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ENGAGING MULTILINGUAL LEARNERS IN MATHEMATICS LEARNING

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ENGAGING MULTILINGUAL LEARNERS IN MATHEMATICS LEARNING

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Education
at the University of Kentucky

By
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ABSTRACT OF DISSERTATION

ENGAGING MULTILINGUAL LEARNERS IN MATHEMATICS LEARNING

As the number of Multilingual Learner (ML) students attending public schools rises, so does the demand for those who can teach them. Research shows that due to the existence of gaps between different types of knowledge, theory, and practice, the results of teacher preparation programs are often fragmented and do not fully benefit participating teachers (Ball, 2000). To address these gaps, a Professional Development (PD) framework, called PrimeD (Professional Development, Research, IMplementation, and Evaluation) has been proposed. It organizes PD for preservice teachers into four phases of Design, Implementation, Evaluation, and Research, and works in a cyclic nature to provide a coherent structure to PD activities. The purpose of my study is to examine possible benefits of PrimeD on secondary mathematics preservice teachers and their reflection on instructional practices that are meant to engage ML students.

KEYWORDS: Mathematics Preservice Teacher Education, Professional Development, Multilingual Learners, Student Engagement

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In loving memory of my father, “Pedar”.

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CHAPTER 1. INTRODUCTION

Problem Statement

Today, Multilingual Learner (ML) students are the fastest-growing student population group attending public schools nationwide (National Education Association, www.nea.org). In 2020, there were nearly five million ML students enrolled in public schools, which reflects the 28% enrollment increase since the year 2000 (Mitchell, 2020). It is estimated that by 2025, one out of four students attending public schools in the U.S. will be a Multilingual Learner.

In addition to their rising number, the significant diversity of the ML population with regard to their age, race, primary language, culture, socioeconomic status (SES), and levels of education also presents a wide array of challenges not commonly encountered by teachers (Freeman & Freeman, 2009). For example, some MLs who are born in the U.S. and speak a language other than English at home are usually more fluent (at least in conversational English) compared to those MLs who have immigrated to the U.S. at an older age. Also, among the immigrant ML population, there is a large diversity of age groups as well as a wide spectrum of English proficiency level and background education (Díaz-Rico and Weed, 2010). It is therefore clear that addressing these challenges, which many teachers are not well-prepared to respond to, would require specialized training.

More specifically, with regard to mathematics learning, the achievement gap at different levels between ML students and non-ML students has long been recognized. As one example, in 2019, based on the data from the National Center for Education Statistics (NCES, 2020), on average, non-ML students scored 23 points higher in mathematics than

ML students in 4th grade, with the achievement gap growing to as much as 42 points in the 8th grade. Research indicates that in addition to mathematical skills, language skills have a significant impact on students' success in mathematics (NYU, 2018). With mathematics classrooms ranging from silent and individual activities to more verbal and social ones, the students are expected to be able to communicate mathematically both orally and in writing. Moreover, regardless of their prior mathematics knowledge, participating in mathematical activities, such as explaining solution processes, proving conclusions, and presenting arguments can be an additional challenge for ML students. For these students, struggling to precisely communicate their ways of thinking and/or ask their questions–to resolve possible misconceptions–works as a barrier that negatively impacts their participation in mathematics learning activities in classroom regardless of their mathematics knowledge background. This can lead ML students to see themselves as not as capable as their non-ML peers in mathematics learning and subsequently develop a fragile mathematics identity. Difficulty to express their thoughts can also harm ML students' self-efficacy, which as Soland (2019) explains, is fundamental to their motivation and achievement causing ML students to have little desire to attempt solving problems and consequently slows down their learning process.

As the number of ML students attending public schools continues to rise so does the demand for those who can teach these students. Based on data from the National Center for Education Statistics (NCES, 2017), the number of educators who are dedicated to addressing the needs of this growing population is substantially low. The shortage of mathematics teachers who are trained on how to implement special techniques in their practices that are beneficial to ML students is concerning. Data shows that expert teachers tend to raise more academically successful students (U.S. Department of Education, 2000). Although, according to Au (2020) standardized tests are created in a way that leave students from diverse cultural background with two options of adapting or being left out, lack of properly trained teachers could have a further negative impact on the achievement gap between ML and non-ML students. Among the reasons experts mention for existence of such shortage is lack of robust educator training. Although teacher preparation programs are considered as one of the most important and effective ways to improve the knowledge and skills of STEM teachers to enhance their performance, research shows that there are often disconnections between what is learned in such programs and what is implemented in the classroom. Therefore, teacher preparation programs do not benefit participating teachers as much due to the existence of gaps between different types of knowledge, theory, and practice (Ball, 2000).

To address these gaps, a Professional Development (PD) framework, called PrimeD (Professional Development, Research, IMplementation, and Evaluation), has recently been proposed which provides a coherent structure to PD activities (Rakes et al., 2017a). PrimeD organizes professional development into four phases of Design, Implementation, Evaluation, and Research, which work in a cyclic nature and occur iteratively throughout the program. A key feature of PrimeD that appears to help participating teachers make stronger connections between field experiences and theories learned in their coursework, as recommended by Gainsburg (2012), is the use of Networked Improvement Communities (NICs) (Bryk, Gomez, & Grunow, 2011; Martin & Gobstein, 2015) to cycle between classroom implementation and whole group engagement in PD sessions. NICs are part of Phase II of PrimeD and are intentionally designed social organizations that are: 1) focused on a common aim, 2) guided by a common problem, 3) develop a shared approach to solve the problem, 4) employ methods of improvement research to develop, test, and refine interventions, and 5) seek to create interventions that can be applied across classrooms. The ultimate goal of this dissertation is to examine how PrimeD helps secondary mathematics teachers to reflect on their instructional practices that can lead to improved engagement of ML students.

Purpose and Research Question

The overall purpose of this study is to examine the possible benefits of using PrimeD as a robust professional development framework on secondary mathematics preservice teachers (MPSTs) to better reflect on their instructional practices with regard to engaging their ML students. Therefore, the research questions of my study are:

1. How do mathematics preservice teachers who have participated in PrimeD project view engagement for their students?
2. How do mathematics preservice teachers who have participated in PrimeD project reflect on their practices that can help engage ML students?

The Researcher

As an ML, now an educator and a student myself, I have always been thinking about how my life could in many aspects be easier if I were a native English speaker, the Language of Instruction (LOI) in most schools and learning institutions in the U.S. I can imagine that it could have worked perfectly as a catalyst in many aspects of my life, from helping my kids with their homework to speeding up working on my own assignments or preparing my lesson plans. When I started teaching mathematics at a local college a few years ago, I was in my late-thirties and more than a decade since I had immigrated to the U.S. The student population of my classes were quite diverse in terms of race, gender, LOI proficiency, Socioeconomic Status (SES), mathematics background knowledge, etc. As I was watching my students trying to learn mathematical concepts, I was wondering how they were feeling about learning mathematics, about my classroom environment, my instructions, and ultimately how these feelings would affect their learning experiences. With my own learning experiences as an ML in mind, I used to constantly reflect on my instructional practices thereby tweaking and tailoring them to better fit my students' needs and improve their mathematics learning.

So, my ultimate goal became facilitating mathematics learning processes for ML students which in turn required preparing mathematics teachers who can incorporate equitable strategies in their practices to help ML students reach their full learning potential.

As a personal experience, I can vividly remember my first day of the 10th grade, where I attended a new high school in a new neighborhood to which we had just moved in. Most of the kids in the class knew each other well and were friends. They were raving about what they had done during the summer and were excited to see each other again. However, it was a totally different experience for me! I was feeling left out and isolated, no one knew me, no one was asking me about anything, as if I were a stranger. I had similar feelings during the lessons in different classes, as well, because teachers did not know me either. When I came back home that day, as I was telling my parents about how my first day had gone, I suddenly burst into tears and told them that I would not go back to that school again. My mom tried to convince me without success and my dad, who was a high school teacher in the district at the time, promised to make an arrangement so that I could attend my old high school, where I had many friends and had a sense of belonging.

Years after, as I was attending university in the US, I experienced similar feelings although I was now an adult and could manage my emotions without becoming overwhelmed. Yet, I was always thinking of young children immigrating to a new country–some without their nuclear family, relatives, and friends–and their feelings and experiences in the new society that has a whole different language, culture, and ways of interactions in different settings such as schools. Therefore, in terms of equity, I think the first step teachers of ML students need to take is to give them the reassurance that they are in a safe place and their needs and feelings are recognized and valued. By creating a sense of belonging and being valued, such practices can help MLs flourish and perform at the same level as their mainstream peers. According to Moschkovich (2013), equitable teaching practices support mathematical reasoning, conceptual understanding, and discourse, and broaden participation for students who are learning English.

Definitions

Below are some definitions that I will build upon throughout this dissertation.

Multilingual Learners (MLs): is an asset-based term used by WIDA standards framework, (2020) to refer to all students who interact in one or more languages other than English on a regular basis.

Engagement: Based on Kuh et al. (2007), student engagement has been defined as "participation in educationally effective practices, both inside and outside the classroom, which leads to a range of measurable outcomes". Krause and Coates (2008) define it as "the extent to which students are engaging in activities that higher education research has shown to be linked with high-quality learning outcomes".

Mathematical Discourse: According to Gee (1996, p. 127), "Discourses are ways of being in the world or forms of life which integrate words, acts, values, beliefs, attitudes, social identities as well as gestures, glances, body positions and clothes." Based on this definition, mathematical discourse is the communication that takes place in classrooms in which students articulate their thoughts and ideas and also consider their classmates' perspectives in the process of understanding a concept. Given this definition, mathematical discourse is obviously beyond just the use of technical language.

Mathematics Register: As defined by Halliday (1978, p. 195), "A register is a set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings. We can refer to the "mathematics register" in the sense of the meanings that belong to the language of mathematics (the mathematical use of natural language, that is: not mathematics itself), and that a language must express if it is being used for mathematical purposes." It is with the help of mathematics register that we can understand how a language builds mathematical knowledge in a different manner compared to other academic subjects. When students are doing mathematics, they are constructing knowledge using symbols, oral and written language, and also visual representations. Mathematical symbols, for instance, facilitate constructing concepts that are difficult to express in ordinary language.

White Language Supremacy: is presented as rejecting students' preferred or primary languages and dialects in an educational setting and rather necessitating the adaptation of linguistic practices of the dominant culture (Caldera & Babino, 2020).

Network Improvement Community (NIC): are intentionally designed social organizations that are focused on a well-specified common aim; guided by a deep understanding of the problem, the system that produces it, and a shared working theory to improve it; disciplined by the methods of improvement research to develop, test, and refine interventions; and organized to accelerate interventions into the field and to effectively integrate them into varied educational contexts (Carnegie Foundation, 2015).

Preservice Teacher: Education students in their junior or senior year who are enrolled in a teacher preparation program and co-teach a class with a mentor teacher at a local high school. This training is considered as the field experience required for receiving their teaching license.

CHAPTER 2. Review of Literature

In this section, I will be presenting the research literature review that elaborates on the reasons why ML students experience mathematics learning differently compared to the students whose primary language is English, the literature relevant to student's engagement, students' sense of belonging to the learning environment, and the importance of preservice teachers' preparation. I will also discuss literature on PrimeD framework as a professional development framework, and a teacher evaluation instrument called $MCOP^2$ (Gleason et al, 2017) that is used to code and quantify participating mathematics preservice teachers' submitted lesson videos.

Multilingual Learners (MLs)

When I started my research, I chose the term Non-Native English Speaker (NNES) to refer to the students who are the subject of my study. The term has evolved during the course of my research and has turned into the asset-based term of Multilingual Learner (ML) adapted from WIDA standards framework. The reason I decided to drop the term NNES was because it was originated from a deficit mindset that prioritizes native English speakers and excludes those whose primary language is not English. Instead, I picked the term English Language Learner (ELL) which got replaced with Multilingual Learner (ML) students later on to remove the linguistic white supremacy factor that was carried in it as it neglects marginalized students' cultures instead of trying to use pedagogies that value and support them (Paris & Alim, 2017).

2.1.1 Switching Cost

In their book, *Understanding by Design Meets Neuroscience*, McTighe & Willis (2019) mention classroom-related stressors for students and explain, from a neuroscientific perspective, how these stressors can negatively affect students' learning process and result in them not be able to learn as well as or as fast as their peers physiologically. Having language differences and feeling of not being accepted by their peers and/or teachers is among the classroom stressors mentioned in the book. Students who are feeling stressed for the reasons mentioned above in mathematics classroom, are likely to become mentally disengaged and drift into random thoughts that are not related to mathematics topics. For teachers, this highlights the importance of creating a climate of respect in their classroom in which all students feel that they are seen, accepted, and treated equally, and their voices are heard.

According to Jevtović et al. (2020), essentially, bilingual individuals have both languages active in their brains at the same time and even when using one language, their brain activates the other language, too. This process is called *parallel activation*. In a bilingual brain, both languages are competing to be chosen, and to choose the right language, bilinguals need to inhibit the language they do not want to use. Inhibiting a language also means that it is harder to re-activate it later–something language researchers call *switching cost*. The results of Jevtović's research also show that even for highly proficient bilinguals, the *switching cost* is larger for mandatory tasks compared to voluntary tasks where they are allowed to choose the language freely. For this reason, the negative impact of classroom-related stressors, such as the one we discussed earlier, is more significant on ML students. I consider this as another evidence of why ML students experience participation in mathematics discourse and activities differently compared to non-ML students.

2.1.2 Mode of Instruction

As Mallet (2011) has shown in his research, ML students can often better understand written information compared to verbal communication. This can be due to the slower pace of written communication compared to the fast pace of conversations, and especially for MLs, due to the wide range of their listening skills and familiarity with pronunciation of words. Therefore, educators can support their students, specifically their ML students, by em, compared to the dynamic classroom-based communication of lectures, by allowing students benefit from the opportunity to process the information at their own pace. It also gives the ML students the chance to see the correct spelling of the words that they are hearing for the first time and be able to translate their notes into their first language using, for example, an online dictionary or Google Translate, etc. to facilitate understanding.

2.1.3 Mathematics Language

One other major reason ML students do not participate in mathematical discourse is their fear of being misunderstood or being asked too many *What* questions (Kamara, 2004). Despite the general assumption that the language of mathematics is global, research shows that language plays a key role in learning context subjects. In his research, Essien (2018) emphasizes the strong relationship between mathematics learning and language. That is because mathematics learning consists of reading, writing, listening, and being able to talk through and discuss ideas that are all activities related to language.

In her research, Prediger (2018) shows that students whose primary language is the language of teaching and assessment outperform those whose primary language is other than the LOI on mathematics assessments. Also, according to Morgan et al. (2014, p. 845), “language has a special role in relation to mathematics because the entities of mathematics are not accessible materially”. Therefore, because of the mathematical ideas being abstract, communicating mathematically requires using mathematical language precisely in addition to the symbols and drawings.

