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Prompted reflective thinking and implications for mathematics teacher efficacy in an elementary mathematics methods course

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PROMPTED REFLECTIVE THINKING AND IMPLICATIONS FOR MATHEMATICS TEACHER EFFICACY IN AN ELEMENTARY MATHEMATICS METHODS COURSE

An Abstract of a Dissertation

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

Approved:

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ABSTRACT

Although student-centered mathematics instruction, rooted in constructivism (NCTM, 2014), enhances students' deep understanding of mathematics, many teachers fail to implement this approach, continuing to use more traditional, procedural instruction (Paolucci, 2015). One reason for these difficulties may be related to their teaching self-efficacy, or a person's beliefs about their ability to complete a task. Wyatt's (2016) expanded teacher self-efficacy model incorporates the reflective cycle and emphasizes the importance of reflection in the development of teacher self-efficacy. This study explored whether encouraging reflection in pre-service teachers may indirectly increase their use of student-centered methods in mathematics by increasing their self-efficacy.

The purpose of this qualitative research study is to investigate the effects of an intervention involving extended reflective activities about mathematics instruction, with the goal of enhancing preservice teachers' mathematics teaching self-efficacy and use of student-centered mathematics instruction as demonstrated in lesson plans. Over an 8-week period, preservice teachers were asked to engage in reflection through the use of reflective prompts after watching videos of teachers implementing student-centered mathematics instruction. These prompts focus on student understanding and the role the teacher plays in this development. Video reflections, lesson plans, lesson plan reflections, open-ended mathematics teaching efficacy responses, and course reflections were analyzed qualitatively using thematic analysis.

Following the intervention, four themes were central across data sources: 1). Greater focus on students, specifically student understanding and student strategies; 2). shift in focus teachers to their role in developing student understanding; 3). change in understanding of mathematics instruction and what it means to teach and develop mathematical understanding, and; 4). expressed confidence in their ability to use student-centered instruction and develop students' mathematical understanding.

A shift in mathematics teaching self-efficacy and expressed confidence in course reflections following the intervention may provide insight on the development and possible sources for PSTs' mathematics teaching efficacy; increasing mathematics teaching efficacy is important as it may increase teachers' willingness to try new instructional strategies, such as student-centered mathematics (Chatzistamatiou et al., 2014; Ross & Bruce, 2007; Zee & Koomen, 2016). The shifts observed in this study add to the literature in the mathematics education community as it can inform educators about how to develop preservice teachers' thinking and shift their reflection to focus on their students which is key to student-centered mathematics instruction.

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INTRODUCTION

Student-centered strategies and constructivism are acknowledged as best practices in mathematics instruction for students, encouraging the exploration of mathematical concepts to connect to students' understanding in order to develop a deeper, conceptual understanding. Mathematics education has changed from "telling" or teacher-centered, which will be referred to as "traditional" mathematics. Student-centered mathematics shifts from the teacher as holder and teller of knowledge to the facilitator of the classroom; students are encouraged to participate and construct their own knowledge and understanding. The National Council of Teachers of Mathematics (NCTM) has outlined desired instructional practices in *Principles to Actions* that are student-centered and explorative in nature to develop conceptual understanding (NCTM, 2014). The eight Mathematics Teaching Practices outline in *Principles to Actions* are: establish mathematical goals to focus learning, implement tasks that promote reasoning and problem solving, use and connect mathematical representations, facilitate meaningful mathematical discourse, pose purposeful questions, build procedural fluency from conceptual understanding, support productive struggle in learning mathematics, and elicit and use evidence of student thinking (NCTM, 2014).

A common trend in these teaching practices is the incorporation of student thinking to direct instructional moves with a goal of developing conceptual understanding of students (NCTM, 2014). Some have coined this change in the nature of mathematics education as the "reform" of mathematics or, "reform-based" or "reform-oriented" mathematics. I will be using “student-centered” when referring to the desired instructional practices.

Research has revealed these instructional strategies are not being implemented consistently with more traditional, procedural approaches still being implemented, aligned with dominant cultural beliefs (Handal, 2003; Paolucci, 2015; Philipp, 2007; Weiss & Pasley, 2004). Hiebert and Grouws (2007) also suggest that teaching for conceptual understanding is still absent in many classrooms in the United States. Researchers have noted that many teachers fail to implement desired mathematics due to the unexpected challenges or pressures they face and their inability to overcome them (Handal, 2003; Steele, 2001; Zeichner & Tabachnick, 1981). Examples include: content knowledge, time availability, resources, work loads, and proper professional development. However, teachers who completed a student-centered mathematics course in a collaborative program were able to withstand these challenges as they set out in their own classrooms (Marbach-Ad & McGinnis, 2009).

Student-centered mathematics instruction is often different than the kind of instructional experiences many preservice teachers and teachers had as students and must be made aware to preservice teachers (Handal, 2003; Paolucci, 2015). Thus, it takes conscientious effort from teachers to change their instructional style. Hiebert and Grouws (2007) note the importance of providing students with the opportunity to learn conceptually. In order to develop this type of learning, teachers must be attentive to their instruction and ensure it aligns with the desired goals (Hiebert & Grouws, 2007). With student-centered methods centered around students constructing knowledge, teachers must feel capable of helping students construct their knowledge rather than providing them with knowledge. Developing teachers' beliefs about their capabilities of instructing with student-centered methods is necessary and deserves further exploration (Smith III, 1996).

The purpose of the proposed study is to enhance the self-efficacy in teaching mathematics in preservice teachers, on the assumption that this will increase the likelihood that they will engage in student-centered mathematics instruction as practicing teachers. To accomplish this goal, this study examines the use of video reflection prompts focused on student learning and understanding in a preservice teacher preparation program over the course of eight weeks. These prompts are focused on student learning to shift the focus of reflection from themselves to the students in hopes of increasing their mathematics teacher self-efficacy. The increase in teacher-self efficacy is desired as self-efficacy can determine what type of instruction one implements in the classroom. An overview of the theoretical frameworks providing foundations for this issue will follow with detailed review on the role of self-efficacy and reflection for both inservice and preservice teachers.

Theoretical Frameworks

At the root of the student-centered mathematics movement lies the theoretical construct of constructivism. Piaget (1973) acknowledges the importance of students and their role in learning, recognizing the student or learner as the constructor of knowledge and understanding through experiences and connections developed. This type of instruction shifts the expectations for teachers (Piaget, 1973). Teachers are now expected to not only understand the content, but understand it in a way that they can connect to each student and their level of understanding (Piaget, 1973).

