5-12-2023

Examining Active Learning in an Online Synchronous Train-the-Trainer Mathematics Professional Development Initiative

Shannon Hart

Recommended Citation

Hart, Shannon, "Examining Active Learning in an Online Synchronous Train-the-Trainer Mathematics Professional Development Initiative." Dissertation, Georgia State University, 2023.
doi: https://doi.org/10.57709/35458918

ACCEPTANCE

This dissertation, EXAMINING ACTIVE LEARNING IN AN ONLINE SYNCHRONOUS TRAIN-THE-TRAINER MATHEMATICS PROFESSIONAL DEVELOPMENT INITIATIVE, by SHANNON HART, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education & Human Development, Georgia State University.

The Dissertation Advisory Committee and the student's Department Chairperson, as representatives of the faculty, certify that this dissertation has met all standards of excellence and scholarship as determined by the faculty.

Christine D. Thomas, Ph.D.
Committee Co-Chair

Janice B. Fournillier, Ph.D.
Committee Co-Chair

Natalie King, Ph.D.
Committee Member

Robert M. Branch, Ed.D.
Committee Member

Christopher C. Jett, Ph.D.
Committee Member

Date

Gertrude Tinker Sachs, Ph.D.
Chairperson, Department of Middle and Secondary Education

Paul A. Alberto, Ph.D.
Dean, College of Education & Human Development

AUTHOR'S STATEMENT

By presenting this dissertation as a partial fulfillment of the requirements for the advanced degree from Georgia State University, I agree that the library of Georgia State University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote, to copy from, or to publish this dissertation may be granted by the professor under whose direction it was written, by the College of Education & Human Development's Director of Graduate Studies, or by me. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this dissertation which involves potential financial gain will not be allowed without my written permission.

_____

Shannon Yvette Hart

NOTICE TO BORROWERS

All dissertations deposited in the Georgia State University library must be used in accordance with the stipulations prescribed by the author in the preceding statement. The author of this dissertation is:

Shannon Yvette Hart
Department of Middle & Secondary Education
College of Education & Human Development
Georgia State University

The director of this dissertation is:

Dr. Christine Thomas and Dr. Janice Fournillier
Department of Middle & Secondary Education
College of Education & Human Development
Georgia State University
Atlanta, GA 30303

CURRICULUM VITAE

Shannon Yvette Hart

ADDRESS: 902 45th Pl NE
Washington, DC 20019

EDUCATION:

Doctor of Philosophy	2023	Georgia State University Teaching and Learning
Master of Science	1998	Brooklyn College Mathematics Education
Bachelor of Arts	1995	Clark Atlanta University Elementary Education

PROFESSIONAL EXPERIENCE:

2022-present	Education Program Coordinator Department of State
2017 - 2022	Mathematics Specialist Redacted
2014 – 2017	Instructional Coach Atlanta Public Schools
2012-2014	Professional Learning Specialist Atlanta Public Schools
2009-2012	Director of Mathematics Fulton County Schools
2007 – 2009	Mathematics Instructional Coach Fulton County Schools
2006	Cadre Coach NCEE/America's Choice
2001 – 2005	UFT Teacher Center Specialist

	New York City Schools
1996 - 2001	Mathematics Teacher New York City Schools

PRESENTATIONS AND PUBLICATIONS:

Hart, Shannon Y. (2014) *Developing a System for Keeping Track of Student Observations*. Georgia Mathematics Conference, Eatonton, GA

Hart, Shannon Y. (2004) Journal Writing: Documenting What Students Have Learned, in *Empowering the Beginning Teacher of Mathematics in Elementary School;* NCTM

PROFESSIONAL SOCIETIES AND ORGANIZATIONS

2017	Onsite Committee, National Council of Supervisors of Mathematics Conference
2017, 2018	Reviewer, National Council of Supervisor of Mathematics Conference proposals
2012-2017	Reviewer, Teaching Children Mathematics journal
2010-2013	Metro West Region Rep, Georgia Council of Teachers of Mathematics Exec. Committee

EXAMINING ACTIVE LEARNING IN AN ONLINE SYNCHRONOUS TRAIN-THE-TRAINER MATHEMATICS PROFESSIONAL DEVELOPMENT INITIATIVE

by

SHANNON HART

Under the Direction of Dr. Christine Thomas and Dr. Janice Fournillier

ABSTRACT

High quality teacher professional development has been linked to increase in student achievement. Active learning is a characteristic of effective professional development (Darling-Hammond et al., 2017; Gulamhussein, 2013). Additionally, there was a positive impact on student achievement in studies where active learning was incorporated in teacher professional development. Active learning occurs when learners interact during the learning process with the content and with one another (Learning Forward, 2011). As such, school districts should examine professional development learning environments to determine if active learning is transpiring. This study examined active learning in one school system's online synchronous mathematics teacher leader train-the-trainer professional development initiative. The study sought to identity what instructional strategies were incorporated and how did the mathematics teacher leaders actively engage.

The school system in this study adopted new more rigorous college and career mathematics standards. To support implementation, the school system instituted a professional development (PD) initiative and contracted external facilitators to provide train-the-trainer professional development to mathematics teacher leaders. The mathematics teacher leaders in turn redelivered the PD in-person to teachers at a school. The PD sessions were conducted online synchronously using the *Zoom* platform.

The study used qualitative research methodology. Symbolic interactionism, constructivism and the Online Synchronous Active Learning Professional Development Framework based on Moore's (1989) *Three Types of Interaction* and Grooms' (2000) *Learner Interaction Model* were used to guide the examination of active learning. Data were collected and triangulated from the recorded videos, the transcribed videos, transcripts of the chats, and small breakout group documents completed by the participants.

The following themes emerged (1) modeling strategies; (2) collaborative conversations; (3) questioning to deepen knowledge; and (4) using online technology tools to convey ideas. The findings indicate active learning is fostered through interaction, facilitators must design learning environments conducive to active learning, mathematics teacher leaders must be provided opportunities to develop their own knowledge base, and facilitation strategies should promote the understanding of mathematics standards and pedagogical practices.

INDEX WORDS: Active Learning, Online Professional Development, Mathematics Professional Development

EXAMINING ACTIVE LEARNING IN AN ONLINE SYNCHRONOUS TRAIN-THE-TRAINER MATHEMATICS PROFESSIONAL DEVELOPMENT INITIATIVE

by

SHANNON HART

A Dissertation

Presented in Partial Fulfillment of Requirements for the

Degree of

Doctor of Philosophy

in

Teaching and Learning

in

Middle and Secondary Education

in

the College of Education & Human Development
Georgia State University

Atlanta, GA
2023

DEDICATION

To my son, James. You watched me persevere through this process and have always been supportive. On this path called life there are many obstacles. They make you stronger, more resilient, teach to adjust, and encourage patience. Always keep your faith and trust God. I love you.

To my mother, Valerie who is an example of never give up. You have always pushed me to achieve my dreams. I love you and thank you for your prayers and support.

To my loving grandmother, Delores. I always look to you for strength and encouragement. Hearing the words “I’m so proud of you” fills my heart with warmth. I love you.

ACKNOWLEDGMENTS

I am so thankful to God who is always at the head of my life. The process has been long with many stops along on the way. Through prayer I kept the faith. God brought me to it so I knew He would bring me through it.

Dr. Thomas and Dr. Fournillier, thank you for your constant support and encouragement. You have been with me from the beginning and kept pushing me. You saw in me what I didn't see in myself. You told me what I needed to hear in the way I needed to hear it. I am so appreciative for having you in my life. I want to thank Dr. King, Dr. Branch and Dr. Jett for your insightful feedback and support through the process.

Thank you, Pat, for encouraging me to pursue a Doctorate degree and staying on me so that I would finish.

Thank you to my fellow doctoral students who started the process with me. We encouraged each other throughout the process.

TABLE OF CONTENTS

LIST OF TABLES ..... **v**

LIST OF FIGURES ..... **vi**

1 THE PROBLEM **1**

Background of the Problem **2**

Statement of the Problem **3**

Purpose of the Study **4**

Research Questions **4**

Significance of the Study **4**

Limitations **5**

Definition of Terms **6**

Theoretical Framework **6**

Symbolic Interactionism **7**

Epistemology of Constructivism **11**

Active Learning **11**

Online Synchronous Active Learning Professional Development Framework **14**

Linking Symbolic Interactionism to Constructivism in Virtual Learning Environments **15**

Overview of the Study **16**

2 REVIEW OF THE LITERATURE **18**

Professional Development Federal Reforms **18**

Effective Professional Development **25**

Teachers Perception of Effective Professional Development **30**

Active Learning **32**

Active Learning in Mathematics Professional Development **35**

Online Professional Development **38**

Train-The-Trainer **41**

3 METHODOLOGY **47**

Conceptual Framework **47**

Qualitative Research Design **48**
Case Study **49**
Rationale for Qualitative Descriptive Case Study **51**
Research Setting and Unit of Analysis **51**
Summary of the Population **53**
Researcher Role **54**
Data Collection Techniques **55**
Analytic Procedures **57**
Confidentiality and Ethics **58**
Validity and Reliability **59**
Trustworthiness **60**
4 DATA ANALYSIS AND RESULTS **61**
Research Context **61**
Session Descriptions **64**
Coding **70**
From Categories to Themes **73**
5 DISCUSSION **88**
Aligning the Initiative to the Framework **89**
Connections to Literature **90**
Implications **94**
Suggestions for Further Research **96**
Final Thoughts **97**
REFERENCES **99**
APPENDICES **109**

LIST OF TABLES

Table 1 Session Video Specifications 53

Table 2 Data Collection Matrix 56

Table 3 Session Topics 64

Table 4 Category Descriptions 72

LIST OF FIGURES

Figure 1. Grooms' (2000) Learner Interaction Model 14

Figure 2. Online Synchronous Active Learning Professional Development Framework Adapted from Grooms' (2000) Learner Interaction Model 15

Figure 3. Linking Symbolic Interactionism to Constructivism in Virtual Learning Environments 16

Figure 4. Wall dimensions for Wallpaper problem 78

Figure 5. Directions facilitator provided to groups after reading excerpt from NCTM's Principles to Actions 81

Figure 6. Group 1 document from Build Procedural Fluency from Conceptual Understanding reading 82

1 THE PROBLEM

Considering budget woes and requirements of federal mandates, school districts need to find alternate cost-effective ways to provide effective professional development to teachers. Recently, school districts have moved towards implementing more online professional development options, as opposed to face-to-face, to improve teacher practice and in turn impact student achievement. School districts often utilize in-house math specialists, or contract with external professional development providers to facilitate professional development. Online synchronous active learning environments in post-secondary courses are effective (Hokanson et al.,2019; Bower et al., 2015; Wei & Chen, 2012). However, there are limited studies on active learning in secondary teacher professional development and even less in online environments. This study examined active learning in one school system's online synchronous train-the-trainer secondary mathematics professional development initiative designed, developed, and facilitated by external providers.

It has been found that professional development is used to improve teacher quality (Mizell, 2010). Every Student Succeeds Act (US Department of Education, 2015) is a federal education reform which mandates state and local education agencies provide high-quality teacher professional development. The federal requirements describe high-quality professional development activities but not how these professional development activities should occur. It is important to note that scholars argue that teacher professional development should incorporate the characteristics of effective professional development (Darling-Hammond et al., 2017; Gulamhussein, 2013). More importantly they claim that incorporating active learning has shown to be an effective approach in professional development (Hokanson et al., 2019; Gulamhussein, 2013). Active learning occurs when learners interact during the learning process with the content

and with one another. As such, school districts should examine professional development learning environments to determine if active learning is transpiring.

Background of the Problem

The school system in this study is responsible for educating approximately 70,000 prekindergarten through 12th grade children. In 2014, the school system's Community Strategic Plan identified key priorities. Priority 1 focused on academic standards.

> Priority 1: The development and implementation of a standards-based educational system that effectively aligns curriculum, instructional frameworks, and assessment systems to a more rigorous college and career ready academic standard (Name Withheld, 2014, p.8).

In the 2015-2016 school year, the school system adopted and implemented new mathematics college and career ready standards for prekindergarten through fifth grade. In the 2016-2017 school year, sixth through twelfth grade math standards were launched. Priority 1 provided teachers with professional development and job-embedded instructional training to support the implementation of more rigorous academic standards, increased opportunities for collaboration across disciplines, and improved educator access to curricular resources and training materials (Name Withheld, 2014). The school system committed to allocate funding to ensure teachers were provided the training necessary to deepen mathematics teachers' knowledge. The school system implemented six professional learning days, two during back-to-school week and one per quarter throughout the school year. The school system researched professional development providers and contracted with an external vendor to develop, design, and facilitate mathematics professional development.

The school system incorporated a train-the-trainer professional development model. The train-the-trainer model "focuses on bringing one or more lead teachers to central workshops,

training them in specific skills or programs, and requiring them to train their colleagues at their home school in the demonstrated skills" (Pancucci, 2007, p. 598). Due to the school system's geographically large area, they opted to provide professional development in an online synchronous environment to eliminate travel costs. The contracted vendors facilitated online synchronous professional development to mathematics teacher leaders, regional mathematics specialists, and system mathematics specialists, who in turn redelivered the sessions to the teachers at their school in a face-to-face environment. Mathematics teacher leaders were mathematics teachers selected by the school principal based on leadership criteria. Regional and system mathematics specialists are former mathematics teachers who have experience in supporting mathematics teachers. In this school system, regional mathematics specialists support local schools and system mathematics specialists provide curriculum guidance and support districts. During this study, references to mathematics teacher leaders also encompassed regional and system mathematics specialists. Professional development survey data indicated the mathematics teacher leaders felt prepared to facilitate the face-to-face teacher professional development after participating in online synchronous professional development. The contracted vendor from here and throughout the study will be called "facilitator." As a school system, facilitators typically deliver professional development virtually. It is imperative that the school system's teachers are actively engaged in online professional development.

Statement of the Problem

Professional development facilitators need ample opportunity to practice knowledge and skills of facilitation. As professional development facilitators mathematics teacher leaders must be provided opportunities to develop their own knowledge base to effectively facilitate professional learning (Perry & Boylan, 2018). They must have and be able to demonstrate their

knowledge of the subject matter of the professional development activity, including subject-specific pedagogical content knowledge (Perry & Boylan, 2018). Instructional strategies that promote active learning during professional development in online environments are essential (Hokanson et al., 2019; Wei & Chen, 2012). Active learning has shown to be an effective approach in professional development; therefore, research examining facilitation methods and teacher engagement could provide researchers more insight. Dede (2006) proposed there is a need for "in-house" research on the best professional development models to serve the local school. There is a need for studies on implementation of high-quality professional development that describe the nature of work educators engage in and whether this work leads to improved knowledge, beliefs, or habits of practice (Marrongelle et al., 2013).

Purpose of the Study

The purpose of the study was to examine active learning in one school system's online synchronous train-the-trainer mathematics professional development initiative.

Research Questions

The following research questions guided the study:

1. What instructional strategies, if any, promote active learning in online synchronous professional development?
2. How do mathematics teacher leaders actively engage in online synchronous professional development?

Significance of the Study

This study provided insight into facilitator's instructional strategies which promoted active learning and mathematics teacher leaders active engagement during online synchronous professional development. Previous research in active learning online mainly focused on higher education undergraduate and graduate students (Hokanson et al.,2019; Bower et al., 2015; Wei &

Chen, 2012). Additionally, research in active learning in mathematics professional development was concentrated on face-to-face environments (Reiten, 2021; Pak et al., 2020; Parrish et al., 2020). This research study contributes to the knowledge base of preparing mathematics teacher leaders to facilitate mathematics professional development, facilitator's actions that promote active learning in online synchronous environments, and the ways mathematics teacher leaders actively engaged in an online synchronous environment. This study also adds professional development methods to deepen educators understanding of mathematics standards and effective pedagogical practices for the mathematics education community. Moreover, it assists school districts to develop a scope of work for external professional development providers to ensure that active learning is present as they facilitate professional development.

Limitations

The study has a number of potential limitations:

1. There is no video of the small group break-out groups therefore strategies described only focus on the whole group setting. Research on small group break-out sessions may produce different or additional strategies.
2. Transcripts of the entire video chat were not available. Any descriptions of what was input in the chat are based on the video where the facilitator read the comments in the chat.
3. Due to limitations of the video, the exact number of participants cannot be determined. The number of participants was derived when the facilitator listed the names in each group prior to the group breakout sessions.
4. I was a participant in session 1, session 2 and session 4. I was aware of my subjectivity. I kept a reflective journal to help me understand the relationship I have to the data and to combat potential biases.

Definition of Terms

The purpose of the definition of terms is to reduce ambiguity. The following terms are operationally defined for this purpose.

- Active learning/Active engagement: Occurs when learners interact during the learning process with the content and with one another.
- Contracted vendor/facilitator: A person or persons external to the school system who are contracted to design, develop and facilitate professional development services.
- Learning environment: Physical location of the mathematics teacher leader and online learning management system where the professional development occurs.
- Learning Management System: A software application where the online professional development occurs.
- Mathematics teacher leaders: Mathematics teacher selected by principal based on leadership criteria, regional mathematics specialists and system mathematics specialists.
- Mathematics standards: Descriptions of the mathematics skills, processes and proficiencies students should have at each grade level by the time they finish high school.
- Online synchronous professional development: Specialized training conducted via electronic technologies using web-based, interactive experiences combining text, video, and sound whereas the facilitator and mathematics teacher leaders are present at the same time.
- Train-the-trainer model: Mathematics teacher leader attends professional development and in turn redelivers the professional development to teachers at school.

Theoretical Framework

A theoretical framework describes the use of a theory (or theories) that guided the study and processing of new knowledge (Collins & Stockton, 2018). Snow's (2011) symbolic

interactionism guided the examination of active learning in online synchronous mathematics professional development. Constructivism is the epistemology foundation. I proposed an Online Synchronous Active Learning Professional Development Framework based on Moore's (1989) *Three Types of Interaction* and Groom's (2000) *Learner Interaction Model* to examine active learning processes in mathematics teacher leader professional development.

Symbolic Interactionism

My theoretical perspective embodies symbolic interactionism. Herbert Blumer (1969) conveys symbolic interactionism as resting on three premises. The first premise is that human beings act towards "things" based on the meanings the "things" have for them. "Things" can include objects, human beings, institutions, ideals, and activities of other human beings. The source of the meaning of the "thing" comes from interaction between people as it relates to the "thing" is the second premise. The final premise states that the person modifies meaning, as the person interacts with the "thing." Symbolic interactionism is grounded in "root images." Root images refer to and depict the nature of the following matters: human groups or societies, social interactions, objects, the human being as an actor, human action, and the interconnection of the lines of action" (Blumer, 1969, p. 6). The "root images" represent the way symbolic interactionism views society and conduct. Symbolic Interactionists have expanded on Blumer's tenets. Snow (2001) extends and broadens Blumer's (1969) symbolic interactionism. Snow argues that Blumer "links symbolic interactionism too tightly and narrowly to the issue of meaning and interpretation" (p.368) which neglects the principle range of viewpoints encompassed under the "interactionist umbrella."

Snow (2001) proposes four "inclusive orienting principles," which are inferred in Blumer's conceptualization but not stated. The four principles are interactive determination,

symbolization, emergence, and human agency. The principle of interactive determination requires comprehending the main "objects of analysis" not only by the perceived intrinsic value to them.

> The principal of interactive determination requires consideration of the interactional contexts or webs of relationships in which they are ensnared and embedded. For all practical purposes, then, neither individual or society nor self or other are ontologically prior but exist only in relation to each other; thus one can fully understand them only through their interaction, whether actual, virtual, or imagined. (Snow, 2001, p. 369)

Snow (2001) posits that interactive determination in symbolic interactionism is necessary because "interactionism typically takes interactional dynamics and processes" (Snow, 2001, p. 370) at different interpersonal levels of social life and should serve as areas of observation and analysis.

> Interactive determination suggests how actions of movements elicit responses by external groupings, in turn, require both strategic and tactical adjustments on behalf of the movements themselves. (Snow, 2001, p. 369)

A very interactive relationship is promoted when movement relates to a "reactive-proactive continuum" within an entity and its people that compromise its environment (Snow, 2001). This ongoing process is a key aspect in the determination of a movement's course and character. Actions of movement elicit responses. Snow suggests a complete understanding of the other three key principles (symbolization, emergency, human agency) of symbolic interactionism ought to incorporate the "interactional contexts in which they are embedded and from which they emerge."

Snow argues the subject of meaning and interpretation in the principle of symbolization has structuralist and constructionist dimensions, which are more complex than Blumer's (1969) three premises.

