. Also, like Dina, Rosie recognized that participating teachers need to see the relevance to their classrooms. Yet, Rosie's words indicated that the learning process participating teachers needed was reciprocal in nature to simultaneously learn and apply their skills. Rosie's decisions on how to respond indicated that she recognized her role as a facilitator in this back and forth process. For example, here Rosie discussed wanting to challenge and further participating teachers' PD needs as adult learners and classroom implementation needs as practitioners as they were reflecting on their lessons over time:

That might be a good time to refer back to the matrix. If we're discussing why now, and you're saying that's beyond where you were, where were you when started this at the beginning of the year? What level discourse was happening in your classroom and where are you now? And let's go back and review what that looks like. And, you know, our final goal is to have them making connections among different ideas. So, are you at that level yet? Or do you feel like you're just approaching it and – I don't know, it's just interesting to bring out how things have changed and how it might be reflected back into what they've talked about this year. (Excerpt 4 from Rosie, February 15, 2018).

Lois's approach almost seemed the opposite of Dina's, in that she primarily focused on participating teachers' needs as adult learners and saw their needs as practitioners as an extension of what they were learning in the PD setting and talked in this way. Like Rosie, her suggestions showed she maintained a focus on the PD goals. Unlike the other participants, Lois heavily discussed her desire to see more responsive discourse (i.e., discourse in which the facilitator steps back more, allowing participating teachers to talk more and assume more responsibility as the PD program promotes. In one of the earlier shared excerpts Lois discussed wanting the facilitator to be comfortable with the silence so the participating teachers "fill that quiet with their own conversations". It is in her reasoning within the following excerpt she explains her views on promoting discourse within the PD setting:

I think one of the things, especially in something about promoting discourse is that you're trying to help teachers see that they can relinquish control and be more of a facilitator than the teacher, the one with all the knowledge. And teachers are going to have to be comfortable with silence or figuring out how to get their students to speak. And not just by talking to themselves or students will very easily catch on that 'oh, if we're quiet long enough, she won't make us do this'. And so, I think she has to model that more than

maybe she did. I would try to. We did a lot of saying like ‘oh, you're not supposed to be talking to me’, ‘look at each other’, ‘stop talking to me’ or ‘I'm just going to sit down’ or ‘I'll just sit here until somebody says something’. And so, they'd start talking, because they knew they were going to be made to. And then they actually—once somebody got it going, they'd usually have a good discussion. And communicate that with them. (Excerpt 5 from Lois, February 12, 2018).

This example also illustrates a message heard more than once within Lois and Rosie’s noticing, which was the need to model and promote the strategies participating teachers needed to learn and apply in their classrooms. They explicitly discussed communicating their expectations, like Lois did above, and making their own use of the strategies and thinking explicit to participating teachers as learning opportunities. The prominence of these messages across their noticing cycles defined their views on facilitation and further differentiated them from Dina and Cecilia, as already mentioned in both their individual cases. Their noticing supports past research that found that experts are able to execute their noticing components as an *integrated* skill set and able to analyze with greater depth and detail than novices (Jacobs et al, 2010; Superfine et al., 2017). PD-specific facilitation experience level along with whose facilitation is being analyzed provided a lens in which to examine differences and similarities across and between participants.

### **Research Question 1: Summary and Discussion**

While the collective results above offer greater insight into participants’ noticing, there are some notable findings that require summarizing. This section highlights some key findings that provide insights into Research Question 1.

## Overall Noticing

First, all participants initiated their noticing around the different components within the Jacobs et al. (2010) noticing framework. Participants' engagement in the noticing cycle also revealed the many instances when they revisited one or more components as they discussed their noticing around one overall idea. Participants' process of revisiting the same component within the same noticing cycle repeated across noticing cycles offers support for researchers' current views of the noticing as a back-and-forth, interrelated process in which the components can co-occur close in time as Jacobs et al., 2010 portrayed (Thomas, 2017). Those viewing another's videos engaged in the back-and-forth process more than the participant who analyzed her own facilitation. Engaging in this back-and-forth process was more pronounced in participants with greater PD-specific facilitation experience.

The expectation was that Lois and Rosie would engage in the back-and-forth noticing process more often given to possess greater PD-specific facilitation experience with the PD program that forms the context of this study. Yet, the variation seen across PD leaders extends the dialogue raised by researchers about the MKT or MKPD that PD leaders need to know (Borko, 2014b) to include examining the MKPD PD leaders with more and less PD-specific facilitation experience possess and the noticing in which they engage. Rosie openly raised this point when she supposed about the role of time with and knowledge of the PD curriculum on facilitation.

Given the interrelated nature of noticing components researchers contend (Jacobs et al., 2010; Thomas, 2017) and the differences in back-and-forth nature observed between participants, one begins to wonder how PD leaders' processing during particular noticing components might influence other components during the noticing process. For example, all participants engaged in interpreting the most and deciding how to respond least and all possessed

ideas around all noticing components, but those with greater PD-specific facilitation experience not only engaged in deciding how to respond more often, they proposed more adaptations, with greater detail, and did so without much prompting.

### **Attending**

The results surrounding the first research question reveal that all participants selectively attended to similar actors and topics. Five main topics emerged across all four participants: participating teachers' thinking, their engagement, discourse or interaction at the group level, PD elements, and the teaching or student learning needs at the classroom level. Participating teachers emerged as the principal actor. Participants' words revealed more specifically that all responded primarily to participating teachers' thinking and understanding. The results indicate that PD leaders may be different than teachers in this regard, given past research revealed that teachers initially attended to teachers rather than students when analyzing classroom instruction (Sherin & van Es, 2009).

More unexpected was that participants sometimes attended directly to students at the classroom level and heavily attended to PD materials. The results showed participants regularly attended to PD materials in tandem with participating teachers to focus on the aspects related to the activity or goals of the scripted PD program. Their attention to multiple actors and topics informed their interpretations, as evidenced in how participants often used the PD materials as references points to gauge participating teachers' thinking and understanding. The attention to PD materials and similar foci raise questions about the role of PD curriculum materials in the facilitation process. Attention to PD materials suggests promise that the provided PD curricular materials may be serving an additional purpose for PD leaders within the PD teaching and learning process, namely for formative assessment purposes. Participants' words and non-verbal 360-video data revealed that they were looking for something specific and they noticed whether

it was present or absent. The use of 360 video in this study implies that this technology supported participants' personal choice during their moment-by-moment noticing after instruction. By attending to the PD prompt and other related written facilitation-support notes within the PD materials in combination with participants' words, participants used this additional information to make sense about participating teachers' current understandings. (i.e., participants interpreted what participating teachers did or did not understand and determine how and why they might respond). That is, participants' noticing of what was present and absent was guided by their expectations. So, these results also support researchers' contentions that noticing is a *selective* process (Mason, 2002) that is guided by one's expectations (Drake & Sherin, 2009).

### **Interpreting**

Results on participants' interpretations revealed additional similarities and differences between participants and offered new insights on PD leaders' noticing. For example, past research examined the dominant stance used by teachers, proposing a trajectory that ranged from evaluative to literal to analytic (Sherin & van Es, 2009). While this study chose not to examine the dominant stance, but all stances used within individual noticing cycles. It was surprising to uncover that all participants used multiple stances to discuss the same overall idea. Individual instances revealed evaluations were more general, while analyses tended to be more specific, but that stances were not mutually exclusive. Furthermore, the two stances that most often co-occurred were evaluations and analyses. There were important related observed differences. The individual viewing her own videos evaluated more often than others. Also, only those with greater PD-specific facilitation experience had analytic dominant stances. These findings cannot negate or support the proposed trajectory or speculate on a similar one for PD leaders, but participants' noticing showed it was possible to evaluate and analyze simultaneously.

Participants' interpretations also revealed two related ideas regarding topics. First, the principal topics of focus during participants' interpretations overlapped with their respective principal topics of focus during their attention. Also, results from all topics of focus by noticing component revealed that participants considered more topics while interpreting than when attending. It was during this component when they considered the most topics within individual noticing cycles, more than when they decided how to respond. It may appear obvious, given the many issues that are part of facilitation but together these findings reveal that participants' noticing was logical and consistent. Participants maintained their focus around overall, particular ideas as engaged in a single noticing cycle. It also reveals the many issues they simultaneously considered and contemplated. Naturally, it was during this component that participants' noticing went beyond the boundaries of the video clip they were analyzing, given participants even considered outside sources.

### **Deciding How to Respond**

Participants' ideas around this noticing component revealed the greatest variation, because of observed differences between those who analyzed their own versus others' facilitation, those with more and less PD-specific facilitation experiences, and on an individual basis. The individual analyzing her own facilitation was less critical compared to others, which appeared to impact her decision-making. All other participants recognized opportunities and proposed more new decisions to improve the whole-group instruction within the video clips. It was so commonplace, that proposing new decisions was the dominant response type for Dina, Lois, and Rosie. In contrast, Cecilia was the only participant who suggested proceeding most often, across her noticing cycles. Those with greater PD-specific facilitation experience proposed new decisions even more often and did so with little prompting. Instances of uncertainty varied, with most expressing conditional statement that needed meeting, but even

conditional statements looked different by participant. Those with greater PD-specific facilitation experience proposed their facilitation response and cited that subsequent participating teachers' reactions would determine if they used their proposed response. Lois and Rosie also proposed alternatives, almost as if they wanted to have back-up options ready to execute based on participating teachers' responses. It was typical that all participants proposed questions in response to participating teachers' thinking based on outlined PD activity goals, but those with greater PD-experience decision-making also suggested adaptations to the planned instruction, that is sometimes referred to as disciplined improvisation (Borko et al., 2014a).

This last point about observed differences when recommending new decisions is especially interesting. Choppin's (2011) research on teacher noticing found that teachers who primarily interpreted using an evaluative stance made adaptations that reduced task complexity. Choppin also found that those who used a primarily analytic stance with greater specificity made adaptations that either maintained or enhanced the task complexity. In this study, Cecilia and Dina primarily evaluated, but both recommended new decisions without reducing the task complexity. Yet, Lois and Rosie, who primarily analyzed, recommended new decisions that either maintained or periodically enhanced the task complexity. I can only conjecture about how participants' attention to the PD materials within this highly-specified PD program may have influenced their decision-making process, but this highlights possible differences between PD leaders and teachers and draws attention to the intricacies involved in decision-making.

The many differences above within this noticing component, including the observed overlap of topics within other components with new emerging principal topics specific to deciding how to respond draws attention to the likely greater complexity of decision-making, as evidenced by prompting instances. Participants had ideas and could provide their reasoning but did not always automatically verbalize them. While this study cannot explain why participants

sometimes did not provide their ideas around decision-making during the moments, it raises new questions. For example, might the decision-making process be more challenging, thereby impacting the vocalization process? Also, does and how might greater PD-specific facilitation experience mitigate the decision-making process? The lack of past findings on this component prevents further comparisons and suggests there is more to learn in future studies.

### **Overall**

Most interesting was the myriad of topics participants simultaneously considered during individual noticing cycles and the similarities seen within participants' principal topics. This finding does not negate the many differences, but it draws attention to their shared experiences. All received some training to lead this highly-specified PD and were provided PD curriculum materials including facilitation supports, which they referenced as part of their noticing process. It is important to remember that this study was situated within the PD program that forms its context. All findings are bounded to the highly-specified PD program that comprises the background of this study. The many topics, highlighted by the breadth and depth of topics, draw attention to the complexity of the instructional process when facilitating highly-specified PD. The findings suggest that PD leaders are sieving through numerous issues that are part of the highly-specified facilitation and learning process and that noticing acts like a filtering process not only in response to ever-present stimuli present in the PD setting, but also in their minds.

The fewest number of topics emerged during attending, further supporting the idea that noticing is a selective process. All considered the same, as well as additional new topics during interpreting. Decision-making revealed a smaller decrease in overall number of topics and a shift to consider new related topics, but their rationale remained heavily tied to their interpretations. So, their filtering process widened before it narrowed again. One might speculate whether this might explain why all participants revisited the decision-making

component least often within individual noticing cycles. It was often a concentrated effort, particularly for those with less PD-specific facilitation experience. Like all other findings, these results raise queries. For example, does and in what ways might greater PD-specific facilitation experience support the *integrated way* past research suggests these interrelated noticing components must be executed (Jacobs et al., 2010; Thomas, 2017). The results already presented in this and the last chapters suggest that these questions deserve further contemplation to support PD leaders' noticing and highly-specified facilitation, particularly those with less PD-specific facilitation experience.

### **Research Question Two: Results**

Although, the previous discussion centered on the decomposed participants' noticing process to draw attention to the distinct components, the results from this study support that the three components of attending, interpreting, and deciding how to respond are interrelated skills for PD leaders leading a highly-specified PD program, as contended by Jacobs et al.(2010). It is important to once again reexamine participants' integrated nature in its entirety. The remainder of this chapter focuses on answering the second research question. I define characteristics across participants' noticing by identifying and illustrating collective themes. Again, interweaving qualitative excerpts highlight similarities and differences across and between participants' foci. I conclude by highlighting and discussing key ideas that answered the second research question.

#### **Themes Across Participants Reveal Areas of Noticing**

Three overarching themes arose across and between participants' noticing and summarized to answer the second research question.

##### **Theme 1: Noticing of PD curriculum content and vision.**

PD leaders can only interpret and respond to which they attend and the findings showed participants attended to PD curriculum materials as a main actor, in conjunction with other actors

during their noticing. Individual instances not only supported that participants attended to PD curriculum materials but revealed that participants continued to utilize the PD curriculum materials as a main resource and tool as they made sense of and decided how to respond to whole-group activities that involved the facilitator and participating teachers under analysis. This finding across PD leaders reveal overlaps with how teachers interact with curriculum materials, which are also highly-scripted by curriculum designers. Choppin (2011) demonstrated that some teachers read curriculum materials for specific ideas about how to navigate a designed activity, questions to ask during the activity, and any reference to potential learner strategies. All participants used the PD curriculum materials in all these ways, as well as a guide to compare and make sense of participating teachers' understandings. It was evident that PD materials mattered for all four participants in this study.

Other research determined that a teacher's curriculum vision (i.e., the knowledge of the design, content, and philosophy of a curriculum) establishes discerning expectations regarding what teachers seek, thereby influencing to what they attend (Drake & Sherin, 2009). Participants' noticing revealed that all had specific expectations about participating teachers' understanding, which involved their noticing around the highly-specified PD materials. Earlier noticing excerpts across participants and the individual cases Lois and Rosie demonstrated both had additional expectations. These two PD leaders with greater level of PD-specific facilitation experience also specified the extent of their discerning expectations with even greater specificity and depth. These findings suggest that PD leaders' visions of the highly-specified PD curriculum may have influenced their noticing. It is not surprising that an understanding of the PD content holds similar benefits for facilitation as it is for teaching classroom instruction, but Lois and Rosie's noticing demonstrated their deeper understanding of the underlying beliefs and goals of the *Project AIM* PD program content and design.

The highly-specified PD program that forms the context of this study offers PD curriculum materials and facilitation supports about instructional ideas. Considering past research (Choppin, 2011), the results from this study suggest this particular PD curriculum may have provided PD leaders the resources and tools to implement instruction. All participants' interpretations and decisions on how to respond considered multiple aspects outlined by the PD curriculum content and goals. Participants not only selectively attended to the PD materials, but also compared other actors' words and actions against their own expectations based on the PD curriculum. Yet, the pronounced differences between participants with more and less PD-specific facilitation experience regarding the depth in topics supports past research that noticing involves more than simply applying one's MKT or MKPD (Borko et al., 2014a). Like past findings on teachers' interactions with curriculum materials (Remillard, 2005; van Es & Sherin, 2017), the differences in depth seen in participants' noticing suggest that PD leaders need to deeply understand the design of particular tasks and tools and coordinated to foster the outlined PD program goals. Rosie's own words revealed the importance of understanding the PD tasks and goals on a deeper level but that employing that knowledge in the moment is challenging.