It is important to investigate how to help teachers develop their practice of student-centered instruction, so it can be encouraged in both preservice and inservice teachers. One factor that may contribute to the likeliness of implementing student-centered approaches is teachers' self-efficacy (Temiz & Topcu, 2013; Zee & Koomen, 2016). Grounded in social cognition theory, "self-efficacy" is defined as one's beliefs about one's capability to perform a task (Bandura, 1977), and this definition will be utilized throughout. Self-efficacy, according to Bandura (1977), is developed through four sources: mastery experience, vicarious experience, verbal persuasion, and physiological states, each further described in detail. Reflective teachers are those willing to purposefully and consciously think about their actions, specifically in the classroom. Reflective thought has been linked to self-efficacy through preservice preparation courses and professional development (Noormohammadi, 2014; Phan, 2014; Ross & Bruce, 2007; Tavil, 2014)

There are three main frameworks that provide the foundation for this study: constructivism, social cognitive theory, and reflection. Constructivism provides the foundation for the shift in mathematics education, and will be referred to as student-centered mathematics throughout. Social cognitive theory provides the theoretical framework for self-efficacy which has many implications for teachers and their instruction in the classroom. Lastly, reflection can possibly provide a source for teacher self-efficacy.

Constructivism

Constructivism shifts the role of both the student and the teacher in education. Piaget (1973) claims that instruction centered around the student: "...require that every new truth to be learned be rediscovered or at least reconstructed by the student, and not just simply imparted to him" (Piaget, 1973, p.16). As the student takes a more active role in their learning, this also requires different instruction from the teacher. This is not to say that the teacher is no longer important, just that their role has changed: "What is desired is that the teacher cease being a lecturer, satisfied with transmitting ready-made solutions; his role should rather be that of a mentor stimulating initiative and research" (Piaget, 1973, p.16). Thus, an understanding of both the content and the needs of the student is required by the teacher (Piaget, 1973).

Additionally, Hiebert and Grouws (2007) recommend to align instruction correctly, the goals for student learning must be specifically identified. In this case, to develop student learning and conceptual understanding, there must be opportunities for this type of learning; to create these types of experiences, teachers must deliberately pay attention to the type of instruction provided.

Self-Efficacy

How one perceives themself can influence how they feel, think, and behave (Bandura, 1977; Bandura, 1982). Bandura (1977) identified four sources for the establishment of self-efficacy: mastery experience, vicarious experience, verbal persuasion, and physiological states. The four sources of self-efficacy as described by Bandura (1997) are as follows: (1) "Mastery experience" refers to when a person experiences something for themself; when these experiences are successful, it raises the expectations they have for mastery; (2) “Vicarious experience” does not include direct experience; instead, the person observes others who may take on a similar role, seeing what outcomes are generated based on how the task is performed; (3) “Verbal persuasion” is when individuals are encouraged that they are able to successfully perform or complete the task by an outside source; and (4) “Physiological states” are when states of emotional arousal from stressful situations can alter self-efficacy. According to Bandura (1997), these four sources alter how a person acts based on their beliefs or perception of the outcome.

According to Bandura (1997), each of the four sources influences self-efficacy differently. Mastery is the most influential of the four sources of self-efficacy, as it is based on personal experiences. Through vicarious experiences, the individual is left to draw conclusions based on their observations; this mode of information is less informative of one’s own ability. Although vicarious experiences are less influential than mastery experiences, it is safer for the individual as they are not taking the risk on themselves. If the person they observed is successful, it is more likely to change their behavior (Bandura, 1977). Verbal persuasion is less influential than the previously mentioned sources of self-efficacy as it does not provide an authentic experience for the individual. The higher self-efficacy one holds, the greater the chance there is in behavior toward a desired outcome, according to Bandura (1977). Another noteworthy aspect of efficacy as described by Bandura (1977): “Modeled behavior with clear outcomes conveys more efficacy information than if the effects of the modeled actions remain ambiguous" (p.197).

In addition to understanding the influences each of the experiences has, Bandura (1977) acknowledges the implications of efficacy on individual performance. Efficacy expectations are how the individual perceives that they can successfully implement the behavior in order to reach the desired outcome. Efficacy expectations influence the effort put forth toward a task and whether or not an individual will persevere in completion of a task. Individuals who are efficacious and believe they will succeed are more likely to succeed (Bandura, 1977). Self-efficacy expectations are higher and more generalized when coming from sources of personal experiences in comparison to vicarious experiences. However, vicarious experiences still provide an opportunity to develop self-efficacy. Regardless of the source of efficacy, the stronger the self-efficacy one has with respect to that task, the more likely it will be completed successfully (Bandura, 1977).

The implications of self-efficacy have been explored for both inservice and preservice teachers. Teacher self-efficacy involves beliefs teachers hold about their ability to engage students and affect their student learning outcomes. Teacher efficacy is two-dimensional as it takes into account a teacher's beliefs about their teaching effectiveness (personal teaching self-efficacy) and the outcomes that will follow (outcome expectancy). How a teacher perceives their ability to control student outcomes, regardless of external factors, suggests that teacher self-efficacy is not only about their teaching effectiveness, but also the success of desired student outcomes. Teacher self-efficacy has been related to the effort a teacher puts forth, their persistence in the face of challenges, and their implementation of various strategies such as student-centered approaches. In fact,

> It is partly on the basis of efficacy beliefs that people choose what challenges to undertake, how much effort to expend in the endeavor, how long to persevere in the face of obstacles and failures, and whether failures are motivating or demoralizing. (Bandura, 2001, p.10)

Teachers who are efficacious and believe they can impact student achievement positively are more likely to do so, as Bandura acknowledges a person's willingness to persevere is dependent upon their self-efficacy (1977, 2001).

With respect to the ability to change efficacy beliefs in pre-service teachers, Chacon (2005) suggests that teacher beliefs for specific tasks are more fluid than more stable, general self-efficacy beliefs. Wyatt (2016) also acknowledges the difference between teacher self-efficacy and general self-efficacy, targeting the former and its interaction with the reflective cycle. Wyatt (2016) highlights the interaction between reflection and teacher self-efficacy with the incorporation of reflection in the self-efficacy cycle. This study targets preservice teachers in hopes of developing their teaching self-efficacy during a mathematics teaching methods course with the guidance of prompted reflection. As teaching self-efficacy is more fluid and task oriented than general self-efficacy (Chacon, 2005), it is reasonable to target teaching-efficacy, more specifically mathematics teaching self-efficacy with preservice teachers given the length of the mathematics methods course offered.

Reflection

According to Dewey (1933), reflection is one's conscientious thought about their actions or ideas. Dewey (1933) defines reflective thinking as: “the kind of thinking that consists in turning a subject over in the mind and giving it serious and consecutive consideration” (p.3). Dewey’s definition of reflection will be used throughout, focusing on conscientious reflection on student-centered instruction. Reflective thinkers may first encounter an issue or state of perplexity which requires thought and the gathering of resources to resolve the aforementioned issue or state of perplexity (Dewey, 1933).