> The principle of symbolization highlights the processes through which events and conditions, artifacts and edifices, people and aggregations, and other features of the ambient environment take on particular meanings, becoming objects of orientation that elicit specifiable feelings and actions. (Snow, 2001 p. 371)

Meaning making and interpretation is individualized, social, taken for granted and vulnerable to change. Instead of questioning whether human beings act toward things in terms of their meaning or how they are symbolized, Snow proposes the following questions:

- How do meanings or symbolizations become taken-for-granted and routinized?
- What kinds of social contexts, organizational forms, relational connections, and social processes are conducive to or facilitative of the routinization of meaning, or what has been referred to as its "sedimentation"?
- And under what conditions and in what ways are sedimented meanings or extant cultural frames fractured, contested, or debated, thus rendering the symbolic basis for action problematic and calling for new or revitalized interpretations and framings? (Snow, 2001, p. 372).

The principle of emergence connects with the meanings and feelings in principle of symbolization. The focus is on the unfamiliar part of social life and dynamic character, the potential for change and the possibility for change in social life, the organization as well as in the related meanings and feelings (Snow, 2001).

> The principle of emergence encompasses processes out of which new, novel, or revitalized social entities, or cognitive and emotional states, arise that constitute departures from, challenges to, and clarifications or transformations of everyday routines, practices, or perspectives. (Snow, 2001, p. 372)

This principle connection to symbolic interactionism stems from Mead's (1938) "emphasis on the novel and emergent nature of the act" and Blumer's (1951) conceptualization of the types of collective behavior as emergent phenomena and new forms of social life. Snow further clarifies; if social changes are considered "emergent phenomena" then the principle of emergence is important to sociological concern because emergence relates to social life. The focus is on those interactions and instances in which emergence is at play.

The principle of human agency refers to the "active, willful character of human actors" (Snow, 2001, p. 373).

> Symbolic interaction views biological, structural, and cultural factors as predispositions or constraints on action without automatically or necessarily determining the character of that action. Social actors take into account the structural and cultural constraints (e.g., roles, social expectations, norms, values) that impinge on situations in which they find themselves in the course of developing their respective lines of action. (Snow, 2001, p. 375)

As emergence focuses on new processes based on interactions in social life, human agency focuses on intentions and actions. As an interactionist, I sought to understand how meaning making is confirmed or changed as mathematics teacher leaders interact with the facilitator, peers, and content. Snow's extended and broadened principles of symbolic interactionism and constructivism guided the study on online synchronous professional development.

Epistemology of Constructivism

Constructivism is a theory of knowledge. Constructivists believe that we impose meaning on the world.

> Meaning is constructed in our minds as we interact with the physical, social, and mental worlds we inhabit, and that we make sense of our experiences by building and adjusting such internal knowledge structures that collect and organize our perceptions of and reflections on reality. (Swan, 2005, p. 1)

Ernest von Glasersfeld (1984, 1990) asserts three principle epistemological tenets of constructivism.

1. Knowledge is not passively accumulated, but rather, is the result of active cognizing by the individual.
2. Cognition is an adaptive process that functions to make an individual's behavior more viable given a particular environment.
3. Cognition organizes and makes sense of one's experience and is not a process to render an accurate representation of reality. (Doolittle, 1999)

The radical characteristic of constructivism lies in the proclamation that “knowledge cannot and need not be ‘true’ in the sense that it matches ontological reality”, it only must be feasible in the aspect that it fits within the “experiential constraints that limit the cognizing organism’s possibilities of acting and thinking” (von Glasersfeld, 1989, p.115).

Active Learning

Learning Forward (2011) recommends professional development be designed to promote active engagement. Active engagement in professional development fosters improvement in educator practice.

> Active engagement occurs when learners interact during the learning process with the content and with one another. Through active engagement, educators construct personal meaning of their learning, are more committed to its success, and identify authentic applications for their learning. (Learning Forward 2011, para 8)

A deeper understanding of new practices is developed as educators are actively engaged with content. Through exploration of individual and collective experiences, learners actively construct, analyze, evaluate, and synthesize knowledge and practices (Learning Forward, 2011).

Active learning is based on constructivist teaching-learning philosophy and "encompasses several research-based strategies designed to engage students in the learning process" (Murthy, Iyer & Warriem, 2015, p. 18). Strategies that promote active learning involve "students doing things and thinking about what they are doing" (Brame, 2016, p. 1; Bonwell and Eison, 1991). The approaches require students to use higher-order thinking and focus on developing skills. "Active learning approaches also often embrace the use of cooperative learning groups, a constructivist-based practice that places particular emphasis on the contribution that social interaction can make" (Brame, 2016, p.2).

Moore (1989) presents types of interactions necessary in higher education distance learning. Moore describes three types of interaction that are essential in distant learning: learner-content, learner-instructor, and learner-learner. Learner-content is defined as the interaction between the student and the subject of study (content). Moore posits learner-content interaction is a "defining characteristic of education" because "it is the process of intellectually interacting with content that results in changes in the learner's understanding, the learner's perspective, or the cognitive structures of the learner's mind" (Moore, 1989, p.1). The interaction between the student and the "expert who developed the subject material" or an expert serving as the teacher is

considered learner-instructor interaction. The instructors seek to peak or maintain student's interest in the content being taught in order to motivate students to learn and encourage self-direction and self-motivation. Learner-learner interaction is "between one learner and other learners, alone or in group settings, with or without the real-time presence of an instructor" (Moore, 1989, p. 3).

> Educators need to organize programs to ensure maximum effectiveness of each type of interaction, and ensure they provide the type of interaction that is most suitable for the various teaching tasks of different subject areas, and for learners at different stages of development. (Moore 1989, p. 3)

Researchers have expanded on Moore's *Three Types of Interaction* and developed models based on it.

Grooms (2000) Learner Interaction Model (Figure 1) provides a visual representation of the three types of interaction and the relationship among them.

> The reciprocal arrows between the learner and each of the three components imply interdependence or some measure of reciprocal influence. The two-directional circular arrows between content, facilitator, and peers illustrate the reciprocal impact each of these components has upon the other. (Grooms, 2000, p. 31)

Grooms posit there isn't an interaction that is more dominant or more essential than another.

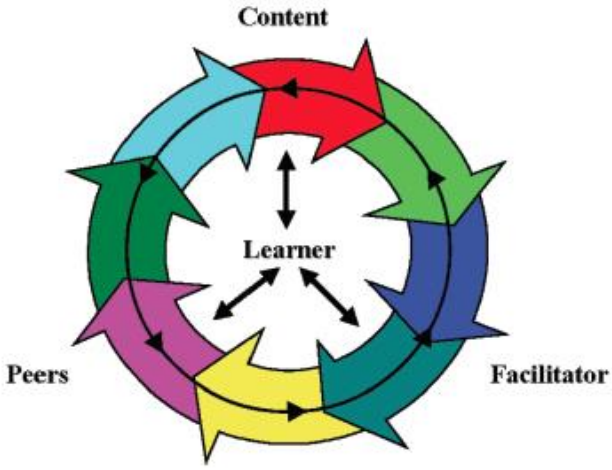

Figure 1. Grooms' (2000) Learner Interaction Model

Moore's (1989) *Three Types of Interaction* model and Grooms' *Learner Interaction Model* served as a basis for developing a framework to examine active learning processes in online synchronous train-the-trainer mathematics professional development. The Online Synchronous Active Learning Professional Development framework guides the examination of active learning as the mathematics teacher leaders engage with the facilitator, content and other mathematics teacher leaders within the learning environment.

Online Synchronous Active Learning Professional Development Framework

Active learning in an online environment takes place within a learning management system (LMS). The learning management system influences how the mathematics teacher leader engages within the learning environment. The LMS in this study is *Zoom*. Zoom is a video conferencing platform which has chat, breakout room and reaction features. The mathematics teacher leaders were physically located in a classroom, in the school library or in an office, either alone or with other peers. When in the same location as other participants, the mathematics teacher leaders either worked on their own laptop using headphones or worked as a group employing one laptop that was projected on a screen with share audio. The learning management

system and the physical location of the mathematics teacher leader while engaging with the LMS make up the learning environment. The learning environment provides additional insight into active learning. The learning management system can affect engagement. What are the capabilities of the learning management system? Within the learning environment the facilitator promotes active engagement with the mathematics teacher leaders, among the mathematics teacher leaders and between mathematics teacher leaders and the content. All interactions occur within the learning environment. In figure 2, the solid lines represent the mathematics teacher leader interaction with content, facilitator, and other educators. The dashed lines represent the instructional strategies led by the facilitator to promote active learning. Active engagement occurs through facilitation.

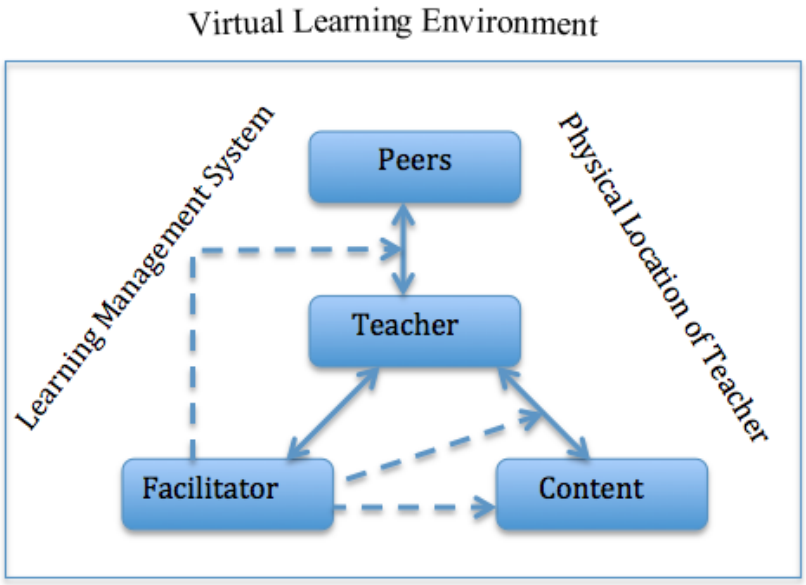

Figure 2. Online Synchronous Active Learning Professional Development Framework Adapted from Grooms' (2000) Learner Interaction Model

Linking Symbolic Interactionism to Constructivism in Virtual Learning Environments

I employed Snow's (2001) principles of symbolic interactionism to analyze active learning environments, how they are facilitated and how mathematics teacher leaders engage in

them (Figure 3). Using constructivism to examine active learning in online synchronous professional development focused on the learning environment. This framework guided what is noticed through interactive determination, symbolization, emergence and human agency. Through the theoretical framework "symbolic interactionism seeks to uncover meanings and perceptions on the part of the people participating in the research" (Crotty, 1998, p. 7).

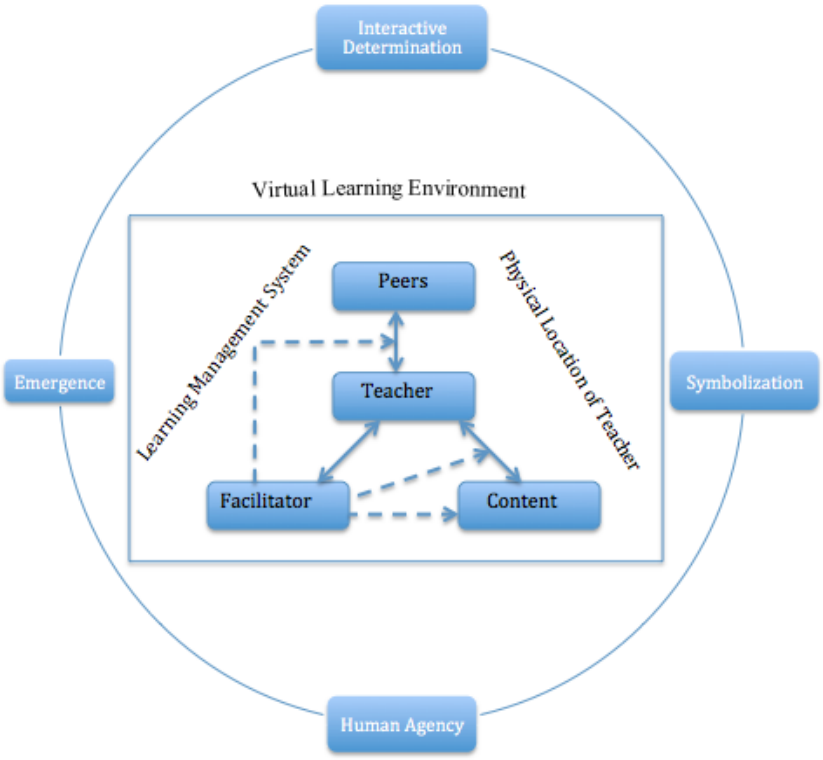

Figure 3. Linking Symbolic Interactionism to Constructivism in Virtual Learning Environments

Overview of the Study

Chapter 1 provides the reader with introduction of the study, statement of the problem, purpose of the study, research questions, and conceptual framework. Chapter 2 highlights bodies of literature, which framed the research questions: Federal reforms and teacher professional development, effective professional development, active learning, active learning in mathematics professional development online professional development and train-the-trainer. Chapter 3

emphasizes the theoretical framework and methodology of the study, including the research setting, data collection techniques, and analytic procedure. Chapter 4 provides the context, overview of the analysis methods and examination of the major themes that emerged. Chapter 5 aligns the professional development initiative to the Online Synchronous Active Learning Professional Development Framework, connects the themes to the literature, presents implications for practice and recommendations for future research.

2 REVIEW OF THE LITERATURE

The purpose of the study is to examine active learning in an online synchronous train-the-trainer mathematics professional development initiative. The literature review begins with background on federal education reforms and teacher professional development requirements. Next, empirical studies linking the quality of teacher professional development to student achievement is highlighted. Research on effective teacher professional development will show active learning is a characteristic. Additional research on teacher's perception of effective professional development supports the use of active learning. Research on active learning in different learning environments, including mathematics professional development is described. Finally, online professional development model is explored with specific emphasis on train-the-trainer model. Research trends indicate there are a limited number of studies examining active learning in online synchronous professional development for secondary mathematics teacher leaders. There is therefore the need to examine if active learning is present and then how professional development facilitators foster active learning and how mathematics teacher leaders engage.

Professional Development Federal Reforms

Federal reforms in education have been enacted to improve student achievement, which lead to an emphasis on teacher professional development. High quality professional development was outlined in the reauthorized Elementary and Secondary Education Act. In 2002, President George W. Bush signed into law the No Child Left Behind Act (NCLB) of 2001 (reauthorization of Elementary and Secondary Education Act [ESEA]). NCLB instituted certain measures designed to increase student achievement and to hold state educational agencies (SEAs) and local educational agencies (LEAs) more accountable for student progress (Editorial Projects in

Education Research Center, 2011). NCLB characterized high quality professional development activities as:

- Improve and increase teachers' knowledge of academic subjects and enable teachers to become highly qualified;
- Are an integral part of broad school wide and district wide educational improvement plans;
- Give teachers and principals the knowledge and skills to help students meet challenging State academic standards;
- Improve classroom management skills;
- Are sustained, intensive, and classroom-focused and are not one-day or short-term workshops;
- Advance teacher understanding of effective instruction strategies that are based on scientifically based research; and
- Are developed with extensive participation of teachers, principals, parents, and administrators. (U.S. Department of Education, 2001)

No Child Left Behind linked student accountability measures to federal funding and held SEAs and LEAs accountable for student outcomes. NCLB propelled the importance on high-quality teacher professional development, directly correlating the quality of teacher professional development to quality of educational opportunities students receive within the classroom. Although NCLB saw improvements in student achievement, there was concern the federal requirements were too stringent.

In an effort to provide states more flexibility with student accountability measures, on December 10, 2015, President Barak Obama signed into law Every Student Succeeds Act

(ESSA). ESSA replaced No Child Left Behind Act (NCLB) with a continued emphasis on teacher professional development and began full implementation in the 2017 – 2018 school year. Professional development remains a focus in ESSA with an outline of activities that are similar to NCLB, but with a significant number of additional activities. ESSA's additional professional development include activities that:

- are designed to give teachers of English learners, and other teachers and instructional staff, the knowledge and skills to provide instruction and appropriate language and academic support services to those children, including the appropriate use of curricula and assessments;
- to the extent appropriate, provide training for teachers, principals, and other school leaders in the use of technology (including education about the harms of copyright piracy), so that technology and technology applications are effectively used in the classroom to improve teaching and learning in the curricula and academic subjects in which the teachers teach;
- as a whole, are regularly evaluated for their impact on increased teacher effectiveness and improved student academic achievement, with the findings of the evaluations used to improve the quality of professional development;
- are designed to give teachers of children with disabilities or children with developmental delays, and other teachers and instructional staff, the knowledge and skills to provide instruction and academic support services, to those children, including positive behavioral interventions and supports, multi-tier system of supports, and use of accommodations;

- include instruction in the use of data and assessments to inform and instruct classroom practice;
- include instruction in ways that teachers, principals, other school leaders, specialized instructional support personnel, and school administrators may work more effectively with parents and families;
- involve the forming of partnerships with institutions of higher education, including, as applicable, Tribal Colleges and Universities as defined in section 316(b) of the Higher Education Act of 1965 (20 U.S.C. 1059c(b)), to establish school-based teacher, principal, and other prospective teachers, novice teachers, principals, and other school leaders with an opportunity to work under the guidance of experienced teachers, principals, other school leaders, and faculty of such institutions
- create programs to enable paraprofessionals (assisting teachers employed by a local educational agency receiving assistance under part A of title I) to obtain the education necessary for those paraprofessionals to become certified and licensed teachers;
- provide follow-up training to teachers who have participated in activities described in this paragraph that are designed to ensure that the knowledge and skills learned by the teachers are implemented in the classroom; and
- where practicable, provide jointly for school staff and other early childhood education program providers, to address the transition to elementary school, including issues related to school readiness. (U.S. Department of Education, 2015)

Every Student Succeeds Act highlights professional development activities that improve and increase a teacher's ability to understand how students learn, analyze student work and achievement, and strategies for improving student academic achievement. The observational and

feedback data should lead to professional development activities, which meets the individual needs of the teachers, by allowing for individualized plans that address the identified areas of need, ultimately leading to increased knowledge and teaching skills for teachers. The changes in ESSA include aligning professional development with the academic goals of the school and local educational agency (U.S. Department of Education, 2015). With constant demands that educational reform models require increased human and material capital, now more than ever, researchers struggle to find ways to provide high-quality professional development accessible by all in order to change teacher practice. A study on active learning in online synchronous train-the-trainer professional development could provide insight about professional development model that is accessible by all. Research indicates there is a correlation between teacher professional development and student achievement.

Professional Development and Student Achievement

Research reinforces many scholars' belief that intense and concentrated professional development supports student's achievement. Yoon, Duncan, Lee, Scarloss, and Shapely (2007) conducted a review of 1,300 studies identified as addressing how teacher professional development affects student achievement. Of the 1,300 studies, only nine met the *What Works Clearinghouse* evidence standards. The What Works Clearinghouse evidence standards "assess the strengths and weaknesses of a study's methodology…and whether results of key statistical tests are verifiable" (Institute of Educational Sciences, 2020, para 1). In the nine studies, teachers received an average of 49 hours of professional development and students' achievement (as measured by the studies) increased by 21 percentile points (Yoon et al., 2007). A meta-analysis study (Blank and de las Alas, 2009) showed a positive effect on "scientifically-based" evidence regarding teacher professional development on improving student mathematics

achievement. Incorporating a treatment group and control group, the pre-post design had an effect size of .21 and the post-only design had an effect size of .13. Common patterns of professional development within the studies contain a "strong emphasis" on instructing on mathematics content and pedagogical content for strategies to teach content to the students. Implementation included multiple activities following the professional development with support from mentors and other teachers to reinforce the learning and provide assistance with implementation. Student achievement is higher for students whose teacher received professional development focused on mathematics content and pedagogical content for strategies to teach content to students. Further supporting the need to examine online synchronous professional development provided by facilitators which focused on mathematics content and pedagogy using active learning instructional strategies.

Further, research shows the quality of professional development affects student achievement. In 2003, the Florida Department of Education launched the Florida Protocol System to combat the issue of ineffective professional development (Slabine, 2011). The Florida Department of Education school districts are measured against 66 standards focusing on four components: planning, learning, implementing, and evaluating. Scoring for each standard ranges from one (unacceptable) to four (excellent). School districts who received a rating of "good" or "excellent" during the 2008-2009 school year showed a greater increase in student achievement on state assessments, further indicating a positive correlation between effective professional development and student outcomes (Slabine, 2011). Incorporating effective strategies, like active learning, in professional development can increase student achievement. This study describing active learning facilitation instructional strategies and how teachers engage in professional development can aid in developing effective professional development.