This brings light to the importance and necessity of equitable and inclusive mathematics teaching and assessment for committed mathematics teachers who are working with ML students. In an early study, Cummins (1984) shows that on average, it takes almost two years for most ML students to become conversationally as fluent as their peers–what is referred to as Basic Interpersonal Communication Skills (BICS) –and five to seven years to become academically as fluent as their peers in English–what is referred to as Cognitive Academic Language Proficiency (CALP).

2.1.4 Situated and Sociocultural Discourse

Early studies of ML students learning mathematics formulated the challenges that ML Latino students faced in terms of solving word problems, understanding vocabulary, and translating from English to mathematical symbols (Cocking & Mestre, 1988; Cuevas, 1983; Cuevas et al., 1986; Mestre, 1981,1988; Spanos & Crandall, 1990; Spanos et al., 1988). Although acquiring vocabulary–a solution that is usually offered to resolve this issue–is a necessity for all ML students, it will not suffice if it has been offered as the only solution. In fact, these students are facing other challenges of mathematics learning, including the reform that is taking place in mathematics classrooms. According to Forman (1996), mathematics classrooms are distancing from silent and individual activities to more verbal and social ones where students are expected to work in small groups and explain their ideas to each other. In such environments, students are expected to communicate mathematically both orally and in writing and participate in mathematical practices, such as explaining solution processes, proving conclusions, and presenting arguments (Moschkovich, 2002).

Besides acquiring vocabulary, another strategy that can help enabling ML students to communicate mathematically in mathematics classrooms is constructing multiple meanings for words rather than having a list of words (Moschkovich, 2002). This is seen as an important distinction between lexicon and register. Unlike the notion of lexicon, the notion of register depends on the situational use of much more than lexical items and includes phonology, morphology, syntax, and semantics, as well as non-linguistic behavior. This solution uses the notion of mathematics register since meanings of different terms are considered based on the context. There may be multiple meanings for a certain term both in English and in ML students' native language. These multiple meanings can be a source of confusion for ML students because they often use the colloquial meaning of these terms while their teachers or other students may use mathematical meaning of them. One good example of this is “a quarter”, which in

English can refer to “a coin” or “a fourth of a whole”, but in Spanish is translated to “un cuarto”, which means “a room” or “a fourth of a whole”.

It should be pointed out that there are some limitations associated with mathematics registers. One of the most important limitations is that the differences between everyday register and mathematics register are not always a source of confusion for students. Students' everyday register and metaphors from their native language can be used as resources for understanding mathematical concepts and communications. Another limitation or challenge of mathematics register is that mathematics is highly technical and includes technical vocabulary such as *sum* or *fraction*. There are also words that are not specifically mathematical, but have certain meanings in mathematics, such as point, borrow, or product. Learning how to use the technical vocabulary in meaningful patterns of language in mathematics can be challenging, especially for ML students.

Another challenge with regard to mathematics register is that, compared to everyday language, the meanings of conjunctions are very technical and precise in mathematics. Conjunctions such as therefore, if, and where are used in certain ways in order to prove theorems or solve problems. Pimm (1987) suggests that the mathematics register can be developed by having students talk formally, by identifying the referents of pronouns, or this one or that part. This helps both students and teachers express their thoughts in the same manner. In addition, it gives teachers an opportunity to realize how much and how deeply their students have understood the concept.

The two strategies discussed above can be interpreted as reducing mathematical discourse to the use of vocabulary. However, a precise description of mathematical communication for ML students, needs to include multiple resources that students use to communicate mathematically. Therefore, another strategy that is called situated and sociocultural discourse is offered which uses the notion of discourse and a situated perspective of learning mathematics (Moschkovich, 2002). This strategy suggests that learning to communicate mathematically is beyond learning vocabulary or understanding meanings in different registers. Rather, it involves social, linguistic, and material resources to participate in mathematical practices. It is known that mathematical discourse increases students' content knowledge (Celedón-Pattichis & Turner 2012; Hansen-Thomas, 2009; Takeuchi, 2015; Turner et al., 2013; Warren et al., 2008) and leads to higher levels of expressed mathematical thinking (Wood et al., 2006). Sacco et al. (2022) argue that when MLs who have difficulties in mathematics learning are not provided with opportunities to get involved in a mathematical discourse, it reflects lack of equity in their teachers' practices. Therefore, while teachers are focusing on enhancing students' understanding of the language of mathematics, any effort to increase their engagement in mathematical discourse will lead to a more equitable learning outcome for all (Bartell et al., 2017).

2.1.5 Wait Time

One factor that can contribute to students' verbal participation in learning activities is the amount of wait time that is given to them. Research shows that, on average, instructors wait less than three seconds after they pose a question and before providing the answer (Duell et al., 1992). While in their research "Supporting teachers in taking up productive talk moves", O'Connor and Michaels (2019) consider offering wait time as an important talk move, they mention that picking up the skill is notably difficult. They further mention that increasing the amount of wait time beyond three seconds has been systematically associated with higher participation in in-class activities and increased complexity of students' responses.

Below are the areas of student achievement and participation improvement that are identified by Rowe (1983) as a result of offering enough wait time:

- An increase in the length of student responses.
- An increase in the number of unsolicited but appropriate student responses.
- An increase in the scores of students on academic achievement tests.
- A decrease in the number of students failing to respond.

2.1.6 Impact of Culture on Academic Learning

According to Sheng et al. (2011), one of the risk factors that contribute to the achievement gap for ML students is the cultural differences they experience between home and school. For ML students, these differences that are emergent in teaching methods, behavioral expectations, daily routines and their relationships with teachers and peers, make the process of adjusting to the dominant culture of the school more difficult. Also, as Nieto and Bode (2012) explain, power is implicated with culture meaning that members of the dominant group in society who have more power consider their cultural values as normal and the cultural values of minorities are considered as divergent or in some cases wrong. Therefore, ML students who feel the pressure to maintain the culture of their native country at home and at the same time in the society incorporate the culture of the country they have moved to, may struggle to keep or create their own identities.

On the other hand, in her research “Mathematics in Cultural Practice”, Nasir (2002) discusses the bidirectional relations between Identity, Goals, and Learning that impact students’ academic performance. Nasir explains that:

- Learning new skills or acquiring new knowledge creates identity and such identity can work as a motivator for new learning.
- Learning new skills or acquiring new knowledge can empower individuals to set new goals for themselves and such goals can become a source of encouragement for more learning.
- New goals emerge from new identities formed in practice, and conversely, achieving new goals can reform individuals’ identities as they see themselves capable of doing new things.

By weaving together what is discussed above, we can conclude that for ML students, the cultural differences between home and school can interfere with the process of their identity formation in different stages which can impact their learning and consequently their academic achievement.

The factors presented and discussed above are among many that differentiate between the mathematics learning experiences of ML and non-ML students.

Engagement

Based on Taylor and Parsons (2011) research, historically, engagement has been measured predominantly by quantitative data such as attendance, standardized test scores, and graduation rates. Most of these measures focus on levels of achievement rather than levels of engagement which should have been measured by factors such as interest, time on tasks, and enjoyment in learning. As Windham (2005, pp 5.7-5.9) recommends, five elements of Interaction, Exploration, Relevancy, Multimedia, and Instruction must be included in the curricula and activities in order for them to be aligned with students' needs in the new technology-rich world. I will use the ALM framework (Moschkovich, 2015) to elaborate on the needs of ML students after discussing these five elements.

2.1.7 Interaction

According to Taylor and Parson (2011), respectful virtual and personal interactions positively affect student engagement. Below are the results of two surveys, "*Imagine a School, Design For Learning"* and "*What did you do in school today?"* (Willms, J. D., Friesen, S. & Milton, P. 2009), that repeatedly show:

- Students want stronger relationships with teachers, with each other, and with their communities. They want their teachers to know them as people.
- Students want their teachers to know how they learn and what they understand and what they misunderstand, and to use this knowledge as a starting place to guide their continued learning.
- Students want their teachers to establish learning environments that build interdependent relationships and that promote and create a strong culture of learning.

Similarly, when the students were asked by Dunleavy & Milton (2009) about their ideal learning environment that can lead to increased engagement, they pointed out learning from each other and people from the community, getting connected with experts, and having more opportunities to express themselves and participate in conversations.

2.1.8 Exploration

Researchers such as Willms, Friesen, & Milton (2009), Brown (2000), Hay (2000), Oblinger & Oblinger (2005), and Barnes et al. (2007) have shown that the most engaging classroom practices are those that are predominantly inquiry-based, problem-based and exploratory. Learning without context jeopardizes knowledge transfer outside of the classroom and leaves learners incapable of taking their knowledge into the field which is more engaging than only reading about theories in classroom.

2.1.9 Relevancy

In order to engage learners, relevancy is a prerequisite. Today's learners tend to learn more by applying the knowledge in real-life rather than being theoretical. As Claxton (2007), Dunleavy & Milton (2009), and Willms, Friesen, & Milton (2009) have shown in their research, working on authentic problems and community issues gives the learners a sense of purpose in learning. In their research, Ramaley, and Zia (2005) present the research-based recommendations of the Board on Children, Youth, and Families' 2004 National Research Council report about the two key points of keeping students motivated and engaged in school:

- Good connections between learners and the social context in which they learn.
- Curriculum and instruction that are relevant to their experiences, culture, and long-term goals.

2.1.10 Multimedia & Technology

It is proven that multimedia and technology, such as cameras, video editing tools, projectors, Smart Boards, sound recording equipment, etc. are helpful in engaging students in learning (Dunleavy & Milton, 2009; Barnes, Marateo & Ferris, 2007a; Project Tomorrow, 2010). Teachers' reports show that increased access to technology in classrooms improved different aspects of student engagement such as time on task, being responsible for learning and being interested in pursuing information further and outside of the classroom (Project Tomorrow, 2010).

In their book "*Celebrating School Improvement*", Parsons, McRae, and Taylor (2006) report that students in K-12 schools used technology to gather, analyze, and share information (pp 110-111), which had positive impact such as higher achievement, higher quality of work, significantly improved student motivation, and increased time spent on tasks.

2.1.11 Instruction

Improving instruction has two aspects of improved curriculum and improved pedagogy. This can be an uncomfortable shift for many teachers as it changes the class dynamic in a way that the teacher has less control on the process of learning, timing, and the content but it helps students to become more familiar with their learning styles and preferences.

In contrast with the common idea that today's students are asking for less work and prefer a more moderate curriculum, many researchers such as Willms, Friesen and Milton (2009), Oblinger and Oblinger (2009), and Parsons, McRae, and Taylor (2006) along with others report that in fact students desire for rigorous and meaningful curricula along with challenging instruction that is engaging.

Engaging ML students in mathematics learning demands more. For instance, according to Zahner et al. (2021), teachers need to consider three principles when designing a secondary mathematics classroom if their intention is for their ML students to benefit from and participate in mathematical discussions. The three principles are grounded in Academic Literacy in Mathematics (ALM) framework (Moschkovich, 2015) that defines academic literacy in mathematics as a) mathematical proficiency, b) mathematical practices and c) mathematical discourse, and are listed below:

- Use a consistent conceptual focus across the unit and carefully choose problem contexts that support the conceptual focus (Mathematical Proficiency).
- Integrate language goals that are linked to mathematical content goals (Mathematical Practices).
- Incorporate structures that enable the widest possible participation in classroom discourse (Mathematical Discourse).

The task of engaging ML students in mathematical discussions is focused on a certain form of engagement for one of the many groups of diverse students. This highlights the importance of teacher preparation programs to train teachers, especially preservice teachers, on how to address the needs of all of their students--who are coming from diverse backgrounds--and increase engagement in their classrooms.

Teacher Preparation Programs

Teacher knowledge that employs teacher's education, personal experiences and skills attained from teacher preparation programs shapes the foundation of all pedagogical decisions that take place in a classroom (Borko & Putnam, 1995). Such knowledge for teaching needs to be able to successfully implement the National Council for Teachers of Mathematics *Principles and Standards for School Mathematics* (NCTM, 2000) for effective teaching that are categorized under six captions of Equity, Curriculum, Teaching, Learning, Assessment and Technology. There are interactions among these principles. For instance, there are interactions among Curriculum, Teaching, Learning and Assessment as teaching produces learning, and assessment is supposed to illuminate both teaching and learning (Ronau & Rakes, 2011). Therefore, teacher preparation programs that consider NCTM's six aspects of teacher knowledge and the interactions among them, can train new teachers for more effective teaching.

In addition, in their research, Caldera and Babino (2020) argue that during the past two decades, the percentage of white teachers has floated around 80% (National Center for Education Statistics, NCES, 2019, U.S. Department of Education, 2016), while according to United States Census Bureau (2018), 54% of students who are attending public schools are considered as "Students of Color". Despite their good intentions, many of these white teachers and even "Teachers of Color" are not well-equipped to implement the instructional practices that value and sustain the cultures of "Students of Color". This reiterates the importance of preparation programs for preservice teachers. Therefore, teacher preparation programs are vital for preservice teachers, especially those who teach a diverse population of students.

PrimeD Framework

Guskey (2000, p. 16) defines professional development as “those processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students”. As the education environment in general is changing because of emergence of new standards, (Common Core State Standards for mathematics and Next Generation Science Standards), development of new technologies and tools, introduction of new theories and practices in STEM education, and the more emphasis on equity, teachers, school administrators, policy makers etc., feel the greater need to get involved in professional development activities in order to adapt their skills with the teaching requirements of the new century.

Investigating the results of engagement in professional development activities for teachers, school administrators, policy makers, etc., that examines the effectiveness of such activities, has long been the subject of research. In order to determine practices that would improve effectiveness of PD activities, Driskell et al. (2016) conducted a comprehensive study to examine the contents of mathematics education technology professional development papers published over several decades. As a result, a PD framework called: Professional Development, Implementation and Evaluation Model (PDIEM), was established. The PDIEM framework was an expanded version of the Professional Development Design Framework (PDDF) of Loucks-Horsley et al. (2010). Driskell’s proposed model was consisted of four phases of Design, Engagement, Implementation and Evaluation with a focus on continuous interaction among the phases, i.e., collaboration among communities of practice, implementation of improved classroom instruction, and a cyclical and continuous evaluation process that involved all stages of the professional development activity.

In 2017, Saderholm et al. proposed a new professional development framework called: The Professional Development: Research, IMplementation and Evaluation (PrimeD) that was adapted from Driskell's PDIEM framework. Similar to PDIEM framework, PrimeD consists of four phases of Design, Implementation, Evaluation, and Research (Figure 1) that are categorized slightly differently. This is the professional development framework used in this research with each phase explained in more detail below. PrimeD structure facilitates designing a PD program that is well aligned with individual teachers' specific school and classroom needs (Philippou, Papademetri-Kachrimani & Louca, 2015).