It's easy to watch somebody else and critique and it's hard when you're up there doing it. Those things come to you later sometimes and you go 'oh, I wish I'd said that.' I think always trying to stay true to the purpose and focus of what you're doing and at the beginning of the class we always said...what are the goals. Yeah. And we were always like, 'okay, it's discourse goals or it's instructional, or whatever.' And just try to stay true to that and to try to keep the conversation, moving forward with that purpose, while referring back to all of the foundational ideas of the PD. It did not happen enough for my satisfaction here and that, like I said, when you're in the moment, I don't know that I would've done any better or differently, but it's just easy for everyone to get away from

what their purpose is. And it's, just as it's easy for students to do that when they're in class. (Excerpt 5 from Rosie, February 15, 2018).

Rosie continued right on, further revealing how her PD curricular vision allowed her to translate her knowledge to facilitation practices that aligned to the PD curricular goals. Her ideas explicitly highlight another area of noticing that hallmarked her and Lois' views as PD leaders: the noticing of facilitation practices aligned to the PD curricular content and vision.

So, one way to maybe keep that from happening is to ask the questions that force them to go back to some understanding. Make them explain things. Model constantly the strategies that you're teaching. I heard you say, and I'm thinking. I don't know, just always in the way you're discussing and presenting it. Not that it'd just be haphazard “hey everybody, what's up.”, but to always be modeling so that they see it in action. And we talked before in the session on how you can bring that back to, you may not have noticed but what did I did just now that increased your discourse over that particular thing. ‘Cause you were not talking and then I, what did I do...Yeah, I think that's something you gotta think about. Yeah. As to kinda keep it focused, on that purpose. (Excerpt 5 from Rosie continued, February 15, 2018).

**Theme 2: Noticing of PD facilitation practices aligned to PD curricular content and vision.**

Rosie's words above remind us how much harder it is to respond in the moment than reflecting afterwards. Her thinking also revealed the potential benefits of a stronger curricular vision on facilitation practices that require periodic adaptations, even during highly-specified PD programs like *Project AIM*. Dietiker, Males, Amador, and Earnest (2018) found that a vision involving strongly-held curricular attending habits might aid the recognition of opportunities embedded in curriculum materials, similar to Lois and Rosie, but also cautioned that it can

potentially make some unaware of slight needed deviations from the design, whether before or during instruction. This might help explain the tension Cecilia expressed with wanting to make adaptations and adhering to the PD design. Cecilia was not the only participant who attended to the PD materials. However, Cecilia directly discussed this tension, suggesting a strong allegiance to the PD curriculum content can very well result in the two-pronged effect Dietiker et al. (2018) discussed.

It was really hard for me at the beginning to pace through this particular PD because it was so rigorous, and so every piece to this puzzle mattered, it was, it's very different than a lesson, per se, in the classroom, that you can tweak, and, okay, so, we spent a little more time on this than I had slated, but it's okay. This is not like that. It's very - I don't want to say rigid, 'cause I think of a negative connotation when I think rigid. I don't mean that. I just mean there is purpose to literally every minute that is scripted here. So, pacing, at the beginning, and this was at the beginning in my opinion. Pacing was very much in the forefront of my mind, 'cause I could tell early on that, woo, there ain't no time to spare. So, and, you can't fully predict. Sure, this discussion was supposed to take 20 minutes, but you can't predict the product that you're going to get when you start asking open-ended questions. So, I think, take that whole—that was definitely, as a facilitator, something that I had to work on was pacing. (Excerpt 6 from Cecilia, January 8, 2018).

As stated earlier, all participants' noticing aligned with similar topics promoted within the PD curriculum materials and all heavily focused on participating teachers' thinking, but Cecilia's words also revealed her focus was *rigid* in the sense that she perceived staying true to the outlined PD plan and script as contradictory to proposing adaptations even though she

perceived the need for some adaptations. This may explain why she offered the fewest adaptations or new decisions on how to respond of all participants.

Both Rosie and Lois offered specific ideas for disciplined improvisation, which entailed responsive facilitation moves beyond asking open-ended question to clarify and support participating teachers' understanding and challenge participating teachers' thinking. Rosie and Lois also provided more-detailed reasoning for their proposed actions. These results suggest that the professional mathematics noticing practices of novice and expert PD leaders may reveal additional findings about this special group of educators who facilitate highly-specified PD. For example, Amador (2016) found that expert teacher educators were more instrumental in drawing conclusions about how to restructure instruction for increased benefits. Multiple excerpts by Rosie (Excerpt 5) and Lois (Excerpts 3 and 5) demonstrated that both proposed restructuring instruction for increased benefits on a level not observed within Dina nor Cecilia's noticing. Both of their suggested facilitation moves also revealed they held a deeper vision, particularly regarding the underlying beliefs behind foundational documents like the *Discourse Matrix* used in the PD program to promote discourse in teachers' classrooms (Sztajn, Heck, & Malzahn, 2013). For example, Rosie directly referenced *Project AIM* terms like "responsive discourse" when discussing her reasoning and Lois discussed using facilitation moves to promote this type of richer discourse that shifts responsibility to the learners, as seen in the following excerpt.

I'm not sure why she's telling them, which things from their list are on this list. That's why I was waiting to see if she was going to do it with the second one too. And that's why I wasn't sure if they had a chance to look over it. If it was like, oh, you'll notice on, you know, A3, look at that. And A6. I'm not sure why she isn't asking them, what do you see on here that's reflective of the list we made? I think, again, any time they can tell it to you it's better. You know sometimes they finish, and you realize they haven't told

you what they're supposed to. And you have to help. But anytime they can tell it to you, or to each other, then they're engaging more than when you're standing up there, 'Oh look that's on your list. It's on this list too'. Having them notice it, they're having to process it, they're having to engage. Or you're sitting there quiet, you know, the room's sitting quiet cause nobody's sharing. But I think people get really frustrated when you go to a training and you're the only voice you're hearing. And so, I think maybe if they hadn't been able to come up with any, her pointing one out might have been nice. Or if they had come up with a few and maybe that's what she's about to do, maybe. (Excerpt 6 from Lois, January 16, 2018).

Dina and Cecilia also made suggestions on how to respond that included an awareness of documents like the *Discourse Matrix*, which included benefits to participating teachers through more exposure. Yet, they appeared to lack knowledge or ideas on how to specifically carry out their actions through facilitation moves. For example, Dina once recognized that the facilitator was trying to support participating teachers' thinking by providing wait time during an activity that required them to apply their understanding of the *Discourse Matrix* to analyze the mathematics discourse in a scenario. Dina even recalled that participating teachers in her cohort had a similar challenge applying their understanding of the *Discourse Matrix*, but she did not outline details when she said participating teachers needed "more practice using the matrix" entailed as part of her noticing. In contrast, Cecilia went a different route by expressing how it might be helpful if the PD facilitation supports offered more guidance when she identified what she perceived as issues. Her interpretations again suggested she did not perceive that she had the flexibility to make adaptations herself that deviated from the outlined activity steps.

Rosie and Lois went one step further to express the importance of making their facilitation moves explicit as a part of support participating teachers, as seen in the following excerpt from Rosie after analyzed a third clip from the same PD session.

I think, during whole group, you have to either get lost, or go into the woodwork, or go somewhere where people are a little uncomfortable. And, again, if I was walking around in small group, and I heard something, I would be calling on people. Or I would be going up, and again, modeling what (Project) AIM does. Going up and saying, 'I'm gonna ask you to talk about this. So just be ready'. And I, 'cause that's what you do with students. And that's what they need to see happening, so that they feel comfortable, because, right now, they are not all included in mathematics. They're not ... They're like the students who, there's five kids in the class who love to talk, and everybody else – And I think, at the end of the night, I would even say, 'I did a few things tonight, and you may not have noticed that I did them, but here is what I did. And this relates back to what the purpose of our professional development is. And we've talked about engaging task or tasks that promote discourse.' But I wanted there to be – 'How would I phrase that? I'm not sure, but I would maybe say, 'A lot of you had really good ideas, but you weren't sharing them in whole group. So, let's just kind of leave thinking about 'does this happen in your classroom? Do you think that student sitting there in the corner, who's ELL, who's not talking, has some really good ideas'? And try to just connect it with their practice, and connect it with how they might be feeling, at the time, 'cause I bet there's people in the room who just don't like talking in whole group. And they might not be making that connection yet. (Excerpt 6 from Rosie, January 11, 2018).

As Rosie continued, she also found herself contemplating the role knowledge of the curriculum content and vision may play *during* instruction for her as a PD leader and participating teachers as practitioners in their classrooms.

And you could also point out that ‘In your classroom, why do you Turn and Talk? Why do you use some of these strategies that we've provided?’ It's because some students do not, are not comfortable, just like you might not be comfortable. And that you, as a teacher, just as I, as a facilitator, need to be moving around and constantly listening, and seeing what's going on, out around the room. I think just that whole modeling, the whole whatever you're trying to facilitate, you have to model through your actions, as well as just standing in the front, teaching it. And that might take more level of – more time and comfort with the (PD) material. (Excerpt 6 from Rosie continued, January 11, 2018).

This excerpt like earlier excerpts reveal that all participants explicitly noticed that, as PD leaders, they support or constrain participating teachers’ learning, because they were charged with implementing the PD. All participants’ noticing also revealed another area of noticing that further highlights the complexity of facilitation that impact PD leaders, namely considering not only participating teachers’ needs as learners within the PD environment but also their simultaneous need as teachers with students as learners within their own classrooms.

**Theme 3: Noticing of participating teachers’ dual learning needs as learners versus practitioners as aligned to PD curricular content and vision.**

All participants were still classroom teachers at the time of the data collection, except Dina who had just left the classroom to serve her first year as a teaching and learning coach in her school. Therefore, it was anticipated that all participants’ noticing would heavily focus on participating teachers as adult learners and that all interpretations would extend to include

classroom application. Other past PD leaders have also cited both areas as important within a PD program (Park Rogers et al., 2007).

Overall, participants contemplated participating teachers' dual needs while simultaneously reflecting on the PD curriculum content and goals, although observed individual variations by participant occurred. At times, the focus naturally shifted more to participating teachers' needs as classroom practitioners and sometimes so much that their attention focused on the needs of classroom students as the main actors of their noticing. Each participant's approach was different, but this theme appeared repeatedly within all participants' noticing. Its presence again exposes the complexity of facilitation and the cognitive processes required to carry out the instructional process. Participants considered participating teachers as learners and the PD curriculum content and goals. Participants also considered participating teachers as practitioners, their elementary classroom curriculum content and standards, learner goals, as well as their role to bridge the two simultaneously within the PD instructional setting as PD leaders. Discussions on connecting participating teachers' dual needs in some way were more pronounced for those watching another's videos. The following excerpt from Dina's noticing reveals that considering the dual needs of participating teachers was a back-and-forth reciprocal noticing process, too. In this excerpt, Dina started to react to participating teachers' expressed concerns after they enacted a discourse strategy as learners during the PD session. She then shifted her focus to their needs as practitioners, which in turn informed her views of their needs as learners and her own decision-making response.

What the participant said about lessons not having closure or things like that and she said that they can go all different ways with the discourse and things. But I think taking it back to some of the things they've done and what you're—that purpose. Having that purpose in your discourse. It shouldn't necessarily go all different ways. So, I think that

she, the participant, was saying something about not knowing where it was gonna go the next day or things like that. So, I don't know. I guess that concerns me that she didn't know what's happening the next day.

So, maybe some conversations, just because I know that they're using the Investigations (district curriculum textbook series) and they were talking about PD and that kind of thing. So, it does have a section in there in the back of professional content and things that maybe reading and seeing what the overall goal is. It may not be that day, might be part of the process that they're working towards, it may not be what she was used to as a closure, you know? That kind of thing, where it's all separate lessons. It may be a little bit broader than that, but I think just making sure to stay on- I think sometimes teachers have to be careful about discourse, not just - I think it's the teacher's responsibility to keep it from going a lot of different directions and not achieving what you're trying to- to get towards, content-wise or strategy-wise, or things like that. And I think that they mentioned some of that in the previous - when they made that chart previously about really being more intentional about what they're going to be doing. Does that make sense?

And when she's [another participating teacher) talking about the vocabulary, I might ask her 'what are some of the things that they've done up until this point that would help them to have that vocabulary'? And I think asking them 'are there some ways that this could help with vocabulary', because if they're having to repeat the active listening and repeat what somebody is saying then they're having a chance to use that vocabulary, as well.

(Excerpt 5 from Dina, January 22, 2018).

It is important to recall that the *Project AIM* design included selecting elementary teacher leaders as PD leaders who taught in some capacity within the same district as the participating

teachers. Just as past research discusses the importance of individual vision regarding curriculum content, the results from this study suggested that these PD leaders not only held visions about curriculum, but also about facilitation and learning practices, as well as well classroom teaching and learning practices. Participants' noticing and underlying reasoning suggest they had expectations that went beyond the PD curriculum, as evidenced in the excerpt from Dina above (see Excerpt 5). Their awareness of participating teachers' dual needs reveal an alignment to select themes participating teachers have expressively valued from a PD, such as a greater focus on classroom application and their needs as learners (Park Rogers, et al., 2007).

The participants' noticing results also suggest that PD-specific facilitation experience may still influence PD leaders' ability to navigate the back and forth noticing process and support participating teachers as both learners and practitioners. This is as evidenced by Rosie and Lois as being the only two participants who went beyond considering participating teachers' dual roles to proposing specific ideas on how to support both roles during PD instruction. In other words, all participants' noticing revealed they perceived these themes as important to facilitation based on the continued resurfacing and simultaneous discussions of these themes. Dina also explicitly used participating teachers' ideas about classroom practices to interpret their needs as adult learners, but Rosie and Lois were able to execute their noticing in a more unified, cohesive manner as Jacobs et al. (2010) described. Both Rosie and Lois' decision-making included activating participating teachers' knowledge and placing them in active roles to address and bridge their own dual needs. In the following excerpt, Rosie revealed her visions of facilitation and learning practices while she explained why she would have followed up on a participating teacher's noticing about trying to steer students' conversation back to the mathematics through a *Project AIM* discourse strategy.

I think the purpose, when you have a room full of teachers, you've got a lot of heads in there that have a lot of experience. So, the whole purpose, the whole beauty of the professional development should be everybody's got something to offer. It's not just the AIM-written up program. It's the ideas all around the room. And I think you have to make sure everybody feels free to share that and feels valued as a member of the PD, that they can contribute. It's not just the facilitator. I guess that would be the purpose there. Just to - there would be more information. It would help the other teachers to deal with such things and it would make the participants feel valued. Still bring up how to get ESL (students) involved, because that's a focus of the program, but to get everybody involved ask 'how can that happen?' It might not be mathematically, at first, but is building that community environment. (Excerpt 7 from Rosie, January 11, 2019).

It is interesting to note that all participants attended to this same particular participating teachers' comment, but Lois' similar decision-making response showed she was the only other participant who noticed an opportunity to draw more participating teachers in to the whole-group discussion to support each other rather than answering herself.

I would have asked if anyone else had similar experiences, as the one who started talking about the misunderstandings that came forth in terms of cards versus tickets, and like what other strategies to use in the classroom with word problems and what not? it shows that *Bet Lines* (a *Project AIM* discourse strategy) are doing their job. That they're getting them to focus on thinking and not just pulling numbers. And that ... we're as guilty of that as the students are. Now she said, 'this probably happens all the time. And we're so focused on the math we don't realize the misconceptions there.' - Hopefully to draw some more people into the conversation 'cause you still have half of the room that hasn't participated at all. Also, I think when you have the issues or suggestions, they always

come across better when they come from someone else in the group, and not the person standing up there who whether you're a classroom teacher or not they forget you're a classroom teacher. (Excerpt 7 from Lois, January 16, 2019).

### **Research Question Two: Summary and Continuing Discussion**

Similarities and differences across and between participants' noticing suggest that participants simultaneously considered multiple issues across these three themes or areas within their role as PD leader facilitating a highly-specified PD program. Their noticing revealed that they were essentially interacting and learning from both the PD designers through the PD curriculum as their educators and the participating teachers during the facilitation process, just as Zaslavsky and Leikin (2004) argued is part of the complex process involved in the construction of a mathematics teacher educator's knowledge. Participants' noticing in this study revealed they valued select themes past participating teachers have expressed they value from a PD, like classroom application (Park Rogers et al., 2007). Participants also heavily attended to participating teachers as learners and PD curriculum. Multiple direct references to the PD curriculum (or sometimes PD designers directly), the facilitator in the video, the participating teachers as adult learners and practitioners, and their own views as PD leaders as observed across participants, although individual differences existed. Together, the results highlight the importance of alignment between stakeholders.