Reflective thinking has an intentional goal or issue in mind, focusing on the needed action(s) to obtain the goal (Dewey, 1933). A goal can be the resolution to an issue or problem (Dewey, 1933). Grimmett and Erickson (1988) suggest that reflection “...engages practitioners in a ‘conversation’ with the problematic situation” (p.9). Schön (1983) also acknowledge a problem or issue for the prompting of reflection, stating: “The practitioner then takes the reframed problem and conducts an experiment to discover what consequences and implications can be made to follow from it” (p.131). Reflective thinking begins with conscientious engagement of the mind over a problem or task.

For many teachers, difficulties, obstacles and pressures arise such as content knowledge, time availability, resources, workloads, and proper professional development when trying to implement desired methods of instruction, causing them to fail at implementing desired methods (Handal, 2003; Steele, 2001; Yost, 2006; Zeichner & Tabachnick, 1981). Teacher self-efficacy may play an important role in the implementation of student-centered mathematics instruction in that higher self-efficacy may increase the likelihood that teachers will implement student-centered instruction and try new strategies (Depaepe & König, 2018; Temiz & Topcu, 2013; Zee & Koomen, 2016). As teachers continue to change their instruction to meet the needs of their students and student-centered mathematics, one can see the importance of an ongoing reflective cycle and how it can focus one's attention and actions on overcoming these issues or obstacles encountered. Braun and Crumpler (2004) state:

> … reflective teachers have developed the capacity to think about their teaching behaviors and the contexts in which they occur. In other words, they can look back on past events; make judgements about them; and, they can alter their teaching practices and beliefs based on the needs of their students. (p.60)

As student-centered mathematics shifts the focus to students as constructors of knowledge (Piaget, 1973), it is important that teachers reflect on their actions and role in developing students' learning.

Although reflection can be a useful component of teaching, it takes time and experience to develop. Dewey (1933) recognizes the ability to develop the idea of reflective thought: "But while we cannot learn or be taught to think, we do have to learn *how* to think well, especially *how* to acquire the general *habit* of reflecting" (p.35). This highlights the importance of teacher preparation programs and their role in the development of reflective thinking of preservice teachers in hopes of continuing this reflection as they transition into their first years of teaching. Teacher preparation programs may provide the opportunity for developing a habit of reflection (Grimmett & Erickson, 1988).

In contrast to Dewey, Schön (1983) emphasizes reflection-in-action for practicing teachers. Schön (1983) highlights the need for practitioners and teachers to reflect in the moment, making decisions. However, Schön (1983) acknowledges reflection on actions stating:

> Practitioners do reflect *on* their knowing-in-practice. Sometimes, in the relative tranquility of a postmortem, they think back on a project they have undertaken, a situation they have lived through, and they explore the understandings they have brought to handling their case. They may do this in a mood of idle speculation, or in deliberate effort to prepare themselves for future cases. (p. 61)

This aligns with teacher preparation program as their intent is to prepare future teachers for classroom situations.

Statement of Problem

Shifts in Secondary-Level Mathematics Instruction and Implications

The National Council of Teachers of Mathematics (NCTM) has outlined desired instructional practices in *Principles to Actions* that are student-centered and explorative in nature (NCTM, 2014). Traditional methods of instruction rely heavily on teachers lecturing students, leading them, often step-by-step, through procedures and specific methods. The role of the teacher has shifted from a direct instructor to a facilitator of students' conversation. The teacher should no longer be viewed as the sole provider of information; all students are seen as resources and contributors of knowledge through collaboration, communication, and problem-solving (Piaget, 1973). Based on constructivism, these standards suggest students build their knowledge by relating it to their prior knowledge in a way that makes sense to them.

The *Principles to Actions* Standards (NCTM, 2014) suggest competency for students in mathematics does not consist of being able to replicate their instructors' procedural processes, but instead being able to problem-solve, reason, explain and communicate their thoughts through difficult problems, tasks, and explorations. These standards (NCTM, 2014) encourage students to actively engage by communicating thoughts to their peers, justifying their answers, and persevering through challenging problems.

The implementation of *Principle to Actions* Standards by NCTM (2014) have not only changed the mathematics that students are learning, but they also require changing the ways teachers instruct (Ball, 1990). The shift in mathematics education has demanded more from teachers, requiring a deeper understanding of content to successfully facilitate environments that provide the opportunity for collaboration, communication, and problem-solving (Ball, 1990; NCTM, 2014). Teachers now have to select and implement cognitively demanding tasks, understand the content well enough to connect and explain multiple modes of representation, and direct discourse amongst students (Smith III, 1996).

This shift in mathematics education for students and teachers will be referred to as student-centered mathematics. The acknowledged benefits and deepened understanding that students can obtain from student-centered mathematics raises the question as to why these standards are not being implemented everywhere. As teachers hesitate with the integration of student-centered instruction (Steele, 2001; Zeichner & Tabachnick, 1981), instances of successful implementation of the standards can provide insight and understanding of how this change can be applied to the classroom.

Self-Efficacy as an Indicator for Instruction

Manouchehri (2003) interviewed teachers that used the desired student-centered approaches in their classrooms to see if they shared common characteristics. In this study, common traits that emerged from interviews included: feeling confident in their ability to determine students’ learning and understanding, feeling strongly about education, seeing their own teaching as a process developing over time, and feeling it was their social duty to educate students, specifically in mathematics, to better society (Manouchehri, 2003). Despite having teachers with varying demographics and situations, participants all felt they were able to control the opportunities for their students to learn versus factors out of their control. These teachers felt their inspiration for implementing student-centered mathematics stemmed from previous personal experiences they had or observed. Some teachers were able to experience student-centered instruction they wanted to reproduce, while others had traditional experiences they did not want to replicate with their own students. These teachers were more willing to take risks with the implementation of the standards as they were more confident with content knowledge and beliefs in their own instructional practices (Manouchehri, 2003). Similarly, Chatzistamatiou, Dermitzaki, and Bagiatis (2014) found that teachers with higher efficacy about their mathematics instruction were more likely to enjoy teaching, felt committed to their profession of teaching, and highly valued mathematics.

With student-centered mathematics instruction, teachers are asked to implement instruction that is often different from their traditional experiences, which can be intimidating as they are asked to implement cognitively demanding tasks that do not rely on step-by-step procedures, often similar to their own experiences (Evans, 2011; Jao, 2017; Paolucci, 2015). As mathematics teachers shift to becoming facilitators of their classrooms, some researchers suggest that traits such as teacher self-efficacy may be responsible for teachers' successful implementation of student-centered mathematics teaching (Manouchehri, 2003). It is reasonable to address these possibilities for the increase in implementation of mathematical standards.