Scholars have provided recommendations for creating, sustaining and assessing professional development around Common Core State Standards. Marrongelle, Sztajn, & Smith (2013) describe the process in developing recommendations designing, developing, implementing and analyzing professional development to support the implementation of Common Core State Standards in mathematics (CCSSM). Mathematics experts from higher education institutions and leading mathematics education organizations, and State Education agencies collaborated to provide professional development design and development recommendations. Professional development should provide opportunities for teachers to engage in CCSSM content and practice standards and incorporate materials that address the standards. Per the CCSSM, professional development design should consider teachers' current knowledge base and occur continuously over an extended period of time with a logical set of experiences. To ensure teacher comprehension is at the depth of CCSSM, experts should facilitate professional development. Evaluation of professional development should occur frequently to determine effectiveness, identify program improvements and revise as needed. The CCSSM work group noted there was a need for studies on implementation of high-quality professional development that describe the nature of work teachers engage in and whether or not it leads to improved knowledge, beliefs, or habits of practice. This study which examined active learning in the facilitation of mathematics teacher leader professional development can meet the need expressed by the scholars.

The federal mandates and need to increase student achievement require a new look at how professional development is delivered to teachers. Common Core State Standards call for students to reason, model with mathematics, engage in meaning making and problem-solving. Creating professional development for teachers to promote these skills in students can be a

challenge (Gulamhussein, 2013). As teachers learn new methods, implementation in the classroom is significant and support is necessary. The professional development should also address areas of concern in order to change teacher practice (Gulamhussein, 2013). Professional development must effectively support teachers in meeting the demands of new reforms, new standards and new teaching strategies. The next section will discuss the literature regarding effective professional development.

Effective Professional Development

Research has shown the structure of professional development should include important characteristics. Gulamhussein (2013) provides a research-based structure for professional development that leads to teachers changing their practice. Gulamhussein highlights five principles of effective professional development:

- The duration of professional development must be significant and ongoing to allow time for teachers to learn a new strategy and grapple with the implementation problem. Extended professional development provides time for teachers to practice the new skill in the classroom. Mastery of a new skill takes time. (Gulamhussein, 2013, p. 14)
- There must be support for a teacher during the implementation stage that addresses the specific challenges of changing classroom practice. Receiving support during implementation as teachers struggle gives them the opportunity to clarify their understanding and adjust how it is being implemented in the classroom and alleviate some frustration. (Gulamhussein, 2013, p. 15)
- Teachers' initial exposure to a concept should not be passive, but rather should engage teachers through varied approaches so they can participate actively in making sense of

new practice. Varied approaches could include discussions, role-playing, reading about the new skill and modeling. (Gulamhussein, 2013, p. 16)

- Modeling has been found to be highly effective way to introduce a new concept and help teachers understand a new practice. Teachers observing experts demonstrating the new concept assist teachers in having a better understanding of the concept and how to apply it in the classroom. (Gulamhussein, 2013, p. 17)
- The content presented to teachers shouldn't be generic, but instead grounded in the teacher's discipline (for middle school and high school teachers) or grade-level (for elementary school teachers). When concepts are presented that are applicable across content areas and grade levels, attention should be given to the specified discipline during the professional development. (Gulamhussein, 2013, p. 17)

Gulamhussein (2013) posits one-time workshops are not effective because the assumption is teachers lack knowledge and providing the knowledge to teachers will change practice. Additionally, learning a new skill is not difficult; it is implementing a new skill where teachers may encounter difficulty. It takes several attempts to master a new skill (Gulamhussein, 2013). Teachers actively participating in professional development allows them the opportunity to engage with the content and new skills.

Further research signifies additional features of effective professional development. Darling-Hammond, Hyler, and Gardner (2017) reviewed thirty-five studies linked to having a positive correlation between teacher professional development, teaching practices and outcomes to determine what elements of professional development are effective. They defined effective professional development as a "structured professional learning that results in changes to teacher knowledge and practices, and improvements in student learning outcomes" (Darling-Hammond

et al., 2017, p.2). Professional development is a combination of "externally provided and job-embedded" activities with the goal to improve and change teacher practice and in turn affect student learning. The study expands on previous research (Gulamhussein, 2013) that delineated five critical features of professional development: content-focus, active learning, coherence, duration, and collective participation.

Darling-Hammond, Hyder, and Gardner (2017) outline seven characteristics of effective professional development: content-focused, incorporates active learning, supports collaboration, uses models of effective practice, provides coaching and expert support, offers feedback and reflection and is of sustained duration. There is a similarity to earlier studies (Gulamhussein, 2013) however; coherence is embedded throughout the features. Content-focused professional development emphasizes discipline specific curricula in the context of what the teacher is teaching. Active learning is vastly different than the traditional lecture-based professional development where teachers are just receivers of information and is evidenced by teachers engaging in activities similar to how students will interact with the content and provides the opportunity for teachers to make sense of the activity. The learning is authentic and meets the needs of adult learners (Knowles et al., 2005). Teachers collaborating in a trusting environment creates a collective body to promote school improvement and impact student outcomes (Darling-Hammond et al., 2017). A collaborative setting provides support for teachers "allowing teachers to take risks, solve problems, and attend to dilemmas in their practice" (Darling-Hammond et al., p.10). Research (U.S. Department of Education, 2001) has shown one-time short professional development sessions are not effective; sustained duration is necessary. Teachers should engage in multiple opportunities over several months and/or throughout a school year. The content

learned in sessions, ideally, is applied in classroom practice between sessions on same topic to improve practice.

Three of the features of effective professional development highlighted by Darling-Hammond, Hyder and Gardner (2017) are new. The new characteristics are use of models and modeling, coaching and expert support, and feedback and reflection. The researcher argues that the use of models and modeling during professional development helps teachers to visualize the ideal teacher practice and understand the new curriculum. Coaching and expert support was evident in thirty of the thirty-five studies. Professional development providers, usually educators, shared expertise, modeled instructional practices, facilitated group discussions and analyzed of student work. One-on-one coaching ranged from observing teachers in the classroom to remote coaching by reviewing a 15-minute video submitted by the teacher. In all instances the teacher received feedback to improve teacher practice. Feedback often occurred in a coaching setting. Providing occasions for teachers to reflect on the feedback is a vital component of professional development. The studies where teachers were given positive and constructive feedback, reflected on the feedback, and made changes to their practice reported an increase in student learning. Active learning is a consistent characteristic of effective professional development among researchers. This study provides evidence of how teachers engaged in active learning during online synchronous professional development.

Although teachers are provided with professional development, research has shown no significant change in teacher practice. Garet et al (2011) conducted a two-year study on the effects of professional development on rational number topics with seventh grade mathematics teachers. The purpose of the study was to learn the role of professional development on the impact of teacher effectiveness. The study sought to determine: “1) What cumulative impact did

providing two years of the specified PD program have on teacher knowledge of rational number topics? (2) What cumulative impact did providing two years of the specified PD program have on student achievement in rational number topics" (Garet et al, 2011)? The study included 100 treatment teachers from 12 districts during the first year and only 50 treatment teachers from 6 school districts the second year. Ten facilitators from two different professional development organizations were involved during the two-year study. America's Choice and Pearson Achievement Solutions provided professional development, through a competitive process. Each provider developed professional development activities following the similar guidelines. The facilitator guides were piloted and went through an extensive review process focusing on accuracy, appropriateness, and coherence of topics before implementation.

The professional development, totaling 114 contact hours, included a summer institute and one-day in-school workshops throughout the year and coaching provided by the facilitator. The study randomly assigned treatment and control conditions within each district. Due to the high teacher turnover within these school districts, it limited the average dosage received by teachers. The average dosage received was 68%. At the conclusion of the study, 23 of the 45 teachers participated in the study the entire two years. On average, 75.7 % of the teachers in the treatment group correctly answered test items that were of average difficulty for the specialty constructed teacher knowledge test, compared with 74.7% of the teachers in the controlled group. The professional development was provided by a contracted professional development provider but did not have a statistically significant impact on student achievement or teacher effectiveness. "While we need to build teachers' capacity for improvement, we also need to be sure that time, effort and scarce resources are expended only on quality programs that teach with and about best practices" (Dede et al., 2009, p. 2). The study examined two different professional

development models but did not describe the facilitation methods. Active learning has shown to be an effective approach in professional development; therefore, this research study which examined facilitation methods and teacher engagement can provide researchers more insight.

Teachers Perception of Effective Professional Development

Previous research analyzed studies to determine characteristics of effective professional development, but the analysis of additional research regarding teacher perception is needed both within the United States and abroad. Matherson and Windle (2017) examined literature on teacher development, teacher learning, professional development and professional development reform to determine what teachers want in professional development. Four themes emerged from the literature. Teachers want professional learning opportunities that: 1) are interactive, engaging, and relevant for their students, 2) show them more than a practical way to teach content, 3) are teacher-driven and 4) are sustained over time. During the professional development sessions teachers want to be actively engaged in practicing the skills, strategies, and techniques as modeled by the facilitator. The practice allows teachers to hone in on skills, strategies, and techniques before applying them to the classroom. “To prepare students for success, teachers must teach them to learn and, in order to do so, teachers must become active learners themselves” (Matherson & Windle, 2017, p.30).

Glasco (2020) conducted a study to determine middle-school teachers perception of effective professional development. Participants included twelve middle school teachers from the Pacific Northwest. The researcher utilized a phenomenological approach with one-on-one interviews, reflective journaling and focus groups. Results showed teachers had a negative view of professional development but value the experience because professional development is important to their lives in order to improve. Teachers want effective professional development.

The characteristics of professional development the middle school educators viewed as effective ways of learning fell under three themes: format, practical application and positive culture. Active learning techniques were a subtheme under format. This study which showed how mathematics teacher leaders were engaged in online synchronous professional development supports educators desire to incorporate active learning strategies.

Beyar (2014) conducted a study to determine teacher perspectives on components of effective professional development. The researcher employed interviews, brainstorming survey, and document analysis. Sixteen elementary teachers from large Turkish school districts who participated in three or more professional development activities over the previous 12-month period were tapped to participate in the study. Each teacher was asked to provide their definition of effective professional development and what components constituted effective professional development based on their experience. Beyar noted, "the participants have determined that effective professional development activities should consist of the following components:

(1) a match to existing teacher needs,

(2) a match to existing school needs,

(3) teacher involvement in the design/planning of professional development activities,

(4) active participation opportunities,

(5) long-term engagement, and

(6) high-quality instructors." (Beyar, 2014, p. 323)

The teacher's perceptions aligned to characteristics of effective professional development as outlined by Darling-Hammond, Hyder and Gardner (2017).

Additionally, Abu-Tineh and Sadiq (2018) conducted a study to determine what teachers in Qatar deemed components of effective professional development. Six hundred thirty-one

(631) teachers were surveyed on their perceptions of features of the effective professional development programs. Abu-Tineh and Sadiq adapted Guskeys list of characteristics of effective professional development to develop a 21-item survey with a 4-point Likert scale ranging from a lot (4) to not at all (1). Independent schoolteachers rated the 'enhances of teacher's content and pedagogic knowledge' characteristic as the highly effective characteristic (M = 3.60/4.00), 'promotes collegiality and collaboration' characteristic (M = 3.55/4.00) and 'focuses on individual and school improvement' characteristic (M = 3.52/4.00) and models high-quality instruction (M=3.4/4.00). The mean on each characteristic was above 3.5 with 4 being the highest possible score. Further supporting US and international teacher's desires for effective professional development.

Active Learning

Active learning methods provide opportunities for students to engage in meaning making. "Based on constructivist teaching-learning philosophy, active learning encompasses several research-based strategies designed to engage students in the learning process" (Murthy, et al., 2015, p. 18). Strategies that promote active learning are "instructional activities involving students doing things and thinking about what they are doing" (Brame, 2016, p.1; Bonwell & Eison, 1991). These approaches require students to use higher-order thinking and focus on developing skills.

> Active learning approaches also often embrace the use of cooperative learning groups, a constructivist-based practice that places particular emphasis on the contribution that social interaction can make. (Brame, 2016 p. 2)

When collaborative group work fosters peer-to-peer interaction in order to develop mental models, active learning embodies constructivist learning theory (Brame, 2016). “The use of active learning strategies in the training program is a must” (Murthy et al., 2015, p. 18).

Furthermore, active engagement is important in online professional development environments. Hokanson, Grannan, Greenler, Gillian-Daniel, Campa, and Goldberg (2019) conducted a study concentrating on synchronous, online professional development workshops for graduate students and postdoctoral. The purpose of the study was to create and analyze a professional development model in order to maximize “participant’s skill development and their commitment to follow-up actions or developing new behaviors” (p.386). The workshop resulted in participant’s increased self-reflective practices and skill-building processes. The students valued the “sense of community” and the ability to reflect on their learning. “Participants suggested that workshops should integrate active learning and skills application with deliberate reflection and community building to increase the potential for long-term change” (p. 386). Hokanson et al. (2019) highlighted the necessity of creating active engagement in online synchronous environments. They promoted the use of reflection, community building, thoughtful discussion, broad participation, and brainstorming when planning and setting goals. Hokanson et al. (2019) suggest there is a need to allow time for participants to “share ideas, receive peer feedback and learn by listening to others” (Hokanson et al., 2019, p. 387). All of which are necessary attributes in online professional development.

Additional research supporting active learning indicates the online learning environment influences social presence. Wei and Chen (2012) developed a framework to investigate social presence in online classrooms and its relevant factors and a questionnaire to measure the factors. The data revealed user interface and social cues as important factors in social presence online.

> When a learning environment has a friendly user interface and rich media, learners can easily share social cues with each other. Verbal and non-verbal cues are very important resources for perceived social presence in online learning environments. (Wei & Chen, 2012, p. 539)

Wei and Chen recommend instructors familiarize users with the online platform and encourage the use of webcams and audio equipment to aid in the transmitting of social cues. They highlighted the need for further research on online learning to consider user interface and social cues as important predictors of social presence. Social presence and teacher presence was the major factor in professional development for teachers (Holmes et al., 2011). Owston, Wideman, Murphy, and Lupshenyuk, (2008) studied program evaluations of three different teacher blended professional development programs. Data from their research revealed teachers wanted additional time to share their ideas, struggles, and accomplishments. A research study analyzing active learning instructional strategies in online synchronous professional development meets the need as outlined in the articles.

Active learning is a necessity for students in both face-to-face and online learning environments. Professional development providers should consider design and implementation factors in online environments. Bower, Dalgarno, Kennedy, Lee and Kenney (2015) examined blended synchronous learning environments to determine how design and implementation factors impacted student learning activity and perceived learning outcomes. Students who were remote (via computer in a different location) participated in classes with students who were face-to-face. Student, teacher and researcher observations were completed before, during and after the lessons. Using the evidence from the observations and survey, the researchers developed a blended synchronous learning design framework. The framework revealed important design and

implementation factors. Design factors indicate designing for active learning, matching tools to technology, and the need to be highly organized as imperative. The implementation factors revealed instructors should have technical knowledge of the learning system and encourage regular student contributions. Bower et al. (2015) suggests additional work be completed to "further validate and refine the framework as well as to develop supporting resources aimed at guiding and assisting educators in its use" (Bower et al., 2015, p.14).

Active Learning in Mathematics Professional Development

National Council of Teachers of Mathematics (NCTM) (2010) professional development research brief highlights core goals of mathematics professional development (PD) and the features needed to support the goals. NCTM denoted research shows PD should foster the growth of mathematics teachers in four main areas.

- Build teachers' mathematical knowledge and their capacity to use it in practice.
- Build teachers' capacity to notice, analyze, and respond to students' thinking.
- Build teachers' productive habits of mind.
- Build collegial relationships and structures that support continued learning. (NCTM, 2010, pp. 1-2)

Providing mathematics teachers an opportunity for active learning is one of the features NCTM determines is needed to support the goals (2010). Teachers should be actively engaged in inquiry and problem solving during professional development. Research showed activities such as lesson planning, reviewing students' work, observing other teachers, facilitating discussions, as reported by teachers, lead to increase in teachers' knowledge and skills (NCTM, 2010; Garet et. al., 2001). This study which highlighted activities mathematics teacher leaders participated in to deepen knowledge of content and practice standards supports NCTM's assertions.

Reiten (2021) investigated the aspects of professional development (PD) that supported secondary mathematics teachers in implementing virtual manipulatives. Virtual manipulatives (VMs) are "an interactive, technology-enabled visual representation of a dynamic mathematical object, including all of the programmable features that allow it to be manipulated, that presents opportunities for constructing mathematical knowledge" (Reiten, 2021, p.4). Fourteen secondary mathematics teachers participated in twenty hours of professional development spread over seven months. The PD focused on content in the teachers' courses, interaction with virtual manipulatives aligned to student learning goals. Teachers identified time as a factor that supported their efforts in implementing virtual manipulatives. Teachers were allotted time to interact with the virtual manipulatives and tasks related to their lessons. "The PD provided opportunities for active learning, whereby teachers directly interacted with VMs and tasks aligned to their upcoming curricula units" (Reiten, 2021, p. 32). Research where facilitators promoted the use of online technology tools to convey ideas aligns with the aspects of the virtual manipulatives study.

Parrish, Byrd, Johnson, and Green (2020) studied teacher's perceptions to understand "how and why middle grades mathematics teachers did or did not fully participate in sustained, content focused professional development" (Parrish et al., 2020, p. 2). The Mathematics Partnership Project (MPP) professional development program was instituted with the goal of "increasing mathematics content knowledge of local middle grades mathematics teachers working in high-need schools" (Parrish et al., 2020, p. 5). The MPP professional development program ran from fall 2012 to summer 2017. The focus of the study was on 2016-2017 academic year. During the 2016-2017 academic year, there were five content-focused face-to-face sessions facilitated by three mathematics faculty and one secondary mathematics education faculty. The

content-focused sessions were delivered through Math Circles, an active learning strategy. “Through active learning experiences and high levels of engagement with other participants and session leaders, teachers have an opportunity to develop their own mathematical content knowledge and problem-solving abilities” (Parrish et al., 2020, p. 6). Data were collected from 23 participants through open-ended surveys and via focus group interviews with 10 random participants. Teachers collaboratively engaged with solving challenging mathematics problems. Most participants identified opportunities for learning mathematics and collaboration through active learning experiences as effective aspects of content-focused professional development. Collaborative conversations were evident during examination of active learning strategies in online synchronous train-the-trainer mathematics professional development.

Pak, Desimone, and Parsons (2020) examined school district leaders’ perceptions of effective professional development as they enact college and career ready standards-based policies. Using case studies from school districts in five states, the authors collected data using structured interviews of school district leaders. Participants included 70 district officials in 24 school districts. Topics covered during the structured interview focused on adoption and implementation of college and career standards, professional development, curriculum, and assessments. One finding reveals “active learning is being used as a mechanism for creating collaborative professional development opportunities grounded in the state’s content standards” (Pak et al., 2020, p. 9). District leaders detailed how they incorporated the characteristics of effective professional development to support deeper learning experiences for teachers as they implement the standards. School districts are combining collective participation with active learning to focus on content knowledge development.

> Districts tended to describe three different forms of active learning with regards to building standards-based content knowledge: teachers developing curricular products aligned to the standards as a form of learning (n = 5), coaches and other district personnel modeling standards-based instruction while teachers act as students (n = 6), and teachers, as well as principals, observing each other's lessons and debriefing the observations (n = 7). (Pak et al., 2020, p.11)

District leaders highlighted benefits of incorporating active learning practices. One leader noted teachers comprehend the content standards more effectively when that have a "product" they are manipulating. Teachers are more engaged in developing standards-based products together, than reviewing a list of standards and analyzing them (Pak et al., 2020). Another administrator submits teachers have the opportunity to make mistakes, practice, and improve. Facilitators modeled standards-based instruction while facilitating professional development for mathematics teacher leaders, which supports the researchers claims.

Online Professional Development

Considering budget woes and requirements of federal mandates, school districts need to find alternate cost-effective ways to provide professional development to teachers. One method utilized is online professional development. There are various models of professional development in education and are delivered in different forms. Examples include self-study, study groups, peer observation, mentoring, workshops, conferences, team meetings, and instructional coaching (Mizell, 2010). The professional development models can be delivered face-to-face and virtual.

Online professional development provides many conveniences for teachers. The National Research Council (2007) defines online professional development as electronic technologies

using web-based, interactive experiences combining text, video, and sound. It is usually asynchronous. Online professional development provides the opportunity for teachers and administrators to participate in professional development anytime, anywhere and is self-paced. Online professional development enables teachers to remain at their schools for professional development, lessening the need for schools to incur additional costs. Professional development programs need to be high quality, coherent, involve active learning, sufficient duration, and encompass collective participation (Yoon et al., 2007).