Participants' words indicated they recognized the impact of these three themes or areas of noticing expertise on the facilitation process and their boundary role as the PD leader in the instruction process. Most prominent was that their noticing of the PD curriculum occurred across all three components of attending, interpreting, and deciding how to respond. These results continue to support that the PD curriculum materials mattered to all four participants. The PD curriculum materials, including facilitation supports, suggest their capacity to support

PD leaders' facilitation within a highly-specified PD program. More specifically, participants' noticing suggested that facilitation supports supported and oriented PD leaders towards the PD curriculum they are tasked with implementing. Multiple results point to PD materials, along with their own discerning expectations, as comparative guides to understand participating teachers' thinking. Yet, the pronounced differences between participants with more and less PD-specific facilitation experience regarding the depth in topics mirrored the caution that van Es and Sherin (2017) raised by reminding us that "it is not so simple to align one's vision of a PD program with the intended goals" (p. 2).

The findings from this study indicate that additional PD leader training may be necessary to further help deepen PD leaders' MKPD and align their multiple visions, particularly for novice PD leaders as suggested by earlier research (Elliott et al., 2009). In the final chapter, includes a proposed model based on the participants' noticing that summarizes their three overarching areas of noticing to highlight the complexity of facilitation and discuss possible implications and directions for future research regarding PD leader noticing supports.

## CHAPTER 6: CONCLUSIONS AND IMPLICATIONS

Professional noticing is still an emerging construct and there is no established definition (Jacobs, 2017), but there seems to be a consensus among those studying noticing to view the process and multiple components as an interrelated set of skills executed in an integrated way (Thomas, 2017). The results from this study support this view of noticing. Furthermore, the increased attention that professional noticing has received in mathematics education has helped to continue to expand the noticing construct. This study further pushed these boundaries, while heeding calls by researchers to better understand the process underlying professional noticing and inform the design of training (Criswell & Krall, 2017).

In the previous two chapters, I presented results within and across participants' moment-by-moment noticing as they analyzed PD whole-group discussions and reflected on issues related to facilitation. The findings and discussions provided insight about participating PD leaders' noticing, thereby answering the research questions. The synthesis of this data into key takeaways and themes offered insights relevant to the fields of facilitation and noticing. The results also provide directions for continued research on facilitation and related PD leader noticing supports.

In this concluding chapter, I summarize key takeaways the findings from PD leaders' noticing portrayed about facilitation and the possible implications. Then, I present the main contributions this study offers on noticing and facilitation. Finally, I discuss the next steps for research related to PD leaders' professional noticing and facilitation support.

### **Key Takeaways and Possible Implications**

Level of experience and the focus of analysis influences one's ability to notice like with other skills. All four participants attended to participating teachers' thinking more than the facilitator's actions, revealing these PD leaders may have possessed learner-centric views and

experiences that make them dissimilar to classroom teachers studied in past research (Jacobs et al., 2010; van Es & Sherin, 2008). Observed differences between participants' noticing in particular also drew attention to the complexity of facilitation, suggesting facilitation is as complex and likely more so than classroom teaching. The following takeaways provide some insights participants' noticing offered on facilitation.

### **The Role of Analyzing on One's Own Versus Others' Instruction on PD leaders' Noticing**

First, differences surfaced between the PD leader who viewed her own videos versus those who viewed another's videos. Cecilia was less critical when analyzing her own facilitation compared to those who analyzed her facilitation. Past literature on teacher noticing found teachers who analyzed their own instruction were less critical (Dick, et al., 2018; Seidel et al., 2011), indicating one possible parallel between PD leaders and teachers. However, there was an overlap in topics relevant to PD facilitation and learning between Cecilia's noticing and others' noticing.

Whether the use of video aided Cecilia's noticing process as she analyzed her own instruction is unclear, but video has been found to support the noticing process (Sherin & van Es, 2009). Differences among those who watched another's video were more pronounced by level of PD-specific facilitation experience, but results from analyzing one's own facilitation within this study support earlier findings that professional noticing is not straightforward (Seidel et al., 2017). Furthermore, video limitations that prevented other PD leaders from analyzing their own facilitation in this study suggest that any findings related to this factor are preliminary hypotheses at best and should be investigated in future studies.

Findings from this study remind the reader that methods should match the purpose and goals. The lesser critique observed across Cecilia's noticing raises dialogue about when PD leaders should and should not reflect on their own facilitation. For example, if the focus is to

orient PD leaders to relevant facilitation and learning practices and other critical incidents as part of facilitation training, then noticing through reflecting on others' videos might be the best method of exploration. However, if the goal is for PD leaders to improve their ongoing instruction, then noticing through reflecting on their own facilitation might be beneficial. PD designers would benefit from exploring this idea further.

### **The Role of PD-specific Preparation as a Part of Facilitation Experiences on PD leaders' Noticing**

None of the PD leaders that participated in this study were true novices, each had experience facilitating the PD program that served as the context for this study. Jacobs' et al., (2010) research on teacher noticing found that teachers with more PD experiences focused on student thinking also shared more ideas on how to respond and engaged in the component of deciding how to respond more often. However, Lois and Rosie had more facilitation experiences or greater expertise with the *Project AIM* PD program. Multiple observed differences when examining level of PD-specific facilitation experiences surfaced, with the greatest observed differences within the component of deciding how to respond.

PD leaders' noticing within this study suggested that level of PD-specific experiences related to the context of this study mattered. Dina possessed the greatest overall facilitation experience. Rosie had the second least. While there were observed overlaps across noticing results in Dina, Lois, and Rosie who all viewed others' videos, Dina's noticing results drew into question the role other past facilitation experiences play in noticing. Rosie herself raised the point about how facilitation expertise comes with more time and familiarity with this PD program. This represents another similarity between facilitation and teaching that needs further exploration. Jacobson and Lehrer (2000) revealed that all teachers who had previous PD experiences focused on student thinking maintained an attention on student thinking. Yet, the

same researchers found that only those who advanced their MKT in a *particular* area of focus through professional learning opportunities interpreted and decided how to respond used teaching methods that afforded deeper content-specific learning opportunities. Differences in participants' noticing by level of PD-specific facilitation experience in this study suggested that PD leaders may benefit similarly through learning and facilitating opportunities in that *particular* mathematical area to hone their facilitation skills. If true, this result raises an already ongoing dilemma regarding facilitation and expertise. How much *minimum* PD-specific training might PD leaders require prior to and/or during implementation so participating teachers experience deeper content-specific learning as designers envision?

### **The Role of Curricular and Other Visions on PD leaders' Noticing**

The PD curriculum appeared to influence PD leaders' noticing in this study. The results from PD leaders' noticing in this study revealed that all attended to the scripted PD materials, which included facilitation supports and considered PD curricular goals during interpreting and deciding how to respond. This finding shows promise that PD materials can orient PD leaders to the PD activities and materials as learners, as well as practitioners charged with implementing the designed PD content and goals. However, observed differences in PD leaders' noticing by PD-specific facilitation experience also highlight past cautions about strongly-held curricular attending habits.

Strongly-held curricular attending habits appear to help some PD leaders notice opportunities embedded in curriculum materials; they also influence others to not notice or suggest deviations needed from the design despite the unfolding moments that would benefit from adaptations (Dietiker et al., 2018). PD leaders' noticing results within this study revealed this two-pronged effect. Cecilia explicitly discussed this tension, pointing to one area that novice PD leaders may benefit from better understanding, namely PD designers' underlying intentions

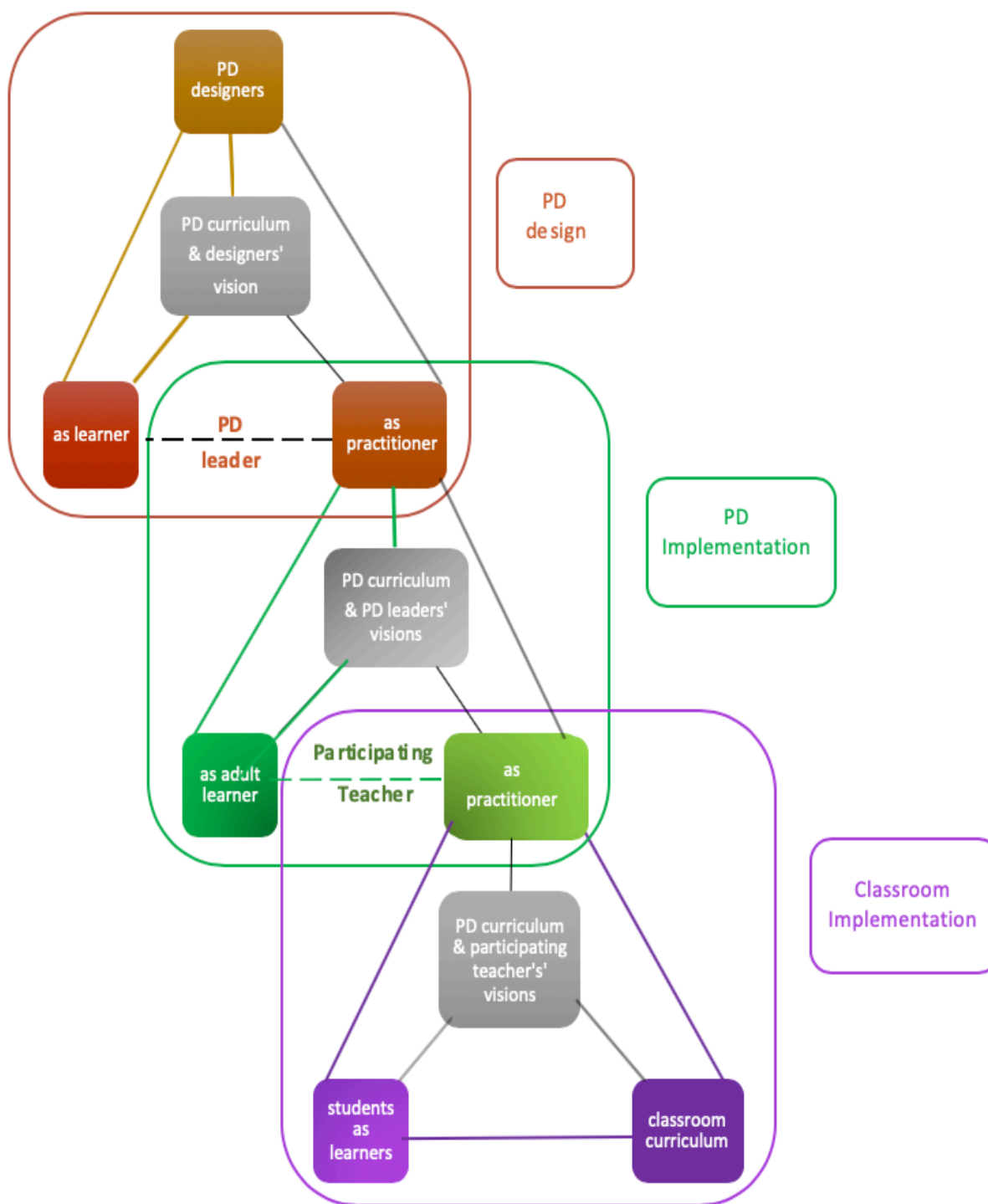
behind the content and materials to support their budding curricular visions. The same evidence that revealed promise in the use of highly-specified PD materials to support stronger curricular visions also suggests they be impeding novice PD leaders' understanding of their choice in making adaptations. Lois' and Rosie's noticing revealed that both held deeper curricular vision. Both Lois and Rosie suggested adaptations that were responsive to the perceived unfolding needs of participating teachers during instruction but continued to consider and support the outlined goals. This is the notion of disciplined improvisation (Borko et al., 2014b)

Uncertainty and tensions in response to PD materials about how to respond among those less PD-specific facilitation experiences indicate that lack of knowledge about the PD content might be a barrier to disciplined improvisation. The results also indicated that novices may benefit from early and ongoing explicit support to bridge their budding PD curricular visions with other visions they already possess and are developing regarding facilitation and learning practices and/or teachers' learning needs as adult learners and practitioners. Cecilia's and Dina's noticing indicate that we have more to learn about how to support PD leaders' engagement in the type of disciplined improvisation that Lois and Rosie envisioned and discussed. Researchers studying facilitation have argued that this complex process underlying the construction of mathematics teacher educator's knowledge involves facilitators interacting and learning from both PD designers and participating teachers (Jacobs et al., 2017). Lois and Rosie did not experience the same uncertainty about how to respond as Cecilia and Dina nor did they express competing interpretations as Cecilia voiced. Lois and Rosie's decision-making implies that these various visions regarding curriculum content, even when highly-specified, and responsive facilitation and learning practices can co-exist through greater MKPD and facilitation experience. Yet, past research cautions that gaining the requisite knowledge to become an effective PD leader takes time and that it is process that is socially constructed and involves in-

depth study and disciplined inquiry (Elliott et al., 2009; Jacobs et al., 2017; Jenlink and Kinnucan-Welsch, 2001).

The three themes found across PD leaders in this study and discussed in the previous chapter showcase three areas of noticing and suggest that facilitation within an elementary mathematics teacher PD setting is likely more complex and requires more extensive knowledge than classroom teaching. The following model summarizes the inherent complexity PD leaders discussed about facilitation as part of their noticing (See **Figure 13**). The figure builds on the Cohen and Ball's (1999) instruction as an interaction triangle model that has been extended to study facilitation (Borko, 2004; Carroll & Mumme, 2007; Nipper & Sztajn, 2008).

For example, Carroll and Mumme (2007) discussed how teaching involves relationships between teacher and student, student and content, and teacher and content, as is similarly shown at the bottom of **Figure 13** in purple and referred to as *classroom implementation*. Carroll and Mumme view the relationships within the PD setting as essentially “bumped out a level” (p. 82). Within the PD setting, the student is the teacher as the adult learner, the teacher is the PD leader, and the content is all that is taught and the complex relationships that teaching entails within the PD setting, including the PD leaders’ understanding of their role in facilitating the learning of participating teachers. **Figure 13** shows this instructional triangle in green within *PD implementation*. The same PD designers view learning to lead mathematics PD curriculum as “bumping this out yet another level” (p. 83). This time the PD forms the curricular content, the student is the PD leader, and the knowledge is required of the teacher, who is the leader of the leader (which in the case of *Project AIM* were the PD designers). Carroll and Mumme state that the knowledge at this level is even more complex, because it involves knowledge of teaching or facilitation and of the PD itself. **Figure 13** shows this instructional triangle in dark orange as part of *PD design*.



**Figure 13.** Proposed model to represent the three areas of moment-by-moment noticing in which PD leaders engage simultaneously.

**Figure 13** extends the model using overlapping instructional pyramids to highlight the complexity of facilitation by portraying intricacies within the three areas of noticing PD leaders' voiced: the PD curriculum as part of the PD design, PD implementation, and classroom implementation. Colors and color variations are used to draw continued attention to the instructional triangles, as well as additions visible within each area by the expansion to pyramids.

For example, PD leaders' noticing revealed that participants considered and made sense of many topics and these relationships involving these different actors *simultaneously*. The shift from triangles to pyramids illustrate participants' noticing of the dual roles for PD leaders and teachers (as shown in dark orange and green color variations), as well as their noticing of PD curriculum in the process (as shown in gray in all three areas). Overlapping the pyramids highlight that PD leaders noticed the interconnectedness of the actors and their distinct roles within these areas (i.e., the role of the actors in one area is connected to their role in the next). The overlapping pyramids also draw attention to the multiple actors and the nested nature of the actors' distinct roles within these three areas and the back-and-forth nature that PD leaders had to navigate to consider the different roles of different actors (i.e., themselves and the participating teachers) as part of the facilitation process. The figure depicts that PD leaders considered the PD content as adult learners and practitioners on a PD design level. PD leaders (as practitioners) also considered the PD content and the dual needs of participating teachers as adult learners and practitioners within PD implementation. PD leaders (as practitioners) even considered participating teachers' and their students' classroom implementation needs.