Role of Reflection

There are many factors that influence teachers' instruction, and as suggested by the aforementioned studies, self-efficacy is one factor that may play an important role in implementation of new strategies (Chatzistamatiou et al., 2014; Ross & Bruce, 2007; Zee & Koomen, 2016), specifically student-centered instruction (Depaepe & König, 2018). Reflective thinking allows teachers to continuously think about and learn from their previous instruction, working to improve it, and possibly increasing their self-efficacy in a cyclic nature. Reflection provides the opportunity for teachers to be more critical of their instruction, thinking about issues that arise, ways to improve, and what can inform them during future teaching situations (Uzun, Yüksel, & Dost, 2013).

Furthermore, Uzun and colleagues (2013) found that with the preservice mathematics teachers, researchers were able to predict their personal mathematics teaching efficacy and teaching outcome expectancy from their reflective tendencies. The study conducted by Uzun et al. (2013) included 125 preservice secondary mathematics teachers, and variables were measured using the Reflective Tendency Scale (RTTS) and the *Mathematics Teaching Efficacy Beliefs Inventory* (MTEBI). Uzun and colleagues (2013) suggest that an increase in preservice teachers' reflective thinking tendencies will result in an increase in self-efficacy beliefs, leading to increased teaching performance. It is reasonable to think about ways to integrate courses, experiences, and activities that can help PSTs develop reflective skills in their teacher preparation programs in hopes of developing their efficacy about mathematics teaching.

Purpose of Study

The issue of lack of implementation of student-centered mathematics has motivated this study; further exploration is needed to discover ways to enhance the likeliness that student-centered mathematics instruction will be implemented in classrooms. As self-efficacy is one trait recognized to increase a teacher's willingness to try new strategies (Temiz & Topcu, 2013; Zee & Koomen, 2016) like implementing the standards outlined by NCTM's *Principles to Actions* (2014) mathematics, it is important to explore possible sources for increasing self-efficacy. Reflection in various modes has been explored by researchers as well as its relationship to teacher self-efficacy (Gabriele & Joram, 2007; Ross & Bruce, 2007; Uzun et al., 2013; Wyatt, 2016; e.g.). This study is motivated by the lack of implementation of student-centered mathematics, increasing teacher self-efficacy, and discovering possible sources for the development of mathematics teacher self-efficacy in preservice preparation programs. The purpose of this study is to investigate the use of prompted reflections focused on student learning and understanding and their relationship to the focus of reflection and preservice teachers' mathematics self efficacy and use of student-centered instruction as depicted in their lesson plans. The following research questions have guided this study:

Research Questions

1. What is the nature of preservice teachers' reflections on mathematics lessons over time, as they engage in use of prompted reflections focused on students' understanding of mathematical content?

2. What is the nature of preservice teachers' mathematical teaching self-efficacy over time, as they engage in use of prompted reflections focused on students' understanding of mathematical content?

3. What is the nature of preservice teachers' use of student-centered methods in mathematics instruction after they have engaged in the reflective activities embedded in the intervention, as reflected in their lesson plans?

CHAPTER 2

REVIEW OF LITERATURE

This study is motivated by the literature on the use of student-centered mathematics instruction which reveals a lack of implementation of these instructional mathematical practices in the initial years of teaching, despite teacher's intentions, due to obstacles, pressures, and challenges faced (Handal, 2003; Steele, 2001; Yost, 2006; Zeichner & Tabachnick, 1981). Additionally, it is motivated by increasing teacher self-efficacy to face these obstacles and pressures, and discovering possible sources for the development of mathematics teacher self-efficacy in preservice preparation programs. This study aims to investigate the use of prompted reflections focused on student learning and understanding and their relationship to the focus of reflection and preservice teachers' mathematics self efficacy. A detailed literature review will follow for self-efficacy, reflection, and the use of videos and prompts and their implications in preservice teacher preparation courses.

"Self-efficacy" is defined as one's beliefs about one's capability to perform a task (Bandura, 1977), and will be used accordingly throughout. Teacher self-efficacy is a teacher's belief in their ability to effectively teach and influence the learning outcomes of their students' learning (Ashton, 1985; Enochs, Smith, & Huinker, 2000). Teaching self-efficacy can be influenced by many factors, both positively and negatively. Teacher self-efficacy has implications for the implementation of student-centered mathematics such as their implementation or lack of. In addition to teacher self-efficacy, more specifically, mathematics teacher efficacy, Briley (2012) defines mathematics teaching efficacy as, "a belief in his or her capability to teach mathematics effectively" (p. 9).

Swars, Hart, Smith, Smith, and Tolar (2007) were able to increase elementary teachers mathematics teaching efficacy through courses in a teacher preparation program. If increasing self-efficacy can increase the likelihood of integration of student-centered practices (Depaepe & König, 2018; Temiz & Topcu, 2013; Zee & Koomen, 2016) and willingness to implement new strategies and persisting in the face of struggle (Chatzistamatiou et al., 2014; Ross & Bruce, 2007; Zee & Koomen, 2016), there is a need to further explore sources for possible increases in mathematics teaching efficacy. The purpose of this study is to further investigate possible sources for increasing teacher self-efficacy, specifically mathematics teacher self-efficacy, and increasing the use of student-centered instruction as demonstrated in lesson plans. One possible source that has been looked at with teacher self-efficacy is reflection, but it is in need of further exploration for the implications it has (Noormohammadi, 2014; Phan, 2014; Ross & Bruce, 2007; Tavil, 2014; Lee & Ertmer, 2006). Dewey (1933) defines reflective thinking as: "the kind of thinking that consists in turning a subject over in the mind and giving it serious and consecutive consideration" (p. 3). Dewey's definition of reflection will be used throughout, focusing on conscientious reflection over student-centered instruction.

Self-Efficacy in Mathematics Education

Teacher Beliefs in Student-Centered and Constructivist Approaches

Traditional beliefs about mathematics education are situated in societal beliefs of the United States, often viewing mathematics as a set of predetermined procedures where students listen to teacher's step-by-step demonstrations followed by individual practice to determine if they mastered the concepts presented (Smith III, 1996). In contrast, many teacher preparation programs encourage the implementation of *Principles to Actions* mathematics teaching standards, focusing on student-centered approaches that encourage collaboration, communication, and building problem-solving skills (NCTM, 2014). It is necessary that preservice teachers understand the "direction in which mathematics education is progressing and their own role in taking it there" (Paolucci, 2015, p. 106). The encouragement of these standards can be seen through student-centered methods courses at the postsecondary level; it is reasonable to ensure PSTs understand their role and the desired mathematics instruction to be implemented in their classrooms..