Research indicates online learning is increasing in popularity with teachers and administrators. A national survey conducted by Hezel Associates (2007) reviewed the effectiveness of various professional development models. The study examined beliefs about professional development surveying approximately 1,700 teachers, school administrators, and district superintendents. Hezel Associates (2007) research found that teachers reported receiving a majority of their professional development via face-to-face workshops, conferences, and during school-based grade-level or content meetings. In addition, teachers spent less time engaging in college courses, online courses or modules, and instructional coaching, but two-thirds stated an interest in participating in an online activity for professional development. Furthermore, they found that superintendents and principals overwhelmingly supported the use of the Internet for professional development, 89% and 83% respectively. Some districts used technology in professional development activities to communicate messages. As reported by superintendents, 10% specified almost all, 26% stated most, and 56% indicated some of district professional development utilized technology. Forty-four percent of superintendents and 38% of principals used feedback from instructional coaches to determine teacher professional development needs

(Hezel Associates, 2007). School leaders and teachers have shown an interest in online professional development.

Similar research found teachers preferred online professional development over face-to-face. Russell, Carey, Kleiman, and Venable (2009), conducted research comparing face-to-face professional development to online professional development for mathematics teachers. Each format occurred over the same eight-week time span and utilized the same instructors, instructional materials, and activities. In both formats of the course, teachers displayed significant gains in their mathematical content, instructional strategies utilized and pedagogical beliefs. Teachers who took the course online were more willing to take the course online in the future, than the teachers who took the course face-to-face (Russell et al., 2009).

An additional study compared online and face-to-face professional development using a quantitative methodology. Scruggs-Thomas (2009) utilized surveys on K-12 teacher perceptions on the effectiveness of online versus face-to-face professional development. The study incorporated a constructivism theoretical framework and andragogy. Ninety percent (frequency=45) of the teacher participants stressed the flexibility to work anytime as a benefit of online professional development. Other benefits of online professional development noted in the study were the "ability to work from any Internet accessible computer" and "lack of travel requirements" (Scruggs-Thomas, 2009).

Although online professional development is a viable alternative, asynchronous learning format does not meet all the necessities of high-quality professional development, because teacher interaction may not be ongoing with teachers working online at any time (McNamara, 2010; Davis-Adams, 2010). There is interaction among the participants within the online learning environment, which can include a discussion board or text chats, but needs to be

structured to deepen teacher's experience (McNamara, 2010). Teachers prefer text chats due to the spontaneity and immediacy (Davis-Adams, 2010). Because of the varied professional development needs, there may be teachers who are at the same school and in the same grade-level that participated with different courses. How can online professional development encompass collective participation and ongoing interaction? Continued studies on the effectiveness of strategies and activities, implemented within a synchronous online learning environment, are areas of research to examine more deeply. This study which showed how facilitators of professional development used active learning instructional strategies and activities to strengthen the pedagogical and content knowledge of mathematics teacher leaders. The following section will describe the train-the-trainer model of professional development.

Train-The-Trainer

Train-the-Trainer (TTT) or training-of-trainers (ToT) is an efficient and cost-efficient method of implementing professional development. "This model focuses on bringing one or more lead teachers to central workshops, training them in specific skills or programs, and requiring them to train their colleagues at their home school in the demonstrated skills" (Pancucci, 2007, p. 598). Perry and Boylan (2018) contend that professional development facilitators (PDFs) must be provided opportunities to develop their own knowledge base to effectively facilitate professional learning. "For PDFs to be credible, they must have and be able to demonstrate their knowledge of the subject matter of the professional development activity, including subject-specific pedagogical content knowledge" (p. 256). Perry & Boylan (2018) designed a study to support the professional learning of professional development facilitators (PDFs) in a secondary science education program and established a framework of different knowledge and skills for facilitators and for teachers. The knowledge needed for mathematics

teachers is vastly different from mathematics teacher educators. Mathematics teacher educators need knowledge of subject matter content knowledge; pedagogical content knowledge; curricular knowledge; and knowledge of context. In addition to the mathematics teacher knowledge, professional development facilitators must absorb various roles as: listener, expert, critical friend, coach and mentor along with workshop leader. PDFs must know how to manage the different roles to meet the needs of the teachers.

Perry & Boylan (2018) posit an additional stage is needed, knowledge of how to facilitate professional learning to teachers who already know how to teach. they must have and be able to demonstrate their knowledge of the subject matter of the professional development activity, including subject-specific pedagogical content knowledge Professional development facilitators need ample opportunity to practice knowledge and skills of facilitation. They also need to have knowledge of the learning community and the beliefs teachers encompass. Data were collected from video observations coupled with collaborative inquiry, which allowed for reflection, shared knowledge, and improved understanding of effective practices. There were seven participants who recorded themselves while conducting professional development over a 5-month period. Each participant shared the videos with other participants and personally reflected on it using pre-established questions. In addition, other participants analyzed the videos. The program led to change in practice and increased knowledge of effective professional development practices. It is imperative to incorporate opportunities for professional development facilitators to “reflect on, analyze, understand and improve their practice” (Perry & Boylan, 2018, p. 269) to be effective facilitators of professional development.

Additional research supports the implementation of the train-the-trainer model to improve facilitation of professional development. Taylor, Yates, Meyer, and Kinsella (2010) reviewed

one districts' effort to meet the needs of secondary teachers' implementation of standards-based assessments using the Train-The-Train model. As a result of a new assessment reform shift from norm-referenced to standards-based, secondary teachers wanted support for assessment design and development. The district incorporated Senior Subject Advisors to provide professional development to teachers. Secondary teachers from the district were selected based on expertise and experience to serve in the role of Senior Subject Advisor (SSA) and were released from their classroom duties.

> SSA's responsibilities included developing teachers' use of evidence to inform teaching practice, enhancing teachers' assessment capability, improving consistency in judgments about assessed work among teachers, promoting professional learning communities, and supporting new leaders to extend professional skills and knowledge by working across schools, drawing on their subject and assessment expertise. (Taylor et al., 2010, p. 87)

The Ministry of Education and faculty from participating universities provided professional development and support during induction and throughout the year. The study sought to determine: (1) How did those appointed to roles as senior subject advisers and the teachers with whom they worked view the role of SSA? and, (2) To what extent did these views support the initiative as a career pathway model for enhancing teacher leadership and development? Results from interviews and surveys revealed SSAs were extremely favorable towards involvement in the program with expectations of improving their own professional learning. The SSAs obtained new understandings of pedagogy, evidence-based assessment practices, leadership and change management. They also increased confidence and abilities to facilitate adult learning. Showing that a Train-the-Trainer model using teacher leaders "capacity building" is an effective model of professional development.

Incorporating the Train-the-trainer model to increase use of technology in the classroom was found to be effective (Pancucci, 2007). A school district incorporated information technology coaches (ITC) in response to the Ontario Ministry of Education and Training mandate to incorporate more technology in the classroom. Information technology coaches provided technology support to teachers in addition to the regular classroom duty. ITCs received professional development over a 3-year period, three half-day in-service sessions the first year and one half-day the second year. Due to budget cuts, the final year training occurred during after school and online. The coaches were expected to provide training on the knowledge and strategies learned to teachers at their school via workshops, peer-to-peer instruction, and other activities. A survey was conducted to determine the extent to which information technology coaches improved their computer knowledge and skills, conducted trainings at the school, and felt if teachers started integrating computers in the classroom, because of the training. Eighty-three teachers served as ITCs and seventy responded to the survey request. Data showed over 70% felt their knowledge and skills improved, over 70% acknowledge the follow-up trainings did occur, and more than 53% stated there was a change in teacher practice with incorporating technology.

Previous research reveals Train-the-Trainer model is effective for increasing teacher use of technology and moreover results indicate it is effective method to train educators on new programs. Weingarten, Rabago, Reynolds, Gates, Yanagida, and Baker (2018) found the Train-the-Trainer model effective for dissemination of sexual violence prevention in schools. The authors recommend the training provide hands-on components and opportunities to practice delivering the training prior to facilitation with feedback. Evaluation of trainers should be conducted to determine the readiness to implement the training. After trainers conduct the

training, follow-up should be provided to debrief and reflect on any suggestions for improvement and challenges. Refresher trainings may be necessary depending on the feedback. “Finally, both formative and summative evaluations of the program should be conducted to: 1) ensure that the program is being implemented with fidelity, 2) examine whether program goals are being met, and 3) determine the costs of achieving these goals” (Weingarten et al., 2018, p. 76). Weingarten et al. (2018) recommend building the knowledge base on whether incorporating Train-the-Trainer model is reducing professional development costs and meeting the professional development goals. Research on using the Train-the-Trainer model to provide professional development to mathematics teacher leaders can meet the needs as outlined by the scholars.

Summary

It is evident from the highlighted research (Yoon et al., 2007; Blank & de las Alas, 2009; Slabine, 2011 Pennington, 2014) on professional development, that teacher professional development impacts student success. Yoon, Duncan, Lee, Scarloss, and Shapley (2007) review of studies on professional development outlined what is required to increase student achievement. Professional development is used to improve teacher-quality (Mizell, 2010). Federal reforms mandate State Education Agencies and Local Education Agencies ensure professional development is of high quality (ESSA, 2015). Effective professional development should incorporate key features in both face-to-face and online learning environments, including active learning (Darling-Hammond et al,, 2017; Gulamhussein, 2013). Incorporating active learning is a necessity in online professional development environment to enhance social presence and meaning making for teachers (Hokanson et al., 2019; Murthy et al., 2015; Wei & Chen, 2012). Mathematics teachers should be actively engaged in inquiry and problem solving during professional development. Teachers and administrators show preference for online

professional development over face-to-face (Russell et al., 2009; Scruggs-Thomas, 2009; Hezell Associates, 2007). Train-the-Trainer (TTT) is an effective and cost-efficient method of implementing teacher professional development (Perry & Boylan, 2018; Weingarten et al, 2018; Taylor et al., 2010). It is important to incorporate effective facilitation strategies to ensure teachers receive high-quality professional development. As school districts contract vendors to facilitate professional development, they should examine methods utilized to foster active engagement to ensure they are effective. Limited research has been conducted on analyzing active learning in online synchronous professional development. This examination of how active learning was incorporated in mathematics teacher leader online synchronous professional development can add to the body of and hopefully narrow the gap in literature.

3 METHODOLOGY

In Chapter 3, I discuss the methodology that framed this study and the related epistemological and ontological stance. Research setting, summary of the population, and researcher role are provided. The data collection technique and analytic procedural method to address the research questions are described. I explain how confidentiality and ethics were maintained as well as how I adhered to qualitative validity, reliability, and trustworthiness.

Purpose of the Study

The purpose of the study was to examine active learning in one school system's online synchronous train-the-trainer mathematics professional development initiative.

Research Questions

The following research questions guided the study:

1. What instructional strategies, if any, promote active learning in online synchronous professional development?
2. How do mathematics teacher leaders actively engage in online synchronous professional development?

Conceptual Framework

Methodology is the "strategy, plan of action, process or design lying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes" (Crotty, 1998, p. 3). In examining active learning in online synchronous professional development, the theoretical perspective is symbolic interactionism; constructivism is the epistemology underpinning which is described in Chapter 1. I proposed an Online Synchronous Active Learning Professional Development Framework based on Moore's (1989) *Three Types of Interaction* and Grooms' (2000) *Learner Interaction Model* to study of mathematics teacher

leaders participating in online synchronous professional development. The research method includes case study, document analysis, and conversation analysis. Qualitative research methodology was used to guide the examination of active learning in online synchronous professional development.

Qualitative Research Design

Qualitative research is an interpretive methodology. Qualitative research is a collection of clarifying processes that transforms the world by making it more visible. Qualitative research expands across disciplines. Denzin and Lincoln (2005) reason, "qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meaning people bring to them" (Denzin & Lincoln, p. 3). Qualitative researchers observe the activities of the world and place their findings in it. Qualitative researchers commit to an "emic, ideographic, case-based position" focusing on specific cases.

Bogden and Biklen (2007) highlight five characteristics of effective qualitative research, 1) naturalistic, 2) descriptive data, 3) concern with process, 4) inductive, and 5) meaning. Naturalistic because qualitative researchers spend time in the research setting and the focus is on the context in which the actions occur. They feel behaviors are affected by the settings in which it occurs. Researchers use data to determine how the circumstances came about.

Data is descriptive in qualitative research. It is analyzed based on the form it was collected (recorded or transcribed). The written word is important to the qualitative process as such quotations are used to describe the phenomena. Everything (gestures jokes, physical environment) in the setting is taken into consideration during analysis. Qualitative researchers are concerned with the process and not just then end results. Concern involves how people make

meaning, how terms and labels are applied in natural settings or activity that are under study (Bogden & Biklen, 2007).

Qualitative research is inductive and meaning making. Researchers collect data and construct knowledge about phenomena during data collection. They use what is learned from the initial data collection to determine what additional data is needed, starting with the big picture and narrowing the focus. Researchers want to know how people make meaning in their lives and use strategies and procedures to ensure accurate depiction of "personal perspectives" (Bogden & Biklen, 2007).

Case Study

Yin (2014) defines case study as investigation into a "contemporary phenomenon (the "case") in its real-world context" (p.2). It is an examination of the case and the outcome of that examination (Stake, 2005). Case study method allows researchers to "retain the holistic and meaningful characteristics of real-life events" (Yin, 2014, p. 4). It contributes knowledge to phenomena related to many facets including individual, group, organizational, social, and political arenas (Yin, 2014). Case study research is a type of descriptive research used to explain how and why questions that focus on "contemporary" events. There is no control over the variables, and they are not easily identified in case study research. Descriptive research is used to describe and explain phenomena when the variables are deeply embedded in the phenomena. In general, the design for case study starts with a wide reach that eventually becomes more focused. The researcher searches for places or people that could be the focus of the study. As new information is obtained, the researcher revises the design and procedure to narrow the topic to a specific setting, subject, or data source to study. Questions are then developed; data is collected

and analyzed (Yin, 2014). Case studies have been used in areas concerning decisions, programs, implementation process and organizational change.

Analytic Induction

Analytic induction is the research strategy utilized in the study to systematically examine the case in order to develop and test theories.

> Analytic induction (AI) is a research logic used to collect data, to develop analysis, and to organize the presentation of research findings. Its formal objective is causal explanation, a specification of the individually necessary and jointly sufficient conditions for the emergence of some part of social life. (Katz, 2001, p. 480)

Initial cases or instance within a case are examined to uncover commonalities and interim explanations. As new cases or instances are inspected and initial theories are contradicted, the explanation is reworked (Katz, 2001).

> Researchers use inductive reasoning to code data and based on these codes, identify patterns and construct potential explanations. As she or he locates exceptions in existing data, or in new cases, the researcher either refines the emerging theme or pattern, and its explanation, to include the exceptions, or explains the presence of the exceptions. (Pascale, 2011, p. 36)

Exceptions are a necessary part of analysis because it indicates how to adjust categories and revise theories. The process continues until exceptions to the pattern are exhausted and the researcher can conclude one's theory is accurate (Pascale, 2011). Pascale (2011) reasons researchers need to provide adequate information in building analyses for readers to evaluate the credibility of their argument.

Rationale for Qualitative Descriptive Case Study

Qualitative research is descriptive and concerned with process. Qualitative research design is best suited for a study examining active learning in online synchronous train-the-trainer mathematics professional development. This study describes the strategies the facilitators incorporated to promote active learning, how the mathematics teacher leaders actively engaged in online synchronous professional development and how the facilitators use the virtual learning to promote active learning. Case study focuses on real-world phenomena. Case study is best used for answering how or why questions in "contemporary" events. The research addresses "how" the facilitators incorporated active learning instructional strategies and mathematics teacher leader engaged in the professional development.

Critiques of case study methodology include lack of rigor and extensive amount of data (Yin, 2014). Following a systematic approach throughout the research process helped me to combat the issue of rigor. The same approach was applied to each professional development session. The use of *NVivo*, a type of Computer Assisted Qualitative Data Analysis Software, from the beginning of data collection aided in managing large amounts of data. Analysis occurred during data collection and not just when data saturation was attained.

Research Setting and Unit of Analysis

Research setting is a geographically large school system. The school system is divided into three geographic areas (Region A, Region B, Region C). The school system adopted college and career ready mathematics standards (CCRSM) (same as Common Core State Standards for Mathematics), whose curriculum standards are rigorous, and research based. In 2015, the school system contracted an external facilitator to design, develop and facilitate professional development events to engage secondary mathematics teachers using research-informed tasks

and productive practices. The focus of the professional development sessions was to provide a deeper understanding of CCRSM content, and the Standards for Mathematical Practice (SMPs). Additionally, the facilitators were to include key concepts structured around the eight mathematics teaching practices referenced in *Principles to Actions: Ensuring Mathematical Success for All*, which represent a core set of high-leverage practices and essential teaching skills necessary to promote deep learning of mathematics.

The school system incorporated a train-the-trainer professional development model. The train-the-trainer model "focuses on bringing one or more lead teachers to central workshops, training them in specific skills or programs, and requiring them to train their colleagues at their home school in the demonstrated skills" (Pancucci, 2007, p. 598). The professional development providers facilitated online synchronous professional development to mathematics teacher leaders who in turn redelivered the sessions to the mathematics teachers at their school in a face-to-face environment.

Although the duration of the secondary mathematics professional development initiative spanned three years (July 2016 – May 2019), the research study only focused on the third year. From September 2018 to April 2019, the external contractor facilitated four online synchronous professional development sessions with mathematics teacher leaders who were responsible for redelivering the same content to teachers at their school in a face-to-face environment. The four sessions were spread out throughout the year, one per quarter of the school year. There are three regions in the school district. The facilitators repeated the same sessions for each region (Region A, Region B, Region C), a total of 12 sessions. In this study, I focused on a different region for each session: 1) Region A, 2) Region B, 3) Region C, 4) Region A. Each session was six hours in length not including the lunch break.

Summary of the Population

The facilitators of the train-the-trainer professional development were a vendor contracted by the district and are not employed by the district. There were four facilitators who rotated presenting each session. One facilitator presented during all sessions, one presented session 1 and session 3, one presented session 2 and session 4, and one presented only during session 4. The participants are mathematics teacher leaders, region mathematics specialists, and system mathematics specialists. Mathematics teacher leaders were classroom mathematics teachers selected by the principal to attend the training and redeliver the training to mathematics teachers at the school on the next district professional development day. The number of participants varied for each region but due to the limitations of the *Zoom* video recording, the exact number of participants is not available. I estimated there are 62 participants. I determined the number of participants by reviewing the portions of the video when the facilitator announced the names of participants in each group. The district mathematics specialists redelivered the mathematics training at schools along with the mathematics teacher leader or alone if the school didn't have a teacher leader. Each session was recorded by the facilitators to allow teacher leaders to go back and review an activity before redelivering. The facilitator divided each session into two parts (Ex. Session 1.1, 1.2) to limit the size of the video due to size limits when uploading to shared drives, except for session 4. See session video specifications in Table 1.

Table 1

Session Video Specifications

Video	Region	Video Length	Facilitator
Session 1.1	Region A	2 hrs 25 min	F1, F2
Session 1.2	Region A	1 hr 25 min	F1, F2

Session 2.1	Region B	2 hrs 41 min	F1, F3
Session 2.2	Region B	2 hrs 3 min	F1, F3
Session 3.1	Region C	1 hr 16 min	F1, F2
Session 3.2	Region C	1 hr 14 min	F1, F2
Session 4.1	Region A	4 hr 8 min	F1, F3, F4

Researcher Role

As the investigator in a qualitative case study, I am subject to my sensitivity and integrity; because of this, I must be aware of my subjectivities. Alan Peshkin (1988), reasons that researchers should explore their subjectivities during their research. As researchers observe themselves, certain personal characteristics will arise while research is conducted. These attributes can "filter, skew, shape, block, transform, construe and misconstrue" what occurs throughout the research project from start to completion (Peshkin, 1988, p.47).

During 2018 – 2019 school year, I served in the role of System Mathematics Specialist for sixth through eighth grade mathematics in the school system. I reviewed and provided feedback on materials utilized by the facilitators during the train-the-trainer sessions. I was a participant in session one, session three and session four of the online synchronous professional development for mathematics teacher leaders. I redelivered session one professional development to secondary mathematics teachers at a school in Region A. Researchers need to be aware of their biases during data collection and analysis. I remained actively aware of my own stance on teacher professional development. I kept a reflective journal during the study to combat biases and show transparency throughout the research process.

Data Collection Techniques

Multiple archival data sources were utilized to ensure that this research study could provide an understanding of how facilitators incorporated active learning strategies, mathematics teacher leaders actively engaged in professional development and how facilitators used the learning environment to promote active learning. Archival data contains existing information originally collected for a purpose other than research (Rabinowitz, n.d). The data is fixed and not subject to change. "Archival researchers collect data they have not generated" (Vogt et al., (2012), p. 86). The data were collected without the needs of the researcher in mind. Therefore, searching and sorting must be done to make the archival data usable for the study (Vogt et al., 2012).