**Figure 13** portrays added intricacies not included within the instructional triangles previously discussed regarding facilitation. For example, PD leaders noticed PD curriculum as a central actor within and across all three areas related to the PD process. PD leaders also viewed themselves and participating teachers with dual needs and roles. They also continued to focus on

need of classroom needs of students learners and the role of the classroom curriculum as part of the math content within classroom implementation. The *Project AIM* PD program was designed to support the instructional triangles as Carroll and Mumme discuss and are represented by PD implementation, as well as PD design. Yet, this figure shows PD leaders in this study viewed facilitation as more complex than traditional instructional triangles have previously portrayed.

### **Contributions on Noticing and Facilitation**

This multi-case study research design offers multiple contributions to the fields of professional noticing and facilitation within elementary mathematics teacher education.

#### **Promoting New Methods to Directly Study the Professional Noticing Process**

First, this study suggests that there are new methodological means to directly study the noticing process from the perspective of the PD leaders, thanks in part to advancing technology.

The use of video has long served as a pivotal medium to aid researchers studying teacher noticing, but directly accessing their noticing in the moment continues to pose a challenge in directly studying what educators notice *during* instruction (Sherin, Russ, & Colestock, 2011).

One of the earlier researchers who studied noticing and has recently explored innovative technologies demonstrated that video can develop a different type of math knowledge for teaching (i.e., how to interpret and reflect on classroom practices (Sherin, 2004). The technology in this study shows initial potential to access noticing *after* instruction and needs further exploration.

This study demonstrated that technological advances can couple traditional post-teaching interviews to access PD leaders' moment-by-moment noticing on facilitation *after* instruction. New 360 video may aid PD leaders' noticing like other video technology, because it involves what past researchers say is the slowing down of the fast pace of instruction, so that explicit noticing of particular aspects of the discussion can be further analyzed (van Es & Sherin, 2002).

However, 360 videos may better support studying PD leader noticing. The results from this study suggest use of 360 video aids the selective attention PD leaders employ during noticing than stationary video. Therefore, the use of 360 video holds promise within future mathematics research and practice by allowing future PD leaders to analyze their own and others' facilitation and engage in the moment-by-moment noticing process after instruction. This video technology could support noticing of select features in others' videos or noticing of one's own videos at various stages in the PD implementation process as a part of responsive PD implementation and support disciplined improvisation. The use of ill-defined focus within 360 videos also further expands the definition of noticing to include moment-by-moment noticing after instruction. All this while heeding calls to study the underlying noticing process that better informs instruction (Criswell & Knall, 2017). Expanding the construct of noticing is an important goal in the field, given the increased attention to teacher noticing (Sherin, 2017).

### **Extending Professional Noticing Construct to Include PD leaders' Noticing**

This study also further expanded the construct of noticing by studying the noticing of a unique group of teachers who teach fellow teachers as PD leaders. By studying this group and their noticing process, this study opened a new productive avenue for understanding the expertise underlying and driving mathematics PD practices within teacher education. By examining PD leaders as a different group from teachers, this study also cautions against forming generalizations about PD leaders when examining teacher noticing.

Research is continuing to emerge on facilitation, suggesting the timeliness of the study to involve a stakeholder whose perspective has identified as critical to understanding PD program needs (Park Rogers et al., 2007). PD designers' perspectives and values have shed light on the great variation previously seen in PD leaders' implemented actions (Borko et al., 2014b; van Es et al., 2014). This study provided an opportunity to better understand elementary mathematics

PD leaders' noticing process and their perceived facilitation strengths, challenges, and needs. Over a decade ago Even (2008) raised the point that we understand little about the level of expertise and knowledge of PD leaders and how best to support them as they facilitate teacher learning. This study draws attention to understanding what and why PD leaders, including novices, notice.

### **Informing Possible Areas of Facilitation Support Needed Based on PD leaders' Noticing**

By providing PD leaders a voice regarding facilitation through *their* words and observations, this study also raised awareness for the goal of forming a more complete picture on how PD leaders can learn and enact effective decision-making facilitation skills that are aligned to PD designers' visions and the needs of participating teachers raised (Elliott et al., 2011). PD leaders' expressions suggest they are simultaneously noticing and considering the needs of all three stakeholders as part of the PD process. Uncovering PD leaders' noticing provided insights into areas PD leaders may need support. This study offers new directions for future exploration. These findings indicate a need to compare emerging PD designers' and PD leaders' visions and ideas regarding quality facilitation as part of gaining a deeper understanding of facilitation. More specifically, this study raises a need for dialogue between stakeholders on how to engage PD leaders in inquiry-based training that further identify and support their facilitation needs. This study also raises questions for training. How can PD leaders develop a deeper curricular vision as learners? How can PD leaders transfer their knowledge to the PD setting as practitioners that requires responsive facilitation practices? Also, how can PD leaders notice opportunities and engage in decision-making disciplined improvisation?

## Suggested Next Steps for Research

### Additional Areas of Facilitation Support Needed to Scaffold Disciplined Improvisation

These findings uncovered possible promises for noticing and facilitation, including new technological means to study PD leaders' noticing and the noticing of highly-specified PD materials as supports to orient PD leaders to PD curriculum content and goals. The four participants' individual and collective qualitative findings raise important questions that should elicit future research with additional PD leaders.

One next step for research might be to further investigate the decision-making of novice PD leaders prior to or early during the PD implementation process. More information is necessary about the noticing process in which PD leaders with less experience engage to understand why more prompting was necessary to uncover their decision-making. Another important related step would be to build on this study and investigate whether and how more PD leaders notice responsive facilitation practices opportunities around both mathematics knowledge for teaching content and pedagogy. It is likely that the focus of the video content influences PD leaders' noticing, but the limitations of this study prevented explorations of this factor. Future research would also benefit from exploring how facilitation training can support novice PD leaders notice opportunities requiring disciplined improvisation that they may otherwise not notice as they develop their curricular vision around highly-specified PD materials. Future answers may lie in examining PD leaders' characterization of *critical incidents* or pivotal teaching as past literature has discussed (Choppin, 2011; Stockero & Van Zoest, 2013; Taylan, 2015). A further inquiry into PD leaders' perspectives would allow PD designers and researchers to identify alignments and misalignment to better focus facilitation support efforts.

### **Relationships between PD-specific MKPD on Noticing Demands During Instruction**

Another direction for research would be to examine the role of PD leaders' MKPD (Borko et al., 2014b) on PD leaders' noticing process. Differences in PD leaders' noticing in this study indicate that MKPD might serve as a buffer but for those who possess greater PD-specific expertise. If true, it draws attention to addressing ongoing tensions between training and scalability. Training efforts need maximizing to help PD leaders develop a deep knowledge of the PD designers' underlying ideas (Elliott et al., 2009). Yet, training time needs minimizing to train the cadre of PD leaders needed to facilitate across multiple locations (Borko et al., 2014b). It is possible that research should focus their attention on understanding noticing variations observed around deciding how to respond. We need to better understand the role MKPD might play on PD leaders' noticing demands during instruction. We also need to better understand how to support disciplined improvisation and the related underlying integrated noticing process. The findings from this study suggest that PD leaders would benefit from ongoing training about underlying designers' beliefs to deepen their understanding of the highly-specified PD curriculum and how to model facilitation practices that support alignment but allow for responsive decision-making adaptations needed during instruction. Future research may benefit from exploring findings within this study for other factors to explore.

### **Synergistic Relationships between Reflections and Professional Noticing**

Lastly, additional research should examine the relationships between reflection and professional noticing to support what may be synergistic processes. Past research has distinguished between professional noticing and reflection with the former as involving recognition of and deciding how to respond *in* the moment and the latter as involving making sense of such events and proposing how to respond *after* the moment (Teuscher, Leatham, & Peterson, 2017). Criswell & McKrall (2017) distinguished the types of reflections different

settings require, with reflection *in* action when noticing *during* instruction versus reflection *on* action when noticing *after* instruction. This study pushed the boundaries on how video technology can require PD leaders to analyze instruction moment-by-moment *after* instruction.

Further research should investigate how these two constructs can be useful together to support PD leaders to better identify what to reflect on (attending), be more critical when analyzing their own sense making (interpreting) and assist them in determining how to respond upon the outcomes of the reflective process (deciding). Research that includes the use of video to help PD leaders reflect on facilitation and notice instructional opportunities may help advance their decision-making process during instruction. That such a possibility exists to potentially advance PD leaders' noticing *during* instruction through reflections *on* facilitation suggests future research is critical to explore these relationships. By studying the teaching level of facilitation and how to support PD leaders' facilitation and noticing during instruction, we can come closer to providing effective PD that supports teacher learning in mathematics PD.

## REFERENCES

- Amador, J. (2016). Professional noticing practices of novice mathematics teacher educators. *International Journal of Science and Mathematics Education, 14*(1), 217–241.
- ATLAS.ti GmbH (2015). ATLAS.ti Mac (Version 7 [Software]). Available from <http://www.atlasti.com>
- Ball, D. L. (2001). Teaching, with respect to mathematics and students. In T. Wood, B. S. Nelson, & J. Warfield (Eds.), *Beyond classical pedagogy: Teaching elementary school mathematics* (pp. 11–22). Mahwah, NJ: Erlbaum.
- Ball, D. L. (2011). Foreword. In M. G. Sherin, V. R. Jacobs, & R. A. Philipp (Eds.), *Mathematics teacher noticing: seeing through teachers' eyes* (pp. xx–xxiv). New York: Routledge.
- Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching – What makes it special?. *Journal of Teacher Education, 59*(5), 389-407.
- Bell, C. A., Wilson, S. M., Higgins, T., & McCoach, D. B. (2010). Measuring the effects of professional development on teacher knowledge: The case of developing mathematical ideas. *Journal for Research in Mathematics Education, 41*(5), 479-512.
- Bobis, J. (2009). *Count Me In Too. The learning framework in number and its impact on teacher knowledge and pedagogy*. Sydney, Australia: NSW Department of Education and Training.
- Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.
- Borko, H., Jacobs, J., Eiteljorg, E., & Pittman, M. E. (2008). Video as a tool for fostering productive discussions in mathematics professional development. *Teaching and Teacher Education, 24*, 417–436.

- Borko, H., Jacobs, J., Seago, N., & Mangram, C. (2014a). 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). Cham, Switzerland: Springer International Publishing.
- Borko, H., Koellner, K., & Jacobs, J. (2014b). Examining novice teacher leaders' facilitation of mathematics professional development. *The Journal of Mathematical Behavior*, 33, 149–167.
- Borko, H., Koellner, K., Jacobs, J., & Seago, N. (2011). Using video representations of teaching in practice-based professional development programs. *ZDM Mathematics Education*, 43(1), 175–187.
- Brodie, K. (2014). Learning about learner errors in professional learning communities. *Educational Studies in Mathematics*, 85(2), 221–239.
- Brophy, J. (Ed.). (2004). *Advances in research on teaching, Vol. 10: Using video in teacher education*. Oxford, UK: Elsevier.
- Carpenter, T. P., Fennema, E., Franke, M. L., Levi, L., & Empson, S. B. (2015). *Children's Mathematics: Cognitively Guided Instruction*. Portsmouth, NH: Heinemann.
- 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, 499–531.
- Carroll, C., & Mumme, J. (2007). *Learning to lead mathematics professional development*. Thousand Oaks, CA: Corwin Press.
- Carter, K., Cushing, K., Sabers, D., Stein, P., & Berliner, D. (1988). Expert-novice differences in perceiving and processing visual classroom information. *Journal of teacher education*, 39(3), 25-31.

- Corwin, Z., & Clemens, R. F. (2012). Analysing fieldnotes: A practical guide. In S. Delamont (Ed.), *Handbook of qualitative research in education* (pp. 489–502). Cheltenham, Glos, GBR: Edward Elgar Publishing.
- Choppin, J. (2011). The impact of professional noticing on teachers' adaptations of challenging tasks. *Mathematical thinking and learning*, 13(3), 175-197. Retrieved from <http://doi.org/10.1080/10986065.2010.495049>
- Choy, B. H. (2014). Noticing critical incidents in a mathematics classroom. In J. Anderson, M. Cavanagh, & A. Prescott (Eds.), *Curriculum in focus: Research-guided practice*, 143-150. *Proceedings of the 37<sup>th</sup> annual conference of the Mathematics Education Research Group of Australasia*. Sydney: MERGA. Retrieved from [https://www.researchgate.net/profile/Ban\\_Heng\\_Choi/publication/265295522\\_Noticing\\_Critical\\_Incidents\\_in\\_a\\_Mathematics\\_Classroom/links/54080b250cf2bba34c248944.pdf](https://www.researchgate.net/profile/Ban_Heng_Choi/publication/265295522_Noticing_Critical_Incidents_in_a_Mathematics_Classroom/links/54080b250cf2bba34c248944.pdf)
- Cohen, D. K., & Ball, D. L. (1999). *Instruction, capacity, and improvement*. Philadelphia: University of Pennsylvania Press.
- Corwin, Z., & Clemens, R. F. (2012). Analysing fieldnotes: A practical guide. In S. Delamont (Ed.), *Handbook of qualitative research in education* (pp. 489–502). Cheltenham, Glos, GBR: Edward Elgar Publishing.
- Creswell, J. W. (2012). *Qualitative inquiry and research design: Choosing among five approaches* [Kindle DX version]. Retrieved from Amazon.com.
- Creswell, J.W., & Plano Clark, V. L. (2011). *Designing and Conducting Mixed Methods Research*. [Kindle DX version]. Retrieved from Amazon.com.
- Criswell, B., & McNall Krall, R. (2017). Teacher noticing in various grade bands and contexts: Commentary. In E. O. Schack, M. H. Fisher, & J. A. Wilhelm (Eds.), *Teacher noticing:*

- Bridging and broadening perspectives, context, and frameworks* (pp. 21- 30). Cham, CH: Springer International Publishing.
- Darling-Hammond, L., Wei, J., Andree, A., Richardson, N., and Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad*. Oxford, OH: National State Development Council.
- DeCuir-Gunby, J. T., & Schutz, P. A. (2016). The role of theory in mixed methods research. In *Developing a mixed methods proposal: A practical guide for beginning researchers* (pp. 17 – 32). Los Angeles, CA: SAGE.
- Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, 38(3), 181–199.
- Dick, L., Sztajn, P., Foote White, T., & Heck, D. (2018). Investigating sociopedagogical norms: Teachers' discussions about own and others' instruction. *Teaching and Teacher Education*, 71, 297 – 307. Retrieved from <https://doi.org/10.1016/j.tate.2018.01.004>
- Dietiker, L., Males, L. M., Amador, J. M., & Earnest, D. (2018). Curricular noticing: A comprehensive framework to describe teachers' interactions with curriculum materials. *Journal for Research in Mathematics Education*, 49(5), 521-532.
- Driscoll, M., Nikula, J., DiMatteo, R. W., & Eagan, M. (2008). *The fostering geometric thinking toolkit: A guide for staff development* (Vols. 1-4). Portsmouth, NH: Heinemann.
- Doerr, H. M. (2006). Examining the tasks of teaching when using students' mathematical thinking. *Educational Studies in Mathematics*, 62(1), 3–24.
- Drake, C., & Sherin, M. G. (2009). Developing curriculum vision and trust: Changes in teachers' curriculum strategies. In J. T. Remillard, B. A. Herbel-Eisenmann, & G. M. Lloyd (Eds.), *Teachers at work: Connecting curriculum materials and classroom instruction* (pp. 321-

- 337). New York: Routledge Taylor, and Francis.
- Dyer, E. B. & Sherin, M. G. (2015). Instructional reasoning about interpretations of student thinking that support responsive teaching in secondary mathematics. *ZDM Mathematics Education*, 48(1-2), 69 – 82. .
- Elliott, J. (2012). Gathering narrative data. In S. Delamont (Ed.), *Handbook of Research Methods on Intuition* (pp. 281–298). Cheltenham, Glos, GBR: Edward Elgar Publishing.
- Elliott, R., Kazemi, E., Lesseig, K., Mumme, J., Carroll, C., & Kelley-Peterson, M. (2009). Conceptualizing the work of leading mathematical tasks in professional development. *Journal of Teacher Education*, 60, 364–379.
- Ephratt, M. (2011). Linguistic, paralinguistic and extralinguistic speech and silence. *Journal of pragmatics*, 43(9), 2286-2307.
- Ericksson, K. A., & Simon, H. (1993). *Protocol analysis: Verbal reports as data*. Cambridge, MA: MIT Press.
- Even, R. (2008). Facing the challenge of educating educators to work with practicing mathematics teachers. In T. Wood, B. Jaworski, K. Krainer, P. Sullivan, & T. Tirosh (Eds.), *The international handbook of mathematics teacher education: The mathematics teacher educator as a developing professional* (Vol. 4). Rotterdam, The Netherlands: Sense.
- Fernandez, C., Llinares, S., & Valls, J. (2012). Learning to notice students' mathematical thinking through on-line discussions. *ZDM Mathematics Education*, 44(6), 747–759. Retrieved from <https://doi.org/10.1007/s11858-012-0425-y>
- Franke, M. L., Carpenter, T. P., Levi, L., Fennema, E. (2001). Capturing teachers' generative change: A follow-up study of professional development in mathematics. *American Educational Research Association*, 38(3), 653 - 689.