The first phase of PrimeD is Design and Development which brings together all stakeholders to come up with a common vision, to set a target outcome, discuss the critical challenges to reach those outcomes, and be prepared to develop strategies to overcome such challenges. Therefore, in this phase, all participants define a challenge space together. It is important to emphasize the importance of teachers being included in developing the challenge space phase to make sure that their ideas are heard and used in designing the professional development that addresses their needs, while promoting agreement and situating the PD experiences within the context of particular classroom or school, as recommended by Philippou et al. (2015). Planning for Networked Improvement Communities (NICs) that are an important part of Implementation phase,

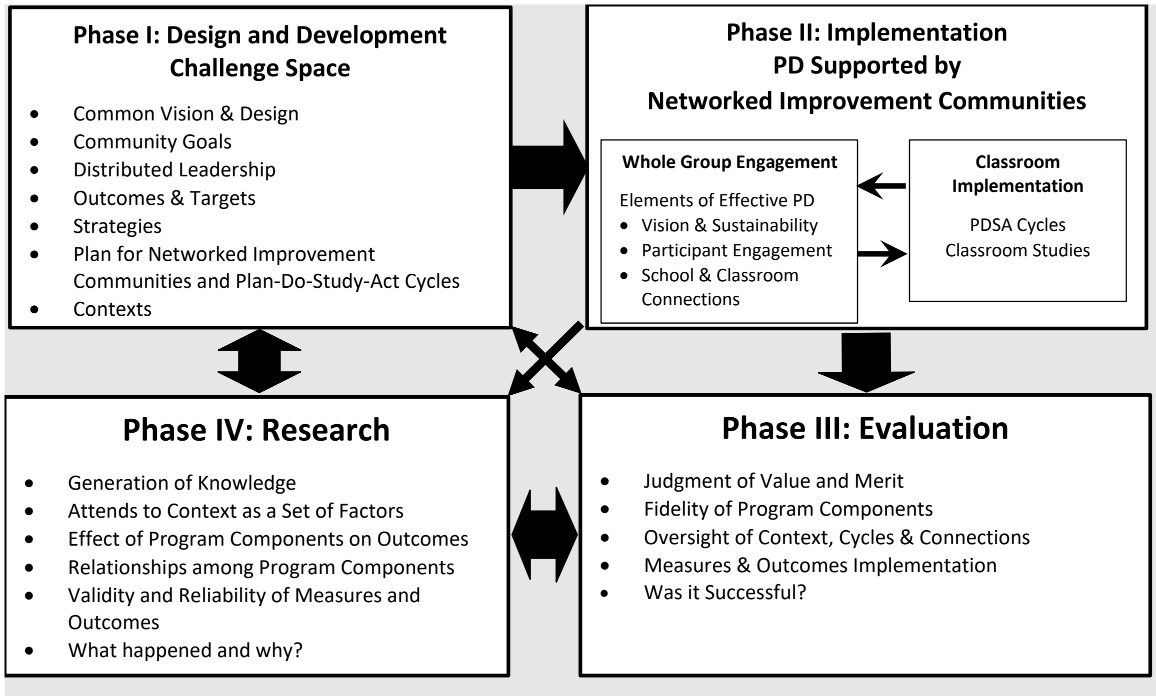

Figure 1: Condensed Model of PrimeD Framework (Saderholm et al., 2017).

also takes place in the Design phase. These communities consist of a group of mathematics preservice teachers, their mentor teachers, and PrimeD researchers, who come together in monthly meetings to solve problems using a Plan, Do, Study, Act (PDSA) cycle, an iterative method for systematic and continued improvement of a process (Figure 2). In the context of education, PDSA cycles are tools that help with monitoring and guiding endeavors of implementing interventions in classrooms. Identifying and planning for an intervention is the first step, followed by data collection on the results, reviewing the results to improve the shortcomings of the innovative change, and plan a new improved cycle based on the results of the previous cycle (Bryk, 2015).

The second phase of PrimeD is called Implementation which is initiated with a "whole group engagement" that is followed by "classroom implementation". In this phase, all PrimeD participants get together in monthly NIC meetings to use effective PD elements that are planned in the first phase (Design) to come up with strategies that can improve the desired aspect of their teaching through PDSA cycles. The results

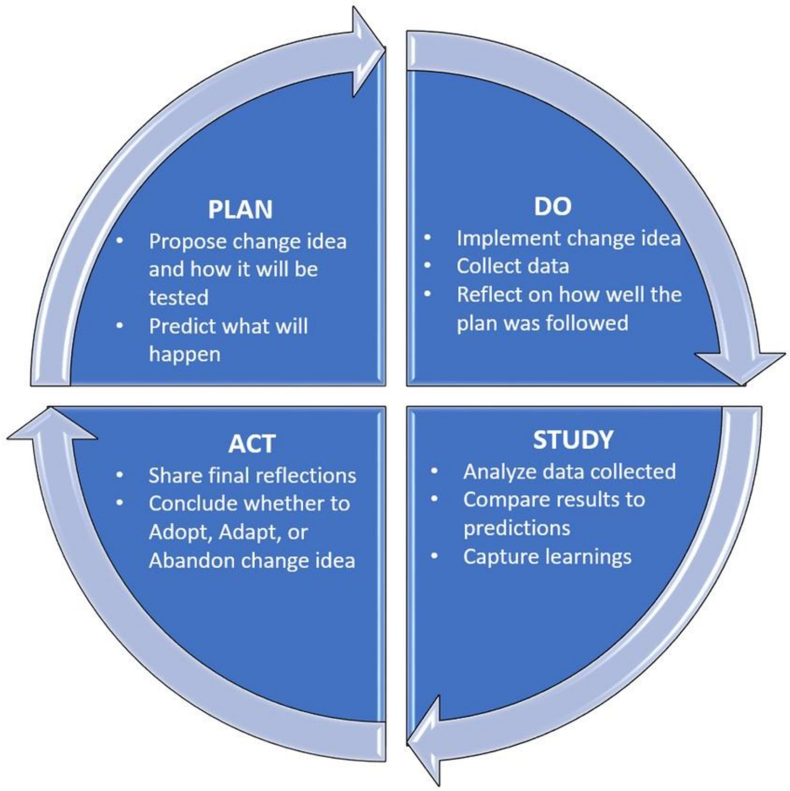

Figure 2: Diagram of a Plan-Do-Study-Act (PDSA) Cycle.

of PDSA cycles, either frustration or progress of the implemented strategy, are shared in the upcoming monthly NIC meeting in the form of artifacts collected in the classroom, data collected, personal reflections, etc. with the goal of learning about other participants' experiences, lessons learned, and the constructive feedback that can facilitate the next cycle development.

The process of “whole group engagement” helps preservice teachers to generate knowledge and provides them with the opportunity to apply research in their classrooms since multiple teachers try out the ideas and solution strategies in different classroom settings and bring their results and experiences to the next meeting. Having field experience supervisors, faculty, PrimeD alumni, and more experienced teachers in the monthly NIC meetings facilitates more meaningful and rich discussions and raises mentoring to a level that is not often present in ordinary PD programs. Participation in the monthly NIC meetings that increases the interaction among different groups of participants and improves levels of engagement for each individual participant is ideal to create effective implementation of PD practices. The implementation process will become a less effective and an isolated practice without the NICs meetings.

The next phase is the Evaluation phase which involves both formative and summative assessment of phases I and II that is ideal to provide the most effective feedback. By assessing the results of the implementation phase, possible pitfalls of the design phase (phase I) are identified. Such feedback loops can address and adjust the identified issues in order to make the implementation phase more productive.

The last phase of PrimeD framework that is called Research, focuses on finding answers to questions such as “what happened during the PD processes and why”. For this reason, this phase is naturally connected to and in constant interaction with the other phases. Such interconnectivity is a unique feature of PrimeD that distinguishes it from other PD programs. Among these interconnections, the integration between the evaluation phase and the research phase is especially important as they both involve analysis and inquiry.

The overall goal of using PrimeD as a PD framework for teacher preparation programs is for the participating teachers to be involved in designing the PD based on their district, school, or their personal needs, and also to position themselves as leaders.

MCOP^2 Teacher Evaluation Instrument

One of the instruments that is used to examine the alignment of the K-16 mathematics classrooms with various standards defined by national organizations with the focus on conceptual understanding is the Mathematics Classroom Observation Protocol for Practices (MCOP^2) instrument (Gleason et al., 2017). The instrument has adopted its mathematics conceptual understanding specifications from Common Core State Standards in Mathematics: Standards for Mathematical Practice (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), Mathematical Association of America (MAA): CUPM Curriculum Guide (Barker, et al., 2004), American Mathematical Association of Two-Year Colleges (AMATYC): “Crossroads” (AMATYC, 1995), “Beyond Crossroads” (AMATYC, 2006), and National Council of Teachers of Mathematics (NCTM): Process Standards (NCTM, 2000).

With its sixteen indicators, the instrument measures two factors of “Student Engagement” and “Teacher Facilitation”, each through subscales of nine indicators (two indicators are shared). The student engagement subscale indicators (indicators 1 through 5 and indicators 12 through 15), measure the degree to which the role of the student has shifted to active engagement, leadership, and collaboration from the traditional passive role. The teacher facilitation subscale indicators (indicators 4 and 16, and indicators 6 through 11), will provide information about how the teacher structures a lesson, guides the problem-solving process, and leads classroom discourse (Gleason et al., 2015). The equitable teaching practices addendum will be used to capture the ways in which all students are able to engage with the mathematics, construct their own knowledge, and share their reasoning and strategies in a positive learning environment (Gleason et al., 2015). Analyses of equity will focus on the ways in which participants relate to student identities (e.g., gender, class, race, culture) through authentic connections. The analyses will also consider the degree to which all students were active participants in sharing ideas, making conjectures, and reasoning collaboratively. The $MCOP^2$ overall score, the two subscales (teacher facilitation and student engagement), and qualitative observation notes will be used to measure pedagogical content knowledge as it is put into practice in lessons. A copy of $MCOP^2$ instrument is included in Appendix A.

CHAPTER 3. METHODOLOGY

Research Design

I employed a convergent mixed methods research design for my study. The design has a single phase consisting of separate quantitative and qualitative data collection and analysis followed by merging and comparing results to see if they confirm or disconfirm one another's findings (Creswell & Creswell, 2018). The Convergent mixed methods research design that is shown in Figure 3 fitted my study well since I collected and analyzed each type of data without the interference of the other type. I combined the results of the quantitative and qualitative data analysis to make conclusions and compare and see how they validate one another.

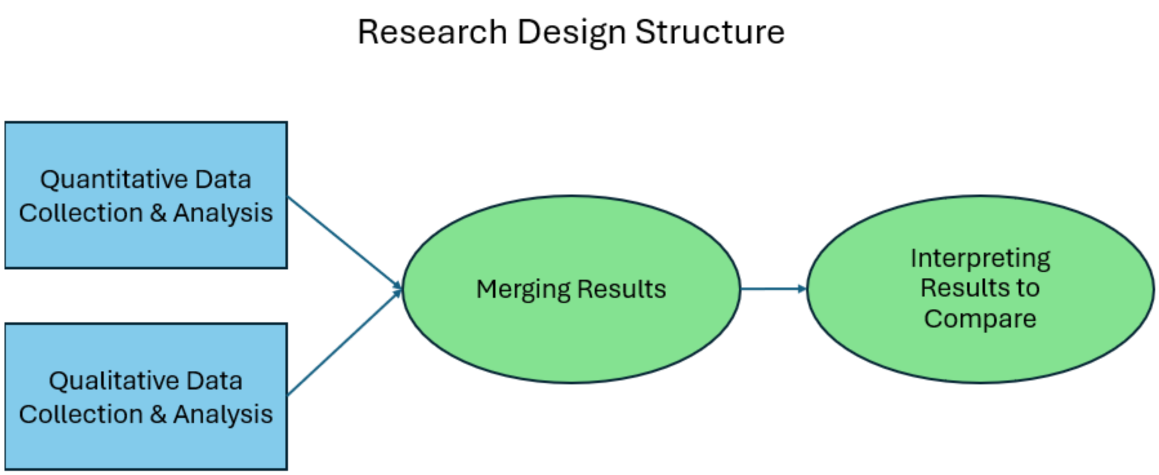

Figure 3: Convergent mixed methods research design (Creswell & Creswell, 2018).

Participants and Sampling

By convenience sampling, I chose the participants of my study from a mixture of more than eighty-three female, male, and non-binary mathematics preservice teachers across four institutions in three Eastern and Southeastern states in the United States during the first three years of the program (2020-23). The four institutions are referred to as Institution 1, Institution 2, Institution 3, and Institution 4, and the first year of the project (2020-21 academic year) is referred to as Year 1, the second year (2021-22 academic year) as Year 2, and the third year (2022-23 academic year) as Year 3 in my writing.

Each year, before the start of the academic year, the undergraduate mathematics preservice teachers attending the four participating institutions were invited to participate in the PrimeD project during their junior or senior year. These individuals are called “preservice teachers”, “interns” or “student teachers”. In my writing I refer to them as preservice teachers. The teachers who were assigned to work with the participating preservice teachers at the local middle or high schools would also participate in the project and are called “mentor teachers” or “cooperating teachers”. After completion of PrimeD first year, those individuals who were part of the project in the previous year, were also invited to continue participating in the project as project “Alumni”. All PrimeD participants provided the researchers with their signed consent forms and were compensated for their time and efforts at the end of each semester through the grant.

Procedures

PrimeD preservice teachers attending Institution 3 and Institution 4 took a mathematics methods course that was taught by a PrimeD project researcher in the fall semester of their senior year and completed their student-teaching in the following spring semester at a local high school. At Institution 2, however, in addition to senior preservice teachers, there were a few participants who were juniors. Also, at institution 2, student teaching had taken place either in a local middle or a high school. Institution 1's schedule was slightly different than the other three institutions because the methods course was taught in the spring semester instead of fall. This shifted the student-teaching to the fall semester of the upcoming academic year for Institution 1 participants.

As part of participation in the PrimeD project, preservice teachers, their cooperating teachers, and the project alumni were expected to participate in monthly NIC meetings, implement PDSA cycles, and together analyze the data, reflect on the results, share with the whole group what worked and what did not in the monthly NICs, and participate in the focus groups at the end of the semester. At each institution, all PrimeD participants attended monthly online NIC meetings three to four times each semester to identify a problem of practice of their own. Table 1 presents the identified problem of practice at each institution during the first three years of the project. As shown in this table, over the course of three years at Institution 2 and Institution 3, the problem of practice and the ultimate goal of the PDSA cycles is centered around increasing student engagement. At Institution 4, however, the goal has been focused on improving various aspects of reform-based teaching, such as questioning, active participation, classroom environment, student exploration prior to lecture, student-centered discussions including discussion about real-world problems, etc. that are also closely related to student engagement.

Table 1: Problem of practice at different institutions.

	Institution 2	Institution 3	Institution 4
Year 1	Student Engagement, Equity for online learning	Building relationship while teaching online, Student engagement in virtual environment	Some aspects of reform-based teaching
Year 2	Student Engagement, Transition to face-to-face learning	Student Engagement	Some aspects of reform-based teaching
Year 3	Student Engagement	Building relationships, Including more real-world problems	Some aspects of reform-based teaching

In between the NIC meetings, the participants conducted Plan-Do-Study-Act (PDSA) cycles with the intention of improving their instructions to eventually resolve the problem of practice and improve their practical instructions. Each alumnus and, preservice and cooperating teacher pair would think of an intervention to implement in their classrooms that targeted the problem of practice in between the two NIC meetings. They would then record the results on their institution’s particular PDSA sheet to report on the data collected and the takeaways from the cycle in the next monthly NIC meeting. At Institution 3, for instance, the preservice teachers would record their desired outcomes, the innovations tried, the data collected, the implementation notes, the outcomes, the reflections, and the revisions for the next cycle on a PDSA sheet that was designed by the local PrimeD researchers.