Video and documents from the sessions are considered archival. The online synchronous mathematics train-the-trainer professional development occurred from September 2018 to April 2019. Data were collected from pre-recorded videos, transcriptions, and documents from four train-the-trainer mathematics teacher leader professional development sessions. The documents the facilitators utilized while facilitating the sessions are PowerPoint, charts, and articles. During the session, when working in break out groups, the mathematics teacher leaders entered discussion information into documents which I titled collaborative group artifacts. The transcript of the chat is a document which shows the responses from when the facilitator asked questions and asked for responses to the placed in the chat. During the research process, I kept a written and audio reflective journal. I wrote about or audiotaped my thoughts related to the research and questions I wanted to explore more. A full list of data sources aligned to each session is in Appendix A. The researcher focused on archival documents used to triangulate data as it relates to the research questions. Table 2 shows the data collection matrix.

Table 2

Data Collection Matrix

Research Question	Sources of Data
1. What strategies promote active learning in online synchronous professional development?	Recorded virtual Train-The-Trainer sessions Transcribed video Transcript of Chat Collaborative group artifacts Facilitator's PowerPoint utilized during the online sessions Researcher Journal (written and audio)
2. How do mathematics teacher leaders actively engage in online synchronous professional development?	Recorded virtual Train-The-Trainer sessions Transcribed video Transcript of Chat Collaborative group artifacts Facilitator's PowerPoint utilized during the online sessions Researcher Journal (written and audio)

I incorporated a methodical way to align the video to the transcription, transcript of the chat, collaborative group artifacts, and facilitator's PowerPoint. *NVivo,* Computer Assisted Qualitative Data Analysis Software (CAQDAS) was used to organize and manage the data. I transcribed the videos using NVivo. I uploaded video to NVivo. I played the video and used the voice typing tool in Google docs for automatic transcription. As the speakers changed, I hit return in the document to start a new line. I played the video the second time and edited the transcription in the Google doc and added speaker's name. To add the transcription to NVivo, I played the video while reviewing the transcription and stopped the video when speaker was finished speaking. I copied the wording from the transcript to the timestamped section in NVivo. I continued this process for each video.

The PowerPoint slide is shown in the video as the facilitator is presenting. I created a column in Nvivo title “PowerPoint”. I added the slide number that aligned with the speaker’s comment, if applicable. An additional column was added for collaborative group artifacts. As I reviewed the group artifacts, I aligned the speakers' wording with the group artifacts. This typically occurred when a speaker was presenting what was discussed in the small groups. When there was a transcript of the chat, the speaker had read the comments from the chat which made it easier to align it to the speaker's comments and slide number.

Analytic Procedures

Document analysis and conversation analysis are the analytic methods utilized for the study. Prior (2003) defines a “document as a product,” a work – frequently an expression of a technology. Humankind develops documents in socially constructed circumstances for a designated purpose. Document analysis is a systematic method for reviewing or evaluating documents—both printed and electronic material (Bowen, 2009). Document analysis is a method for reviewing material in print and video. Like document analysis, conversation analysis is studying information that has been recorded in texts, media and visuals.

Conversation analysis (CA) purports to explain the methods or practices people employ to construct the actions and interactions of everyday life.

> CA assumes that action and interactions are inextricably tied to their context of production. The relation between action/interaction and context is reciprocal: the context is in part constituted by the actions/interactions performed and the actions/interactions are responsive to the context of their construction. (Pomerantz, 2011, p.3)

The orderly connected practices that make up our everyday lives are sense-making practices. When participants engage in these practices, they collaboratively construct an understanding of

their own and their co-interactants' conduct (Pomerantz, 2011). Conduct in interaction is linked to the "context of its production and understanding" (Pomerantz, 2011, p.4) therefore conversation analysis examinations are conducted in naturally occurring settings.

> Recordings are made of the naturally occurring actions and interactions. These recordings serve as resources for and constraints on the analyst, who can thereby view and review the interaction in developing an analysis. The recordings also serve as a resource for those who read the analysis; it enables them to review the same materials employed by the analyst. (Pomerantz, 2011, pp.4-5)

Traditionally synchronous interactions have been the major emphasis in conversation analysis but asynchronous studies with the technological developments have been more common in recent years. Transcripts are customarily compiled of the interactions under study. The transcripts provide details regarding "what and how things were said and, when relevant, provide an indication of the visual aspects of an interaction" (Pomerantz, 2011, p.5). Making observations from the recorded interactions and transcripts is an integral starting point for conversation analysis. The CA observations are focused on increasing "understanding of practices that people use and rely on when they interact, practices with which they make sense of their own and others' conduct and with which they can accomplish their actions and activities" (Pomerantz, 2011, p.10). Coding in conversation analysis aids in the understanding.

Confidentiality and Ethics

In examining active learning in online synchronous train-the-trainer mathematics professional development, I ensured ethics and confidentiality were maintained. Ethical issues may arise throughout the research process from conception to written statement. Researchers need to consider ethical issues in archive research (McKee & Porter, 2012). I maintained a reflective journal during each step in the research process to reflect on my motives for

conducting the research and to construct the meaning the research has for me. A reflective journal helped me to understand the relationship I have to the data and combat potential biases. Reflection legitimizes and validates research procedures (Mortari, 2015). I examined the types of archival documents, who were the custodian of the documents and under what circumstances were the documents archived. I met with the school district professional development specialist to discuss the online synchronous professional development sessions and why the sessions were recorded. The specialist provided the limitations in the use of the video and additional training documents. The school district has sole copyright of all components of the sessions. In my journal writing I took into account copyright and privacy issues based on the discussion. I preserved confidentiality by using pseudonyms for names, schools and the school system. My computer and NVivo software were password protected.

Validity and Reliability

Verification strategies should be applied to check for validity and reliability. Morse, Barrett, Mayan, Olson, and Spiers (2002) argue verification strategies which are used by the researcher during the inquiry process allow for attainment of reliability and validity. The strategies are investigator responsiveness, methodological coherence, theoretical sampling and sampling adequacy, data collection and analysis, thinking theoretically, and theory development.

> These strategies, when used appropriately, force the researcher to correct both the direction of the analysis and the development of the study as necessary, thus ensuring reliability and validity of the completed project. (Morse et al., 2002, p. 17)

Investigator responsiveness relates to the researcher's creativity, sensitivity, flexibility and insight while employing verification strategies which determines the reliability and validity of the study. The goal of methodological coherence is to ensure linkage between the research question and the components of the method, which matches the data and analytic process.

The sample must be adequate. “Sampling adequacy, evidenced by saturation and replication, means that sufficient data to account for all aspects of the phenomenon have been obtained” (Morse et al., 2002, p. 18). Having an active analytic stance while collecting data allows forms a connection between what the researcher knows and what the researcher wants to know. The fourth characteristic, thinking theoretically, ensures ideas which develop from the data are reconfirmed in new data. The new ideas are then verified in data already collected (Morse et al., 2002). There is a constant checking and rechecking. Finally, “theory development is to move with deliberation between a micro perspective of the data and a macro conceptual/theoretical understanding” (Morse et al., 2002, p. 19). The theory is developed because of the research process and serves as an outcome of the research process and as a prototype for comparison and further development of the theory. My use of verification strategies contributed to and built reliability and validity which in turn ensures rigor.

Trustworthiness

Lincoln and Guba (1985) have established criteria to establish the trustworthiness of a research study: credibility, transferability, dependability, and confirmability. Credibility speaks to the truth of the research findings. To establish credibility, I used multiple data sources (triangulation) and peer debriefing with a colleague who is not a mathematics content specialist. Transferability is the extent to which the findings are applicable to other context or settings. I kept a reflective journal to provide a “thick description” of the research process. Dependability shows the findings are consistent and supported by participants and if duplicated the results would be similar. Confirmability ensures the findings are unbiased and able to be confirmed by other researchers. I established an audit trail to address dependability and confirmability. The audit trail includes reflective journal, decision making process and emergence of the findings.

4 DATA ANALYSIS AND RESULTS

The purpose of this study was to examine active learning in an online synchronous train-the-trainer mathematics professional development initiative. The researcher focused on archival documents used to triangulate data as it relates to the research questions. The online synchronous mathematics train-the-trainer professional development occurred from September 2018 to April 2019 and material was collected to maintain a record of it. Documents from the session are considered archival. Archival data that were used are the recorded videos of the train-the-trainer sessions, transcribed videos, transcript of the chat, collaborative group artifacts and researcher journal. This chapter provides the context of the professional development initiative, coding process and an examination of the major themes that emerged. The following research questions guided the study:

1. What instructional strategies, if any, promote active learning in online synchronous professional development?
2. How do mathematics teacher leaders actively engage in online synchronous professional development?

Research Context

The school system in this study adopted new mathematics academic standards to impact student achievement and ensured professional development was provided to improve teacher practice. The goal of the professional development initiative was “Build the capacity of educators to ensure that all students meet or exceed the expectations of the college and career ready standards for mathematics (CCRSM)” (Name Withheld, 2014). College and career ready standards are identical to Common Core State Standards for Mathematics (CCSM). Common

Core State Standards are descriptions of the skills students should have at each grade level mathematics by the time they finish high school (Gewertz, 2015) (See Appendix C).

The school district provided teachers professional development and job-embedded instructional training to support the implementation of more rigorous academic standards, increased opportunities for collaboration across disciplines, and improved educator access to curricular resources and training materials (Name Withheld, 2014). The school system contracted an external facilitator to design, develop and facilitate professional development events to engage secondary mathematics teacher leaders (MTLs) using research-informed tasks and productive practices. The school system incorporated a train-the-trainer professional development model. The focus of the professional development sessions was to provide a deeper understanding of college and career ready mathematics content standards, and the standards for mathematical practice (SMPs). The standards for mathematical practice describe ways in which student practitioners of the discipline of mathematics ought to engage with the content as they grow in mathematical maturity and expertise (NGAC & CCSSO, 2010). Additionally, the facilitators were to includes key concepts structured around the eight mathematics teaching practices- referenced in *Principles to Actions: Ensuring Mathematical Success for All*:

- Effective teaching and learning
- Establish mathematics goals to focus learning
- Implement tasks that promote reasoning and problem solving
- Use and connect mathematical representations
- Facilitate meaningful mathematical discourse
- Pose purposeful questions
- Build procedural fluency from conceptual understanding

- Support productive struggle in learning mathematics
- Elicit and use evidence of student thinking.

The NCTM six *Guiding Principles*—teaching, learning, equity, curriculum, assessment, and technology were also included. They represent a core set of high-leverage practices and essential teaching skills necessary to promote deep learning of mathematics. The school system tasked facilitators with coherently sequencing the learning experiences to engage participants in an active process.

The facilitator in online professional development selected the learning platform and created the space that fosters active learning. The facilitator selected the *Zoom* online platform. *Zoom* features incorporated during the sessions were break out rooms, chat, sending of files, video, audio, share screen, rename yourself and reactions. The reactions (thumbs up, heart, yes, no, away (coffee cup), raise hand, go slower, go faster) allowed for non-verbal feedback from the participants. Participants were asked to print out documents emailed to them by the facilitators prior to the session. The documents included the Facilitator Guide, Facilitator Handout Packet, and Participant Handout Packet. Participants were asked to join the session ten minutes prior to the start time to troubleshoot any audio and video issues. At the beginning of each session, the facilitators provided detailed instructions, modeled how to use the Zoom platform and had participants practice using the features. Participants were muted unless talking and their videos were on. Videos were turned off during independent work time. Additional online technology tools incorporated during the sessions were Jamboard, Google Sheets, Google docs, and Padlet. More details on how the tools were utilized are provided in the session descriptions.

Session Descriptions

Table 3

Session Topics

Session Number	Location	Facilitator	Participants	Topic
Session 1	Region A	F1, F2	6	• Investigate how the big idea of two-dimensional shapes manifests across grade levels • Examine standard for mathematical practice 7 and 8 • Explore and reflect on educator's belief about curriculum and how these beliefs influence decisions about teaching and learning
Session 2	Region B	F1, F3	24	• Explore coherence in statistics standards. • Instructional moves that support pose purposeful questions in *Principles to Actions* • Examine ideas around assessments productive and unproductive beliefs
Session 3	Region C	F1, F2	16	• Examine productive and unproductive beliefs about tools and technology • Examine instructional moves that support "Build procedural fluency from conceptual understanding • Examine tools and technology impact on learning and efficiency
Session 4	Region A	F1, F3, F4	16	• Engage in formative assessment task to gain deeper understanding of statistics standards (independence and conditional probability) • Examine beliefs about examining a culture of professionalism

	• Identify instructional moves that Support Productive Struggle • Identify supports in place and create action plans to sustain shared learning

All Sessions

Each session began with an introduction of the facilitators and the participants checking their audio. The facilitators then reviewed the school system goal of the professional development initiative. Group norms were shared and the learning outcomes for the session were discussed. The sessions were divided into sections. After each section, the mathematics teacher leaders (MTL) anticipated and prepared for redelivery of the section. They worked in small group breakouts to discuss how to facilitate the section, how to address any misconceptions and resistance which may arise, and any perspective time challenges. The responses were recorded on a Google spreadsheet and groups shared out their findings to the whole group.

Session 1

The Facilitator provided the prompt for the participants to experience a lesson on a 6^{th} grade geometry standard.

> "Wallpaper comes in long rectangular strips which 24 inches. If Jamie lays the strips vertically, can she cover the wall without wasting any paper? Explain. If Jamie lays the strips horizontally, can she cover the wall without wasting paper? Explain."

The facilitator provided a few minutes for participants to work independently. Facilitator asks questions to participants to guide discussion about to the problem. An assessment item was provided, and the participants discussed similarities and differences to the wallpaper problem.

Next activity, the participants were divided into two groups. Group 1 read Standards for Mathematical Practice (SMP) 7 and other group read Standards for Mathematical Practice (SMP)

8 to develop a clear understanding of it. Each group was placed in breakout rooms to discuss their designated SMP. When they came back to the whole group, the shared what they learned about each SMP. The participants were directed to go to a Google sheet with each tab labeled: SMP 7 – What is the teacher doing, SMP 7 – What is the student doing, SMP 8 – What is the teacher doing, SMP 8 – What is the student doing. Participants added ideas to each tab. Keeping the focus on the geometry standards, participants reviewed Geometry progressions document and worked in small groups to discuss how geometry changes from 6th grade through high school. Then made connections to SMP 7 and SMP 8.

The final activity focused on curriculum. Facilitator asked the prompt "What is Curriculum?" and instructed participants to put answers in the chat box. The facilitators read the responses. The participants read "Tale of Two Teams" scenario and listed productive and unproductive beliefs that were evident in the scenario. They were placed in break out rooms to discuss. Then shared out as a whole group. They reflected on the ideas of curriculum by responding the questions: What do you agree with, argue with, aspire to, or want to apply?

Session 2

The participants experienced a lesson on an 8th grade statistics standard. The facilitator went through as a teacher modeling questioning and mathematics teacher leaders participated as if they were students. As they were going through the lesson, they entered their answers in a Google Form. During the lesson mathematics teacher leaders jotted down the questions the facilitator was asking while doing the lesson to be utilized in a next section. Next, the participants reviewed the statistics progressions document for 6th-8th grade and high school. The facilitator assigned roles to each person. Using Padlet, participants wrote any interesting things they noticed while reading that was important for the other grade bands to know.

The next section focused on posing purposeful questions. Participants reviewed the questions they wrote down from the statistics lesson and categorized them into gathering information, probing thinking, making the mathematical visible, encouraging reflection and justification. They added the questions under each category in a Google form. Facilitator guided a whole group discussion on "Which of the questions assessed or advanced your mathematical thinking?" Continuing with posing purposeful questions, mathematics teacher leaders reviewed student work and posed three questions which could assess or advance mathematical reasoning or sense making for students. The questions were discussed within the breakout rooms and added to the Padlet with student work.

The assessment section began with the participants completing an assessment Frayer Model. The participants worked independently to write a definition of assessment, characteristics of assessment, and examples and non-examples of assessment. Facilitator asked for responses and wrote down responses in the Frayer Model viewed using a document camera. Finally, three different assessments were provided to the participants. In breakout groups, participants input on a Google slide similarities and difference among the assessments, evidence of mathematical understanding and how the assessment might be used.

Session 3

Mathematics teacher leaders (MTLs) engaged in a high school geometry task. They reviewed the lesson and typed in the chat what resources they might use to solve this task. The facilitator read the comments from the chat. The MTLs independently completed the task using a ruler, pencil, and graph paper. Then they discussed their strategies in breakout rooms and shared their findings to the whole group. The facilitator used the Zoom reactions to assess the comfort level of the participants knowledge of GeoGebra online math tool. Participants played with the

GeoGebra technology to familiarize themselves with it. Collaboratively, in breakout groups they completed the same task using GeoGebra.

Mathematics teacher leaders read a scenario "An eighth-grade teacher's use of technology to develop mathematical skill and understanding" from *NCTM's Principles to Actions.* In breakout rooms they discussed "How were the tools and technology used to promote mathematical sense making" and "how did the teacher help the student make sense of the math using the tool." Then shared out their discussion in the whole group. They explored Tools and Technology unproductive beliefs from *NCTM's Principles to Action.* There was a list of unproductive beliefs on Padlet. As a breakout group they discussed possible solutions to make the belief productive and added it to the Padlet. MTLs compared the group solutions to the productive beliefs listed in the book.

Finally, the focus was on how to build procedural fluency. Participants listed what they know about building procedural fluency and what they want to know about it. They read an excerpt in *NCTM's Principles to Action* and discussed in breakout groups: what I learned, what does it mean in your role, what questions I still have. The participants then completed different geometry tasks with concepts which lead up to the high school Geometry lesson. They made a list of conceptual tasks embedded in the lesson which build fluency required for the high school Geometry lesson.

Session 4

This session began with a reflection on the three-year professional development initiative. In small group breakout room, the mathematics teacher leaders reflected on personal learning since the beginning of the first session in 2016. The prompt was "what I use to think…. now I think." They shared out in the whole group.

Next the participants engaged in a conditional probabilities task. They completed the task independently to develop a strategy to solve the problem. Then they worked within their small breakout groups to develop a joint strategy and shared out to the whole group. The facilitator asked participants to respond in the chat to the following prompt: What standards for mathematical practice were evident in the lesson? The facilitator instructed the participants to create a T-chart and list when a student is engaged in productive struggle and the corresponding teacher action. The participants discussed in breakout rooms and in the whole group shared one student action and corresponding teacher action. The facilitator typed the responses in the Google sheet. The mathematics teacher leaders read Productive Struggle from *NCTM Principles to Action* and compared it to the T-chart. They discussed what confirms/supports their thinking, anything that should be added to the T-chart and raised any questions or interesting comments.

After the participants read a case study of how two teachers facilitated the conditional probabilities task, they provided feedback and suggestions on how they would move the teacher to a more ideal state. Using the feedback and suggestions, they discussed in small groups any new student behaviors that would be seen if the teacher applied the feedback and suggestions.

The final section focused on professional. The facilitator asked participants to put their response to “What is your definition of professionalism” in the chat box. Each unproductive belief and productive belief about the culture of professionalism was listed, one per Padlet. The mathematics teacher leaders listed on the Padlet what teacher behaviors and/or systemic structures would a shift towards productive beliefs and promote a culture of professionalism across the school system. In small breakout groups, they identified how their thinking progressed over the span of the professional development initiative and what factors contributed to the change in thinking.

Data Analysis

Coding

An inductive concrete procedural model was utilized. The first cycle coding scheme was based on the Online Synchronous Active Learning Professional Development Framework. The seven videos were transcribed using *NVivo 12* software to align the video with audio. The transcripts were cleaned to remove identifying information. Initially, I coded using the interactions using predetermined codes: TeacherL – Facilitator (TF), TeacherL – TeacherL (TT), TeacherL-Content (TC). The initial codes were based on any interaction between MTL and facilitator as well as MTL with MTL and MTL and content. Because each session is divided into two parts, the initial interaction coding only consisted of the first half of Session 1. After I coded the TeacherL-Facilitator (TF), TeacherL-TeacherL (TT), and TeacherL-Content (TC) interactions, I realized I wasn't getting enough information to make some determination about themes. The codes were too broad and didn't have any context.

I redid first cycle coding utilizing process coding and descriptive coding. Saldaña (2013) describes process coding as "uses gerunds ("ing" words) to connotate actions in the data" (Saldaña, 2013, p. 96). Process coding is appropriate when searching for ongoing action/interaction taken in response to a situation and consequences of the action/interaction (Saldaña, 2013). Descriptive coding "summarizes in a word or short phrase - most often as a noun – the basic topic of a passage of qualitative data" (Saldaña, 2013, p. 88).