- Fredenberg, M. D. (2015). Factors considered by elementary teachers when developing and modifying mathematical tasks to support children's mathematical thinking (Doctoral dissertation, UC San Diego). Retrieved from <https://escholarship.org/uc/item/1hb9w06s>
- Forsey, M. (2012). Interviewing individuals. In M. Sinclair (Ed.), *Handbook of Research Methods on Intuition* (pp. 364–376). Cheltenham, Glos, GBR: Edward Elgar Publishing.
- Franke, M. L., Webb, N. M., Chan, A. G., Ing, M., Freund, D., & Battey, D. (2009). Teacher questioning to elicit students' mathematical thinking in elementary school classrooms. *Journal of Teacher Education, 60*(4), 380-392.
- Gardiner, W. (2012). Coaches' and new urban teachers' perceptions of induction coaching: Time, trust, and accelerated learning curves. *The Teacher Educator, 47*(3), 195-215.
- Gilbert, L. S., Jackson, K., di Gregorio, S. (2014). Tools for analyzing qualitative data: The history and relevance of qualitative data analysis software. In M. J. Spector, J. M., Merrill, M. D., Elen, J., & M. J. Bishop (Ed.), *Handbook of research on educational communications and technology* (pp. 221–236). New York, NY: Springer.
- Goldsmith, L. T., Doerr, H. M., & Lewis, C. C. (2014). Mathematics teachers' learning: A conceptual framework and synthesis of research. *Journal of Mathematics Teacher Education, 17*, 5–36.
- Goldsmith, L. T., & Seago, N. (2008). Using video cases to unpack the mathematics in students' mathematical thinking. In M. S. Smith & S. N. Friel (Eds.), *Cases in mathematics teacher education: Tools for developing knowledge needed for teaching* (AMTE Monograph 4) (pp. 133-145). San Diego, CA: Association for Mathematics Teacher Educators.
- Google Drive. (2012). Available from <https://www.google.com/drive/>
- Ingram, J., & Elliott, V. (2014). Turn taking and 'wait time' in classroom interactions. *Journal of Pragmatics, 62*, 1-12. Retrieved from <https://doi.org/10.1016/j.pragma.2013.12.002>

- Jacobs, V. R. (2017). Complexities in measuring teacher noticing: Commentary. In E. O. Schack, M. H. Fisher, & J. A. Wilhelm (Eds.), *Teacher noticing: Bridging and broadening perspectives, context, and frameworks* (pp. 273 - 279). Cham, CH: Springer International Publishing.
- Jacobs, V. R., Lamb, L. L., & Philipp, R. A. (2010). Professional noticing of children's mathematical thinking. *Journal for Research in Mathematics Education*, 41(2), 169 -202.
- 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.
- Jacobs, V. R., Seago, N., & Koellner, K. (2017). Preparing facilitators to use and adapt mathematics professional development materials productively. *International Journal of STEM Education*, 4, 30. Retrieved from <https://doi.org/10.1186/s40594-017-0089-9>.
- Jacobson, C., & Lehrer, R. (2000). Teacher appropriation and student learning of geometry through design. *Journal for Research in Mathematics Education*, 31(1), 71–88.
- Jenlink, P. M., & Kinnucan-Welsch, K. (2001). Case studies of facilitating professional development. *Teaching and Teacher Education*, 17, 705–724.
- Kazemi, E., Elliott, R., Mumme, J., Carroll, C., Lesseig, K., & Kelley-Petersen, M. (2011). Noticing leaders' thinking about videocases of teachers engaged in mathematics tasks in professional development. In M. G. Sherin, V. R. Jacobs, & R. A. Philipp (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes* (pp. 97–116). New York, NY: Routledge.
- Koellner, K., Jacobs, J., & Borke, H. (2011). Mathematics professional development: Critical features for developing leadership skills and building teachers' capacity. *Mathematics Teacher Education and Development*, 13, 115–136.

- Kowal, S., & O'Connell, D. C. (2014). Transcription as a crucial step of data analysis. In U. Flick (Ed.), *The SAGE Handbook of qualitative data analysis* (pp. 64–78). London, UK: SAGE Publications Ltd.
- Linder, S. M. (2011). The facilitator's role in elementary mathematics professional development. *Mathematics Teacher Education and Development, 13*(2), 44–66.
- LoCascio, S. J., Smeaton, P. S., & Waters, F. H. (2016). How induction programs affect the decision of alternate route urban teachers to remain teaching. *Education and Urban Society, 48*(2), 103–125.
- Luna, M., Russ, R., & Colestock, A. (2009). Teacher noticing in-the-moment of instruction: The case of one high school teacher. Paper presented at the annual meeting of the National Association for research in science teaching (NARST), Garden Grove, CA.
- Krebs, A. S. (2005). Analyzing student work as a professional development activity. *School Science and Mathematics, 105*(8), 402–411.
- Martino, A. M., & Maher, C. A. (1999). Teacher questioning to promote justification and generalization in mathematics: What research practice has taught us. *The Journal of Mathematical Behavior, 18*(1), 53–78.
- Marvasti, A. B. (2014). Analyzing observations. In U. Flick (Ed.), *The SAGE handbook of qualitative data analysis* (pp. 354–367). London, UK: SAGE.
- Mason, J. (2002). *Researching your own practice: The discipline of noticing*. London: Routledge.
- Mason, J. (2011). Noticing: Roots and branches. In M. G. Sherin, V. R. Jacobs, & R. A. Phillip (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes*. New York, NY: Routledge.

- Maxwell, J. A. (2005). *Qualitative research design: An interactive approach* (Vol. 41). Thousand Oaks, CA: Sage.
- Merriam, S. B. (2009). Qualitative case study research. In *Qualitative research: A guide to design and implementation* (pp. 39–54). San Francisco, CA: Jossey-Bass.
- Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: SAGE.
- Namey, E. E., & Trotter, R. T., III. (2005). Qualitative research methods. In G. Guest, & E. E. Namey (Ed.), *Public health research methods* (pp. 443–482). Los Angeles, CA: SAGE.
- National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Retrieved from <http://standards.com.nctm.org/document/index.htm>
- National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards for mathematics*. Washington, DC: Authors.
- Nipper, K., & Sztajn, P. (2008). Expanding the instructional triangle: Conceptualizing mathematics teacher development. *Journal of Mathematics Teacher Education*, 11(4), 334- 341.
- Odell, S. J., & Ferraro, D. P. (1992). Teacher mentoring and teacher retention. *Journal of Teacher Education*, 43(3), 200-204.
- Park Rogers, M., Abell, S., Lannin, J., Wang, C., Musikul, K., Barker, D., & Dingman, S. (2007). Effective professional development in science and mathematics education: Teachers' and facilitators' views. *International Journal of Science and Mathematics Education*, 5, 507 – 532.
- Patton, M. Q. (2015). *Qualitative research & evaluation methods* (4th ed.). Los Angeles, CA: SAGE.

- Pitoe, V. J., & Maila, W. M. (2012). Towards constructivist teacher professional development. *Journal of Social Sciences*, 8(3), 318-324.
- Philipp, R., Jacobs, V. R., & Sherin, M. G. (2014). Noticing of mathematics teachers. In S. Lerman (Ed.), *Encyclopedia of Mathematics Education* (pp. 465-466). Dordrecht: Springer.
- Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research*, 75(2), 211-246. Retrieved from <https://doi.org/10.3102%2F00346543075002211>
- Rosaen, C. L., Lundenberg, M., Cooper, M., Fritzen, A., & Terpstra, M. (2008). Noticing noticing: How does investigation of video records change how teachers reflect on their experiences? *Journal of Teacher Education*, 59(4), 347-360.
- Roulston, K. (2014). Analysing interviews. In U. Flick (Ed.), *The SAGE handbook of qualitative data analysis* (pp. 297–313). London, UK: SAGE Publications Ltd.
- 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.
- Saldana, J. (2008). An introduction to Codes and Coding. In *The Coding Manual for Qualitative Researchers*. Los Angeles: Sage Publications.
- Schoenfeld, A. H. (1998). Towards a theory of teaching-in-context. *Issues in Education*, 4(1), 1–94.
- Schifter, D. (2011). Examining the behavior of operations: Noticing early algebraic ideas. In M. G. Sherin, V. R. Jacobs, & R. A. Philipp (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes* (pp. 204–220). New York: Routledge.
- Seago, N. M., Jacobs, J. K., Heck, D. J., Nelson, C. L., & Malzahn, K. A. (2013). Impacting teachers' understanding of geometric similarity: Results from field testing the Learning

- and Teaching Geometry professional development materials. *Professional Development in Education*. Advance online publication. Retrieved from <https://doi.org/10.1080/19415257.2013.830144>
- Seago, N., Mumme, J., & Branca, N. (2004). *Learning and teaching linear functions: Video cases for mathematics professional development, 6–10*. Portsmouth, NH: Heinemann.
- Seidman, I. (2013). *Interviewing as qualitative research* (4<sup>th</sup> ed.). New York: Teachers College Press.
- Seidel, T., Stürmer, K., Blomberg, G., Kobarg, M., & Schwindt, K. (2011). Teacher learning from analysis of videotaped classroom situations: Does it make a difference whether teachers observe their own teaching or that of others?. *Teaching and Teacher Education*, 27, 259 – 267.
- Sherin, M. G. (2001). Developing a professional vision of classroom events. In T. Wood, B.S. Nelson, & J. Warfield (Eds.), *Beyond classical pedagogy: Teaching elementary school mathematics* (pp. 75-93). Mahwah, NJ: Erlbaum.
- Sherin, M. G. (2007). The development of teachers' professional vision in video clubs. In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 383-395). Mahwah, NJ: Erlbaum.
- Sherin, M. G. (2017). Exploring the boundaries of teacher noticing: Commentary. In E. O. Schack, M. H. Fisher, & J. A. Wilhelm (Eds.), *Teacher noticing: Bridging and broadening perspectives, context, and frameworks* (pp. 273 - 279). Cham, CH: Springer International Publishing.
- Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, 20, 163-183.
- Sherin, M. G., Jacobs, V. R., & Philipp, R. A. (2011a). Situating the study of teacher noticing. In

- Mathematics teacher noticing: Seeing through teachers' eyes*. New York, NY: Routledge.
- Sherin, M. G., Russ, R. S. (2015). Teacher noticing via video: The role of interpretive frames. In B. Calandra & P. J. Rich (Eds.) *Digital Video for Teacher Education: Research and Practice*. New York, NY: Routledge.
- Sherin, M. G., Russ, R. S., & Colestock, A. (2011). Accessing mathematics teachers' in-the-moment noticing. In M. G. Sherin, V. R. Jacobs, & R. A. Phillip (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes*. New York, NY: Routledge.
- Sherin, M. G., Russ, R. S., Sherin, B. L., & Colestock, A. (2008). Professional vision in action: An exploratory study. *Issues in Teacher Education*, 17(2), 27-46.
- Sherin, M. G., & van Es, E. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of Technology and Teacher Education*, 13, 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.
- Silver, E.A., & Suh, H. (2014). Professional development for secondary school mathematics teachers using student work: Some challenges and promising possibilities. In S. Li, Y., Silver, E. A., Li (Ed.), *Transforming mathematics instruction: Multiple approaches and practices* (pp. 283-309). Cham, Switzerland: Springer.
- Simon, M. A., Tzur, R., Heinz, K., Kinzel, M., & Smith, M. S. (2000). Characterizing a perspective underlying the practice of mathematics teachers in transition. *Journal for Research in Mathematics Education*, 31(5), 579-601.
- Stahnke, R., Schueler, S., & Roesecken-Winter, B. (2016). Teachers' perception, interpretation, and decision-making: A systematic review of empirical mathematics education research. *ZDM Mathematics Education*, 48(1), 1 - 27.

- Stake, R. E. (2006). *Multiple case study analysis*. New York: NY: Guilford Press.
- Star, J.R., Lynch, K., & Perova, N. (2011). Using video to improve preservice mathematics teachers' abilities to attend to classroom features. In M. G. Sherin, V. R. Jacobs, & R. A. Phillip (Eds.), *Mathematics teacher noticing: Seeing through teachers' eyes* (pp. 117-133). New York: Routledge.
- Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve preservice teachers' ability to notice. *Journal of Mathematics Teacher Education*, *11*, 107-125.
- Stein, M. K., Remillard, J., & Smith, M. S. (2007). How curriculum influences student learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 319–369). Charlotte, NC: Information Age Publishing.
- Stein, M. K., Smith, M. S., Silver, E. A. (1999). The development of professional developers: Learning to assist teachers in new settings in new ways. *Harvard Educational Review*, *69*, 237 - 269.
- Stein, M. K., & Smith, M. S. (2011). Mathematical tasks as a framework for reflection: From research to practice. *Mathematics Teaching in the Middle School*, *3*(4), 268-275.
- Stigler, J. W., & Hiebert, J. (2009). Closing the teaching gap. *The Phi Delta Kappan*, *91*(3), 32 – 37.
- Stockero, S. L., Van Zoest, L. R. (2013). Characterizing pivotal teaching moments in beginning mathematics teachers' practice. *Journal of Mathematics Teacher Education*, *16*, 125-147.  
Retrieved from <https://doi.org/10.1007/s10857-012-9222-3>
- Sun, J., & van Es, E. A. (2015). An exploratory study of the influence that analyzing teaching has on preservice teachers' classroom practice. *Journal of Teacher Education*, *66*(3), 201–214.
- Superfine, A. C., Fisher, A., Bragelman, J., & Amador, J. M. (2017). Shifting perspectives on

- preservice teachers' noticing of children's mathematical thinking. In E. O. Schack, M. H. Fisher, & J. A. Wilhelm (Eds.), *Teacher noticing: Bridging and broadening perspectives, context, and frameworks* (pp. 273 - 279). Cham, CH: Springer International Publishing.
- Sztajn, P. (2003). Adapting reform ideas in different mathematics classrooms: Beliefs beyond mathematics. *Journal of Mathematics Teacher Education*, 6, 53 – 75.
- Sztajn, P., Borko, H., & Smith, T. M. (2017). Research on mathematics professional development. In J. Cai, (Ed.) *Compendium for Research in Mathematics Education*. Reston, VA: NCTM.
- Sztajn, P., Heck, D., & Malzahn, K. (2013). Project AIM: Year three annual report. Raleigh, NC: North Carolina State University (Chapel Hill, NC: Horizon Research, Inc).
- Sztajn, P. Marrongelle, K. & Smith, P. (2012, March). Supporting implementation of Common Core State Standards for Mathematics: Recommendations for professional development. Retrieved from <http://cadrek12.org/resources/supporting-implementation-common-core-state-standards-mathematics-recommendations-professi>
- Taylan, R. D. (2015). Characterizing a highly accomplished teacher's noticing of third-grade students' mathematical thinking. *Journal of Mathematics Teacher Education*, 20(3), 259 – 280. Retrieved from <http://doi.org/10.1007/s10857-015-9326-7>
- Tekumru-Kisa, M. & Stein, M. K. (2017). Designing, facilitating, and scaling-up video-based professional development: Supporting complex forms of teaching in science and mathematics. *International Journal of STEM Education*, 4(27), 1 – 9. Retrieved from <http://doi.org/10.1186/s40594-017-0087-y>
- Teuscher, D., Leatham, K. R., & Peterson, B. E. (2017). From a framework to a lens: Learning to notice student mathematical thinking. In E. O. Schack, M. H. Fisher, & J. A. Wilhelm (Eds.), *Teacher noticing: Bridging and broadening perspectives, context, and*

- frameworks* (pp. 273 - 279). Cham, CH: Springer International Publishing.
- Thomas, J. N. (2017). The ascendance of noticing: Connections, challenges and questions. In E. O. Schack, M. H. Fisher, & J. A. Wilhelm (Eds.), *Teacher noticing: Bridging and broadening perspectives, context, and frameworks* (pp. 273 - 279). Cham, CH: Springer International Publishing.
- Thompson, A. G. (1984). The relationship of teachers' conceptions of mathematic and mathematics teaching to instructional practice. *Educational Studies in Mathematic*, 15(2), 105 – 127.
- van Es, E. A. (2012). Examining the development of a teacher learning community: The case of a video club. *Teaching and Teacher Education*, 28(2), 182-192.
- 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, 571-596.
- van Es, E. A., & Sherin, M. G. (2006). How different video club designs support teachers in “learning to notice”. *Journal of Computing in Teacher Education*, 22, 125-135.
- van Es, E. A., & Sherin, M. G. (2008). Mathematics teachers' “learning to notice” in the context of a video club. *Teaching and Teacher Education*, 24, 244–276.
- van Es, E. A., & Sherin, M. G. (2017). Bringing facilitation into view. *Journal of STEM Education*, 4(1), 1-6. Retrieved from <https://doi.org/10.1186/s40594-017-0088-x>
- van Es, E. A., Tunney, J., Goldsmith, L. T., & Seago, N. (2014). A framework for the facilitation of teachers' analysis of videos. *Journal of Teacher Education*, 65, 340–356.
- Yackel, E. & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education*, 27(4), 458 –477.