Teacher beliefs are developed through experiences they have lived or encountered, and they can vary from teacher to teacher and classroom to classroom. Unfortunately, many teachers' experiences are with traditional and/or procedural methods (Evans, 2011; Jao, 2017; Handal, 2003; Paolucci, 2015). Critical reflection on their own mathematical experiences while situating themselves in the goals of mathematics education is important to develop understanding of their role in mathematics education (Paolucci, 2015). Some of the differences in teacher beliefs and their impact on instruction can be attributed to varying situations and aspects of the complex and diverse classroom life (Hannula et al., 2016).

In a study of 95 preservice elementary teachers, a positive relationship was found between mathematics teaching efficacy and their belief about what it means to learn and do mathematics; more sophisticated beliefs about mathematics were held by preservice teachers with stronger efficacy beliefs (Briley, 2012). Preservice teachers' beliefs about the nature of mathematics were found to have a statistically significant relationship to their mathematics teaching efficacy; preservice teachers were more likely to believe the nature of mathematics involved "understanding and sense making" if they believed that effective teaching of mathematics can produce the desired outcome: student learning (Briley, 2012, p.8). If preservice teachers develop a deeper understanding about mathematics teaching and student learning, it may provide the opportunity for a change in their beliefs about the effectiveness of student-centered mathematics instruction.

Implications of Teacher Self-Efficacy

Some researchers have suggested that preservice teachers with higher self-efficacy are more likely to use student-centered instructional practices and behavior strategies (Temiz & Topcu, 2013; Zee & Koomen, 2016). Several studies provide insight about the role self-efficacy plays in the instruction utilized in a classroom (Chatzistamatiou et al., 2014; Depaepe & König, 2018; Ross & Bruce, 2007; Zee & Koomen, 2016). Findings from the study conducted by Temiz and Topcu (2013) showed a positive correlation between teachers' efficacy beliefs and constructive-based instruction. Teachers with high self-efficacy beliefs are more likely and willing to teach and incorporate student-centered and student-centered activities into their classrooms (Depaepe & König, 2018; Temiz & Topcu, 2013). Additionally, teachers with positive self-efficacy are also more willing to implement new strategies and persist in the face of struggle (Chatzistamatiou et al., 2014; Ross & Bruce, 2007; Zee & Koomen, 2016).

This trend is not unique to only these few studies. In a synthesis of 165 articles over a 40 year span, Zee and Koomen (2016) recognized many emerging themes about teacher self-efficacy stating: “Taken together, results from studies on the consequences of [teacher self-efficacy] for classroom processes indicate that high-efficacy teachers, and especially those with more experience, tend to effectively cope with a range of problem behaviors; use proactive, student-centered classroom behavior strategies and practices; and establish less conflictual relationships with students” (p. 998). While this review recognizes the positive relationship of self-efficacy in the classroom, Depaepe and König (2018) explored several specific factors: general pedagogical content knowledge, self-efficacy and reported instructional practice with 342 preservice teachers. In this study, preservice teachers rated themselves over five months on their instructional practice. Cognitive activation, classroom management, and provision of learning support for students are the components of their instructional practice reported on. It was discovered that self-efficacy of preservice teachers “significantly reported” the instructional practices reported (Depaepe & König, 2018, p. 189). Thus, according to the authors, teacher’s levels of self-efficacy could predict reports of teachers’ own instructional practices.

Role of Educator Preparation Programs in Effecting Shifts in Mathematics Teaching

Bandura (1997) suggests that self-efficacy develops early on in careers, and remains mostly unchanged. Teacher self-efficacy may be most malleable in the preservice years. As teachers continue to teach, they typically keep the same beliefs, making them more difficult to change (Hoy & Spero, 2005). Therefore, it may be important to target preservice teachers in order to shift them towards considering endorsing self-efficacy beliefs that support student-centered instructional methods. In service of this goal, it may be important to expose preservice teachers to student-centered instruction. If preservice teachers do not challenge their more traditional personal experience or beliefs, observations or experiences similar to their prior experiences can reinforce their more traditional beliefs. Hine (2015) suggests that preservice teachers should be provided with the opportunity for multiple experiences that incorporate student-centered methods.

Despite the integration of student-centered pedagogy into teacher preparation courses, researchers note that teachers with intentions of implementing the standards often fail to do so in their initial years of teaching because of unexpected challenges they encounter (Handal, 2003; Steele, 2001; Zeichner & Tabachnick, 1981). Beginning teachers can feel unprepared for the common obstacles and challenges they face, feeling their teacher preparation programs did not fully prepare them (Hine, 2015). For example, content knowledge, time availability, resources, work loads, and proper professional development continue to be factors that may support or undermine successful student-centered instruction of secondary mathematics. Teachers who completed a student-centered mathematics course in a collaborative program were able to withstand these challenges as they set out in their own classrooms (Marbach-Ad & McGinnis, 2009).

Student-centered methods courses provided during teacher education programs can help preservice teachers prepare to address these challenges. As teachers begin instructing in their own classrooms, transitioning from preservice to inservice teachers, they may begin to encounter some of these challenges for the first time (Marbach-Ad &

McGinnis, 2009; Yost, 2006). However, it should be noted that in a longitudinal study of preservice teachers transitioning to their own classrooms in the first year or two, they were able to maintain their beliefs about teaching mathematics, for example, valuing real-world applications in the classroom instead of rules or algorithms and skills they believed students needed in order to be successful in mathematics. The beliefs they held as beginning inservice teachers were similar to those they held previously as preservice teachers, despite having to face some of the difficult challenges for the first time. In fact, teachers said that teaching student-centerd mathematics was easier in their second year, as they had more experience (Marbach-Ad & McGinnis, 2009).

Similarly, Bruce and Ross (2008) found an increase in teacher's efficacy and their use of student-centered teaching after partaking in professional development including reflective practices. This professional development included observations of a peer, peer coaching, and peer interviews. The authors found that after professional development, the teachers tended to implement student-centered instruction and innovative instruction. Further, the researchers note the importance of the different sources available for teachers to make judgement about their ability to influence student learning: mastery experiences (practicing the desired instruction themselves), vicarious experiences (through peer observations), verbal persuasion (through peer coaching), and physiological and emotional cues. Bruce and Ross (2008) state, "The nexus of efficacy information sources reinforced one another to provide the participants with strong positive messages about their teaching which, in turn, encouraged further risk-taking and implementation of challenging strategies" (p.363). In other words, teachers were able to draw on different experiences and sources for the development of their efficacy and demonstrate the ability to implement student-centered instruction.

Wyatt (2016) created a framework that expanded on that of Tschannen-Moran, Woolfolk Hoy, and Hoy (1998), focusing on the role of the teacher self-efficacy. Wyatt (2016) acknowledges the fluidity of teacher self-efficacy in comparison to general self-efficacy (GSE) which tends to be more stable. This more fluid, teacher self-efficacy, "feed into the development of more stable and robust GSE beliefs" (Wyatt, 2016, p.22). Also recognized in this newer framework is the interaction of the reflective cycle and teacher self-efficacy (Wyatt, 2016). Focusing on changing and increasing teacher self-efficacy which is acknowledged to be more fluid creates the opportunity for possible change in the more stable, general self-efficacy.