I used process coding to describe the actions of the facilitator and mathematics teacher leaders. The first person listed in the code had initiated the interaction with the second person listed. For instance, Teacher Leader-Facilitator (TF) would indicate the teacher leader is addressing the facilitator. A TF code is different from a FT code. Facilitator-Teacher Leader (FT) indicates the facilitator is addressing the teacher leader. Additional codes were added based

on the F-T interactions. The Facilitator-Teacher Leader codes described the facilitators interaction, for example “FT- group directions” indicate the facilitator provided the group with directions. “FT-Respond to TeacherL’s question” signifies a teacher asked a question and the facilitator responded. For the Teacher Leader-Facilitator codes (TF), I added the interaction between the teacher leader and facilitator, for example asking a question.

Descriptive codes denote how facilitators provided instruction on the use of the learning platform and how they established virtual learning environment etiquette. The descriptive codes also demonstrate who the teacher leaders were addressing what was taking place. TeacheL-All (TA) to distinguish when a teacher leader was talking to the entire group (facilitator and TeacherLs). I added additional teacher leader and facilitator codes: TeacherL-TeacherL (TT), TeacherL-Content (TC), Facilitator-Content (FC) codes. I reviewed the first half of session 1 again using the more specific coding. I then coded Session 1.1 with the new coding scheme. The codes and descriptions are listed in Coding Scheme in Appendix B. I continued the coding scheme with the remainder of the session’s videos, video transcripts, chat transcript, and group artifacts. I continued to add additional codes as more interactions occurred.

For second cycle coding, I incorporated pattern coding to reorganize the data into categories. Text interpretation occurred and was placed into categories based on commonalities. See Table 4. There were codes that didn’t seem to fit in a category. It was instances where teacher leaders were referring to the issues they were having with technology (LE - different computer than use to) or issue with someone else’s technology (Learning Environment - Open Mic).

Table 4

Category Descriptions

Process Coding/Descriptive Coding	Categories
Facilitator-follow-up-general, Facilitator-Chat-Specific-Q, Facilitator-follow- question-specific, Facilitator-TeacherL-specific Q, Facilitator-TeacherL-General Q,	Asking Questions
Facilitator responds to TL question, TeacherL-F-General, TeacherL-F-Specific,	Responding to Questions
Facilitator TQ-ask group	Redirecting Questions to others
Facilitator-Ask to respond in chat, Facilitator-Content-ask to share on camera, Facilitator-Raise hands, Teacher leader respond in chat	Using Zoom features to respond
Facilitator-TL- enter responses in shared document, Teacher leader responds in group document	Responding in Group document
Facilitator read responses from chat, LE-F use of zoom functions, LE-F-Zoom engagement guidance	Using Zoom features to facilitate
Facilitator-content-guiding questions while reading, Facilitator-groups structured questions	Guided questions during activity
Facilitator showing on camera, Teacher Leader All-Refer to Content, Teacher Leader-All-Show on Camera, teacher leader showing	Explaining strategies utilized
Facilitator-content-assign different readings, Facilitator- need answer from all, wait time, Facilitator - TL - haven't heard from in a while, Facilitator - TL - Need more time, Facilitator - time allotted for activity, Facilitator - Content - specific page, Facilitator - content- checking do they have it	Facilitation strategies
Facilitator – restate TL statements, TeacherL-All-Refer to other teacher leader ideas, TeacherL-All-Refer to facilitator's comment,	Referring to others' comments
Facilitator – Pick a person to share, TeacherL-TeacherL, Facilitator-group assign roles, Facilitator-group directions	Sharing out group discussions

From Categories to Themes

As I incorporated the second cycle coding, themes began to emerge. Four themes emerged from the categories. The first theme is modeling strategies. Mathematics teacher leaders modeled strategies to solve tasks. The second theme is collaborative conversations. Collaborative conversations occurred when the facilitator and mathematics teacher leaders were actively engaged in discussions about the content. The third theme is questioning to deepen knowledge. The facilitator asked questions to expand thinking and challenge ideas. The mathematics teacher leaders asked questions to clarify understanding. The fourth theme is to convey ideas using online technology tools. The facilitators utilized online technology tools to obtain information. Mathematics teacher leaders utilized online technology tools to show thinking. The evidence supporting these themes has some overlap. For example, facilitators may have modeled strategies using online technology tools or evidence of collaborative conversations were supported by the online documents the groups completed during discussions.

Evidence of Theme One: Modeling

Modeling was used to strengthen facilitation strategies, pedagogical practices, and understanding of college and career ready mathematics standards via problem solving. In this study, modeling is defined as demonstrating how to execute a strategy, skill, or process. Facilitation strategies included how to implement a sorting activity in the face-to-face session compared to virtual and incorporating wait time/think time. Posing purposeful questions and thought processes while solving a problem was modeled by mathematics teacher leaders.

Facilitators described face-to-face facilitation strategies as outlined in the mathematics teacher leader (MTL) redelivery instructions document. Because MTLs were tasked with redelivering the training in person, facilitators designed the professional development with the

intention of it being implemented in a face-to-face environment. For the train-the-trainer sessions, facilitators adapted the activities to a virtual environment, therefore, explaining the difference allowed the MTLs to understand what process to go through when redelivering it. One of the activities adapted to virtual environment required mathematics teacher leaders to categorize questions they heard, during a statistics lesson, into gathering information, probing thinking, making the mathematical visible, encouraging reflection and justification. They added the questions under each category in a Google form.

Facilitator 3:

> Okay. You guys. So that was a quick two minutes, and I want to highlight a difference between what we're going to do here in the train-the-trainer session and what you'll do in your session. So, as teachers are categorizing their questions, you would have four pieces of chart paper hanging up around the room. At the top of each piece of chart paper, you'd have each question category. So one would have gathering information, probing thinking, et cetera. The teachers would quietly do just a... not a gallery walk, but they would write their responses for each question that they thought fell under each category. So it gives them a chance to get up and walk around. Again, we don't have that opportunity to do that with you, so we're going to do it in this virtual space with a Google form link.

The active learning strategy of sorting questions into categories required MTLs to analyze the questions before placing them. Facilitator 3 explained how the activity will be different in the face-to-face environment and further describes another facilitation strategy of getting teachers to move around after sitting for a while.

Facilitators modeled how to incorporate wait time/think time. When the facilitator practiced extended wait time and/or indicated they were practicing wait time, it allowed time for

thinking and prompted math teacher leader responses. “Wait time” is the silence between a teacher’s question and the student's response (Ingram & Elliot, 2014). Research has shown in face-to-face environments, “teachers should wait at least 3–5 seconds for students to respond, with longer wait times when students—or teachers—need more time to think” (Rezmer, Trager, Catlin, & Poole, 2020; Stahl, 1994; Tobin, 1987). Virtual environments need extended wait time to allow for think time and typing responses in chat. Facilitator 3 mentions “wait time” in five different instances. Facilitator 4 also references “wait time” in acknowledgement of facilitator 3’s comment. Facilitator 3 asks participants “Who wants to share what you’re about to do” and then waited 20 seconds and said, “See I’m practicing wait time, yall.” Facilitator 4 waited sixteen seconds and states “Okay. That was me practicing. Like Facilitator 3 said, practicing my wait time.” Facilitator 1 also mentioned giving MTLs time to process thinking. Facilitator 1, “But I like the fact that you do have to have some of that independent think time.”

Facilitator 4:

> When you're facilitating this, you're going to give teachers some independent think time to reflect individually.

Facilitator 3:

> And I'm going to give you two minutes of personal think time to think about…

Facilitator 4:

> So that was a minute, but we don't have any definitions in the chat box, so I'm going to give you guys some more think time.

Mathematics teacher leaders acknowledged the importance of independent think time.

MTL C:

> Then I had to start talking through my thinking. Then when I started talking through my thinking…

MTL S:

> I want to just add to what MTL C had said and how important, when we're doing these sessions, that you give us our own private think time first, before we dip into it so that I have the time to come up with my method or how I'm thinking about it and my own representation before I see someone else's.

Wait time/think time as a facilitation strategy prepares mathematics teacher leaders to fully engage with the content and collaborative conversations.

Mathematics teacher leaders modeled posing purposeful questions, an effective teaching practice. In small group breakout rooms, MTLs were directed to develop questions they would ask students to advance their thinking using student work Padlet. The student work was a New York State Common Core Math 8th grade statistics lesson. The directions below were listed at the top of the student work Padlet.

> Directions: 1) As a group, analyze the student work for the math task you completed earlier today. Look for strategies, misconceptions, and different levels of understanding.
>
> 2) Choose one of the work samples and write at least three questions that could assess or advance the student's mathematical reasoning. You will have 20 minutes to work on this.
>
> Please choose a timer and a reporter for your group before time concludes.

In reviewing sample student work, Group 1 wrote questions they would ask Student C on the student work Padlet.

> “Last question: Ask student to clarify are you saying that being female actually caused you to like drama? Question #4: Does your answer imply there is association between the 2 variables? Does preference imply association? Justify using the given data.

After leaving the breakout rooms and returning to the whole group session, the facilitator asked groups to share their thinking on why they chose their questions.

Facilitator 4:

> I'm going to go over to group one. I thought this was very intriguing here. What you wrote for your last question. So group one could one of you guys unmute and maybe talk to us about your thinking around these questions?

MTL K:

> For our first question, we just felt that perhaps the student was too fast to answer it. So, therefore, we wanted them to clarify and hopefully reread the question to understand where they went wrong. And on question number four, we felt that just to write justify was not clear enough. We felt that it was better if we asked them to use the data, it was more open-ended, because then they tie the questions to data.

Another example of modeling is demonstrated in Group 1’s response They modeled their thinking process around developing purposeful questions.

Active learning is shown when MTLs modeled the process to solve problems. Facilitator 3 clarifies the statements made and provides directions to help the MTL elaborate on her ideas.

Facilitator 2:

> I want you to think about if she was to lay the vertically and they only came 24 inches wide. Can she cover the wall without wasting any paper? Can she cover the wall without wasting paper horizontally?

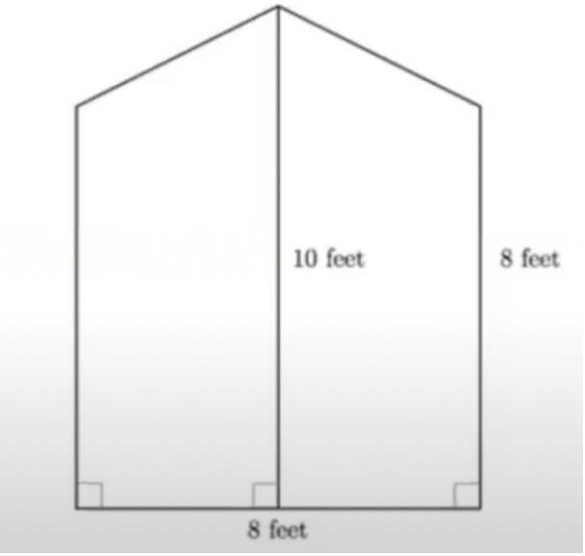

Figure 4. Wall dimensions for Wallpaper problem

MTL P:

Yes, she can do it without wasting any paper

Facilitator 2:

Tell me all about it.

MTL P:

She will have to cut some pieces off and change the orientation.

Facilitator 2:

so not wasting but technically moved. So what is she moving, what is she cutting? Help me to understand that.

MTL P:

So I guess at the top of the wall where it's triangular. She would cut off the, let's see, 24 inches wide I don't know how to say it but I know what I know.

Facilitator 2:

Alright, alright So just describe what she is going to do. Where she starts

MTL P:

So, at 8 ft tall, up that is where your triangle begins. So that is where you would have to make a cut. A diagonal cut

Facilitator 2:

So, she is (inaudible) long strip down it and she is going to cut across and (inaudible)those two pieces and stick them over. (MTL P says yes and nods in agreement). Will it work MTL J, horizontally?

MTL J:

So, the question really is how are we going to lay this wallpaper out horizontally? So, you've got a 10-foot span and then you're going to go up another two feet from that so that's going to give you what 144 inches and when you divide that by the 24 goes in there six times. So, you should be able to.

Evidence of Theme Two: Collaborative Conversations

Active learning is fostered through collaborative conversations. Collaborative conversations occurred when the facilitator and mathematics teacher leaders were actively engaged in discussions about the content and teaching practices. The learning platform provides a means for interaction and dialogue, but the facilitator must intentionally design instruction to promote dialogue (Peck, 2021). One mathematics teacher leader references how the discussion helped her. “So having that discussion was helping me talk through the problem itself and helping me figure out how to solve the problem.” An example of collaborative conversations occurred when mathematics teacher leaders expanded on other teacher leaders and/or facilitators comments and strategies.

The mathematics teacher leaders read Support Student Productive Struggle excerpt from *NCTM Principles to Action*. They discussed in small breakout rooms what confirms/supports their thinking, anything that should be added to the Teacher Actions/Student Actions T-chart and raised any questions or interesting comments. Groups shared in the whole group what was discussed. During the group share out discussions, mathematics teacher leaders added ideas on to what their group member presented. Groups also made connections from their own group discussions to what other groups shared. MTL A suggests the system allow for test retakes because in life we are allowed retakes. MTL V adds another suggestion to the system discussion "administrator see a student struggling in your classroom and that that is okay and you want the students to struggle…..And so I think that's an entire kind of system discussion." MTL W further extends MTL V's thoughts to include the community.

MTL W:

> And so, it's not just in the school, it's also in the community that we have to educate the parents about the difference in terms of growth mindset and what that means for the student in the classroom.

During the discussion, Facilitator 4 guides the conversation by summarizing statements made by the MTLs.

Collaborative conversations occurred as mathematics teacher leaders debriefed the professional development after each section was presented. To prepare for redelivery of the section, MTLs worked in small group breakouts to review and discuss reflective questions developed by the facilitators. Conversations centered around how to facilitate the section, how to address any misconceptions and resistance which may arise, and any perspective time challenges. The responses were recorded on a Google spreadsheet and groups shared out their

findings to the whole group. MTLs provided solutions to address potential issues. One solution was to have a parking lot. "We'll have a parking lot where they can post it up there because if you try and transition everybody out of this than you're going to be talking about five or six different things." Another group member chimes in "The idea of having sticky notes is to get people to write down any final thoughts and put them up on a on a parking lot so we can make sure we can get back to them and everyone's voice is heard."

Evidence of Theme Three: Questioning to Deepen Knowledge

Questioning promoted and enhanced critical thinking. Facilitators asked follow-up questions based on mathematics teacher leaders' responses in the chat box and group breakout room documents. Mathematics teacher leaders asked questions to clarify understanding of redelivery of the training. Clarifying understanding was shown to deepen knowledge. Questioning methods fostered active learning.

Facilitator 1 provided the following task directions: Read handout P-08, "Build Procedural Fluency from Conceptual Understanding" excerpted from NCTM's Principles to Actions (Figure 5). Figures 6 shows how group 1 responded to the prompt in the "Building Procedural Fluency from Conceptual Understanding" Google Sheet.

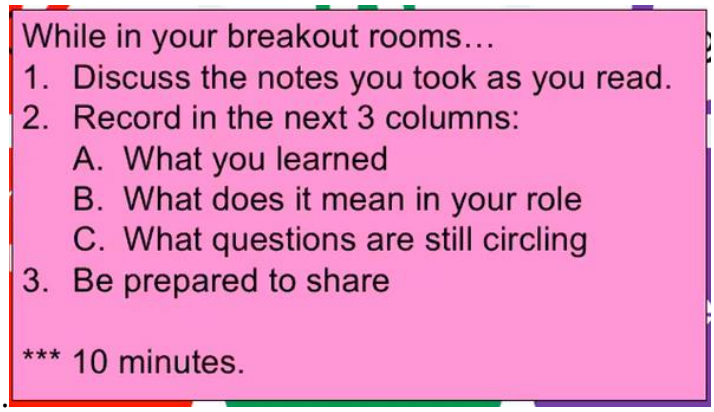

Figure 5. Directions facilitator provided to groups after reading excerpt from NCTM's Principles to Actions

Know	Want to Know	Learned	Reading relates to my role
Students need time to practice procedures so they fully understand the concepts	How can we close the gap between procedural and conceptual understanding?	As the teacher we should allow the students to have more control over the strategies and methods they use to solve problems.	Understanding that learning is a shared responsibility
Practice should be brief, engaging, purposeful, and distributive	How do we gauge how much is enough when it comes to practice?	Allow them to discuss and explain why they chose a particular method.	
Giving too many problems is not effective-students tend to shutdown	What are some proven techniques to engage students?		

Figure 6. Group 1 document from Build Procedural Fluency from Conceptual Understanding reading

After the small group discussion, groups shared out what they learned and how the reading relates to their role. Facilitator 1 asked clarifying questions based on the discussion and questions to compare current thinking about building procedural fluency to thoughts prior to reading the excerpt.

MTL M:

> In support of MTL P suggestion, I do that MTL P but I do not give the numerical (problem). Like, if it's problem number one answer, I don't put this as the answer to number one. So if I have 10 problems, I'll put in random order on my board, 10 different solutions. And then they have to match If your answer is not on the board, go back and check your work.

Facilitator 1:

> So, clarifying question for MTL M, when you give feedback or when you give the answer, is it just the answer or is there actually work and stuff involved as well?

MTL M:

No, I just post the answers and then if they have questions about how I arrived at that solution, and they were unable to, then I'll help that group one on one.

Facilitator 1:

Did anybody think about fluency in a different way in the past?

MTL X:

Fluency, a lot of people think fluency means just fast, and in time drills and things like that. But if you're thinking about fluency in that you're flexible in able to use it whenever you need it. Like that example, we read about of the student with the chips in the math class that was putting down the chips, and then just automatically knowing the fraction of what they were doing. To me that's true fluency of being able to adapt the math to a situation fluently knowing what to do as opposed to just fast reciting facts.

Additionally, Facilitator 1 asks mathematics teacher leaders to explain their thinking when they responded to the prompt, “What are examples and non-examples of assessment.”

Facilitator 1:

Ooh, it's not a grade! Tell me more about that, MTL F. Your group said that assessment is not grades.

MTL F:

An assessment should be informing the student and the teacher how the student is moving toward mastery. It's not always that final grade. It's actually what's going on during the assessment.

Facilitator 1:

Static tests and quizzes that don't allow for learning later on. Tell me more, MTL E.

MTL E:

> Yeah, so I think then if it's static, if this is a moment in time and we're done and I can't really use that anymore, then that's an evaluation as opposed to an assessment.

Clarifying understanding and explaining thinking deepened knowledge of the speaker and listeners. Mathematics teacher leaders asked questions to clarify understanding. Understanding took many forms: facilitation process, content, how to do an activity, and process for redelivery.

MTL A (Clarifying the purpose of an activity):

> Okay. Not to belabor the point …. but if we (referencing mathematics teacher leaders) don't know these types of questions, then how can we expect teachers to know? If we don't want them to understand these question types, why are we even talking about question types? It feels just a little bit disjointed.

MTL N (Clarifying how to redeliver the training):

> Yeah. So just for my frame of reference, are we going through this training with the intention that... I will be leading this training, or am I co-facilitating this virtually? I'm just a little confused in terms of what I... So for me to frame what I need to get out of this, I kind of need to know what am I doing with it?

Evidence of Theme Four: Convey Ideas Using Online Technology Tools

Technology was used to effectively convey ideas. Facilitators directed mathematics teacher leaders to respond in the *Zoom* chat or the small group documents. Facilitators read MTLs ideas that were put in the chat and asked follow-up questions to understand thinking. Mathematics teacher leaders used *Zoom* features to explain thinking. MTL used *Geogebra,* an online mathematics tool, to explain how the group solved a high school geometry problem.

Another MTL used the webcam feature to show how he solved a middle school geometry problem on a piece of paper.

Facilitators asked mathematics teacher leaders to respond in chat to certain prompts. The prompts were provided on the slide or verbally. Facilitators provided shared documents for each group to capture their thoughts and take notes. Mathematics teachers leaders typed responses in the chat or on a document template provided by the facilitator.

Some responses from the chat (slide 06 – What do you notice about the figure?)

- It is bi-trapezoidal (MTL E made that term up)
- Students can break it up differently into a triangle and a rectangle
- Are we sure the trapezoids are congruent
- The middle vertical segment appears to be a segment bisector of the bottom one
- We have a length and width for the square on the bottom and we have a base and height on the triangle on the top.

Mathematics teacher leaders used a Google Sheet to describe the actions of teachers and students for Standards for Mathematical Practice. There were two groups each assigned to a different reading. One group completed a short reading on Standards for Mathematical Practice (SMP) 7 (Look for and make us of structure) and the other group on Standards for Mathematical Practice 8 (Look for and express regularity in repeated reasoning). They discussed what is the standard asking for teachers to do in the classroom. After sharing thoughts and ideas as a whole group, MTLs used a Google Sheet with tabs labeled “What actions are the teacher taking and What action are the students taking” for both SMP 7 and 8 to jot down their ideas.