Yin, R. K. (2003). *Case study research: Design and methods* (Vol. 5). Thousand Oaks, CA: Sage.

Zaslavsky, O., & Leikin, R. (2004). Professional development of mathematics teacher educators: Growth through practice. *Journal of Mathematics Teacher Education*, 7(1), 5-32.

**APPENDICES**

## Appendix A: Participant Consent Form

### *Gaining Insight into PD Leaders' Perspectives during the Mathematics Professional Development Process: A Multi-Case Study of Four Elementary PD Leaders' Noticing*

Dear Participant,

The following information is provided for you to decide whether you wish to participate in the present study. You should be aware that you are free to withdraw at any time.

The purpose of this comparative narrative case study is to gain insight into selective noticing skills of PD leaders that taught the same university-led elementary mathematics PD to their fellow elementary teachers. In this exploratory study, incidents that you (as participants) notice are intended to remain open based on your interpretation of "interesting", but the overall analyses will include topics guided by prior research in addition to topics cited by you (as participants).

Data will be collected at 4 points, including a pre-meeting interview. Data collection sources will involve a pre-meeting background interview (transcripts per PD leader), three video-based, noticing interview sessions (transcripts per interview for each PD leader), screen recordings of select audiovisual materials (pre-selected video clips of whole-group discussions from prior PD sessions) and researcher notes and memos. All interview sessions will be videotaped. You are one of four elementary PD leaders that comprise the total number of participants for this data collection.

Please do not hesitate to ask any questions about the study either before or during the time you are participating. I would be happy to share my findings with you for verification after the tentative research is completed and again when my write-up is complete. However, I want to assure you that your name will not be associated with the research findings, and only I, as the student researcher, will know your identity as a participant.

There are no known risk and/or discomforts associated with this study. The expected benefits associated with your participation are the information you may learn about your own noticing skills and the opportunity to participate in a qualitative research study. Your data will become part of my dissertation, but will not be used towards a future publication without your express written permission.

Please sign and date your consent with full knowledge of the nature and purpose of the procedures. A copy of this consent form will be given to you to keep.

Participant Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Researcher Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
Mona Tauber, Mathematics Education, NCSU, Student Researcher

**Appendix B: Video-based Noticing Interview Plan and Timeline**

<b>Time</b>	<b>Interview #</b>	<b>Video Clip WG Focus Prompts &amp; Video Length</b>	<b>Main PD Activities (Context)</b>
<b>Dec 2017</b> <b>45-60 min ea</b>	<b>Pre-interview</b>	n/a (met to explain study, gain formal consent, conduct background interview, and familiarize participant with 360-degree video viewing feature of sample PD video clip)	n/a (See the following <a href="#">Appendix C</a> for pre-interview guide)
<b>Jan 2018</b> <b>1-1.5 hr ea</b>	<b>Interview 1</b>	<b>Video Clip 1: 0:09:50 – 0:14:27 (abt. 4.5 min) – Session 8</b> <b>Video Clip 2: 42:00 – 48:37 (abt 6.5 min) – Session 8</b> <b>Video Clip 3: 0:53:15 – 1:01:53 (abt. 8.5 min) – Session 8</b>	<b>Debrief Connection to Classroom Practice Task, Considering Access for English Learners during Planning, &amp; Recap Main Ideas</b>
<b>Session 8</b>	Think Aloud 1: 15-20 min	Debrief Connection to Classroom Practice Task (after implementation of Bet Lines strategy) <ul style="list-style-type: none"> <li>• “What was one success and one challenge of implementing the Bet Lines strategy in your classroom?”</li> <li>• “What insights did you gain into your students’ mathematical thinking by using the Bet Lines strategy?”</li> <li>• “How did the Bet Lines strategy support student, in particular English learners, engagement with the story problem and their mathematical discussions?”</li> </ul>	Debrief Connections to Classroom Practice Task (references mentioned from Facilitation Session 8 Plan, p. 5, Slide 4)
<b>Session 8</b>	Think Aloud 2: 20-25 min	Looking Back at Math Task 1 & 2 (after receiving Task Features and Discourse handout) <ul style="list-style-type: none"> <li>• Based on the features of tasks that promote discourse and limit discourse, how would you characterize Math Task 1? Math Task 2?</li> <li>• What is your evidence (e.g., what features do you notice)?</li> </ul>	Characterizing Mathematics Tasks (references mentioned from Facilitation Session 9 Plan, p. 12, Slide 13)

<b>Session 8</b>	Think Aloud 3: 25-30 min	<p>Whole Group Discussion (after reading article)</p> <ul style="list-style-type: none"> <li>• “What are important features of tasks that support discourse and equitable access in the classroom?”</li> <li>• “When selecting tasks during the planning of a lesson, what can you do to make sure you have discourse-promoting tasks that are accessible to <b>all</b> your students?”</li> <li>• “What are challenges in finding such tasks?”</li> </ul> <p>High Expectations and English Learners “High expectations combined with a teaching and learning environment in which meanings are co-constructed by teachers, students, and parents will greatly increase the success of inner-city Latino children in mathematics.” (pg. 187)”</p> <ul style="list-style-type: none"> <li>• How does this statement relate to your own experiences teaching English learners?</li> </ul>	Considering Access for English Learning During Planning (references mentioned from Facilitation Session 8 Plan, p. 13, Slides 14-15)
<b>Jan 2018</b>  <b>1-1.5 hr ea</b>	<b>Interview 2</b>	<p><b>Video Clip 4: 49:12 – 58:03 (abt. 9.5 min) – Session 9</b>  <b>Video Clip 5: 0:26:48 – 0:31:00 (abt 4 min)</b>  <b>Video Clip 6: 1:05:38 – 1:09:34 (about 4 min)</b>  <b>Video Clip 7: 1:18:56 – 1:25:12 (about 6 min)</b></p>	<b>Talk Chain in Action &amp; LEA in Action</b>
<b>Session 9</b>	Think Aloud 4: 30-40 min	<p>Summary of Key Ideas (at end of PD session)</p> <ul style="list-style-type: none"> <li>• “What important ideas did you learn about the Think Aloud and Draft &amp; Final Copy strategies?”</li> </ul> <p>Recap Key Ideas (if and as necessary)</p> <ul style="list-style-type: none"> <li>• “The Think Aloud strategy is meant to engage students in understanding the task and its context.”</li> <li>• “The Draft &amp; Final Copy strategy is meant to help students think through and discuss solutions to a problem and create a well-organized representation of their collective mathematical thinking for sharing with the whole group.”</li> </ul>	Recap Main Ideas (references mentioned from Facilitation Session 9 Plan, pp. 23 – 24, Slide 35)

<b>Session 10</b>	Think Aloud 5: 15-20 min	After Scripted Talk Chain Prompt (“What type of mathematics discourse do you think is most used in your school? What evidence do you have for that?”) <ul style="list-style-type: none"> <li>Ask participants if they have any initial questions about the Talk Chain strategy.</li> </ul>	Talk Chain in Action (references mentioned from Facilitation Session 10 Plan, p. 13, Slide 16)
<b>Session 10</b>	Think Aloud 6: 15-20 min	LEA Classroom Script <ul style="list-style-type: none"> <li>“How is the discussion and creation of the ‘story’ helping students summarize and make sense of the key mathematical ideas about subtraction?”</li> </ul>	LEA in Action (references mentioned from Facilitation Session 10 Plan, pp. 21-22, Slide 33)
<b>Session 10</b>	Think Aloud 7: 20-25 min	Compare the LEA Experiences <ul style="list-style-type: none"> <li>In what ways did each LEA experience support/hinder students in making sense of the key mathematical ideas about subtraction?</li> <li>What are some important teacher questions or actions that help guide the mathematical conversation in each experience?</li> </ul>	LEA in Action (references mentioned from Facilitation Session 10 Plan, pp. 23-24, Slide 36)
<b>Feb 2018</b>  <b>1 – 1.5 min ea</b>	<b>Interview 3</b>	<b>Video Clip 8: 0:11:10 – 0:18:26 (abt 7 min)</b> <b>Video Clip 9: 0:49:26– 0:58:03 (about 7.5 min)</b> <b>Video Clip 10: 1:06:05 – 1:10:46 (abt 4.5 min)</b>	<b>Debrief Connection to Classroom Practice Task (own stdt work analysis) &amp; Mini-Lesson: Questions to Ask Yourself (handout)</b>
<b>Session 12</b>	Think Aloud 8: 25-30 min	Debrief Connection to Classroom Practice Task (own student work analysis) <ul style="list-style-type: none"> <li>Briefly describe the mathematics lesson. <ul style="list-style-type: none"> <li>What were your goals?</li> <li>What was the task?</li> <li>How did you Launch/Explore/Discuss the lesson? What strategies did you use?</li> </ul> </li> <li>Select <b>1 piece</b> of student work to share with your small group. <ul style="list-style-type: none"> <li>What did this student’s work tell you about his/her mathematical understanding of subtraction?</li> </ul> </li> <li>Any additional “wonderings”?</li> </ul>	Debrief CCP about their experience planning and implementing a lesson using a responsive discourse-promoting task and analyzing two pieces of student work (references mentioned from Facilitation Session 12 Plan, p 6, Slide 5)

<b>Session 12</b>	Think Aloud 9: 30-35 min	<p>Questions to Ask Yourself (questions &amp; ideas about handout)</p> <ul style="list-style-type: none"> <li>• Which questions need further clarification?</li> <li>• Which questions do you find particularly helpful for planning lessons that promote responsive discourse and engage ALL students, including English learners?</li> </ul>	Questions & Ideas about Mini-Lesson: <i>Questions to Ask Yourself</i> handout
<b>Session 12</b>	Think Aloud 10: 15-20 min	<ul style="list-style-type: none"> <li>• What could be the teacher's goals? <ul style="list-style-type: none"> <li>○ Mathematics content?</li> <li>○ Discourse?</li> </ul> </li> </ul> <p>How would you describe or map this lesson? (+ image of the three phases of Math Teaching Guide)</p> <ul style="list-style-type: none"> <li>• Discussion on how to characterize the mathematics discourse took place after they moved into small group discussions for about 2 minutes (starts at 1:11:22 – 1:13:43; that last part is only partially captured on the 360 video – abt 1 min, so can't watch fully)</li> </ul>	The Original Lesson: Straw Javelin Contest (references from Facilitation Session 12 Plan, pp. 16-17, Slides 19-20)

## Appendix C: Pre-Interview Protocol on PD Leaders' Backgrounds

### Demographic Questions:

#### 0 Background:

- a. **Demographics (gender, race):** female, white
- b. **Current credentials** (degrees earned, incl. major, minor –whether math ed or not; endorsements, other credentials & where studied/earned degrees):
- c. **Years of teaching experience (incl. elementary) & years of experience teaching math (incl. elementary and years of experience using CCSS-M standards or mathematical practices):**
- d. **Awards earned (if any):**
- e. **Current position (& grade level if applicable):**
- f. **Current district/school committees:**
- g. **Years of PD facilitation experience (type (i.e., workshops, ongoing highly-specified PD, etc.), duration of each, & focus/purpose of each; include all–encourage PD leader to elaborate as needed to capture facilitation experience before and after Project AIM):**

### Questions on mathematics facilitation experiences and current self-perceptions:

**I would now like to ask you some questions to get an idea of your views and experiences teaching math to elementary teachers (i.e., math PD leader), but please feel free to also consider experiences teaching math elementary children if/as if helps you consider your answer as a PD leader. (Please add on and/or explain anything beyond what I ask.)**

1. **How comfortable do you feel as a PD leader or teacher of other teachers and having mathematical conversations with them that require discussing and promoting newer approaches to teaching and learning math concepts and practices since more recent**

**CCSS-M standards and practices were adopted?**

- a. Do you feel equally comfortable discussing math content and pedagogy?**

**Explain.**

- b. How strong do you think your math content and pedagogical knowledge are?**

**Elaborate** (e.g. may mention knowledge of alternative or multiple student approaches/strategies, setting up lessons that require to learn and use CCSS-M mathematical practices, etc.).

- 2. Do you teach or have you taught other topics to teachers outside the area of mathematics –whether in your district or elsewhere?**

- a. If yes, which? Explain.**

- 3. What have you learned as a PD leader from your different facilitation experiences?**

Current instructional views as a mathematics PD leader:

- 4. What expectations do you have for yourself as a PD leader during math instruction and discussions? What do you expect of the teachers? (i.e., what is your role versus their role?)**

- 5. I'd like to gain some more insight into how you plan for and use math discourse when you serve as a PD leader.**

- a. Do you think discourse is important for teacher to advance their own MKT?**

**Why (& what are the benefits)?**

- b. What are some challenges when holding discussions with fellow teachers (for you and other teachers)?**

- c. How have your fellow teachers responded to talking about math? (give an exp. if possible)**

- 6. I'd also like to learn a little about your current perceptions of math.**

- a. Do you see your roles for teaching and learning math as similar or different from how you were taught math? (Feel free to consider your own former teachers growing up, university instructors that taught math methods courses, or even fellow teachers who led PD you have taken.) If different, which experiences and/or training has helped you change your approach to teaching and learning math?
  - b. How do you formatively assess or gauge whether teachers have reached the goals you set or are on the right path during instruction? How comfortable are you redirecting teachers when needed to move towards the goals?
7. Which overall goals do you have as a PD leader for teachers who teach elementary school math?
8. How well do you think most elementary teachers understand the current math concepts and skills themselves – meaning: do they understand the standards, and more specifically, the concepts and skills they are expected to teach? Explain.
  - a. How (if at all) does that impact your views on teaching and the learning for you as a PD leader?
  - b. How does it impact your role as a PD leader (may mention benefits and/or challenges)?