If a teacher feels that they cannot affect student learning outcomes through teaching mathematics (i.e. their teaching self-efficacy), they are more likely to avoid shifting to a student-centered approach that emphasizes inquiry (Marbach-Ad & McGinnis, 2009). Research in other content areas have also shown promise in the effects of teacher self-efficacy and the implementation of curriculum reform. Cerit (2013) found this to be true for nearly 300 elementary teachers, measuring both efficacy and willingness to implement curriculum reform. Specifically, Cerit (2013) found that student engagement and instructional strategies in teachers' efficacy beliefs have an effect on the implementation of curriculum reform.

Additionally, there is evidence that suggests that upon completion of a student-centered mathematics course as practicing teachers, teachers increased their self-efficacy, content knowledge, and attitudes towards mathematics (Evans, 2011). The increase in self-efficacy also increases the teachers' willingness to take risks in their classroom as they feel that they are able to affect student learning outcomes. Teachers acknowledged the importance of understanding the implementation of problem-solving in their classrooms (Evans, 2011). Additionally, Smith III (1996) suggests that preservice teachers need to understand and recognize that their students' learning and the effectiveness of their teaching can vary from one context to another. Again, this highlights the importance of teacher self-efficacy, which can be task specific. Further explorations of the types and significance of experiences preservice teachers have at the postsecondary level that influence their self-efficacy should be considered.

In many teacher preparation programs, preservice teachers complete methods courses, observe inservice teachers, and have teaching experiences of their own in classrooms. These varying experiences can provide different opportunities for teachers to address and change their self-efficacy. As evidenced by the aforementioned studies, self-efficacy is an important indicator in the classroom, especially in the face of challenges when implementing student-centered mathematics. "Efficacy beliefs are the foundation of human agency. Unless people believe they can produce desired results and forestall detrimental ones by their actions, they have little incentive to act or to persevere in the face of difficulties" (Bandura, 2001, p. 10). We need to help preservice teachers develop a belief in their ability to implement student-centered mathematics successfully.

Sources of Self-Efficacy from Experiences Offered in Educator Preparation Programs

Mastery experience is the most influential source of self-efficacy, and vicarious experiences are the second most influential source (Bandura, 1977), both of which are found in teacher preparation programs. In teacher preparation courses, vicarious experiences can be carried out through field-based, text-based, or video-based observations. Both field-based and text-based vicarious experiences have lead to increases in personal and teaching efficacy for preservice teachers (Matney & Jackson, 2017).

It is important to note that sources of efficacy can be different for teachers. Gabriele and Joram (2007) used a talk-aloud method to explore sources for teacher self-efficacy in elementary teachers for both novice and veteran teachers. They found that veteran teachers use different criteria to judge efficacy information than that of novice teachers. As preparation programs consider what types of experiences should be implemented for preservice teachers, it should be noted that even though field- and text-based experiences caused an increase in personal and general teaching efficacy, there is a slight difference in the two. Participants that took part in the field-based experience had higher levels of self-efficacy for both personal and general teaching efficacy, in comparison to those who participated in the text-based vicarious experience (Matney & Jackson, 2017). Although mastery experiences are the greatest predictors of self-efficacy, both types of experiences can play a positive role in changing preservice teachers' efficacy beliefs. It is reasonable to explore the opportunities and experiences in which teacher self-efficacy beliefs can be changed to be able to ensure preservice teachers have access to these opportunities in their teacher preparation programs.

In addition, findings from a study conducted by Hine (2015), suggest that preservice teachers feel the need to have more mathematical content in their preparation programs, more mathematical pedagogy in their preparation programs, and that their practicum (mastery) experiences “confirmed initial perceptions of teaching readiness.” This suggests that teacher preparation programs influence their feeling of preparedness prior to the practicum, which reinforces it. If teachers are unsuccessful or have experiences (both as a learner and a teacher) that are unsuccessful with inquiry-based methods, they are less likely to implement these strategies and believe that students will learn through these strategies (Lotter et al., 2018). Preservice teachers noted that the experiences were the most useful experiences they had in their preparation program because they were able to learn the most about teaching in the classroom (Jao, 2017). Therefore, it is necessary to address these beliefs prior to this experience to ensure that practicum experiences are reinforcing student-centered mathematics pedagogy, not more traditional practices.

Mastery experiences need not to only take place in classroom settings with students; benefits can come from mastery experiences within methods courses as well. Preservice teachers participating in a study conducted by Temiz and Topcu (2013) were observed during microteachings with their peers and scored on their implementation, or lack thereof, of student-centered instructional approaches. Prior to their microteachings, preservice teachers were able to ask their instructor on ways to improve their instruction during the planning phase and given advice on how to ensure the effectiveness of the lesson. Teacher self-efficacy was measured by the Teacher Self-Efficacy Scale, and student-centered approaches were evaluated using a translated version of the Reformed Teaching Observation Protocol (RTOP). After evaluating the observed lessons on student-centered approaches using the RTOP, it was observed that preservice teachers' higher efficacy correlated with more student-centered approaches. Researchers Temiz and Topcu (2013), suggest that preservice teachers can improve their student-centered instruction and efficacy when given the opportunity to practice student-centered approaches. Benefits for teachers' self-efficacy can be observed from many experiences, mastery and vicarious. Due to time constraints and other logistical factors in teacher preparation courses, considerations must be made when selecting the types of experiences for preservice teachers in teacher preparation programs.

Reflection

Wyatt (2016) expanded Tschannen-Moran et al.'s (1998) teacher efficacy model to incorporate the reflective cycle into the development of teacher self-efficacy, emphasizing the importance of reflection in the development of teacher self-efficacy. As the goal of the present study is to develop teacher efficacy and determine possible sources of teacher self-efficacy, the role of reflections in preservice teacher preparation programs will be explored further.

Reflective Thinking on Student-Centered Experiences

Teacher preparation programs are able to offer opportunities that can assist inservice teachers as they begin teaching. For example, Yost (2006) looked at a volunteer sample of second year teachers who had graduated from the same teacher preparation program. Participants felt that they faced many obstacles and felt unsupported in their teaching experience within their schools. However, they also noted that the numerous and diverse experiences they had as a preservice teacher in their preparation program played an important role in what they currently viewed and saw as indicating success. Participants who used a model from their teacher preparation program of critical reflection were successful in dealing with challenges, both academic and behavioral (Yost, 2006). This is an important finding as it emphasizes the importance of including reflection during teacher preparation programs and how habits of reflection can be carried on and successfully implemented in the subsequent beginning years of teaching. While developing preservice teachers who are completely prepared to implement student-centered methods in all content areas is an impossible task during such a short period of time, Hiebert, Morris, Berk, and Jansen (2007) instead suggest preparing teachers with the skills to analyze and continuously improve their teaching through focusing on student learning.