Mathematics teacher leaders took advantage of the functionality of the *Zoom* platform. They explained their thinking and used the webcam to show the example while explaining. The share screen function was also used to demonstrate their thinking.

MTLT J (describing the above wallpaper problem using webcam):

> But I did figure out how to share it with you guys though. You see my iPhone join the meeting? I'm just going to get rid of this half because that's the other half of the thing so let's just pretend my wallpaper went up and made this triangle and then this triangle that you see already cut in half so the way I was able to do it by rotating and shifting was okay so I took this triangle and just moved it so just a translation and then I took this triangle and rotated.

MTL M (showing how to use Geogebra using screen share):

> Can I share my screen real quick to make a point? When we created and constructed the two quadrilaterals it was nice to be able to select a line and find the midpoint or select a segment, find the midpoint. But we found when we were trying to do the classification of that inner quadrilateral, we wanted to look at the angle measures. This angle A, here is about 85 degrees and then we went to the measure angle B, if you didn't input it in the same direction so clockwise, counterclockwise it's going to give you an exterior angle measure rather than interior.

Facilitation of technology tools necessitates pre-planning. The facilitator had to create the Teacher/Student Actions Google Sheet prior to the session. The facilitator preselected a rich task which required multiple entry points for mathematics teacher leaders to share problem solving processes using technology. Mathematics teacher leaders entering information on

Teacher/Student Actions Google sheet and using webcam and sharing screen are evidence of active engagement.

Summary

This chapter outlined context of the professional learning initiative, coding process and the themes that emerged from the categories based. The data yielded four themes. Each of the overarching themes were presented with the supporting data from the recorded videos, transcribed video, transcript of the chat and group artifacts. The next chapter focuses on the interpretation of the themes in relation to the previously discussed research.

5 DISCUSSION

In concluding this research study, this chapter will revisit the four themes that emerged, connect the findings to the Online Synchronous Active Learning Train-the-Trainer Professional Development Framework and relevant literature. Additionally, the chapter presents the implications for practice, recommendations for future research, and a closing statement about the study.

Summary of Study

Using qualitative research design within an Online Synchronous Active Learning Professional Development Framework, this study examined active learning in one school system's online synchronous train-the-trainer mathematics professional development initiative. To support the implementation of new more rigorous college and career ready standards, the school system contracted facilitators which designed, developed, and implemented the professional development sessions. Incorporating active learning strategies has shown to be an effective approach in mathematics professional development (National Council of Teachers of Mathematics, 2010; Pak et al., 2020; Parrish et al., 2020; Reiten, 2021). This research focused on facilitation methods and teacher engagement with an active learning lens. This study filled the gap in the literature by describing active learning facilitation methods and corresponding mathematics teacher leader active engagement while learning new standards and pedagogical practices, in an online synchronous environment.

Discussion of the Findings

The study addressed the following research questions:

1. What instructional strategies, if any, promote active learning in online synchronous professional development?

2. How do mathematics teacher leaders actively engage in online synchronous professional development?

In examining active learning in online synchronous train-the-trainer mathematics professional development four themes emerged: (1) modeling strategies; (2) collaborative conversations; (3) questioning to deepen knowledge, and (4) using online technology tools to convey ideas.

Aligning the Initiative to the Framework

The Online Synchronous Active Learning Professional Development Framework was the lens used to examine a school system's professional development initiative. Active learning was evident as mathematics teacher leaders (MTLs) interacted with the facilitator, the content, and other participants within the virtual learning environment. Facilitator moves promoted active learning as mathematics teacher leaders engaged in solving problems aligned to the standards. Questioning was key to deepen the understanding of mathematics standards and pedagogical practices. Facilitators asked follow-up questions after participants shared what was discussed in small group breakout sessions or what was input on collaborative group documents. Interactions were also observed when facilitators modeled facilitation strategies and participants modeled problem solving strategies during the train-the-trainer sessions.

The physical location of the participants did not hinder engagement. Collaborative conversations were evident in the recorded video sessions when mathematics teacher leaders were alone in their location, or when in the same room with peers sharing a screen and audio, or when in the same room with peers but each having their own audio and video. Mathematics teacher leaders remained actively engaged by actively listening when making statements that referenced other MTLs and facilitator's comments.

The capabilities of the learning management system, Zoom, aided in the active engagement with chat, webcams, share screen, and reactions. Mathematics teacher leaders responded to facilitators questions in the chat or on shared group online documents. Mathematics teacher leaders shared their screen or utilized the webcam to model while explaining their thinking about a mathematics concept or pedagogical practice.

The Online Synchronous Active Learning Professional Development Framework assisted me in not just looking at the content of the sessions but also focusing on the learning environment. I examined how mathematics teacher leaders engaged in professional development from various locations, what the learning platform contributed or hindered and the potential impact on learning. The results of the study showed me the physical location of the mathematics teacher leaders didn't have any impact, negative or positive, on the learning. The learning management system was a more important factor. The model may need to be adjusted to show that important context.

Connections to Literature

In Chapter 2, studies on active learning in mathematics professional development, online professional development and train-the-trainer methods were examined. Active learning has shown to be effective in professional development (Brame, 2016;; Bower et al., 2015; Davis-Adams, 2010; Gulamhussein, 2013; Hokanson et al., 2019; McNamara, 2010; Murthy et al., 2015; Wei and Chen, 2012) and more importantly in mathematics professional development (National Council of Teachers of Mathematics, 2010; Pak et al., 2020; Parrish et al., 2020; Reiten, 2021). Train-the-trainer research shows what is needed to effectively redeliver professional development (Perry & Boylan, 2018; Pancucci, 2007; Taylor et al., 2010). The focus of the train-the-trainer professional development was on new academic standards and

effective pedagogical practices. After completing the training, mathematics teacher leaders were expected to redeliver professional development in a face-to-face environment. This study examined how facilitation strategies and active engagement was evident in online synchronous train-the-trainer mathematics professional development which has similarities to previous research on active learning. This section will discuss in further detail how the results of this study relate to the findings of the empirical studies reviewed and to other published literature.

Research has shown mathematics professional development should foster growth of mathematics teachers in four areas, which were evident in this study.

- Build teachers mathematical knowledge and their capacity to use it in practice.
- Build teachers capacity to notice, analyze, and respond to students thinking.
- Build teachers productive habits of mind.
- Build collegial relationships and structures that support continued learning. (NCTM, 2010, pgs. 1-2)

There were instances of building mathematical knowledge in the activities that focused on understanding college and career ready mathematics standards. Mathematics teacher leaders built mathematical knowledge as they solved the 6th grade geometry wallpaper task and aligned the concepts to an assessment problem. In another session, MTLs played the role of students as they experienced an 8^{th} grade statistics lesson. Additionally, they utilized an online mathematics tool, Geogebra, to solve a high school geometry task. To build teachers capacity to notice, analyze and respond to students thinking, teachers analyzed student work (statistics concept) and posed purposeful questions that would advance student thinking. The productive habits of mind are the college and career ready standards for mathematical practice (SMP) (See Appendix C). Mathematical teacher leaders compared SMP 7 (Look for & make use of structure) and SMP 8

(Look for & express regularity in repeated reasoning) and listed teacher actions and corresponding student actions for each SMP. Collaborative conversations during small group breakout sessions built collegial relationships and structures.

Perry and Boylan (2018) contend that professional development facilitators (PDFs) must be provided opportunities to develop their own knowledge base to effectively facilitate professional learning. “For PDFs to be credible, they must have and be able to demonstrate their knowledge of the subject matter of the professional development activity, including subject-specific pedagogical content knowledge” (Perry & Boylan, 2018, p. 256). Furthermore, Perry and Boylan (2018) posited knowledge is needed of how to facilitate professional learning to teachers who already know how to teach. During the online synchronous professional development sessions, mathematics teacher leaders practiced the activities they were to redeliver in the face-to-face sessions. The facilitators described the facilitation strategies for the face-to-face sessions which was vastly different than the online sessions. During the online sessions, mathematics teacher leaders used Google Forms to sort question types but when implementing the sessions, mathematics teacher leaders were to utilize sticky notes and chart paper. The facilitation strategies presented to mathematics teacher leaders support the previous research.

McNamara (2010) purported interaction among the participants within the online learning environment needs to be structured to deepen the teacher’s experience. In this study, facilitators asked follow-up questions and extended wait time/think time which allowed for mathematics teacher leaders to engage in active learning. Facilitators also incorporated small group breakout sessions, and . shared what was discussed while in the small group. Additionally, there were documents with guided questions or places for the small groups to document their thoughts. The mathematics teacher leaders interacted within the chat when facilitators asked for them to

respond in the chat. Using the chat enables teachers to see everyone's responses and multiple responses are allowed at one time, which is a limitation of talking in an online environment such as Zoom (Bucholz, 2021). Based on group discussion, share out, and responses in chat, the facilitator asked follow-up questions of individuals and/or groups. In this study, the facilitation strategies promoted understanding of mathematics standards and effective teaching practices through interaction which aligns with previous research.

Design factors indicate it is imperative to design for active learning, match tools to technology, and to be highly organized (Bower et al., 2015). The selection and strategic use of the Zoom platform provided the ability to design for active learning. Facilitators designed learning environments conducive to active learning. Facilitators utilized the full functionality of the learning management system to promote interaction and social presence. Also, facilitators were very knowledgeable of the platform as evidenced by the modeling of how to use the features at the start of each session. Facilitator expertise and ease in using the Zoom platform is similar to previous design factor research.

The implementation factors revealed instructors should have technical knowledge of the learning system and encourage regular student contributions (Bower et al., 2015). Facilitators int this study incorporated opportunities for mathematics teacher leaders to use the breakout room feature, chat feature, webcam and share screen. They provided instruction on the Zoom features at the start of each session to enable mathematics teacher leaders to become comfortable with using it. Wei and Chen (2012) recommended that instructors familiarize users with the online platform and encourage the use of webcams and audio equipment to aid in the transmitting of social cues. The mathematics teacher leaders practiced using the various functions of the Zoom platform at the start of each session. Comfortability with using the platform was evident during

the sessions as mathematics teacher leaders used the camera to show their work and shared their screen. Facilitation methods directing mathematics teacher leaders to utilize the learning methods supports Bower et al. (2015) research.

Implications

School districts will adopt new mathematics academic standards and need to prepare mathematics teachers to understand and teach them. Training mathematics teacher leaders to support the implementation of new standards using active learning strategies is an effective practice. Mathematics teacher leaders participated in train-the-trainer professional development to build knowledge about new academic mathematics standards, effective teaching practices and facilitation strategies. The implications for practice highlight opportunities for school systems to incorporate active learning in online synchronous learning environments.

Mathematics teacher leaders as professional development facilitators need ample opportunities to develop their own knowledge base to effectively facilitate professional learning. They must have and be able to demonstrate their knowledge of the subject matter of the professional development activity, including subject-specific pedagogical content knowledge (Perry & Boyles, 2018). Mathematics teacher leaders' engagement with the activities and collaborative conversations discussed in this study provide insight into the time commitment needed to experience, practice, and reflect on the professional learning activities to effectively redeliver professional development to mathematics teachers.

The selection of the online learning management system plays an integral role in active learning in the learning environment. Practitioners should investigate the learning platform to determine the capabilities. The platform should allow for the ease of incorporating small group interaction and chat. The available participant controls should include screen sharing, audio and

video, meeting reactions (nonverbal), and raise hand functionality. The platform should have the ability to record the sessions for trainers to review before redelivering professional development.

Teacher participants in Scruggs-Thomas (2009) noted that flexibility to work anytime, ability to work from any internet accessible computer, and lack of travel requirements were benefits of participating in online professional development. School Districts incorporating online professional development have the potential for cost-saving measures because participant travel is not needed. Online professional development can be accessed from anywhere regardless of the geographical location. Moreover, online professional development provides more access to much needed professional development to improve mathematics understanding and pedagogy.

Focused collaboration was a consistent theme throughout the study. Supporting collaboration is a characteristic of effective professional development (Darling-Hammond et al., 2017; Gulamhussein, 2013). Mathematics educators typically collaborate within their school grade level or content-specific community. Online professional development allows for mathematics educators to collaborate across schools and across grade bands to obtain varied perspectives and support with understanding mathematics content.

There is limited literature available that reports strategies which promote active engagement in online synchronous professional development and the role of the learning platform in the learning environment. "The use of active learning strategies in the training program is a must" (Murthy et al., 2015, p. 18). Wei and Chen (2012) highlighted the need for further research on online learning to consider user interface and social cues as important predictors of social presence. This study described how facilitators promoted active learning and how mathematics teacher leaders engaged in active learning. This study demonstrated how facilitators incorporated instruction on the online platform.

Suggestions for Further Research

Research has shown that incorporating active learning is a necessity in professional development environments (Bower et al., 2015; Brame, 2016; Davis-Adams, 2010; Gulamhussein, 2013; Hokanson et al., 2019; Learning Forward, 2011; McNamara, 2010; Murthy et al., 2015; Wei & Chen, 2012). Previous studies have focused on active learning in group settings and did not focus on the learning platform. In this regard, this study proposes recommendations for future research on active learning using various online learning platforms, active learning in online break out rooms, and incorporating facilitation strategies from this study. Additional research may also include the voice of the mathematics teacher leaders and mathematics teachers who experienced the face-to-face professional development. Specific suggestions for future research are below:

1. Knowing the impact of the online synchronous professional development on mathematics teacher leaders and the mathematics teachers who received the face-to-face training would add insight into the active learning process. Do the mathematics teacher leaders feel they received what was needed to redeliver the training? What do mathematics teachers say about how the mathematics teacher leaders redelivered the professional development?
2. “Active learning approaches also often embrace the use of cooperative learning groups...” (Brame, 2016 p. 2). Exploring facilitator moves that promote active learning in small group break out rooms and how participants are engaged in active learning is an area in which more research is needed.

3. The learning platform is integral to active engagement. Research examining how different learning platforms affect active engagement in the online learning environment could guide practitioners' selection.

Final Thoughts

I embarked on this study, in essence, to do my job better. I am always looking to learn, grow and to positively impact classrooms. Over the course of my 25+ years of educational experience, I have participated in professional development as a mathematics teacher, instructional coach, mathematics director, school improvement specialist, professional learning specialist, and state math specialist. I have designed, developed, and facilitated face-to-face, online synchronous, and online asynchronous professional development. I have gone through the process of contracting professional development providers from developing the Statement of Work that outline project goals and deliverables to reviewing contractor proposals and ultimately selecting a provider. I worked with contractors as they designed, developed, and facilitated mathematics professional development. Professional development has changed over the years but what doesn't change is the cycle of adopting new academic standards and preparing teachers to teach them and improving pedagogical practices. This study examined one school system's approach. I am heavily invested in professional development and improving the implementation of it. Who wants to be bored in professional development? I don't. I want to be actively engaged.

During this research, I attempted to take an outsider looking in approach, but I was too heavily involved at the time of initiative to be an outsider. I positioned myself as a teacher-researcher reflecting on her own practice. Now that I have done the study, I realize how much of me informed the approach I took. At first, I mainly focused on the technology because that was my (teacher) interest in the study. The researcher side needed to go back and highlight the

mathematics content, pedagogical practices, and mathematics standards and bring them to light. I thought about the needs of the mathematics education community considering this study.

What impact can this study have? I rested on; the needs keep changing. Active learning has been a consistent need in the mathematics education community. You might need strategies for active learning in professional development or using Zoom platform to promote active learning. You may want to know how to encourage collaborative conversations or how to incorporate a train-the-trainer model. Take from this study what is needed at that time you need it. As I look at active learning in online synchronous professional development going forward, I feel there is a need to stress accessibility in the online platform. It should be an inclusive learning environment.

REFERENCES

Blank, R. K., & Alas, d. l. (2009). *Effects of teacher professional development gains in student achievement: How meta analysis provides scientific evidence useful to education leaders*. Retrieved from Washington, D.C.: http://www.ccsso.org/Documents/2009/Effects_of_Teacher_Professional_2009.pdf

Blumer, H. (1969). *Symbolic interactionism: perspective and method*. Englewood Cliffs: Prentice-Hall.

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theories and methods, 5th edition*. New York, NY: Pearson Education, Inc.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(27-40).

Bower, M., Dalgarno, B., Kennedy, G. E., Lee, M. J. W., & Kenney, J. (2019). Design and implementation factors in blended synchronous learning environments: Outcomes from a cross-case analysis. *Computers & Education, 86*, 1-17.

Brame, C. (2016). Active learning. *Vanderbilt University Center for Teaching.* Retrieved from https://cft.vanderbilt.edu/guides-sub-pages/active-learning/

Bucholz, E.K. (2021) Creating a Welcoming and Engaging Environment in an Entirely Online Biomedical Engineering Course. *Biomed Eng Education* **1**, 165–169

CARE: Community Alliance of Research and Engagement. (n.d.). Beyond scientific publication: Strategies for disseminating research findings In Yale Center for Clinical Investigation (Ed.). New Haven, CT.

Collins, C. S., & Stockton, C. M. (2018). The Central Role of Theory in Qualitative Research. *International Journal of Qualitative Methods, 17*(1), 1609406918797475. doi:10.1177/1609406918797475

Crotty, M. (1998). *The Foundations of Social Research*. St. Leonards: Allen and Unwin

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective Teacher Professional Development*. Palo Alto, CA: Learning Policy Institute.

Davis-Adams, R. (2010). *A case study of professional development in online environment: The experiences of a group of elementary teachers* (Doctoral Dissertation), New Mexico State University, Las Cruces, New Mexico.

Dede, C. (Ed.) (2006). *Online professional development for teachers: Emerging models and methods*. Cambridge, MA: Harvard Education Press.

Dede, C., Ketelhut, J., Whitehouse, P., Breit, L., and Erin M. McCloskey. (2009). A research agenda for online teacher professional development. *Journal of teacher education, 60*(8).

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research. In N. Denzin & Y. Lincoln (Eds.), *The Sage Handbook of qualitative research 3rd edition*. Thousand Oaks, CA: Sage Publications

Doolittle, P. (1999). Constructivism and Online Education. Retrieved from http://www.trainingshare.com/resources/doo2.htm

Editorial Projects in Education Research Center. (2011). Issues A-Z: No Child Left Behind. *Edweek*. Retrieved from http://www.edweek.org/ew/issues/no-child-left-behind/

Elo, S., Kääriäinen, M., Kanste, O., Pölkki, T., Utriainen, K., & Kyngäs, H. (2014). Qualitative Content Analysis:A Focus on Trustworthiness. *SAGE Open, 4*(1), 2158244014522633. doi:10.1177/2158244014522633

ESSA. (2015). Every Student Succeeds Act of 2015, Pub. L. No. 114-95 § 114 Stat. 1177 (2015-2016)

.

Ezzy, D. (2002). *Qualitative analysis: Practice and innovation*. New York: Routledge.

Franzosi, R. (Ed.) (2008). *Content analysis*. (Vols. 1-4). SAGE Publications Ltd, https://www.doi.org/10.4135/9781446271308

Garet, M., Wayne, A., Stancavage, F., Taylor, J., Eaton, M., Walters, K., . . . Doolittle, F. (2011). *Middle School Mathematics Professional Development Impact Study: Findings After the Second Year of Implementation (NCEE 2011-4024)* (I. o. E. S. National Center for Education Evaluation and Regional Assistance, U.S. Department of Education Ed.). Washington, DC

Gewertz, C. (2015) The Common Core Explained. *Edweek* retrieved from https://www.edweek.org/teaching-learning/the-common-core-explained/2015/09

Glasco, C. (2020). *Middle School Teacher Perceptions of Effective Professional Development Practices: A Phenomenological Study.* (Concordia University St. Paul). Retrieved from https://digitalcommons.csp.edu/cup_commons_grad_edd/461

Groom, L. (2000). *Interaction in the Computer-Mediated Adult Distance Learning Environment: Leadership Development Through Online Education.* Regent University.

Guba, E., & Lincoln, Y. (1985). *Naturalistic Inquiry*. Thousand Oaks, BA: Sage Publications.

Guba, E., & Lincoln, Y. (1994). Competing paradigms in qualitative research. In N. Denzin & Y. Lincoln (Eds.), *Handbook of qualitative research, 3rd Ed* California: Sage

Gulamhussein, A. (2013). *Teaching the Teachers: Effective Professional Development in an Era of High Stakes Accountability*: The Center for Public Education.

Händel, M. et al (2022). The webcam and student engagement in synchronous online learning: visually or verbally?. *Education and Informational Technologies* **27**.