Support/Opportunities for Own MKT Growth:

9. I'd like to learn a little about other opportunities you have received to help you grow professionally as a teacher and PD leader of mathematics.
  - a. What forms of support have you received within your district to help you advance your own MKT (human or other materials as resources)? Do you

**work with other in your district on a periodic or regular basis (e.g. in a PLT)? Explain.**

**b. What forms of support have you sought outside your district (e.g. university classes)? Explain.**

**10. Which of these resources and/or opportunities have helped you as a PD leader better gain the knowledge and methods needed to teach recently adopted mathematics curriculum and practices to fellow teachers? Explain.**

**11. Are there any supports or opportunities you wish you still had or still want, so you can continue to grow as a PD leader?**

Open “Forum” Question

**12. What else, if anything, would you like to share about your story as you progressed from teaching math an elementary teacher to now also teaching fellow teachers as a PD leader?**

### **Appendix D: Semi-Structured, Video-Based, Noticing Interview Protocol**

Each interview will follow this same overall semi-structured format:

Say only during 1<sup>st</sup> initial interview:

**The video was captured using a 360° camera. That means you can scan the entire PD setting at all times similar to if you were physically present right now. It has not been edited, so the video shows all that was happening at that particular time during the PD, but it is trimmed to start at the beginning of that particular whole group interaction and end when that whole group interaction ends.** Now briefly demonstrate how to navigate 360° viewing feature using the sample video clip. Provide participants sufficient time to navigate the video clip using the feature tool. Allow participants to ask questions and feel comfortable enough, so they can begin to shift their focus to the content rather than solely navigating the tool.

Say during 1<sup>st</sup> video-based, noticing interview only, but make framework available at the start of each subsequent session (if needed):

**You have experience as a PD leader, including for Project AIM. As you know, I am interested in what you notice as a PD leader when viewing a whole-group activity between teachers and a PD leader who participated in the Project AIM PD. The questions I will ask you will revolve around the three areas of this noticing framework.** Now show a copy of the framework and briefly explain each of the three components that comprise noticing according to Jacobs et al. (2010); See Appendix E).

Repeat the following set of instructions at the start of each noticing interview:

**All video clips we will watch together come from the same one 2016-2017 cohort. While the WGDs we will watch during our sessions together will vary in length, please pause the video clip whenever you notice something that catches your attention – anything**

you find it **“interesting”**. You can pause the video clip as often as you like during the viewing, but if you do not pause the video clip within any 3-minute span, I will pause it after 3 minutes lapses or once the clip ends, whichever comes first. During each time we pause, I want you to think aloud to share what you found interesting and why. While continuing to point to each of the three components, ask: **Feel free to continue by sharing what that particular aspect you found interesting meant to you (what you understand about that aspect) and why. Please continue to share how you would respond if you were facilitating at this moment and why. I will ask the same questions involving the areas mentioned in the framework.**

Repeat the following set of instructions prior to each Think Aloud (before each new video clip watched):

**We will now view another video clip of a whole-group (WG) activity from the same/different PD session. Prior to this WG activity...provide a context and brief summary of the math activity teachers engaged in prior to the WC activity; display any handouts teachers received, facilitation notes, and/or show video footage needed to help PD leaders gain background of what happened prior to this WG activity. **The WG prompt they are about to discuss is: ...share WG prompt. Do you have any other questions regarding the activity?****

**(OPTIONAL RESEARCHER PROMPTING):** As needed, ask one or more the following questions during each video clip viewing pause to capture all aspects of participant’s noticing revolving around the three components within the noticing framework (revisit Appendix E):

- 1) Ask to seek attending: **Please share what you found interesting and/or caught your attention at this moment.**
- 2) (regarding reasoning): **Why was this interesting to you?**

- 3) Ask to seek interpreting &/or further reasoning: **What does XX (reference whichever action, words, strategy use or other event to which the PD leader attended) mean to you or what does that help you understand about XX (e.g., about the teachers' understandings about mathematics)?** (Seek explanation. If needed/unclear, clarify and/or probe further).
- 4) **Anything else you want to add on to explain what XX means to you?**
- 5) Ask to seek deciding how to respond &/or further reasoning: **How would you respond if you were facilitating at this moment? Why?**
- 6) **Is there anything else that you would want to learn or do at this moment before you would move on? (If yes) Please share.**
- 7) Ask if PD leader says yes to Question 6 and repeat asking questions 1-6 until the answer is no to Question 6. **Is there anything else that stood out to you or you found interesting at this moment or up to this point in the video clip?**

To ask at the at end of interview session only:

- 8) Ask after all Think Alouds during that session: **Is there anything else you noticed during this WG interaction that you want to discuss? Explain.**
- 9) Ask after all Think Alouds during that session, including final Think Aloud during the final session: **You had a choice when navigating the focus when viewing the 360 video clips. How did you decide what to focus on as the whole group interaction was unfolding on the screen?**

### Appendix E: Video-based, Noticing Interview Guiding Framework \*



Definitions to help you understand the three interrelated noticing components or skills I would like you to focus on:

- a) *attending*: what you observe (or observe is missing) that you find interesting at any given moment (e.g., some action(s), a teachers' response/words, or something else),
- b) *interpreting*: how you make sense of what you observed (i.e., what you specifically infer, analyze, and/or reason about what you know or understand based on what you found interesting),
- c) and *deciding how to respond*: how you would specifically plan to respond based on your own interpretation

\* components from the Jacobs, et al. (2009); self-created, decomposed definitions for purposes of this study

### Appendix F: Emerging Codebook with Examples

	Code	Definition *P = participating teacher *F = facilitator	Examples	Past Research Guidance (if applicable), with number key
1.	<i>participating teachers' thinking or understanding</i>	<p>Focused on substance of the ideas raised by participating teachers. Usually involves a direct reference to <u>participating teachers' words or non-verbal communication as an indication of their thinking or understanding</u> (1).</p> <p>Focus may involve expressing uncertainty about Ps' current understanding within focus or direct confusion about ideas expressed by Ps, or even <u>desire to pursue teacher thinking or desire to make sense of what P was thinking (known as pursues P thinking or sense-making)</u> (2)</p> <p>It does NOT include a reference to a non-verbal cue, e.g., nodding (in agreement) without reference to P thinking or understanding. However, wanting to follow up to find out more from others might indicate a desire to understand P thinking or understanding if that is directly stated.</p>	<p>“She (P) voiced a common challenge...I would like to hear if others had a similar challenge or have an idea on how to solve it.”</p> <p>“I am unsure if the teacher understood the purpose of the strategy or she was just concerned with broadening participation.”</p> <p>“I wonder, which way it is? It is that she just doesn't have time and everybody wants to have it and then they're all like, "Oh man"? Or is it like she actually thinks everybody has to have a chance to share?”</p> <p><b>NON-EXAMPLE:</b> “I found it interesting that multiple teachers were nodding, but nobody was voicing their ideas in response.”</p>	<p>(1) = Sherin, M. G., Russ, R. S., Sherin, B. L., &amp; Colestock, A. (2008)</p> <p>(2) = Stockero, S. L., Van Zoest, L. R. (2013)</p>
2.	<i>participating teachers' engagement or participation</i>	<p>Focused on <u>the quality or amount of</u> (1) teacher <u>participation in a given moment</u> (1)</p> <p>This could also include referencing <u>the need to broadening participation to engage more Ps</u> (3).</p> <p>It could also include mention of how to engage more Ps or reference to lack of</p>	<p>“I found it interesting that multiple teachers were nodding, but nobody was voicing their ideas in response. I think that's a problem given it's a PD about teaching discourse. “As the facilitator I would want Ps involved into this discussion.”</p>	<p>(1) = Sherin, M. G., Russ, R. S., Sherin, B. L., &amp; Colestock, A. (2008)</p> <p>(3) = van Es, E. A., Tunney, J., Goldsmith,</p>

		<p>participation or engagement. It may even mention encouraging Ps to speak.</p> <p>It could also be a reference to P’s non-verbal body language cues, e.g. looking at the speaker versus looking at cell phone or other a non-verbal cue, e.g., Ps nodding (to show some participation or involvement)</p>	<p>“I find myself looking what those around the speaker are doing. Are they paying attention or are they checked out?”</p>	<p>L., &amp; Seago, N. (2014)</p>
<p>3.</p>	<p><b><i>participating teachers’ MKT or readiness to learn</i></b></p>	<p>Any attention to <u>participating teachers’ current or future mathematical understanding</u> (4). It might be a reference to <u>structure the conversation to arise for the purpose of supporting deeper understanding</u> (4). It could also include concern about <u>the current needs of Ps to further their mathematical understanding</u> (4) (content or pedagogy).</p> <p>This type of understanding could apply to their readiness to learn or MKT as adult learners or practitioners in the classroom, but must directly reference what they need to know.</p> <p><u>This could include emphasizing the meaning of the mathematics, Ps’ sense-making</u> (2) (not the same as participant trying to make sense of Ps’ knowledge – see #1, but may occur together), or <u>error or confusion on the part of one or more Ps in relation to MKT/math understanding (incorrect mathematics, mathematical contradiction, or P confusion)</u> (2). It could be related their content understanding or pedagogical understanding</p>	<p>“...I think that’s due to lack of content knowledge. So, they’re following along with [the curriculum series], without considering the professional development piece.”</p> <p>“...I think just that just that they're noticing where the students are and what types of strategies that they're using is important to know. Well [laughs], because I think there's a lot of teachers that don't really understand subtraction....”</p> <p>“...the article was accessible to them. They understood what the purpose in the article was, they agreed with the ideas and the concepts that were offered in the article...It's tough when you offer up literature, and it's just out of the boundaries of where they're ready to be in that moment.... not because they're incapable...sometimes an article could be a little challenging to fully digest. But it seemed as though this literature piece was fully digestible, and that they were on it, and that they agreed, and they could immediately connect it to their own classroom, to their own experiences.”</p>	<p>(4) = Elliott, R., Kazemi, E., Lesseig, K., Mumme, J., Carroll, C., &amp; Kelley-Peterson, M. (2009)</p> <p>(2) = Stockero, S. L., Van Zoest, L. R. (2013)</p>

<p>4.</p>	<p><b><i>participating teachers' concerns</i></b></p>	<p>Like #1 above, it does focus on Ps' expressed ideas, but rather than revealing or trying to understand Ps' thinking or understanding of a concept or idea, this is about how Ps directly express some concern and/or how their words reveal a perceived P concern in the eyes of the PD leader who is observing the clip. The concern could be regarding <u>any</u> topic expressed within the PD setting – e.g., MKT, barrier, carrying out discourse strategy in classroom etc.</p> <p>This may involve any comment or question P raises at that moment. It may also involve the desire to address or further discuss a P concern that is perceived to be valid or invalid. It may even lead into discussion on solutions related to P concerns.</p> <p>This code usually gets coded with another that expresses the nature or theme of the P concern (e.g., if the expressed concern is about desire to promote discourse but expressed difficulty with time to involve more of their students, then also coded with #16 below).</p>	<p>“...She (P) voiced a common challenge...I would like to hear if others had a similar challenge or have an idea on how to solve it.”</p> <p>“...I think she (P) said something about not knowing what was gonna be next day or things like that...I guess that concerns me that she didn't know what's happening the next day...”</p> <p>“Well, they're being open and honest, and sharing maybe new challenges that they foresee. I would hope that they're also, you know, thinking about, "Okay, what could we do to, um, help this challenge?" But I kinda doubt that...I would want to channel that back in...”</p>	
<p>5.</p>	<p><b><i>anticipation of expected responses</i></b></p>	<p>Reference to <u>expected or unexpected P solutions or responses on any topic</u> (5) (words or actions, related to math or pedagogy). This could be for any reason, e.g. they possess background knowledge or experience, so it may appear as participants compare it to some other source to express some expectation.</p> <p>If related to ideas about the classroom instruction, may rely on own <u>past</u></p>	<p>“...I have a feeling she (F) just killed the chain...Because now instead of it continuing naturally, like it's supposed to happen, she got involved once there was no one assigned anymore – And I think now other people aren't going to be able to jump in. But maybe I'll be wrong...”</p> <p>“... We skipped explore. Okay, that's what I was expecting.... Cause I was anticipating, you heard me... she may</p>	<p>(5) = Kazemi, E., Elliott, R., Mumme, J., Carroll, C., Lesseig, K., &amp; Kelley-Petersen, M. (2011)</p> <p>(6) = Sherin, M. G., Russ, R. S. (2014)</p>

		<p><u>experience of teaching and how students responded to predict responses (6)</u>                  If related to ideas about the PD instruction, may rely <u>on own recollection of past Ps from the time of their own facilitation experience(s) to predict responses. (6)</u></p> <p>This does NOT include instances when participant read the anticipation notes from the F <u>guide at the time of the interview</u> to express that is expect (NOTE: these are PD designer notes on what to anticipate or expect). Instead, this is meant to capture when a participant anticipates using their own MKPD/knowledge of the PD, past experiences, P current thinking, etc.</p>	<p>have skipped it because they'd already talked about think-pair-share...”</p> <p>“I would...and maybe that will come a bit further...”</p>	
6.	<b><i>recollection from own past facilitation experience</i></b>	<p>Participant’s <u>recollection of own past instructional experiences (6)</u> as facilitator (related to Project AIM or otherwise). Essentially the viewer is making a connection between what is viewed to her own past facilitation experience</p> <p>This could be remembering one’s own facilitation experience or trying out a strategy in a classroom with students during the time when they a facilitator for the PD. It could also be recalling how former participants responded in the past.</p>	<p>“...Because we used to do that and that. Oh my goodness, the discussions were amazing because they had to....”</p> <p>“...So, this didn't surprise me. I saw this too (laughs) ... they had trouble with it...”</p>	(6) = Sherin, M. G., Russ, R. S. (2014).
7.	<b><i>facilitator response or preparedness</i></b>	<p>This involves any reference <u>regarding the facilitator’s decisions or actions (4)</u> in the video clip. It could be a positive comment or negative concern, so any attention to F’s decisions or actions made. It could also involve vocalizing possible tensions involved in observed facilitator decision at that moment.</p>	<p>“...I think that shows the teacher did not understand the purpose. I think it’s the facilitator’s job to address it. I expected her to do that, but she didn’t. I might first want to know if anyone else thinks the same by asking for responses, but I would not have let this conversation end without ensuring she understood, because there may be</p>	(4) = Elliott, R., Kazemi, E., Lesseig, K., Mumme, J., Carroll, C., & Kelley-Peterson, M. (2009).