All preservice teachers and the alumni were also expected to record and submit two lesson videos (“pre” and “post”) from their teaching. The alumni who were in-service teachers, submitted their “pre” video early in the fall semester and their “post” video close to the end of the spring semester, while the preservice teachers submitted both their “pre” and “post” lesson videos from the beginning and end of their student teaching semester in the spring, ~~respectively~~.

The first year of the PrimeD project happened to be in the middle of COVID-19 pandemic. Therefore, across four institutions, preservice teachers from the first cohort of PrimeD (Year 1, 2020-21 academic year) took the methods course and student-taught in a variety of instructional modalities including face-to-face, virtual, or hybrid due to COVID-19 protocols in place.

In the quantitative and qualitative data collection part, I will explain the reasons why I did not have access to either the quantitative or the qualitative data from Institution 1 and therefore I had to withdraw it from my research. Table 2 includes more detailed information about the context of the four institutions participating in PrimeD project and their student demographics.

Table 2: Description of institutions participating in the PrimeD project.

Institution	Type	Average Demographics	Quantitative Participants	Qualitative Participants
Institution 1	Private Liberal Arts school	63% White, 21% Black, 9% Hispanic, 16% Other race/ethnicity, 57% female, 43% male, 55% first generation	0	0
Institution 2	Very High Research, Hispanic Serving Institution (HSI)	48% White, 11% Black, 26% Hispanic, 6% Asian, 4% multi-racial, 4% non-resident alien, 1% not specified, 55% female, 45% male	Year 1: 7 Year 2: 10 Year 3: 5 **Total: 22**	0
Institution 3	Very High Research, land-grant institution	77% White, 12% Black, 11% Hispanic, 48% female, 52% male	Year 1: 11 Year 2: 8 Year 3: 4 **Total: 23**	5
Institution 4	High Research, doctoral degree granting public school	68% White, 15% Black, 2% Hispanic, 15% Asian, 66% female, 34% male	Year 1: 6 Year 2: 6 Year 3: 6 **Total: 18**	3
Total			63	8

3.1.1 Quantitative Data Collection

At Institution 1, Institution 3 and Institution 4, the quantitative data were collected by requiring PrimeD preservice teachers to submit two lesson video recordings (“pre” and “post”) from the beginning and the end of their student-teaching semester. The alumni were asked to submit a “pre” video in the fall and a “post” video in the spring semester of the year of their participation. At the end of each academic year, during the summer, all project researchers across four institutions, including the project supervisor, project PIs, Co-PIs, and the Graduate Research Assistants, were assigned a certain number of submitted “pre” and “post” videos to code using the MCOP^2 instrument. At the end of Year 1, each lesson video was coded by two PrimeD project researchers to increase the validity of the coding process and the average of the two scores was recorded as the final score for each indicator. At Institution 2, due to district policies in place that would restrict teachers from recording their lessons, the lessons were observed by a local PrimeD researcher live. Due to the availability and scheduling issues for the local research team, the participants’ lessons could only be observed by one PrimeD researcher and therefore were single coded. From the beginning of Year 2, only a sample of lesson videos from Institution 1, Institution 3 and Institution 4 were randomly selected to be double coded.

The MCOP^2 scores of the lesson videos were recorded on a Qualtrics account that was shared across four institutions. As I was working on extracting the quantitative data from the Qualtrics account for analysis, I encountered some incomplete data. For instance, for some participants, the MCOP^2 scores were only available for either “pre” or “post” lesson videos while for some others, both “pre” and “post” scores were missing. This could have happened because of the participants not submitting both “pre” and “post” lesson videos or any videos at all or, it could have happened because the PrimeD researchers in charge, did not code the lesson video(s) that they were assigned. For example, as I was working on the analysis of the quantitative data, I noticed that some MCOP^2 scores for videos submitted for Year 3 by Institution 4 participants were missing. Before omitting that piece of data from my study, I checked the shared account to make sure the videos had been submitted. Then, I checked the coding assignment document and identified the researchers in charge and reached out to each of them individually to ask for completion of the coding assignment. I had to omit the participants associated with the remaining incomplete data from my study. I did not find any complete (both "pre" and "post" $MCOP^2$ scores) quantitative data for any of the participants at Institution 1. In total, for my study, I had access to sixty-one pairs of "pre" and "post" lesson videos either single or double coded that were available on Qualtrics. Since the focus of my study is on engagement in mathematics learning, I only analyzed the $MCOP^2$ scores of the nine indicators within the student engagement subscale that are shown in Table 3. I had access to these data as a Graduate Research Assistant attending Institution 3 who had joined the project from the beginning of the second year (Year 2, 2021-22).

Table 3: $MCOP^2$ Student Engagement Subscale Indicators (Gleason, 2017).

Indicator 1	Students engaged in exploration/investigation/problem solving.
Indicator 2	Students used a variety of means (models, drawings, graphs, concrete materials) to represent concepts.
Indicator 3	Students were engaged in mathematical activities.
Indicator 4	Students critically assessed mathematical strategies.
Indicator 5	Students persevered in problem solving.
Indicator 12	There were a high proportion of students talking related to mathematics.
Indicator 13	There was a climate of respect for what others had to say.
Indicator 14	In general, the teacher provided wait-time.
Indicator 15	Students were involved in the communication of their ideas to others (peer-to-peer).

$MCOP^2$ indicator 1 focuses on exploration, investigation and problem solving in mathematics teaching. For students to be able to use their mathematics knowledge flexibly and in various situations, they must have been given opportunities to engage in exploration, investigation and problem solving that relates to their procedural knowledge. This also helps the students develop the very important and beneficial skill of problem solving as a way of thinking (Barker et al., 2004).

MCOP^2 indicator 2 emphasized the importance of using various representations such as models, graphs, manipulatives, compass & protractors, etc. by students rather than only observing their teachers to use them. While some representations such as manipulatives are provided by the teacher, the students drawings or graphs are counted as representations as well.

MCOP^2 indicator 3 measures the extent of student engagement in mathematical activities that are defined as investigating, problem solving, reasoning, modeling, calculating, or justifying, in writing or verbal.

MCOP^2 indicator 4 is concerned about the students' ability to distinguish and consider a suitable and efficient strategy to solve a given problem or task.

MCOP^2 indicator 5 is focused on students' perseverance in problem solving that is beyond completing tasks and assignments and means for students to overcome obstacles while engaging in problem solving.

MCOP^2 indicator 12 measures the proportion of students who actively speculate, or reason and respond to others' speculations. All students need to be involved in classroom discourse for it to be considered high rather than discourse that is dominated by a few students.

MCOP^2 indicator 13 emphasizes the importance of creating a climate of respect in classrooms which allows all students to communicate effectively by listening, questioning, and critiquing each other.

MCOP^2 indicator 14 considers if appropriate amount of wait time that is aligned with the question or task depending on its complexity, is offered.

MCOP^2 indicator 15 is focused on the mathematics talk that happens in the classroom and among the students which requires teacher's support or will predispose certain population of students (Mercer & Wegerif, 1999; Mercer, Wegerif, & Dawes, 1999; Rojas-Drummond & Mercer, 2003; Rojas-Drummond & Zapata, 2004).

In order to find teachers' scores for student engagement subscale, Gleason (2017) suggests adding up the scores for MCOP^2 indicators 1-5 and 12-15.

3.1.2 Qualitative Data Collection

I collected the qualitative data for my study by conducting semi-structured interviews with eight PrimeD participants. In spring semester of Year 3, I designed an interview protocol that would capture the main ideas presented in the nine MCOP^2 indicators within the student engagement subscale. The interview protocol was reviewed, revised, and approved by my dissertation committee chair. A copy of the interview protocol is included in Appendix B. During the same period, in the spring semester of Year 3, I prepared and sent an invitation email to all Year 1, Year 2, and Year 3 PrimeD participants attending Institution 3. At Institution 1, Institution 2, and Institution 4, the PIs of the project forwarded my interview invite email to their institution's participants on my behalf and encouraged them to participate.

By the end of Year 3 spring semester, I was able to recruit five interview participants, four from Institution 4 and one from Institution 3. Two of my Institution 4 interview participants were PrimeD alumni who had participated in the project as preservice teachers during Year 1, one was a MPST who had gotten the opportunity to be on the job and cover the full classes as a long-term substitute teacher, and one was an in-service teacher who was participating in the project as an alumnus. Since this participant had never participated as a preservice teacher in the PrimeD project, the results of the qualitative data analysis from her were only used to be compared with the results of the other interview participants for triangulation purposes.

The interview participant from Institution 3 was also participating in the project as an alumnus at the time of interview and had participated in the project as a preservice teacher in Year 2. In the fall semester of Year 4, I sent the invitation email to all MPSTs to participate in the interview with me once again, in the hope of recruiting any participants from Institution 2 and Institution 1 and more participants from Institution 3 and Institution 4. This time I was able to recruit four more MPSTs from Institution 3 who were participating in the project as alumni, but I had no luck in recruiting participants from either Institution 1 or Institution 2. Two of the interview participants recruited from Institution 3 were alumni who had participated as a preservice teacher in the PrimeD project during Year 1, one was an alumnus who had participated as a preservice teacher in the PrimeD project during Year 2 and the last one was an alumnus who had participated as a preservice teacher in the PrimeD project during Year 3.

Table 4: Demographic information of interview participants.

Interview Participants	Institution	Role	Student Teaching	Gender	Race
Brooks	Institution 4	Alumni (Sp23)	Year 1	Male	White
Gavin	Institution 4	Preservice Teacher (Sp23)	Year 3	Male	Asian
Parker	Institution 4	Alumni (Sp23)	Year 1	Non-Binary	White
Rachel	Institution 3	Alumni (Sp23)	Year 2	Female	White
Lilian	Institution 3	Alumni (Fa24)	Year 1	Female	White
Sara	Institution 3	Alumni (Fa24)	Year 3	Female	White
Monica	Institution 3	Alumni (Fa24)	Year 1	Female	White
Jill	Institution 3	Alumni (Fa24)	Year 2	Female	White

I conducted all interviews online, via Zoom and audio recorded the interviews. I prepared the transcripts within 24 hours after the interview as they were fresh in my mind, and reviewed and checked the potential errors and added some notes if needed to make sure the nature of the conversations was well reflected in the transcripts. To maintain the interview participants' privacy, I used pseudonyms for their names and any other individual or institution names that would happen to appear in our conversations. Before starting the interviews, I informed all interview participants that the interviews will be audio recorded and the pseudonyms will be used to preserve their identity, and they verbally consented to theses.

As it is shown in Table 4, most of the interview participants are white and English is the primary language for all of them. Also, the majority of the interview participants are monolingual teachers (except for two), and one is teaching in a European country, to students whose primary language and culture differs from hers.

Data Analysis

3.1.3 Quantitative Data

I examined the scores of PrimeD participants' lesson videos for each MCOP^2 indicator at each institution using Wilcoxon test to identify the indicators that have changed significantly. The reason I chose Wilcoxon test to analyze the data is because MCOP^2 scores are considered as ordinal data and I have a pair of scores (for "pre" and "post" videos) for each participant. I also compared sum of the nine student engagement scores for "pre" and "post" video of each participant using paired t-test to measure the significance of differences in their means.

3.1.4 Qualitative Data

I used Thematic Analysis (Maguire & Delahunt, 2017) to identify themes within the qualitative data collected from the interviews. I coded the data manually using inductive coding that is a ground-up approach which allows the codes to emerge from the raw data without any prior preconceptions. I color-coded the phrases that were referring to the same idea and organized them as categories in an Excel sheet. In the next round of analysis, I identified the emergent subcategories. The overarching themes were formed by connecting these subcategories and categories.

To increase the validity of my study and have a more comprehensive understanding of the data, I performed triangulation (Patton, 2002) by practicing member checking with my interview participants. To do so, after coding all interview transcripts, I sent individual follow-up emails to all interview participants and attached the interview transcript and the table of themes that had emerged from our conversation. I requested them to review and confirm if the themes correctly captured what they meant to point out or, disconfirm in case there were any misunderstanding or misinterpretation involved in the themes. All eight participants responded and approved the themes emerged from our interviews.

3.1.5 Mixed Methods Analysis Summary

To answer the first research question of this study, I intend to combine the quantitative results with the qualitative findings since the $MCOP^2$ indicators that I am considering for my research are focused on student engagement and so are the interview questions that I have designed to conduct the semi-structured interviews.

To answer the second research question, though, I will only rely on the qualitative findings because $MCOP^2$ instrument does not measure any aspects of teachers' reflection on their practices.

CHAPTER 4. FINDINGS

Results of Quantitative Data Analysis

The results of analysis of the $MCOP^2$ scores of lesson videos of preservice teachers based on their cumulative scores (Table 5) show that during the first year of the program on average 72% of the preservice teachers from Institution 2, Institution 3, and Institution 4, who participated in the PrimeD project improved sum of their $MCOP^2$ scores on the nine student engagement subscale indicators. In the second year, the number dropped to 43%, and in the third year, on average 38% improvement was observed on sum of $MCOP^2$ scores on the nine student engagement subscale indicators.

These results demonstrate the general positive impact of PrimeD professional development framework on empowering MPSTs in terms of student engagement in mathematics learning. My interpretation of the results is that during the first year of the project, because of the COVID-19 restrictions in place, the "pre" and "post" lesson videos were recorded from classes held in a variety of modalities and this has influenced the process of coding the submitted videos, and consequently the $MCOP^2$ score. Because of the inconsistency in the data collection processes, I consider Year 1 results less reliable than those for Year 2 and Year 3. In Year 2 and Year 3, however, the observed improvements in $MCOP^2$ scores are very similar, which can be partly attributed to the fact that "pre" and "post" lesson videos were recorded from classes that were held in-person (i.e., the same modality) in these two years.

The breakdown of the results based on individual institution shows that during the first three years of the project, on average, 52% of MPSTs who participated from

Institution 2 improved sum of their MCOP^2 scores on the nine student engagement subscale indicators. This number is 46% and 55%, respectively, for Institution 3 and Institution 4, as presented in Table 5.

These results indicate that while MPSTs who participated from Institution 4 have benefited the most from being involved in the PrimeD project, MPSTs from Institution 2 and Institution 3 have also improved their scores within a similar range.

Table 5: Percentage of participants who improved sum of their MCOP^2 (Gleason, 2017) scores on student engagement subscale indicators.