Both mastery and vicarious experiences can provide an opportunity for reflective thinking (Matney & Jackson, 2017). Jao (2017) created a mathematics methods course that modeled student-centered behaviors through the implementation of activities. Following the activities, whole-class discussion took place, in which preservice teachers reflected on the activity. Preservice teachers then implemented their own lesson, getting feedback from their peers during the whole-class discussion, and they were also asked to reflect on their own implementation. Preservice teachers noted that they appreciated the reflective time, as it allowed them to develop a deeper understanding of student-centered approaches. Reflective time allowed them to critically reflect upon and discuss their experiences with their peers. This course, that offered modeling and student-centered experiences (both mastery and vicarious experiences), complemented with opportunity for reflection, resulted in a slight increase in teacher efficacy beliefs (Jao, 2017), although the results were not significant.

Additionally, Chatzistamatiou and colleagues (2014) found that teacher self-efficacy was a significant predictor of their use of teaching with and for self-regulation. Self-regulation is a cyclic relationship between planning, implementation, and reflection. A teacher can use reflection to help develop their efficacy by critically assessing their instruction (Ross & Bruce, 2007). Reflection can allow teachers to analyze instruction, synthesizing and hypothesizing methods for improvement.

This cycle of planning, teaching, and reflection is suggested to help increase teachers' self-efficacy, resulting in the use of inquiry-based strategies. Lotter et al. (2018) created a professional development model including sessions where teachers participated in whole-group and small-group inquiry-based instruction, experiences with students, and opportunities for reflection. The inservice teachers who participated in this study reported that the reflection sessions were valuable for their learning and teaching. Their findings also revealed gains in self-efficacy as a result of their reflective sessions; four of the five essential inquiry features showed improvement (Lotter et al., 2018). Both preservice and inservice teachers have been shown to benefit from reflective sessions with peers following experiences.

Kong (2010) investigated the reflection of preservice teachers before and after watching videos of their teaching. Preservice teachers were asked to reflect on an implemented lesson, watch the video of their lesson, reflect on the video, and then revise how they would instruct based on their reflections. Reflections were scored on a four-level reflection rubric, and the main finding was that student-teachers engaged in deeper reflection after the viewing of the videos in comparison to their reflections prior to watching their videos. Breaking this down, student-teachers increased in both the quantity and depth of reflection in “Professional Knowledge on Teaching” and “Discipline and Classroom Management.” Despite the increase in quantity and depth in each of these categories, it is to be noted that there was no statistically significant increase in the category “Pupils and Pupil-Teacher Interaction.” Developing this view of teaching, focusing on students, is difficult for preservice teachers (Kong, 2010).

Shifting Focus of Teacher’s Reflection

While there are many different opportunities that can be offered for reflection, it is important to not only look at the type of reflection that is occurring, but also what the focus of that reflection is. According to Pyper (2014), teacher self-efficacy in preservice teachers has also been shown to relate to teacher concern and orientation. Higher teacher efficacy was related to expressions of impact-concern along with task-concerns and self-concerns. Low teacher efficacy primarily related to self-concern. As teachers completed the program, a shift from self-concern to a combination of all three concerns was observed with an increase in teacher self-efficacy (Pyper, 2014). It is instructive to explore the focus of preservice teachers’ reflections and the role in plays in the development of their teacher self-efficacy, in order to gain a greater understanding of the types of experiences that might enhance their self-efficacy during their programs. Bandura (2001) states:

> The metacognitive capability to reflect upon oneself and the adequacy of one's thoughts and actions is another distinctly core human feature of agency. Through reflective self-consciousness, people evaluate their motivation, values, and the meaning of their life pursuits. It is at this higher level of self-reflectiveness that individuals address conflicts in motivation inducements and choose to act in favor of one over the other. (p. 10)

Focusing on student learning and understanding can allow teachers with intent to implement student-centered mathematics to focus on the same aspects as the student-centered movement: the students.

A shift in concern or focus on students' learning is necessary for quality instruction (Hiebert et al., 2007). Hiebert et al. (2007) acknowledge a need for reflection outside the classroom experience and suggest that it can be used to enhance their learning from teaching experience. They also suggest a framework that has teachers focusing on students' learning to develop conscious reflection on the everyday occurrences in the classroom. This framework suggests four skills: specifying learning goals, using evidence to assess goal achievement, hypothesizing why the lesson went or did not go as planned, and proposing change for the next implementation. These are skills typical of inservice teachers, but the authors suggest a need to help preservice teachers be intentional about these phases of instruction. Although there is not empirical evidence to support this framework, it is a gap in literature that needs further exploration.

Too often, preservice teachers focus on their own teaching behaviors and not the learning and understanding experienced by the student (Chamoso, Cáceres, & Azcárate, 2012; Gelfuso & Dennis, 2014; Seung, Park, & Jung, 2014). Hatton and Smith (1995) looked at written reflections of preservice teachers and coded them on four themes: descriptive writing (not reflection), descriptive reflection, dialogic reflection (reasoning includes a discourse with oneself), and critical (reasoning involving broader contexts). The largest number of reflections were classified as descriptive reflection, describing the situation at hand. Chamoso et al. (2012) found that preservice teachers in their study focused mainly on teaching and methodology rather than on learning. In the preservice teachers' reflections, the focus was mostly on content (Chamoso et al., 2012). Gelfuso and Dennis (2014) recorded verbal reflections of literacy preservice teachers and found that preservice teachers did not focus on teaching and student learning, instead primarily focusing on issues of management and relations with collaborating teachers. Seung et al. (2014) investigated evidence-based reflections of preservice teachers and their mentors in science classrooms. Preservice teachers tended to reflect in three categories: broad interpretations of inquiry, teacher-centered focus, focused more on non-scientific issues.

As teachers begin in their initial years of teaching, many obstacles and pressures are faced (Handal, 2003; Steele, 2001; Yost, 2006; Zeichner & Tabachnick, 1981). Of these, great focus is placed upon student learning of content and the amount of content covered. Beginning teachers are pressured to meet all of these standards (Ward & McCotter, 2004). Ward and McCotter (2004) realize this and suggest,

> The emphasis on student learning related to standards presents an opportunity, however, when it becomes the very fabric of reflection, rather than the barrier that precludes it. In fact, teacher examination of student work and student learning can be an excellent vehicle for reflection. (p. 244-245)

There is a need for pre-service and beginning teachers to change their focus from reflection on self to reflecting on the learning and understanding of the student.