		<p>It could involve expressed comments about concerns or tensions with working with adult learners.</p> <p>It could also be an understanding of the F’s decision, stating they likely would not done the same (e.g., whether sensed hesitation to make Ps’ confusion public, which they understand and might not address or validating the decision the P made in response.)</p>	<p>others who also don’t fully understand when to use this strategy.”</p> <p>“I don’t think the F should pretend to have all the answers either, but it is important for Ps to discuss possible problems with...”</p> <p>“I’d like to believe I would have done the same in this moment if I were facilitating. I would want to be understanding of the situation, but I admit it bothers me when...”</p>	
<p>8.</p>	<p><b>facilitator move suggestion*</b></p>	<p>Could also focus on F desired or undesired decision/action <u>in response to something unanticipated, such as change in instruction</u> (1)</p> <p>OR commonly used instructional routines (e.g., wait time, restating Ps’ ideas, asking another P to revoice the idea, etc.) (1)</p> <p>Could be:</p> <ul style="list-style-type: none"> <li>- <u>Orienting group to the task or maintaining a focus on the task or key ideas</u> (3)             <ul style="list-style-type: none"> <li>a) <b>Launching</b> (3) pose prompt to elicit P ideas</li> <li>b) <b>Contextualizing</b> (3) provide additional information about the classroom context and mathematics lesson</li> <li>c) <b>Redirect</b> (3) shift discussion to maintain focus back on task</li> <li>d) <b>Point to evidence</b> (3) use evidence to reason</li> </ul> </li> </ul>	<p>“I, too, might have wanted to go on, but she asked a relevant question, so I would have stopped to see where it was going.”</p> <p>“I really think this is time to just employ wait time. It’s a complex idea and the Ps might need to think. If that alone doesn’t get Ps talking, I might ask Ps to turn and talk to a partner and then share out as a whole group.”</p> <p>“...that might be a good time to refer back to the Matrix. If we’re discussing <i>why</i> now, and you’re saying that’s beyond where were you when you started this, at the beginning of the year? What level discourse was happening in your classroom and where are you now? And let’s go back and review what that looks like...”</p>	<p>(1) = Sherin, M. G., Russ, R. S., Sherin, B. L., &amp; Colestock, A. (2008).</p> <p>(3) = van Es, E. A., Tunney, J., Goldsmith, L., &amp; Seago, N. (2014). AND Tekkumu-Kisa &amp; Stein (2017)</p> <p>(7) = Project AIM PD program (unpublished)</p>

		<ul style="list-style-type: none"> <li>e) <b>Make connections</b> (3) between Ps' ideas raised during the discussion</li>   <li>- <u>Sustaining an inquiry stance</u> (3)             <ul style="list-style-type: none"> <li>a) <b>Highlighting or Lifting Up</b> (3) provide direct attention or orienting Ps to noteworthy idea presented by another P to emphasize and/or for further discuss</li> <li>b) <b>Offering an example explanation</b> (3) provide interpretation as example</li> <li>c) <b>Countering</b> (3) offer an alternative point of view</li> <li>d) <b>Clarifying</b> (3) F restating P's idea or P revoicing another P's ideas</li> <li>e) <b>Pressing</b> (prompt Ps to explain their reasoning and/or elaborate on their ideas)</li> </ul> </li>   <li>- <u>Supporting group collaboration</u> (3)             <ul style="list-style-type: none"> <li>a) <b>Validate Ps' ideas</b> (3) confirm and support Ps' contribution</li> <li>b) <b>Distributing participation</b> (3) invite Ps to share different ideas or call on specific Ps who have not shared to engage them into the process</li> <li>c) <b>“standing back”</b> (3) decision by F to NOT interject when Ps are talking</li> </ul> </li> </ul> <p>Could reference F using <u>AIM-specific discourse strategy or part of the strategy</u> (7)</p>		
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		at that moment. See #14 below for list of strategies.		
9.	<b>Discourse or interaction</b>	<p><u>Focused on conversation or interaction between (1) F &amp; P or P &amp; P (7). This could refer to any process by which ideas were articulated and discussed in a group setting.</u></p> <p>(1)</p> <p>Examples may be negative, e.g. referencing miscommunication or a lack of conversation.</p> <p>It could even refer to an attention to issues that are impacting the discourse and communication due to what different people are doing during the interaction. In others, they may be recognizing a breakdown in communication.</p>	<p>“I don’t think that’s what she (P) just said. It seemed like the F was adding a lot more to what the participant had said.”</p> <p>“No one is talking.”</p> <p>(Ps and F talking) “They (Ps) are talking right now. They are not listening to her.”</p>	<p>(1) = Sherin, M. G., Russ, R. S., Sherin, B. L., &amp; Colestock, A. (2008).</p> <p>(7) = Project AIM PD program (unpublished)</p>
10.	<b>PD Climate</b>	<p>Reference to the <u>social environment</u> (8) (e.g., group dynamics, cohesion, lack of cohesion, enjoyment, or even grouping or other arrangement that impacts the climate). It is different from #14 below, because this looks at the perceived human side or issues that impact the emotional or social aspects of PD environment.</p>	<p>“The participants seemed to really enjoy that activity.”</p> <p>“I really do not like the setup of the room. People have their backs to each other, so we can’t see them or their reactions.”</p>	<p>(8) = van Es, E. A., &amp; Sherin, M. G. (2008)</p>
11.	<b>PD Structural Elements</b>	<p>This could be any non-human structural element of the PD setting (e.g., transition time, <u>PD resources/materials like The Discourse Matrix, The Math Teaching Guide, other handouts</u> (7))</p>	<p>“I wonder if they are looking for some resource. Maybe <i>The Discourse Matrix</i>. I am curious because I don’t know why that would need it right now. It is definitely a transition time.”</p> <p>“...I guess the only thing I'm really noticing right now is what they're talking about matches with what the facilitator notes...”</p>	<p>(7) = Project AIM PD program (unpublished)</p>

<p><b>12. <i>specific PD activity expectations</i></b></p>		<p>Reference to meeting activity goals explicitly referenced in PD curriculum guide. This is different from #13 below in that someone is discussing goals and outcomes at the specific activity level. The focus is on addressing the specific questions or working towards the outlined activity goals.</p> <p>Like any other codes that overlap, references to both addressing the activity questions and some broader goal or purpose should receive both codes.</p>	<p>“...So, I'm not sure if she was talking about somebody that was an ELL learner or not, because the original question was about whether it helped the ELL learners...”</p> <p>“...I think that was a goal of this discussion...to find out what the difference is in the discussion. What was happening that was not happening in the other, and vice versa? How did it play out? So, they're highlighting all those...”</p> <p>“...I felt like the responses and the participants weren't particularly on task and answering the questions that were asked of them. Um, they weren't giving specifics...”</p>	
<p><b>13. <i>broader PD Goals</i></b></p>		<p>Reference to meeting a broader PD goal, whether explicitly or implicitly outlined by Project AIM within PD curriculum guide and other materials.</p> <p>For example, Project AIM is a PD focused on mathematics discourse and strives for greater student-student OR P-P discourse, known as responsive discourse, so might reference the importance of Ps talking to each other and less F talk; Project AIM also focuses on including all learners in the mathematics classroom, so may reference English Language learners or emergent communicators.</p> <p>Project AIM also outlines overall goals for each session, so participant might reference</p>	<p>“...That participant did a good job of kind of tying it back into the ELL. Just that I know in previous sessions, they were trying to make that connection with those- with those students....</p> <p>“...it all comes back to purposeful planning, and what you can have a really cool strategy but if you're not planning a purpose for it, what's your mathematical purpose, what's your discourse purpose, then it's just a time filler...I think there's a way to bring back the discussion they just had about that cool thing back to the teacher guide that the majority of the work is behind the scenes... you could go back to so we've given you a lot of strategies in</p>	

		<p>these overarching goals. Must be an explicit reference to a goal or purpose within the PD program.</p> <p>This does not include general goal of every math teacher PD to advance teachers' MKT/</p>	<p>this PD hat you choose to use at the correct, at the right time for your purpose..."</p>	
14.	<i>Project AIM discourse strategies/scaffolds and/or their purposes</i>	<p>Could reference AIM-specific discourse strategy or part of the strategy at that moment, but for highlighting benefits. This is different from recommending their use as a F move (#3), but these strategies include:</p> <ul style="list-style-type: none"> <li>- <b>Turn and Talk</b> (7) both partners share</li> <li>- <b>Think-Pair-Share</b> (7) , aka Think-Pair-Rehearse-Share think individually, share with partner, then share with whole group</li> <li>- <b>Think Aloud</b> (7) modeling own thinking</li> <li>- <b>Retelling</b> (7) saying again in own words</li> <li>- <b>Draft &amp; Final Copy</b> (7) group creates copy and revises to present final copy</li> <li>- <b>Talk Chain</b> (7) revoices last idea, then shares own idea</li> <li>- <b>Talk Triangle</b> (7) involves talker, listener, and questioner</li> <li>- <b>Bet Lines</b> (7) make predictions</li> <li>- <b>Four Square</b> (7) 4 representations</li> <li>- <b>LEA or Language Experience Approach</b> (7) summarizes concepts learned</li> </ul>	<p>"...if the purpose of Bet Lines is..., I would ask..."</p> <p>"... I would like for them to have a conversation about the role of the teacher in draft and final copy. Because the one person's comment about..."</p> <p>"...They never mentioned that draft and final copy is usually done in a group...Oh, you could kill conversation with draft and final copy if it wasn't implemented correctly. So, I'm going to go with the assumption they know that they're all supposed to be working together and not individually, but it will be interesting to see..."</p>	(7) = Project AIM PD program (unpublished)
15.	<i>facilitation or learning needs or roles at PD level</i>	<p>Reference to ideas related to the <u>roles of the F/P OR facilitation or adult learning need</u> (4) that requires attention at that moment. Within the PD setting. It could be about how to teach concepts, promoting</p>	<p>"...I think that shows the teacher did not understand the purpose. I think it's the facilitator's job to address it. I expected her to do that, but she didn't. I might first want to know if anyone else</p>	(4) = Elliott, R., Kazemi, E., Lesseig, K., Mumme, J., Carroll, C., &

		<p>connections to some overarching goal/PD goals, planning ahead, modeling behavior, or other such concern that is part of the duties of the F or P during the PD process. The focus is at a broader level, not a reaction to the particular facilitation within the video clip, which is a different code (see F responses)</p> <p>It could be a positive or negative concern or focus, so any attention to decisions made that impact the teaching or learning process. It could also involve vocalizing possible tensions involved in observed facilitator decision at that moment and the perceived participants' needs.</p> <p>It could involve expressed comments about concerns or tensions with working with adult learners in a PD setting.</p> <p>It could also support the F's decision, stating they likely would not done the same, but must still be related to the instructional process.</p>	<p>thinks the same by asking for responses, but I would not have let this conversation end without ensuring she understood, because there may be others who also don't fully understand when to use this strategy."</p> <p>"I don't think the F should pretend to have all the answers either, but it is important for Ps to discuss possible problems with..."</p> <p>"I'd like to believe I would have done the same in this moment if I were facilitating. I would want to be understanding of the situation, but I admit it bothers me when..."</p>	<p>Kelley-Peterson, M. (2009).</p>
<p>16.</p>	<p><i>teaching or student learning needs at classroom level</i></p>	<p>Similar to #15 above, but the focus is on the classroom level. So, references are about <u>participating teachers as practitioners with their students in their classrooms</u> (1). Participants might reference the teacher's or students' roles or their needs within the mathematics classroom instructional setting. The difference to #11 is that the focus is on the classroom level.</p> <p>Focus might be on attention to T implementation at the classroom level. It reveals a consideration of teachers' practice-</p>	<p>"I question "Are they (students) more engaged and talking more because they're being given very procedural algorithm task? I could really want that discussion to happen with the teachers."</p> <p>"...I would, as a facilitator, wanna make sure I definitely spent time like circling back to them after they had played with them in the classroom with students. And seeing kind of what they said and what they thought. You know, how did they prepare for think alouds to make</p>	<p>(1) = Sherin, M. G., Russ, R. S., Sherin, B. L., &amp; Colestock, A. (2008).</p>

		<p>based needs or challenges to implement the ideas within their own classroom.</p> <p>Focus might be on teaching and learning issues impacting students and their learning within the classroom. Like #10 above, it reveals a consideration of the teachers or students who are impacted by the choices the Ps make in their own classroom as teachers.</p> <p>This may involve a focus on students' learning needs or issues that impact their understanding during instruction. It may also involve challenges students or teachers face that impact <u>instruction</u>. It could also include issues that only impact subgroups, like ELs.</p> <p>NOTE: not just any mention of students, student subgroup, or teachers gets this code. Instead, they must draw attention to instruction at the classroom issue. If this is a follow up to a perceived P concern (see #12 below), it may get both codes.</p>	<p>sure they knew where to stop? Did they notice their students were just mimicking them? Or were they starting to actually be able to share their thinking and their process? How did draft and final copy work? How much support did they offer the students while they were working on it? ...”</p> <p>“...so they mentioned challenges they faced...so what are some solutions? ...”</p> <p>“...So, how can you as the facilitator of your classroom, just as I'm facilitating this PD, get us back to learning about the strategy we're supposed to learn about and talking about the question that was initially asked. Because in your classroom, if it goes south, you want to have a strategy to bring it back...”</p>	
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## Appendix G: Idea Unit Coding Scheme

### 1) ATTENDING:

- a. **Actor(s)** of Focus (individual who is the subject of focus, human or non-human; code all that apply):
  - i. *Facilitator* (reference to facilitator in the viewed video clip)
  - ii. *Participating Teachers* (reference to one or more adult learner in the viewed video clip)
  - iii. *PD curriculum/PD designers* (reference to ideas promoted through PD curricular materials or those who designed the PD curriculum materials)
  - iv. *Student at classroom level* (reference to students in general within the classroom setting or students within participating teachers' classrooms)
  - v. *Other* (reference to another human non-human element seen in viewed video clip, e.g., PD setting)
- b. **Topic(s)** (area or issue of focus; see list of generated codes in Appendix F above; code all that apply)

### 2) INTERPRETATIONS:

- a. **Stance(s)** (nature of interpretation; code all that apply)
  - i. *Evaluative* (judgmental statements, positive or negative)
  - ii. *Literal* (recounting of events or retelling to describe events that occurred within the viewed video clip)
  - iii. *Analytic* (shared inferences with provided specific evidence or detail cited as reasoning or explanations)

AND

- b. **Level of Specificity** (only one)
  - i. *General* (without details or specifics in explanation and/or reasoning)
  - ii. *Specific* (with details in reasoning from within video or outside the video)

AND

- c. **Source of Inference(s)** (boundary of events examined; code all that apply)
  - i. *Within Video* (i.e., reference to some element viewed within the viewed video clip)
  - ii. *Outside Video* (i.e., reference to some element outside the viewed video clip)

AND

- d. **Topic(s)** (area or issue of focus; see list of generated codes in Appendix F above; code all that apply)

### 3) DECIDING HOW TO RESPOND:

- a. **Response Type** (proposed decision, with level of certainty; code only one)
  - i. *No new decision/Proceed* (no proposed decision expressed or recommendation to continue as planned or observed)
  - ii. *Uncertainty/Conditional* (expressed uncertainty about how to proceed or what to do and/or expressed a stipulation that must precede before decision would be carried out)
  - iii. *New Decision* (proposed decision expressed that is new or different than observed so far)

AND

- b. **Relative Point(s) of Reasoning** (relative positionality for reasoning; code all that apply)
- i. *No/little Reasoning* (vague/unclear or no reasoning expressed)
  - ii. *Retrospective Reasoning* (reference to past event that already happened in relation to time when proposing next step, whether within or outside video)
  - iii. *Prospective Reasoning* (reference to future event that is yet to occur in time, including if they share anticipated responses based on proposed next step)
- AND
- c. **Topic(s)** (area or issue of focus; see list of generated codes in Appendix F above; code all that apply)

### Appendix H: Audit Trail

Date	Topic	NOTES
7/2017	Contacted 4 potential PD leaders separately via email regarding willingness to participate in this exploratory study; explicitly stated that this was just an initial email to determine interest and that I would seek formal consent once my plan is approved	Reason: purposeful sample; all share same phenomenological experience of Project AIM facilitation & taught last two most recent iterations of PD
7/2017	received reply from P1; informally agreed to participate via email	Disclosed to P that I will be in touch once I receive approval for formal consent & to set up dates/times
7/2017	received reply from P2; informally agreed to participate via email	Disclosed to P that I will be in touch once I receive approval for formal consent & to set up dates/times
7/2017	received reply from P3; informally agreed to participate via email	Disclosed to P that I will be in touch once I receive approval for formal consent & to set up dates/times
7/2017	received reply from P4; informally agreed to participate via email	Disclosed to P that I will be in touch once I receive approval for formal consent & to set up dates/times
9/2017	Received committee approval to begin pilot study and continue with proposed study	
10/2017	Received reply from two other former Project AIM facilitators; both agreed to participate via email	
11/2017	Conducted pilot study with two other former Project AIM facilitators	Each thanked through a gift card
11/2017	Received IRB approval as exempt from the policy as outlined in the Code of Federal Regulations (Exemption: 46.101. Exempt b.2)	
11/2017	Contacted four former PD leaders again to request participation and set up initial pre-interview session	
12/2017	Received formal consent and conducted initial pre-interview sessions with all four participants	

1/2018 – 2/2018	Data collection (conducted all 10 think alouds during planned 3 noticing interviews with all four participants)	Each participant received \$100 Amazon gift card after completing final noticing interview
3/2018- 4/2018	Sent and received interview data as transcripts	
4/2018- 5/2018	Checked all transcripts and cleaned up data to segment data into 40 total think alouds (10 per participant)	
5/2018- 6/2018	First peer review	Use math ed peer (see methods for procedure)
5/2018- 10/2018	Data analyses conducted (All steps)	
7/2018- 8/2018	Member check	Questions answered; no issues surfaced that required resolving
11/2018	Second peer review	Utilized two different peers as liaisons and reviewers (with K-5 PD experience) to gain new insight into researcher interpretations of data (see methods for procedures)