Hezel Associates. (2007). *PBS TeacherLine National Survey of Teacher Professional Development 2005-2006*. Syracuse

Hokanson, S. C., Grannan, S., Greenler, R., Gillian-Daniel, D. L., Campa III, H., & Goldberg, B. B. (2019). A Study of Synchronous, Online Professional Development Workshops for Graduate Students

and Postdocs Reveals the Value of Reflection and Community Building. *Innovative Higher Education*, *44*, 385–398.

Holmes, A., Signer, B., & MacLeod, A. (2011). Professional development at a distance: A mixed-method study exploring inservice teachers' views on presence online. *Journal of Digital Learning in Teacher Education, 27*(2), 76-85.

Huang, Q. (2022) Does learning happen? A mixed study of online chat data as an indicator of student participation in an online English course. *Education and Information Technologies* **27**,

Institute of Education Sciences (IES). (2020). Frequently Asked Questions. Retrieved from https://ies.ed.gov/ncee/wwc/FAQ

Ingram, J. & Elliott, V. (2016) A critical analysis of the role of wait time in classroom interactions and the effects on student and teacher interactional behaviours, *Cambridge Journal of Education*, 46:1, 37-53, DOI: 10.1080/0305764X.2015.1009365

Ingram, J. & Elliott, V. (2014) Turn taking and ‘wait time’ in classroom interactions, Journal of Pragmatics,

Volume 62, 1-12

Katz, Jack. (2001) “Analytic Induction” in International Encyclopedia of the Social and Behavioral Sciences. Neil J. Smelser and Paul B. Baltes, eds. Oxford, U.K.: Elsevier. Vol. 1, Pp. 480-484.

Koohang, A., Riley, L., Smith, T., & Schreurs, J. (2009). E-Learning and Constructivism: From Theory to Application. *Interdisciplinary Journal of e-Skills and Lifelong Learning, 5*, 91-109.

Kuhn, T. (1962). *The Structure of Scientific Revolutions*. Chicago, IL: University of Chicago Press.

Learning Forward. (2011). Learning Designs. Retrieved from https://learningforward.org/standards/learning-designs

Lynch, P., Holden, M.T., Foley, A., Harrington, D. & Hussey, J. (2013) Engaging entrepreneurs with a blended problem-based learning degree programme. in Wankel, C., & Blessinger, P. (Eds.). *Increasing student engagement and retention in e-learning environments: Web 2. 0 and blended learning technologies* (pp. 199-227) Emerald Publishing Limited.

Marrongelle, K., Sztajn, P., & Smith, M. (2013). Scaling Up Professional Development in an Era of Common State Standards. *Journal of Teacher Eduation, 64*(3), 202-211.

Matherson, L., & Windle, T. M. (2017). What Do Teachers Want from Their Professional Development? Four Emerging Themes. *Delta Kappa Gamma Bulletin, 83*(3), 28-32.

Mayring, P. (2014). *Qualitative content analysis: Theoretical foundation, basic procedures and software solution* Retrieved from http://nbn-resolving.de/urn:nbn:de:0168-ssoar-395173

McKee, H. A., & Porter, J. E. (2012). The Ethics of Archival Research. *College Composition and Communication, 64*, 59-81.

McNamara, C. L. (2010). *K-12 Teacher participation in online professional development.* (Doctoral Dissertation), California State University, San Marcos, CA.

Mizell, H. (2010). *Why professional development matters*. Oxford, OH: Learning Forward.

Moore, M. (1989). Three Types of Interaction. *American Journal of Distance Education, 3*(2), 1-7.

Morse, J. M., Barrett, M., Mayan, M., Olson, K., & Spiers, J. (2002). Verification Strategies for Establishing Reliability and Validity in Qualitative Research. International Journal of Qualitative Methods, 1(2), 13–22. https://doi.org/10.1177/160940690200100202

Mostellar, T. (2008). *Relativism: A Guide for the Perplexed*. London: Continuum International Publishing Group.

Murphy, E. (1997). Constructivism: From Philosophy to Practice. Retrieved from http://www.ucs.mun.ca/~emurphy/stemnet/cle.html

Murthy, S., Iyer, S., & Warriem, J. (2015). ET4ET: A Large-Scale Faculty Professional Development Program on Effective Integration of Educational Technology. *Educational Technology & Society, 18*(3), 16-28.

National Council of Teachers of Mathematics (2010) Professional development research brief: mathematics professional development. Reston (VA)

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). Common Core State Standards. Washington, DC

National Research Council. (2007). *Enhancing professional development for teachers: Potential uses of information technology. Report of a workshop*. Washington D.C.: National Academies Press.

Name Withheld (n.d.). Community Strategic Plan: Volume II • School Years 2013/14 – 2017/18.

Owston, W., H., Murphy, J., and Lupshenyuk, D. . (2008). Blended teacher professional development: A synthesis of three program evaluations. *Internet and Higher Education, 11*, 201-210.

Pak, K., Desimone, L. M., & Parsons, A. (2020). An integrative approach to professional development to support college- and career- readiness standards. *Education Policy Analysis Archives*, *28*(111).

Pancucci, S. (2007). Train the Trainer: The Bricks in the Learning Community Scaffold of Professional Development. *Train the Trainer: The Bricks in the Learning Community Scaffold of Professional Development, 1*(11).

Parrish, C. Byrd, K., Johnson, T., Dasinger, J. & Green, A. (2020) Middle Grades Mathematics Teachers' Mixed Perceptions of Content-Focused Professional Development, RMLE Online, 43:8, 1-16, DOI: 10.1080/19404476.2020.1814626

Peck, K.F. (2021). Anyone? Anyone?: Promoting inter-learner dialogue in synchronous video courses, *Computers and Composition*, Volume 62

Pennington, K. (2014). How state takeover school districts shake up teacher professional development. Retrieved from https://www.americanprogress.org/issues/education/report/2014/06/05/90836/how-state-takeover-school-districts-shake-up-teacher-professional-development/

Perry, E., & Boylan, M. (2018). Developing the Developers: Supporting and Researching the Learning of Professional Development Facilitators. *Professional Development in Education*, *44*(2), 254-271.

Peshkin, A. (1988). In search of subjectivities-one's own. *Educational Researcher*, *17*(7), 17-21.

Pomerantz, P. & Fehr, B. (2013). Conversation Analysis: An Approach to the Analysis of Social Interaction in Discourse Studies: A Multidisciplinary Approach. London: SAGE Publications Ltd.

Prior, L. (2003). *Using Documents in Social Research*. Thousand Oaks: SAGE Publications, Inc.

Rabinowitz, P. (n.d.). Collecting and Using Archival Data. Retrieved from https://ctb.ku.edu/en/table-of-contents/evaluate/evaluate-community-interventions/archival-data/main

Reiten, L. (2021). Professional development supporting teachers' implementation of virtual manipulatives. *Contemporary Issues in Technology and Teacher Education, 21*(3).

Rezmer, B. E., Trager, L. A., Catlin, M., & Poole, D. A. (2020). Pause for effect: A 10-s interviewer wait time gives children time to respond to open-ended prompts. *Journal of experimental child psychology, 194,* 104824. https://doi.org/10.1016/j.jecp.2020.104824

Russell, M., Carey, R., Kleiman, G. & Venable, J.D. (2009). Face-to-face and online professional development for mathematics teachers: A comparative study. *Journal of Asynchronous Learning Networks, 13*(2), 71-87.

Scruggs-Thomas, T. (2009). *Online vs. face-to-face: Educator opinions on professional development delivery methods.* (Doctoral Dissertation), University of Alabama, Tuscaloosa.

Silver, C., & Lewins, A. (2014). *Using software in qualitative research*. Thousand Oaks, CA: Sage Publications Ltd.

Slabine, N. A. (2011). *Evidence of effectiveness*. Retrieved from https://learningforward.org/docs/pdf/evidenceofeffectiveness.pdf:

Snow, D. (2001). Extending and Broadening Blumer's Conceptualization of Symbolic Interactionism. *Symbolic Interaction, 24*(3), 367–377.

Stake, R. E. (2005). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The sage handbook of qualitative research 3rd. Ed.* (pp. 443-465). Thousand Oaks, CA: Sage Publications.

Swan, K. A constructivist model for thinking about learning online. In J. Bourne & J. C. Moore (Eds.), *Elements of Quality Online Education: Engaging Communities*. Needham, MA: Sloan-C.

Taylor, M., Yates, A., Meyer, L. H., & Kinsella, P. (2011). Teacher professional leadership in support of teacher professional development. *Teaching and Teacher Education, 27*, 85e94.

U.S. Department of Education. (2001). Elementary and Secondary Education Act. Retrieved from http://www.ed.gov/esea

U.S. Department of Education. (2015). *Every Student Succeeds Act*.

Wei, C., & Chen, N. (2012). A model for social presence in online classrooms. Educational Technology. *Research and Development, 60*, 529–545.

Weingarten, C., Rabagoa, J., Reynolds, J., Gates, K., Yanagida, E., & Baker, C. (2018). Examining the utility of a train-the-trainer model for dissemination of sexual violence prevention in schools. *Child Abuse & Neglect, 80*, 70-79.

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). Thousand Oaks: SAGE Publications, Inc.

Yeung, M. W. L., Yau, A. H. Y., & Lee, C. Y. P. (2022). How should webcams be used in online learning under COVID-19: A co-orientation analysis of teachers' and students'

perceptions of student social presence on webcam. *Journal of Computer Assisted Learning*, 1– 18.

Yoon, K. S., Duncan, T., Lee, S. W.-Y., Scarloss, B., & Shapely, K. L. (2007). *Reviewing the evidence on how teacher professional development affects student achievement (Issues & Answers Report, REL 2007-No. 033)*. Washington, D.C. : U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest.

Zhang, M., Lundeberg, M. , McConnell, T. J. , Koehler, M. J. , & Eberhardt, J. (2010). Using Questioning to Facilitate Discussion of Science Teaching Problems in Teacher Professional Development. *Interdisciplinary Journal of Problem-Based Learning, 4*(1).

APPENDICES

Appendix A

Table 5

Data Resources

Session	Name	Type	Description
1,2,3,4	Researcher Reflective Journal	Notebook, Audio Recording	Journal which describes the researchers thoughts and questions about the data and study.
1	Carousel-Region A	Excel Document	Four tabs with labels: SMP 7 Teachers What actions are the teachers taking?, SMP 7 Students What actions are the students taking, SMP 8 Teachers What actions are the teachers taking?, SMP 8 Students What actions are the students taking?
1	Region A-Group 1	Excel Document	Four Tabs with labels: Section 1, Section 2, Section 3, Section 4 Guided Questions are provided to discuss in small groups to reflect on facilitating the redelivery of the professional development.
1	Region A – Group 2	Excel Document	Four Tabs with labels: Section 1, Section 2, Section 3, Section 4 Guided Questions are provided to discuss in small groups to reflect on facilitating the redelivery of the professional development.
1	Productive-Unproductive- Region A	Word Document	Responses from mathematics teacher leaders regarding productive and unproductive beliefs in the scenario
1	Responses from Chat Region A	Word document	List the responses from the chat and the corresponding PowerPoint slide.
1	Session 1.1	Video	Video recording of the first part of Session 1
1	Session 1.2	Video	Video recording of the first part of Session 1

1	Session 1.1	Word document	Transcription of session 1.1 video
1	Session 1.2	Word document	Transcription of session 1.2 video
1	Session 1 PowerPoint	PowerPoint	Session 1 PowerPoint
2	Session 2.1	Video	Video recording of the first part of Session 2
2	Session 2.2	Video	Video recording of the first part of Session 2
2	Session 2.1	Word document	Transcription of session 2.1 video
2	Session 2.2	Word document	Transcription of session 2.2 video
2	Session 2 PowerPoint	PowerPoint	Session 2 PowerPoint
2	Region B – Slide 18-Group 1	Screenshot	Questions developed by group while analyzing student work.
2	Region B – Slide 18-Group 2	Screenshot	Questions developed by group while analyzing student work.
2	Region B – Slide 18-Group 3	Screenshot	Questions developed by group while analyzing student work.
2	Region B – Slide 18-Group 4	Screenshot	Questions developed by group while analyzing student work.
2	Region B – Slide 18-Group 5	Screenshot	Questions developed by group while analyzing student work.
2	Region B – Slide 18-Group 6	Screenshot	Questions developed by group while analyzing student work.
2	Region B-Question Type Activity-Slide 13	PDF Document	Questions developed by groups sorted by type.
2	Bivariate Data	Excel	Group responses to Student Task
2	Assessment Discussion	PDF Document	Group responses to questions about the student assessment.

3	Session 3.1	Video	Video recording of the first part of Session 3
3	Session 3.2	Video	Video recording of the first part of Session 3
3	Session 3.1	Word document	Transcription of session 3.1 video
3	Session 3.2	Word document	Transcription of session 3.2 video
3	Session 3 PowerPoint	PowerPoint	Session 3 PowerPoint
3	Topic: Building procedural fluency from conceptual understanding	Excel Document	KWL chart completed by groups based on reading.
3	Responses for Unproductive Belief-Padlet	PDF Document	Responses to unproductive beliefs about tools and technology.
3	Region C – Section Reflections	Excel Document	Four Tabs with labels: Section 1, Section 2, Section 3, Section 4 Guided Questions are provided to discuss in small groups to reflect on facilitating the redelivery of the professional development.
4	Session 4	Video	Video recording of the first part of Session 4
4	Session 4	Word Document	Transcription of session 4 video
4	Session 4 PowerPoint	PowerPoint	Session 4 PowerPoint
4	Tchart-teacher/student	Word Document	List of productive struggle productive beliefs participants added to teacher and student list from reading.
4	Region A – Section Debrief	Excel Document	Four Tabs with labels: Section 1, Section 2, Section 3, Section 4 Guided Questions are provided to discuss in small groups to reflect on facilitating the redelivery of the professional development.

4	Region A – Productive Belief Promoting Productive Culture Padlet	PDF Document	Group responses: “What teacher behaviors and/or systemic structures would support a shift toward productive beliefs and promote a productive culture in the school system?”

Appendix B

Table 6

Coding Scheme

Name	Description
Facilitator - any questions	When the facilitator asks are there any questions?
Facilitator - Ask T Read slide T think time	Facilitator asks the teacher leader to read slide and think about the content
Facilitator - Content	Facilitator interacts with the content
Facilitator - Content - agenda	Facilitator interacts with the content-Describes agenda for the day
Facilitator - content - assign different readings	Facilitator assigns the reading to different groups/individuals
Facilitator - Content - specific page	Facilitator directs teacher leaders to read a specific page
Facilitator - content- checking do they have it	Facilitator describes all the documents the teacher leaders should have and check to see if they have it.
Facilitator - Content- guiding question while reading	Facilitator provides the teacher leaders with guided questions while reading
Facilitator - Follow-up general	Facilitator asked follow-up question to participants response to Facilitators general questions
Facilitator - group assign roles	Facilitator asks groups to assign roles while in the break out rooms
Facilitator - Group directions	Facilitator provides group directions
Facilitator - Group directions before breakout	Facilitator gives group directions before teacher leaders go into breakout rooms.
Facilitator - groups structured questions	Facilitator provides structured questions to the groups to discuss while in break out rooms.
Facilitator - Need answer from all	Facilitator informs the teacher leaders they are waiting for answers from everyone in the chat.
Facilitator - Pick a person to share	Facilitator asks groups to pick a person to share.

Facilitator - respond to TL question	Facilitator responds to teacher leaders' question
Facilitator - Restate TL statements	Facilitator restates teacher leaders' comment
Facilitator - TL - haven't heard from in awhile	Facilitator selects a teacher leader they haven't heard from.
Facilitator - TL - Need more time	Facilitator asks teacher leaders if they need more time.
Facilitator - time alloted for activity	Facilitator provides the time the teacher leaders will have to complete the activity.
Facilitator - TQ- ask group	Teacher leader asks the facilitator a question. The facilitator puts the question out to the whole group for a response.
Facilitator- Read responses from chat	The facilitator asks a question, then read the responses the teacher leaders put in the chat.
Facilitator showing on camera	The facilitator uses the camera to demonstrate.
Facilitator -TL enter responses in shared document	Facilitator asks teacher leaders to enter responses in a shared document. This is for the whole group, not a group document.
Facilitator-Ask to respond in chat	Facilitator asks teacher leaders to respond in the chat.
Facilitator-Chat-Specific-Q	Facilitator asks teacher leader a specific question based on the comment the teacher leader put in the chat.
Facilitator-Content-ask to share on camera	Facilitator asks participants to use the camera to share work.
Facilitator-follow-up question-specific	Facilitator asks follow-up question
Facilitator-Raise hands	Facilitator asks teacher leader to raise hand to answer the question.
Facilitator-Teacher Leader- specific Q	Facilitator asks specific question to teacher leader.
Facilitator-Teacher Leader -General Q	Facilitator asks general question to the whole group or everyone within a small group.

LE - different computer than use to	Learning Environment – teacher leader is using a different computer than they normally use.
LE - F - use of the zoom functions	Learning Environment - Facilitator asks teacher leaders to respond using a zoom function.
LE - F - Zoom engagement guidance	Learning Environment - Facilitator provides directions on how to use Zoom
Learning Environment - Open Mic	Learning Environment - Someone has their Mic open.
Teacher Leader - ALL	Teacher Leader interacts with all.
Teacher Leader - All - Refer to Content	Teacher Leader references the content
Teacher Leader - All-Refer to other teacher leader ideas	Teacher Leader refers to another teacher leaders' comment
Teacher Leader - All-Refer to facilitator's comment	Teacher Leader refers to facilitator's comment
Teacher Leader - All-Show on Camera	Teacher Leader uses camera to show example.
Teacher Leader-Content	When the teacher leader is interacting with the content.
Teacher Leader-F-General	When the teacher leader is responding to the facilitator's general question.
Teacher Leader-F-Question	Teacher Leader asking the facilitator a question
Teacher Leader-F-Specific	Teacher Leader responds to facilitator's specific questions
Teacher Leader responds in chat	Teacher Leader responds to the facilitator's question in chat.
Teacher Leader responds on group document	Teacher Leader responds in the group document.
Teachers Leader Showing	Teacher Leader uses the camera to show paper to help explain.
Teacher Leader-Teacher Leader	When teacher leaders are interacting with teacher leaders
Wait Time	Facilitator mentions wait time.

Appendix C

College and Career Ready Standards (similar to Common Core State Standards)

Standards for Mathematical Practice

1. Make sense of problems & persevere in solving them
2. Reason abstractly & quantitatively
3. Construct viable arguments & critique the reasoning of others
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
7. Look for & make use of structure
8. Look for & express regularity in repeated reasoning

Grade 6 Overview

Ratios and Proportional relationships

- Understand ratio concepts and use ratio reasoning to solve problems.

The Number System

- Apply and extend previous understandings of multiplication and division to divide fractions by fractions.
- Compute fluently with multi-digit numbers and find common factors and multiples.
- Apply and extend previous understandings of numbers to the system of rational numbers.

Expressions and Equations

- Apply and extend previous understandings of arithmetic to algebraic expressions.
- Reason about and solve one-variable equations and inequalities.

- Represent and analyze quantitative relationships between dependent and independent variables.

Geometry

- Solve real-world and mathematical problems involving area, surface area, and volume.

Statistics and Probability

- Develop understanding of statistical variability.
- Summarize and describe distributions.

Grade 7 Overview

Ratios and Proportional Relationships

- Analyze proportional relationships and use them to solve real-world and mathematical problems.

The Number System

- Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers. expressions and equations
- Use properties of operations to generate equivalent expressions.
- Solve real-life and mathematical problems using numerical and algebraic expressions and equations.

Geometry

- Draw, construct, and describe geometrical figures and describe the relationships between them.
- Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.

Statistics and Probability

- Use random sampling to draw inferences about a population.
- Draw informal comparative inferences about two populations.
- Investigate chance processes and develop, use, and evaluate probability models.

Grade 8 Overview

The Number System

- Know that there are numbers that are not rational and approximate them by rational numbers. Expressions and Equations
- Work with radicals and integer exponents.
- Understand the connections between proportional relationships, lines, and linear equations.
- Analyze and solve linear equations and pairs of simultaneous linear equations.

Functions

- Define, evaluate, and compare functions.
- Use functions to model relationships between quantities.

Geometry

- Understand congruence and similarity using physical models, transparencies, or geometry software.
- Understand and apply the Pythagorean theorem.
- Solve real-world and mathematical problems involving volume of cylinders, cones and spheres.

Statistics and Probability

- Investigate patterns of association in bivariate data.

High School Overview

The high school standards specify the mathematics that all students should study in order to be college and career ready. The high school standards are listed in conceptual categories:

- Number and Quantity
- Algebra
- Functions
- Modeling
- Geometry
- Statistics and Probability

Conceptual categories portray a coherent view of high school mathematics; a student's work with functions, for example, crosses a number of traditional course boundaries, potentially up through and including calculus.