Institution	**Year 1**	**N**	**Year 2**	**N**	**Year 3**	**N**	**Avg.**
Institution 2	86%	7	30%	10	40%	5	52%
Institution 3	64%	11	50%	8	25%	4	46%
Institution 4	66%	5	50%	4	50%	6	55%
Avg.	72%		43%		38%		

The more detailed report on the percentage of MPSTs' improvement on each one of the MCOP^2 indicators in student engagement subscale is presented in Table 6. The table shows that based on the available three-year data from Institution 2, Institution 3, and Institution 4, on average, Institution 3 has the largest percentage of participating MPSTs who improved their observed practices associated with MCOP^2 indicator 1 (investigation and problem solving), indicator 2 (using variety of means to represent concepts), indicator 4 (assessing mathematical concepts critically), indicator 5 (perseverance in problem solving), indicator 12 (mathematical discourse), indicator 13 (creating climate of respect), and indicator 14 (providing wait time). Similarly, on average, Institution 2 has the largest percentage (47%) of participating MPSTs who

Table 6: Percentage of MPSTs' improvement on scores of each MCOP2 indicators (highest values shown in bold).

MCO P^2 Indicator	Institution 2				Institution 3				Institution 4			
	Y1	Y2	Y3	Avg.	Y1	Y2	Y3	Avg.	Y1	Y2	Y3	Avg.
1) Students engaged in exploration/investigation/problem-solving.	43	20	40	34	64	38	75	**59**	17	33	33	28
2) Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent concepts.	29	50	40	40	64	50	50	**55**	50	33	17	33
3) Students were engaged in mathematical activities.	71	30	40	**47**	64	25	50	46	17	33	17	22
4) Students critically assessed mathematical strategies.	43	30	40	38	64	50	50	**55**	50	33	17	33
5) Students persevered in problem solving.	29	20	20	23	55	63	25	**48**	33	17	67	39
12) There were a high proportion of students talking related to mathematics.	71	20	20	37	73	25	25	**41**	33	50	33	39
13) There was a climate of respect for what others had to say.	57	40	40	46	82	50	50	**61**	33	50	67	50
14) In general, the teacher provided wait-time.	71	40	20	44	45	75	50	**57**	17	33	17	22
15) Students were involved in the communication of their ideas to others (peer-to-peer).	57	30	40	42	73	38	25	45	67	50	50	**56**

improved the form of student engagement that is measured by MCOP^2 indicator 3 (mathematical activities in their classrooms). By comparison, Institution 4, on average, has the largest percentage (56%) of participating MPSTs who improved on MCOP^2 indicator 15 (peer-to-peer communication of ideas).

I also examined the MCOP2 “pre” and “post” scores to identify the specific areas that have improved. Wilcoxon signed-rank one-tailed test results indicated that there were no indicators that had improved significantly at Institution 2 (Table 7). However, at Institution 3, the scores of all Year 1, 2, and 3 MPSTs’ “post” videos for Indicators 12, 13 and 14 were statistically significantly higher than their scores for “pre” videos (Table 8). Similarly, at Institution 4 the scores of MPSTs’ “post” videos for Indicator 15 was statistically significantly higher than their scores for “pre” videos (Table 9).

Table 7: Wilcoxon signed-rank test results on Institution 2, Year 1, 2 & 3 data.

Institution 2								
			Pre		**Post**			
MCOP2	**N**	**n**	**Mean**	**Median**	**Mean**	**Median**	**W**	**p-value**
Ind 1	22	12	1.39	1.5	1.41	1.5	38	0.47
Ind 2	22	15	1.36	1	1.34	1	58.5	0.46
Ind 3	22	16	1.86	2	2.20	2	46	0.12
Ind 4	22	16	1.18	1	1.43	1.75	53	0.22
Ind 5	22	6	0.84	1	0.95	1	8	-
Ind 12	22	14	1.86	1.5	1.95	2	48	0.39
Ind 13	22	15	1.64	2	1.89	2	44	0.18
Ind 14	22	15	1.80	2	2.10	2	37.5	0.10
Ind 15	22	16	1.34	1	1.52	1	58.5	0.31

For Indicator 12 at Institution 3, before the intervention Md=1 and Mean=1.26 while after the intervention Md=2 and Mean=1.87 with p-value of 0.008. For Indicator 13 at Institution 3, before the intervention Md=1 and Mean=1.17 and after the intervention Md=1 and Mean=1.76 with p-value of 0.01. For Indicator 14 at Institution 3, before the intervention Md=2 and Mean=1.70 and after the intervention Md=2 and Mean=2.24 with p-value of 0.025.

Table 8: Wilcoxon signed rank test results on Institution 3 Year 1, 2 & 3 data.

Institution 3								
			Pre		**Post**			
MCOP2	**N**	**n**	**Mean**	**Median**	**Mean**	**Median**	**W**	**p-value**
Ind 1	23	21	1.57	1.5	1.93	2	85.5	0.15
Ind 2	23	18	1.04	1	1.48	1	48	0.051
Ind 3	23	18	1.78	2	2.28	2.5	54	0.08
Ind 4	23	19	0.85	1.5	1.28	1.5	59.5	0.08
Ind 5	23	21	0.75	1	1.52	2	82.5	0.13
Ind 12	23	15	1.26	1	1.87	2	18	0.008*
Ind 13	23	20	1.17	1	1.76	1	43.5	0.01*
Ind 14	23	17	1.70	2	2.24	2	35	0.025*
Ind 15	23	18	1.13	1.75	1.57	1.5	57.5	0.11

For Indicator 15 at Institution 4, before the intervention Md=1 and Mean=0.91 and after the intervention Md=1.5 and Mean=1.63 with p-value of 0.013.

Table 9: Wilcoxon signed rank test results on Institution 4 Year 1, 2 & 3 data.

Institution 4								
			Pre		**Post**			
MCOP2	**N**	**n**	**Mean**	**Median**	**Mean**	**Median**	**W**	**p-value**
Ind 1	16	12	1.53	1.75	1.44	1	33.5	0.33
Ind 2	16	11	1.06	1	0.97	1	27	0.30
Ind 3	16	9	1.84	2	1.91	2	20	-
Ind 4	16	14	1.09	1	0.88	1	40	0.22
Ind 5	16	9	1.28	1	1.47	1	16	-
Ind 12	16	12	1.31	1	1.53	2	26.5	0.16
Ind 13	16	13	1.66	1	1.97	2	32	0.17
Ind 14	16	8	2.25	2	2.19	2	16	-
Ind 15	16	13	0.91	1	1.63	1.5	13.5	0.013*

I also performed a paired t-test on sum of all PrimeD participants' "pre" and "post" scores for the nine Student Engagement indicators to identify any significant improvement in student engagement in participants' practices. The results show that for "post" values, Mean=12.467 and for "pre" values Mean=14.975. The difference between the mean values shows 2.508 points increase and statistically significant ($\alpha=0.05$). Figure 4 shows how I examined the impact of improving MCOP^2 indicator 13 (creating climate of respect), and indicator 14 (providing wait time) on indicators 1 (engagement in problem solving), 3 (engagement in mathematical activities), 4 (critically assessing mathematical strategies), 5 (perseverance in problem solving), 12 (mathematical discourse), and 15 (peer-to-peer communication of ideas), by analyzing the MCOP^2 scores of "pre" and "post" lesson videos. The reason I chose to examine the impact of indicators 13 and 14 on the indicators listed above is because the results of qualitative data analysis highlight the importance of offering wait time (indicator 14) and building teacher-student relationships and peer support, that are aligned with creating a climate of respect and a safe environment, on improved student engagement in mathematics learning (indicator 13).

The result of such analysis (Figure 4) indicates that during the first three years of the project and across Institution 2, Institution 3, and Institution 4, thirty-four MPSTs have improved creating climate of respect in their classrooms, i.e., improved scores on $MCOP^2$ indicator 13, and twenty-seven MPSTs have improved offering appropriate amount of wait time in their practices, i.e., improved their scores on $MCOP^2$ indicator 14.

Among the thirty-four participants who improved creating a climate of respect in their classrooms, on average, 52% increased students' engagement in exploration and investigation ($MCOP^2$ indicator 1), 52% increased students' engagement in mathematical activities ($MCOP^2$ indicator 3), 55% increased students' critical assessment of mathematical strategies ($MCOP^2$ indicator 4), 50% increased students' perseverance in problem-solving ($MCOP^2$ indicator 5), 64% increased mathematical discourse ($MCOP^2$ indicator 12), and 58% increased peer-to-peer communication of ideas ($MCOP^2$ indicator 15).

Similarly, among the twenty-seven participants who improved offering wait time after assigning a task or asking a question in their classrooms, on average, 51% increased students' engagement in exploration and investigation ($MCOP^2$ indicator 1), 55% increased students' engagement in mathematical activities ($MCOP^2$ indicator 3), 51% increased students' critical assessment of mathematical strategies ($MCOP^2$ indicator 4), 44% increased students' perseverance in problem-solving (MCOP^2 indicator 5), 51% increased mathematical discourse (MCOP^2 indicator 12), and 59% increased peer-to-peer communication of ideas (MCOP^2 indicator 15).

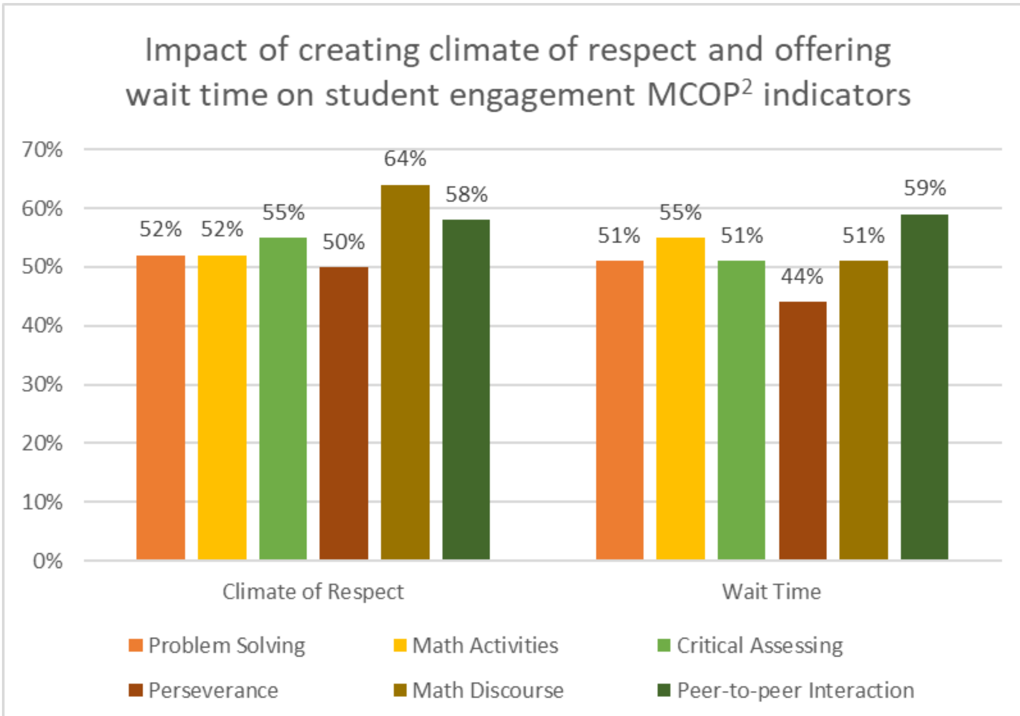

Figure 4: Impact of creating a climate of respect and offering wait time on other MCOP^2 indicators.

An important takeaway from the results presented in Figure 4 is that both offering wait time (after posing a question or assigning a task to students) and creating a climate of respect in the classroom have a significant positive impact (roughly 50-60%) on the six MCOP^2 indicators that measure engagement. However, it seems that the latter, i.e., creating a climate of respect in the classroom, leads to slightly higher improvements in the results.

These results are indeed a proof of the success of the PrimeD framework in creating a robust collaborating environment in which the participating teachers could act as leaders to identify, address, and solve challenging classroom problems with significant level of success, in this case the engagement of ML students.

Results of Qualitative Data Analysis

Results of the qualitative data analysis show three major groups of themes. First, are the themes specific to the perception of interviewees regarding student engagement in mathematics learning. Second, are the themes related to the impact of participation in PrimeD project on interviewees' beliefs and instructional practices, in general. Third, are the themes about how PrimeD participants reflect on their practices that can increase engagement in mathematics learning for ML students. Each of these themes are discussed in more detail below.

4.1.1 Student Engagement Themes

Based on the results of qualitative data analysis, prior to their participation in PrimeD project, MPSTs considered student engagement as students making eye contact, taking notes, investigating mathematical concepts, asking, and answering questions, and talking about mathematics with their peers.

> *Brooks: So, I see engagement as students mostly talking through math ideas with others, even if it's not necessarily like the idea we want just yet, or like the concept or the procedure we want just yet. I do take a lot of value in students being able or wanting to talk in math discourse. But math discourse can also look like students being diligent in taking their notes or writing down their ideas for example. And in that way, students are willing to share the process of their thinking through writing as well. I also consider that to be engagement.*

Jill: I expect them to be taking notes and asking questions answering my questions as I ask them. If we're doing something more collaborative, I expect that they talk with their peers, asking questions to their peers, etc.

Parker: So, last year I would define it as students coming up to the board and giving their answers. I would define it as, um, students engaging in mathematics in a way that is beyond just rope memorization. I would define it as students investigating different mathematics concepts before they go on to like a formal procedure for it. Um I would also say engagement is like talking to other folks that are learning mathematics. So, working in groups making sure they understand the concepts with each other.

The participants also noted that student engagement is higher in more advanced mathematics classes and that activities that give the students an opportunity to move around the classroom help increase engagement. Also, it was noted that implementing mathematical activities such as Kahoot, Escape Rooms, Buckets, Scavenger Hunts, and real-world problems within the lessons can increase student engagement among both ML and non-ML students. Moreover, creating a variety of such activities and providing the students with opportunities to move around the classroom can have a furthermore positive impact on student engagement.

Monica: I found the most successful thing as far as engagement is to get them standing at their vertical boards in groups. So, I do a lot of that… I would like to do that more because I know that they engage more in it and they retain a lot more of it, but I would say that has been really successful and then just like the mere fact of just changing up what I do. So, if I do a scavenger hunt activity for the first unit, I won't do that again a second unit. I'll do an escape room or a pixel art. Like I just constantly have different activities because I feel like they get bored of the same thing and then they're like, I don't really want to do this.

Sara: I do a lot of group work, both random groups and students getting to pick their work. Another strategy I use is we do a lot of work on whiteboards around the room, students love to write on whiteboards, they're more likely to engage if I give them a whiteboard and a paper … I do real-world stuff; students appreciate that and I think are more likely to engage even when it's harder than non-real-world stuff. Trying to think of other examples. Oh, and I do a lot of games, and competitions which is again, an example of extrinsic motivation.

Student engagement among ML students is reported to be less compared to the non-ML students due to the dominance of verbal communication in classrooms. In addition to the different ways that ML students communicate, which has roots in their cultural differences compared to non-ML students, their developing language proficiency can restrict their ability to ask questions, participate in discussions, and grasp the verbal instruction initially and fully. All these factors can have a negative impact on the process of mathematics learning.

ML students are reported to feel more comfortable communicating in writing, though, using pictures, or through small phrases. They prefer to work either individually or in small groups, and when it comes to sharing, they would rather be sharing their ideas with their teacher and not the whole class.

> *Brooks: Like when I go to them individually, they like to communicate or at least in general, they communicate more through their writing, through smaller phrases through pictures or pointing out certain parts of their process rather than the verbal.*

> *Lilian: We're looking at number sentences with percentages and so like the word that typically means to multiply, is multiplication, we'll go through and I'm like, okay, what does that word mean in a math context? So, more deciphering the sentence and picking out those words that we know and that we've gone over, kind of clearing them in to okay when we approach a question like this, maybe we don't understand all of the words in English, but let's see which ones do we know and can we cut that list down? Pictures are so key sometimes like just having them there and like this.*

> *Rachel: Yeah, I do think that they can struggle with that [communicating in English]. If I'm just verbally asking a question, if I don't have it written down, they might get a little bit more lost. So, I do try and write down most of the things I say.*

Some codes and subthemes that appeared in the process of analyzing interview transcripts, which led to emergence of student engagement major themes, are shown in Figure 5.

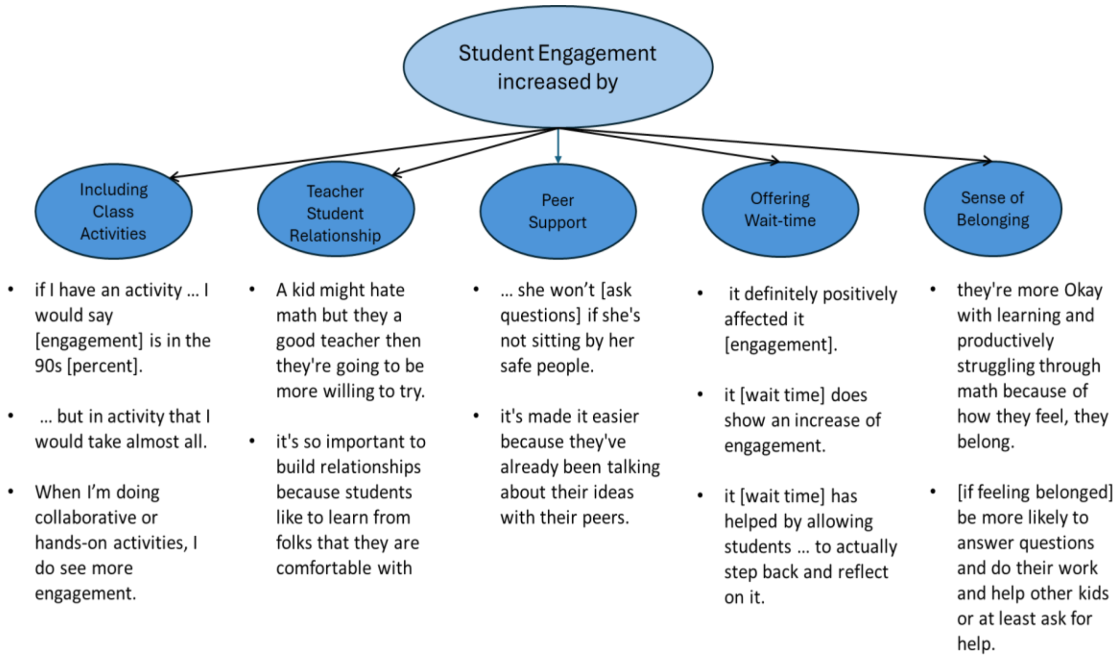

Figure 5: Student engagement themes.

The Impact of PrimeD Themes

According to the participants in my interviews, involvement in PrimeD project has helped them gain a deeper insight into student engagement in mathematics learning that goes beyond their prior perception of engagement as note taking, active listening, and asking or answering questions in the classroom. Their participation has opened their eyes to new strategies that, once implemented, can create real student engagement in classrooms.

> *Sara: I would probably have defined engagement as just listening or just taking notes, but now I would consider engagement to be actively thinking or actively*

working as opposed to passively listening or writing … It's certainly given me new strategies and opened my eyes, like I said to what real engagement is.

Rachel: I guess it made me maybe more aware of different types of engagement. I don't know if it's really helped build it or not but maybe it's kind of helped me know what to look for in different kids better and how to try at least to get that engagement up in different situations.

Lilian: I think especially my first year of teaching, it was really nice to be exposed to all of these different review activities and just promoting that student engagement with students who did not want to be there at all. My students were just so low in math and that was like, okay, how can I make this not boring, with me just sitting on the board and going on and on for 60 minutes.

Two of the interview participants also pointed out that PrimeD project has emphasized the importance of conceptual understanding of mathematics topics for the students rather than procedural knowledge and fluency. For this reason, according to one interview participant, lesson planning has become harder and more time-consuming. However, the flip side is that teaching has become easier since more student thinking happens in the classroom.

Parker: I would say that my participation helped a lot. It made me think more deeply about what it means for folks to think about the content knowledge, the conceptual understanding before the procedural understanding.

Brooks: I think so much of math is discovery and looking at a problem and making sense of the idea of the problem before really getting into the procedure of it. And so, I would say the PrimeD just really emphasized that.

Sara: I would say my experience in PrimeD, you know, when it showed me, or when it taught me, that students should be more engaged than just passively listening or writing notes. My job as a teacher became both easier and harder. Because it's obviously much easier to plan lessons if I'm just standing at the front talking. But it's harder in terms of lesson planning, designing lessons that are engaging. But it's easier at the moment because when students are taking on the cognitive load, I don't have to think for everyone. It's obviously easier in that way.

It has also been stated that PrimeD project has underscored the importance of peer-to-peer interaction in the classroom and has positively impacted their mathematics learning.

> *Brooks: I would say it's affected my instruction just to have students participate in ways that just allow them to write and interact with their peers without having to go too much into the formal note taking process or anything like that.*
>
> *Jill: I would prefer them [students] to engage with their classmates more than they are to me because I just think that collaboration is such a big deal. Now that was also like my student teaching year so that might have just been something that came with experience, but I do think PrimeD had a lot to do with it.*
>
> *Rachel: Sometimes I've tried and said that same thing seven times, but then hearing it from that one kid, that's next to you might just click better.*

The importance of receiving feedback from other PrimeD participants and learning about the new interventions and ideas that they try in their classrooms was also brought up in a few of the interviews.

> *Lilian: … so appreciative of the feedback and just the ideas that I gather from those teachers …*
>
> *Gavin: I think what PrimeD really helped me do was get a lot of feedback. So, we meet several times and you get to talk to a wide variety of people a wide variety of times in their life or parts of their career. So, what was really nice was to be either people agree with the solution or disagree with the solution feel like something could have done better or maybe something wasn't done very well and it's kind of see their point of view.*

Some codes and subthemes that appeared in the process of analyzing interview transcripts which led to emergence of "impact of PrimeD" major theme are shown in Figure 6.

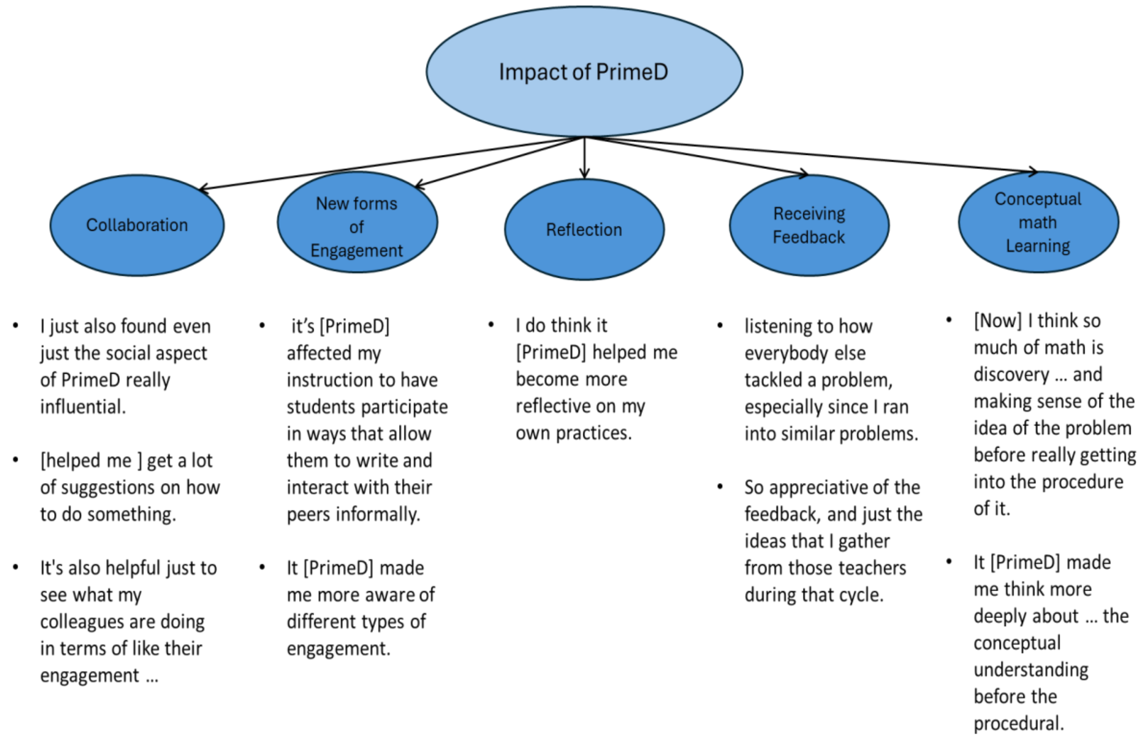

Figure 6: PrimeD Themes.

4.1.2 MPSTs' Reflections on their Instructions

The most frequently repeated item within the reflection themes is related to the impact of wait time on ML students' engagement in the classroom. It states that offering enough wait time provides all students (including ML students), who have not had a chance to participate much in class discussions, with an opportunity to get involved and have their voices heard and their ideas recognized. Also, providing wait time increases ML students' engagement and helps them with word problems.

> *Brooks: I think it's [providing wait-time] especially helpful for them because even if they don't engage as much verbally in that little couple minutes of discussion time I provide, I do still encourage everyone to like write any interesting ideas down like in those margins I mentioned before and I think it does encourage them to just be thoughtful in writing their own ideas and so in terms of the verbal*

discourse, it doesn't have as much effect I think. But it does show an increase of engagement in terms of listening to ideas and making sense of them when they write them down.

Lilian: … I think this [providing wait-time] has greatly helped them, especially if it's a word problem that we're working on.

Sara: I would say it's definitely positively affected it [student engagement].

Jill: I think it helps to give them [MLs] wait-time because they need a couple extra seconds to join in.

The other item within reflection themes that is related to the participation of ML students in class discussions, states that teachers valuing outload responses decreases ML students' participation in class discussions. On the other hand, looping ML students in the conversations and calling them can help improve their participation in class discussions more as they can easily get sidelined by the faster communication pace of the mainstream students and the teacher.

Brooks: But in terms of the whole class discussion, I feel like the way I presented it has been valuing the out loud spoken verbal responses, which I believe that ML students, that's not the way I communicate with them. … If I engage them in the conversation first, before their peers, usually that leads to them being able to like to interact more… I think it's more reassuring to these students when they're the initiators of the conversation. … I guess because I'm sort of the, I don't know this age in the room, I'm the person with the math knowledge, trying to instill math knowledge in my students. I think, because I'm the one interacting with them, maybe they feel more comfortable when they get to talk with me first before they start to talk with their peers about it.

Sara: I think sometimes they, [ML] students that might take a bit longer to think of what they want to say, get talked over unless I specifically call them to the forefront so, unless I give them like a seat at the table to speak. I think that they often get spoken over. So, I think that those are helpful intervention strategies.

Another item within reflection themes, emphasizes the importance of building strong teacher-student relationships. This is particularly true for ML students because of their unique linguistic and cultural needs. It helps teachers create a supportive learning environment in which their ML students feel reassured of being accepted and welcome in the classroom and can participate more meaningfully and more confidently in classroom conversations.

Parker: I just think it's so important to build relationships because students like to learn from folks that they are comfortable with. … I know students that have literally told me that I'll do what we have to do for your class, I'll do anything you ask me, because I like you, I won't do it for the other teacher.

Rachel: I think honestly, it's taking the time to get to know them [the students] better as a person will also help them want to learn more in my classroom. I think that goes for any kid whether they're ML or not.

Jill: I think I would want to say that most of them feel like they belong in my classroom, and that's because I put my relationship stuff first. … I think if they feel welcome in here they want to be here. They'll do what I ask them to. I think relationship building has a lot to do with like behavior management stuff. They'll do what I ask because they respect me and they feel welcomed and loved or safe here that they'll do what's expected of them.

One interview participant pointed out that if teachers show their ML students that they care, spend extra time, and try hard to meet their needs, they are more likely to feel responsible, work hard, and get more engaged in mathematical activities and learning mathematics, in general.

Sara: I speak Spanish so for some students I try and make if I have like word problems, real-world problems. I will try to go ahead and translate them into Spanish and then give them two copies so that they could look through it. I do not speak Ukrainian… I try, like I said, to translate assignments into Spanish or I'll try using google translate to do it in Ukrainian and give it to those students. And they are way more likely to engage that way because you know, not just because it's easier for them. But I also think that there's a sense of this person, you know, my teacher took the time to translate this for me so I should do it because she worked hard to translate it for me.

At my school, there is a massive Ukrainian population that is just arrived. We really need or I would love if we had an adult in the building whose job was to *translate or help the Ukrainian students assimilate… So, I would I really go out of my way to, like I'm trying to learn Ukrainian. I'm really going on in my way to try and make sure they know that they have that they belong here.*

Based on another interview participant, being involved in the PrimeD project has helped her reflect more on her practices. Such reflection is a very important and necessary aspect of teachers' professional development as it allows them to critically assess their instructional strategies and become aware of what areas need revision or growth.

Rachel: I do think it helped me become more reflective on my own practices, not just like look at the students. Like, I mean, if everyone's struggling and that might not be the content that could just be me and how I'm presenting it and teaching it. So, I think it has made me more reflective on myself and try to always improve and change what I'm doing to be better for the kids.

The increased collaboration among teachers is another emergent theme that was mentioned in the interviews. Such collaboration is important and needed to support teachers who are new in the field. Also, participating in the PrimeD project has helped MPSTs be more open to sharing their struggles, expressing their concerns, and seeking help without feeling embarrassed. Development of such feelings of vulnerability and openness allows participating teachers to become more genuine in their teaching and build more meaningful relationships with their colleagues and their students.

Brooks: I just also found even just the social aspect of PrimeD has been really influential for me. I was always such an individual person in the way I learn and in the way I learned to be a teacher but like it's just made me understand this is also what I try to instill in my students now it's just that it's okay to ask for help. It's okay to seek out the help of your peers and like I tell that myself too now, because of the PrimeD project, that really collaboration, it's a teaching process, but it's also a learning process, for the students, and for the teacher.

Gavin: So, what I really enjoyed was listening to how everybody else kind of tackled a problem, especially, since I ran into similar problems so it was nice to see that I wasn't the only one who's had the issue but it was nice to be able to try different things and see how they work specifically in my class. And one of the things that definitely stuck with me was that you can give a lot of examples, get a lot of suggestions on how to do something.

Some codes and subthemes that appeared in the process of analyzing interview transcripts which led to emergence of "Reflection" themes are shown in Figure 7.

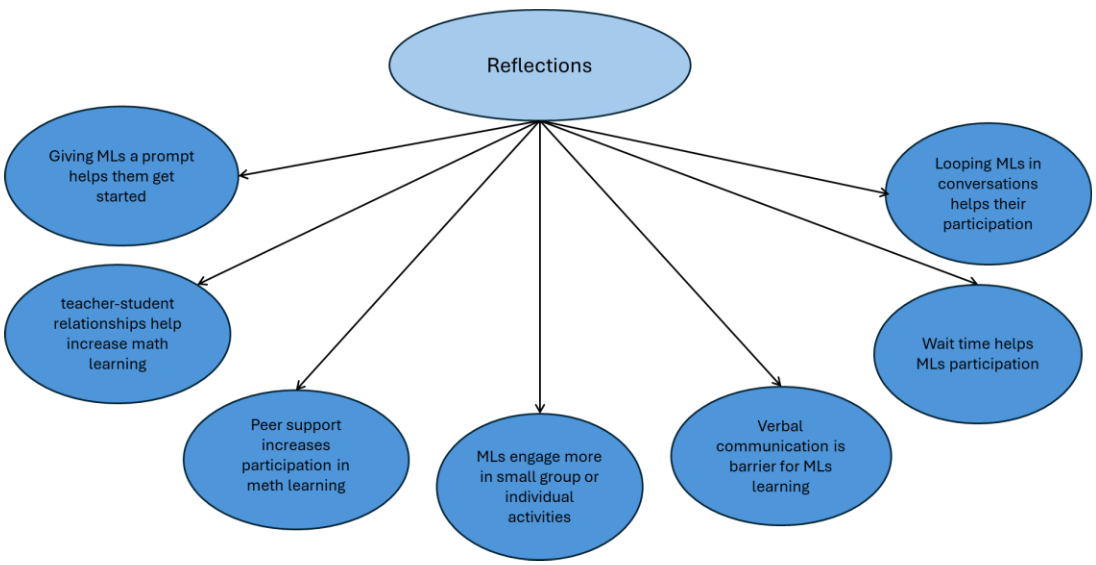

Figure 7: Reflection themes.

Table 10 presents all themes and subthemes that have emerged from the interviews and the number of participants who mentioned them.

Table 10: Themes emerged from preservice teachers' interviews.

Student Engagement Themes	**Participants Frequency**
Higher in more advanced classes	4
Higher with activities and real-world problems	3
Having a sense of belonging increases engagement	3
Higher with varying activities	2
Building relationship with students increases engagement	2
Providing wait time increases engagement	2
Impact of PrimeD Themes	
Importance of collaboration	5
Getting new ideas from other participants	4
Introduced different forms of engagement	3
Helped teachers reflect on their practices	2
Receiving valuable feedback from other participants	2
Helped increase engagement	2
Focused on conceptual mathematics learning	2
MPSTs' Reflection on their Instructions Themes	
Building teacher-student relationships help increase math learning	4
Peer support increases participation and math learning	4
MLs engage more in activities within small groups or individually with teacher	4
Less for MLs because verbal communication is a barrier	4
Providing wait time helps MLs participate	3
Written instruction and breaking down tasks help MLs communicate	2
Looping MLs in conversations helps them participate	2
Building relationships helps MLs' learning	2
Giving a prompt helps MLs get started	1
Tailoring lessons to fit MLs' needs makes them responsible to do the work	1

Mixed Methods Results Summary

The results of quantitative and qualitative data analyses that are associated with offering wait time, and creating a climate of respect in classrooms, are well aligned. They validate one another and answer the first Research Question of this study. Both types of results highlight the positive impact of acceptance and creating a climate of respect in the classroom on mathematical discourse and perseverance in problem-solving, and the positive impact of offering wait time on mathematics discourse.

To answer the second Research Question, I can only rely on the qualitative data analysis results because the $MCOP^2$ instrument does not collect any data from teachers' reflections on their practices. Participating in PrimeD project has made the teachers become more reflective on their practices as they implement interventions, collect data, and study the data within the PDSA cycles. Most of the interview participants have appreciated the collaborative aspect of the PrimeD project as a resource to receive feedback and seek new ideas that can help them overcome challenging situations.

The results of quantitative data analysis (Table 6) which shows the largest improvement for participants from Institution 3 is associated with creating a climate of respect, students' investigation and exploration and offering wait time in classrooms is consistent with the emergent themes from interviews conducted with participants attending the same institution that focus more on the impact of offering wait time, mutual respect, and including mathematical exploratory activities in lessons.

Similarly, the results of qualitative data analysis associated with Institution 4 are well aligned with what was concluded from the institution's participants in quantitative data analysis (Table 6) that was focused on the importance of peer-to-peer communication and its positive impact on student engagement.

In general, the reflections provided by the participants in the interviews centered around higher engagement of ML students in small groups rather than whole class activities, challenges of verbal communication for ML students, the positive impact of the writing mode of the instruction on their mathematics learning, offering wait time to get them involved in the mathematical discussions in the classroom, and teachers' effort to loop them in the conversations.

CHAPTER 5. IMPLICATIONS AND SIGNIFICANCE

Implications

In their research, "Secondary Teachers and English Language Learners (ELLs): Attitudes, Preparation and Implications", Rubinstein-Avila and Lee (2014) offer a handful of instructional changes that secondary mathematics teachers can implement in their lessons to encourage peer-to-peer interaction among their ML students to increase their overall active participation in classroom. Below are a few examples that are consistent with findings of my study:

- Providing scaffolds for written assignments such as sentence starters, when necessary.
- Having students working in pairs of ML and non-ML students.
- Having small groups to solve problems. (Berg et al., 2012; Rubinstein-Avila 2013; Sox and Rubinstein-Avila 2009).
- Allowing MLs to communicate about the content with each other in their native language to improve learning by sharing ideas about complex concepts in their dominant language (Berg et al. 2012; Rubinstein-Avila 2006, 2013).

As another example, Cardimona (2018) suggests problem-solving strategies that secondary mathematics teachers of ML students can benefit from while offering wait time. These strategies involve asking a procedural question to check students' comprehension of a topic and to draw students' attention to emphasize the importance of a specific part of the problem. Then, she suggests breaking down the problems into smaller doable pieces and asking guiding questions from the students as they are working on the activity as a whole group. This strategy helps ML students participate in whole-group activities more confidently and without the fear of making mistakes because of their limited English proficiency. Such collaboration also helps ML students to reflect on and build upon previous answers and have a better understanding of what the problem-solving process is. From my own personal experience, which was also mentioned by one of the interview participants, sometimes ML students have different ways of thinking to solve problems that need to be valued and seen as an asset.

Moreover, Cardimona (2018) claims that as most mathematics teachers are not trained to teach their ML students, it is important for school districts or individual schools to offer PD programs that teach similar strategies to mathematics preservice teachers. The preservice teachers can implement such strategies in their classrooms daily and without spending a significant amount of time or the need to change their lesson plans.

PrimeD as a PD program has benefited the participating MPSTs in different ways, such as creating a safe collaborative environment to get new ideas to improve their growth skills. Receiving feedback from the faculty and other participants on the interventions they could try to implement in their classrooms to improve the challenge space has supported them to become more prepared and more confident as they start their teaching career. Participation in PrimeD project has also reformed MPSTs' perceptions of student engagement, has emphasized the importance of conceptual mathematics learning, and has helped them better reflect on their instructional practices. The cyclic nature of the PrimeD has allowed MPSTs to collect data after implementing an intervention, interpret the data, and tweak the intervention based on the results, so that it better fits their students' needs.

Significance

The overall findings show the positive impact of creating a climate of respect in a classroom on six different aspects of student engagement in mathematics learning. More precisely, between 50% and 64% improvement in student exploration and problem solving, student engagement in mathematical activities, students' ability to critically assessing mathematical strategies, students' perseverance in problem solving, students' participation in mathematical discourse, and peer-to-peer communication of ideas is associated with creating a climate of respect in a secondary mathematics classroom. This is consistent with what Taylor and Parson (2011) express in their research that respectful teacher-student interactions, whether in a virtual or face-to-face setting, has a positive impact on student engagement. Also, creating a climate of respect in classrooms makes the class environment safe for students who are feeling stressed because of being different (physically, linguistically, etc.) from others which according to McTighe and Willis (2019) can improve engagement in mathematics learning for them.

Similarly, the positive impact of offering wait time on six different aspects of student engagement in mathematics learning that is presented in Figure 4 is supported by the research of O'Connor and Michaels (2019) that indicates increasing the amount of wait time is associated with higher participation in class activities and increased complexity of students' responses. The findings show between 44% and 59% improvement in student exploration and problem solving, student engagement in mathematical activities, students' ability to critically assessing mathematical strategies, students' perseverance in problem solving, students' participation in mathematical discourse and peer-to-peer communication of ideas is associated with creating a climate of respect in a secondary mathematics classroom.

Involvement in PrimeD project has helped participants become aware of the new forms of engagement and emphasized the importance of conceptual mathematics learning for the students. It has also helped the participants reflect more on their instructional practices, become more conscious of the needs of their ML students, on how to become involved in the processes that empower MLs, and subsequently help them participate in mathematics learning more effectively.

Moreover, the positive impact of including real-world and exploratory mathematical activities in lessons, on student engagement is emphasized in findings that is aligned with findings of researchers in the field (Willms, Friesen, & Milton, 2009, Brown, 2000, Hay, 2000, Oblinger & Oblinger, 2005, and Barnes et al., 2007) that state the most engaging classroom practices are those that are predominantly inquiry-based, problem-based and exploratory.

Limitations and Future Research

The main limitation of this study is associated with the quantitative data analysis process. During Year 1, COVID-19 pandemic restrictions affected the modality of PrimeD project. Therefore, the "pre" and "post" video recordings of the participants in Year 1 are from their online or hybrid classes rather than in-person classes. This created some inconsistency with the quantitative data analysis process that was using MCOP^2

instrument since, for instance, student engagement, perseverance in problem-solving, and peer-to-peer communication could take different forms or become harder or in some cases impossible to observe in an online or hybrid classroom setting.

Also, Gleason (2017) recommends using the $MCOP^2$ instrument to evaluate teachers' performance formatively because not all the ideas associated with the instrument indicators can be observed during a single lesson. Observing 3-6 lessons on different days in a single classroom is ideal to evaluate the teacher's instruction. In this study, $MCOP^2$ has been used to evaluate two class observations while there was no restriction for participants to record their "pre" and "post" videos from the same period of a class. Therefore, there is no guarantee that the "pre" and "post" video recordings are from a single class with the same student population which can interfere with the interpretation of the differences in participants' $MCOP^2$ scores. Also, my research did not examine the impact of other possible factors on student engagement.

For the qualitative data collection and analysis processes, I believe if I were able to recruit participants from Institution 2, I could have concluded stronger implications because according to the institutions' demographic information, supposedly, Institution 2 has the largest number of MPSTs who teach ML students.

For future research, I would like to investigate the instructional strategies that can be implemented in secondary mathematics classrooms and can improve mathematics learning experiences of small population of ML students who attend high school in white rural areas. As two of my interview participants who teach mathematics at a rural high school and have a few numbers of Ukrainian ML students stated, these MLs can be among the most underprivileged populations of diverse student who attend public schools in the U.S. since their teachers and classmates are less familiar with their needs and the means to support them. The situation could be similar or somewhat better for other non-Spanish speakers who have been more commonly studied. As my work suggests, an important factor in closing the achievement gap in mathematics learning between these ML students and their non-ML peers is improving practices effectiveness through reflection and culturally responsive teaching.

Teachers’ sense of community and belonging:

As Pendergast (2020) shows in her research, teachers’ feeling of being accepted, respected, receiving social and supervisory support as well as having positive relations with colleagues and parents are predictors of developing sense of belonging for teachers. Preservice teachers who participated in the PrimeD project have had the opportunity to be part of a community (NIC) in which they could receive feedback and interact with teachers from other school districts and their mentor teachers as well as the faculty researchers. In future research, I would like to examine how being part of NICs and sharing their goals and values can impact teachers’ beliefs of what they can do as members of the team, and consequently, increase their sense of belonging to the school where they teach.

APPENDIX A: MATHEMATICS CLASSROOM OBSERVATION PROTOCOL FOR PRACTICES (MCOP^2)

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

1) Students engaged in exploration/investigation/problem solving.

SE		Description	Comments
3		Students regularly engaged in exploration, investigation, or problem solving. Over the course of the lesson, the majority of the students engaged in exploration/investigation/problem solving.	
2		Students sometimes engaged in exploration, investigation, or problem solving. Several students engaged in problem solving, but not the majority of the class.	
1		Students seldom engaged in exploration, investigation, or problem solving. This tended to be limited to one or a few students engaged in problem solving while other students watched but did not actively participate.	
0		Students did not engage in exploration, investigation, or problem solving. There were either no instances of investigation or problem solving, or the instances were carried out by the teacher without active participation by any students.	

2) Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent concepts.

SE		Description	Comments
3		The students manipulated or generated two or more representations to represent the same concept, and the connections across the various representations, relationships of the representations to the underlying concept, and applicability or the efficiency of the representations were explicitly discussed by the teacher or students, as appropriate.	
2		The students manipulated or generated two or more representations to represent the same concept, but the connections across the various representations, relationships of the representations to the underlying concept, and applicability or the efficiency of the representations were **not** explicitly discussed by the teacher or students.	
1		The students manipulated or generated one representation of a concept.	
0		There were either no representations included in the lesson, or representations were included but were exclusively manipulated and used by the teacher. If the students only watched the teacher manipulate the representation and did not interact with a representation themselves, it should be scored a 0.	

3) Students were engaged in mathematical activities.

SE		Description	Comments
3		Most of the students spend two-thirds or more of the lesson engaged in mathematical activity at the appropriate level for the class. It does not matter if it is one prolonged activity or several shorter activities. (Note that listening and taking notes does not qualify as a mathematical activity unless the students are filling in the notes and interacting with the lesson mathematically.)	
2		Most of the students spend more than one-quarter but less than two-thirds of the lesson engaged in appropriate level mathematical activity. It does not matter if it is one prolonged activity or several shorter activities.	
1		Most of the students spend less than one-quarter of the lesson engaged in appropriate level mathematical activity. There is at least one instance of students' mathematical engagement.	
0		Most of the students are not engaged in appropriate level mathematical activity. This could be because they are never asked to engage in any activity and spend the lesson listening to the teacher and/or copying notes, or it could be because the activity they are engaged in is not mathematical – such as a coloring activity.	

4) Students critically assessed mathematical strategies.

SE	TF	Description	Comments
3	3	More than half of the students critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher.	
2	2	At least two but less than half of the students critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher.	
1	1	An individual student critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher. The critical assessment was limited to one student.	
0	0	Students did not critically assess mathematical strategies. This could happen for one of three reasons: 1) No strategies were used during the lesson; 2) Strategies were used but were not discussed critically. For example, the strategy may have been discussed in terms of how it was used on the specific problem, but its use was not discussed more generally; 3) Strategies were discussed critically by the teacher but this amounted to the teacher telling the students about the strategy(ies), and students did not actively participate.	

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Mathematics Classroom Observation Protocol for Practices (MCOP^2)

5) Students persevered in problem solving.

SE	Description	Comments
3	Students exhibited a strong amount of perseverance in problem solving. The majority of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), the majority of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem.	
2	Students exhibited some perseverance in problem solving. Half of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), half of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem.	
1	Students exhibited minimal perseverance in problem solving. At least one student but less than half of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), at least one student but less than half of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem. There must be a road block to score above a 0.	
0	Students did not persevere in problem solving. This could be because there was no student problem solving in the lesson, or because when presented with a problem solving situation no students persevered. That is to say, all students either could not figure out how to get started on a problem, or when they confronted an obstacle in their strategy they stopped working.	

6) The lesson involved fundamental concepts of the subject to promote relational/conceptual understanding.

TF	Description	Comments
3	The lesson includes fundamental concepts or critical areas of the course, as described by the appropriate standards, and the teacher/lesson uses these concepts to build relational/conceptual understanding of the students with a focus on the "why" behind any procedures included.	
2	The lesson includes fundamental concepts or critical areas of the course, as described by the appropriate standards, but the teacher/lesson misses several opportunities to use these concepts to build relational/conceptual understanding of the students with a focus on the "why" behind any procedures included.	
1	The lesson mentions some fundamental concepts of mathematics, but does not use these concepts to develop the relational/conceptual understanding of the students. For example, in a lesson on the slope of the line, the teacher mentions that it is related to ratios, but does not help the students to understand how it is related and how that can help them to better understand the concept of slope.	
0	The lesson consists of several mathematical problems with no guidance to make connections with any of the fundamental mathematical concepts. This usually occurs with a teacher focusing on procedure of solving certain types of problems without the students understanding the "why" behind the procedures.	

7) The lesson promoted modeling with mathematics.

TF	Description	Comments
3	Modeling (using a mathematical model to describe a real-world situation) is an integral component of the lesson with students engaged in the modeling cycle (as described in the Common Core State Standards).	
2	Modeling is a major component, but the modeling has been turned into a procedure (i.e. a group of word problems that all follow the same form and the teacher has guided the students to find the key pieces of information and how to plug them into a procedure.); <u>or</u> modeling is not a major component, but the students engage in a modeling activity that fits within the corresponding standard of mathematical practice.	
1	The teacher describes some type of mathematical model to describe real-world situations, but the students do not engage in activities related to using mathematical models.	
0	The lesson does not include any modeling with mathematics.	

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

8) The lesson provided opportunities to examine mathematical structure. (symbolic notation, patterns, generalizations, conjectures, etc.)

TF	Description	Comments
3	The students have a sufficient amount of time and opportunity to look for and make use of mathematical structure or patterns.	
2	Students are given some time to examine mathematical structure, but are not allowed adequate time or are given too much scaffolding so that they cannot fully understand the generalization.	
1	Students are shown generalizations involving mathematical structure, but have little opportunity to discover these generalizations themselves or adequate time to understand the generalization.	
0	Students are given no opportunities to explore or understand the mathematical structure of a situation.	

9) The lesson included tasks that have multiple paths to a solution or multiple solutions.

TF	Description	Comments
3	A lesson which includes several tasks throughout; or a single task that takes up a large portion of the lesson; with multiple solutions and/or multiple paths to a solution and which increases the cognitive level of the task for different students.	
2	Multiple solutions and/or multiple paths to a solution are a significant part of the lesson, but are not the primary focus, or are not explicitly encouraged; **or** more than one task has multiple solutions and/or multiple paths to a solution that are explicitly encouraged.	
1	Multiple solutions and/or multiple paths minimally occur, and are not explicitly encouraged; **or** a single task has multiple solutions and/or multiple paths to a solution that are explicitly encouraged.	
0	A lesson which focuses on a single procedure to solve certain types of problems and/or strongly discourages students from trying different techniques.	

10) The lesson promoted precision of mathematical language.

TF	Description	Comments
3	The teacher "attends to precision" in regards to communication during the lesson. The students also "attend to precision" in communication, or the teacher guides students to modify or adapt non-precise communication to improve precision.	
2	The teachers "attends to precision" in all communication during the lesson, but the students are not always required to also do so.	
1	The teacher makes a few incorrect statements or is sloppy about mathematical language, but generally uses correct mathematical terms.	
0	The teacher makes repeated incorrect statements or incorrect names for mathematical objects instead of their accepted mathematical names.	

11) The teacher's talk encouraged student thinking.

TF	Description	Comments
3	The teacher's talk focused on **high levels** of mathematical thinking. The teacher may ask lower level questions within the lesson, but this is not the focus of the practice. There are three possibilities for high levels of thinking: analysis, synthesis, and evaluation. ***Analysis*** : examines/ interprets the pattern, order or relationship of the mathematics; parts of the form of thinking. **Synthesis**: requires original, creative thinking. **Evaluation**: makes a judgment of good or bad, right or wrong, according to the standards he/she values.	
2	The teacher's talk focused on **mid-levels** of mathematical thinking. **Interpretation**: discovers relationships among facts, generalizations, definitions, values and skills. **Application**: requires identification and selection and use of appropriate generalizations and skills	
1	Teacher talk consists of **"lower order"** knowledge based questions and responses focusing on recall of facts. **Memory**: recalls or memorizes information. **Translation**: changes information into a different symbolic form or situation.	
0	Any questions/ responses of the teacher related to mathematical ideas were rhetorical in that there was no expectation of a response from the students.	

12) There were a high proportion of students talking related to mathematics.

SE	Description	Comments
3	More than three quarters of the students were talking related to the mathematics of the lesson at some point during the lesson.	
2	More than half, but less than three quarters of the students were talking related to the mathematics of the lesson at some point during the lesson.	
1	Less than half of the students were talking related to the mathematics of the lesson.	
0	No students talked related to the mathematics of the lesson.	

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

13) There was a climate of respect for what others had to say.

SE	TF	Description	Comments
3	3	**Many** students are sharing, questioning, and commenting during the lesson, including their struggles. Students are also listening (active), clarifying, and recognizing the ideas of others.	
2	2	The environment is such that **some** students are sharing, questioning, and commenting during the lesson, including their struggles. Most students listen.	
1	1	Only a **few** share as called on by the teacher. The climate supports those who understand or who behave appropriately. **Or** Some students are sharing, questioning, or commenting during the lesson, but most students are actively listening to the communication.	
0	0	No students shared ideas.	

14) In general, the teacher provided wait-time.

SE		Description	Comments
3		The teacher **frequently** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.	
2		The teacher **sometimes** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.	
1		The teacher **rarely** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.	
0		The teacher **never** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.	

15) Students were involved in the communication of their ideas to others (peer-to-peer).

SE		Description	Comments
3		**Considerable** time **(more than half)** was spent with peer to peer dialog (pairs, groups, whole class) related to the communication of ideas, strategies and solution.	
2		**Some** class time **(less than half, but more than just a few minutes)** was devoted to peer to peer (pairs, groups, whole class) conversations related to the mathematics.	
1		The lesson was primarily teacher directed and little opportunities were available for peer to peer (pairs, groups, whole class) conversations. A few instances developed where this occurred during the lesson but only lasted less than 5 minutes.	
0		No peer to peer (pairs, groups, whole class) conversations occurred during the lesson.	

16) The teacher uses student questions/comments to enhance conceptual mathematical understanding.

	TF	Description	Comments
	3	The teacher **frequently** uses student questions/ comments to coach students, to facilitate conceptual understanding, and boost the conversation. The teacher sequences the student responses that will be displayed in an intentional order, and/or connects different students' responses to key mathematical ideas.	
	2	The teacher **sometimes** uses student questions/ comments to enhance conceptual understanding.	
	1	The teacher **rarely** uses student questions/ comments to enhance conceptual mathematical understanding. The focus is more on procedural knowledge of the task verses conceptual knowledge of the content.	
	0	The teacher **never** uses student questions/ comments to enhance conceptual mathematical understanding.	

Additional Notes: Preservice or Inservice. Live or Video. #Students, Grade Level, topic/subject, date, other demographics, school, etc.

Was an indicator marked lower based on teaching practices or student engagement on the MCOP2 that were due to inequity? If yes, which points of the rubric?

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APPENDIX B: MCOP² STUDENT ENGAGEMENT SUBSCALE INTERVIEW QUESTIONS

1) Can you talk about the math classes you teach and your student population in these classes? What proportion of your students are considered MLs? Can you describe/tell me more about your MLs? Can you also tell me more about your students whose primary language is English—are they racially diverse across the different math classes you teach?

2) How would you define engagement for your students as a mathematics teacher? How has this changed with your participation in PrimeD, if at all?

3) What proportion of your students do you think are usually engaged in class activities? Do you see the same proportion within your ML student's population? **(MCOP^2-1)**

- Why do you think the levels of engagement are different?

4) What strategies do you use to engage your students in class activities? **(PDSA example)**

- What different/additional strategies (if any) do you use to engage more ML students in class activities?
- Do you think these strategies have been effective?

5) Can you describe a little about your PDSAs?

- Do your students stay engaged longer as a result of your PDSAs? **(MCOP^2-5)**

6) In your instruction, how do you facilitate class discussions (teacher-student or peer to peer) in your classroom? **(MCOP^2-12)**

- Are the PDSA interventions helpful to engage your ML students as well? If not, how have you tried to get them engaged in class discussions?

7) In your instruction, what steps do you take to encourage your students to share (including their struggles), comment, actively listen and recognize others' ideas in your classroom? **(MCOP^2-13)**

- Are the interventions helpful to encourage your ML students as well? If not, how have you tried to get them share their thoughts/ideas and/or comment others'?

8) In your instruction, what steps do you take to provide wait-time in your classroom? (MCOP2-14)

- How has this affected your students' engagement in mathematical discussions/discourse?

- How has this affected your ML students' engagement in mathematical discussions/discourse?

9) In general, to what extent has your instruction affected your students' participation in mathematical discourses after being engaged in PrimeD project? **(MCOP^2-15)**

- Have you noticed any patterns -- similarities or differences among the groups of your students (ML, non-ML, racially diverse)?

10) In what ways participation in PrimeD project influenced you and your teaching (of MLs) as a teacher candidate?

- Most valuable aspects?
- What additional supports/resources do you think you will need to be able to teach your ML students in a more effective way?

11) To what extent do you think your students have a sense of belonging to your class? How? What about your ML students? What about your racially diverse students?

- Do you think such a sense of belonging has affected engagement in your class? How?

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VITAE

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ACADEMIC BACKGROUND

Ph.D. Candidate (Education Sciences, STEM Education), University of Kentucky

Dissertation: 'Secondary Mathematics Preservice Teachers and Multilingual Learner Students' Engagement in Classroom'

Graduate Certificate, Data Mining for Advanced Analytics, UC San Diego

Conducted data and text mining studies and statistical analysis on large datasets using R, Weka, and Transact-SQL.

M.Sc. in Pure Mathematics, Al-Zahra University, Tehran, Iran

Thesis: 'An Approach for Image Classification by Coloring Fuzzy Graphs.'
Minor: Graph Theory, Machine Learning

B.Sc. in Applied Mathematics, Shahed University, Tehran, Iran

Minor: Computer Programming, Optimization.

RESEARCH AND GRANT EXPERIENCE

AUG 2021 – PRESENT: Research Assistant (University of Kentucky), Professional Development: Research, Implementation, and Evaluation (PrimeD, NSF Award #2013250)

Served both Implementation and Evaluation roles as a graduate Research Assistant on a collaborative research project across four institutions (University of Kentucky, University of Central Florida, University of Maryland Baltimore County & Berea College).

- Evaluation: Managed, implemented, and assessed the evaluation of the project Implementation by observing monthly NIC meetings across four participating institutions and evaluating the meetings using the designated observation form to assess various aspects of the meeting ant its alignment with the overall project goals, as part of the evaluation team.

- Focus Groups: Organized the logistics, scheduling, and communication with all participants by sending out invitations, securing appropriate venues, and ensuring that all necessary materials and resources were available for the session.

Facilitated discussions among participants by guiding the conversation, asking open-ended questions, encouraging participation, and ensuring that all voices were heard and respected. Collected qualitative data through participant responses, interactions, and discussions by detailed notes and/or audio recording the sessions (with participants' consent) to capture their key insights.

- Coded submitted pre- and post- lesson videos of participating secondary mathematics preservice teachers by reviewing them and utilizing the MCOP2 (Mathematics Classroom Observation Protocol for Practices and Instruction) instrument for coding. This involved analyzing classroom behaviors, instructional strategies, student interactions, and other relevant variables.

- Coded Focus Group data by reviewing the data collected from all participants across four institutions and by working collaboratively with other researchers to ensure consistency and reliability in the coding process. We shared insights, discussed interpretations, and collectively analyzed the data to enhance the validity of the findings by identifying key themes, patterns, and insights within the focus group transcripts to understand participants' perceptions, experiences, and perspectives related to the PrimeD project and its outcomes.

- Coordinating: Coordinated and co-led the local monthly NIC meetings. Coordinated and conducted introductory sessions for project participants on how to use Swivl Robots for lesson recording and provided support and assistance as needed. Collected and prepared the recordings and uploaded them to the shared Box cloud folder ensuring they were accessible to relevant project stakeholders.

PRESENTATIONS AND PUBLICATIONS

Conference Presentations

Fisher, M., Mohr-Schroeder, M., Amick, L., **Zareie, P.** (February 2022). The impact of synchronous online teaching on student teacher observations during the COVID-19 pandemic. *Association of Mathematics Teacher Educators (AMTE),* Las Vegas, NV.

Zareie, P. (March 2024). Engaging Multilingual Learner (ML) Students in Mathematics Learning. Dissertation presentation, *Spring Research Conference*, University of Louisville, Louisville, KY.

TEACHING EXPERIENCE

Fall 2023: Co-Instructor, Secondary Mathematics Methods, Department of STEM Education, University of Kentucky.

2019 – Present: Adjunct Faculty, Math & Statistics, Bluegrass Community & Technical College.

2006 – 2008: Volunteer Math Instructor, Children's Charity Organization, Tehran, Iran.

2004 _ 2006: Teaching Assistant & Tutor, Dept. of Mathematics, Al-Zahra University, Tehran, Iran.

2001 – 2003: Tutor, Dept. of Mathematics, Shahed Univ., Tehran, Iran.

OTHER EXPERIENCE

Fall 2023, Member of new-faculty search committee, Dept. of STEM Education, U. of Kentucky.

Fall 2023, Supervisor of secondary mathematics teacher candidates, U. of Kentucky.

Spring 2022, Member of Spring Research Conference committee at the University of Kentucky. Reviewed articles, organized sessions, helped with administrative tasks.

TEACHING & PROFESSIONAL SKILLS

- Experienced user of Canvas & Blackboard LMS systems in traditional/online courses.
- Experience working with marginalized students and those from diverse backgrounds.
- Creative and analytical thinker. Able to work both independently and in a team.
- Excellent mentoring and communication skills.