Development of Intentional Reflection

To address the concern of teachers' focus in their reflection, there must be an intentional component that can guide teachers to the desired focus. Gelfuso (2016) recognizes the importance of preservice teachers' reflection and the necessary guidance of educators to focus reflection. Chamoso et al. (2012) recognize the need for additional research in focusing reflection, shifting preservice teachers focus to that of the needs of the children in their care. The focus of preservice teacher reflection will be further explored in the following studies. Barnhart and van Es (2015) found that with structured support in a video-based course, preservice teachers had "higher levels of sophistication" with respect to student thinking.

Common themes have been found for both inservice and preservice teachers. Boody (2008) conducted a study of teachers and found that "a majority of the teachers were self-assessing only to ensure that they were doing their jobs properly. There was no indication that they wanted to improve in their own performance in order to enhance and enrich student-learning" (p. 176). The teachers also recognized the importance of student feedback but did not use it to change and improve their future lessons. Thus, although the teachers were being reflective, the focus was on their own performance and not what it meant for students' learning and understanding.

Although preservice teachers may reflect, the focus of their reflection can vary from situation to situation. Duquette and Dabrowski (2016) used Ward and McCotter's four levels of reflection framework to analyze preservice teachers' reflections. They emphasized the collaboration of these preservice teachers with a teacher educator in reflections; after reflecting, teacher educators asked questions about student engagement and learning expectations to focus preservice teachers and develop their understanding on the given situation. The intent of the discussions was to focus on preservice teachers' "technical competence and student needs, with the aim of improving the quality of their teaching and student achievement" (Duquette & Dabrowski, 2016, p. 587). Again, this framework reiterates the importance of intentional reflection to focus preservice teachers' thinking on student learning and understanding.

Providing the opportunity to be intentional to preservice teachers is suggested to help them develop their analysis of everyday classroom practices. Wilkerson, Kerschen and Shelton (2018) developed a vignette recording sheet that focused preservice teachers' attention on mathematical practices and mathematical teaching practices. The recording sheet included four questions attending to the two practices along with one question about the relationship of this reflection and the preservice teachers own practice.

Wilkerson and colleagues developed this recording sheet because they had noticed preservice teachers were focusing on other details when observing case studies and videos. They wrote their own vignettes and developed the recording sheet to align the focus on mathematical and mathematical teaching practices. After their use, researchers found that preservice teachers tended to focus on the mathematical practices and mathematical teaching practices, even providing specific evidence rather than focusing on student behavior and other classroom details. Researchers felt this "...led to richer discussions about what each MP and MTP looks like in practice" (Wilkerson et al., 2018, p. 370). A common theme emerges in these two studies: intentional reflection can develop and shift focus, but it can be done in varying ways.

In addition to videos and vignettes, reflection on preservice teachers' own teaching can provide another opportunity for reflection. Cattley (2007) explored reflective practices in preservice teachers with eight participants who wrote reflective logs during their practicums. Prior to their reflective writings, preservice teachers were exposed to the four levels of quality reflection. Upon reviewing their logs and talking with participants, it was suggested that reflection on the breadth of their teaching role allowed them to develop their professional identity. Participants also verbally stated that the prompts were helpful in the reflection process. Cattley (2007) suggests: "there needs to be supportive structures in place in addition to setting a reflective writing task" as well as "the provision of a scaffold of suitable prompt questions" (p. 345). The development of prompts for reflection should be given much consideration.

For example, Lee and Ertmer (2006) developed question prompts for students watching instructional videos on technology implementation. While students working in groups showed an increase in perceptions of knowledge and efficacy, students working individually did not have an increase in perceptions of knowledge. Results indicated an unexpected finding from the prompted group and non-prompted group. The group without prompts experienced greater gains in perceptions of knowledge and skills as well as self-efficacy when working individually. Lee and Ertmer (2006) suggest:

> Question prompts that direct reflection could be more effective when they are not focused narrowly in specific directions. Prompts could be more effective if they afford learners the freedom to choose their own approaches to processing the information gained from vicarious experiences. (p. 76)

Determining what goals are targeted in the development of preservice teachers can help with the formulation of writing prompts to ensure their alignment with desired outcomes.

Another example of the implementation of reflection prompts is the study conducted by Jacobs, Lamb and Philipp (2010). This study looked at preservice and inservice teachers responses to prompts after viewing a video or a collection of student work. Comparisons were made on the number of years of participation in professional development. Researchers used prompts that focused attention on student's strategies, student's understanding, and future instructional decisions based on students' understanding. Based on their prompts, results indicated that attending to students' strategies and interpreting the understanding of the students increased with both years of experience and 2 years of participation in professional development. Similarly, how to respond and make instructional decisions increased with experience and 4 years of participation in the professional development program. The most shocking finding was the high levels of attending to students' strategies of the professional development participants in comparison to nonparticipants. Similarly, participants in the professional development focused on student understanding more than nonparticipants. Jacobs et al. (2010) suggest: "Thus, like expertise in attending, expertise in interpreting children's understandings is neither expertise adults routinely possess something that teachers generally develop solely from years of teaching" (p. 188).

The following study investigates question prompts and self-efficacy; tied to the aims of the present study. Lee and Ertmer (2006) investigated the relationship between questioning and self-efficacy, forming their study on the basis that group discussions and question prompts may affect self-efficacy through the use of vicarious experiences. Two groups of college students were compared: students that received question prompts or students that received a checklist of items to view. Although no significant differences were found between the two groups, Lee and Ertmer (2006) suggests that this may have been due to too narrowly focusing students on the questions as opposed to focusing on the vicarious experience. They suggested that question prompts avoid too narrowly focusing students.

The courses in teacher preparation programs and the experiences had during this time may be the last opportunity for preservice teachers to experience student-centered mathematics before entering into their own classrooms. Preservice teachers can be included in the classroom as active members in order to develop skills of reflection on their planning and implementation of lessons. Whereas many of the experiences preservice teachers have are vicarious, there is a need to make these experiences more meaningful, and reflective practices, specifically prompted reflection, could possibly provide that opportunity.

Use of Video for Reflection

There are many methods that researchers have used to capture teachers and preservice teachers' reflections: diaries, journals, and talk-aloud methods (Davis, 2006; Gabriele & Joram, 2007; Schmidt, Klusmann, Lüdtke, Möller, & Kunter, 2017). In addition to these methods, video observations and reflections offer additional opportunities for reflection. Videos offer a convenient scenario where the type of instruction can be carefully selected to target specific strategies. Additionally, video can be slowed down to allow preservice teachers to see the many components of classroom instruction and interaction between the teacher and the students. The following study conducted by Yung, Wong, Cheng, Hui, and Hodson (2007) was built not only on the implementation of videos, but the reflection upon the videos to develop analytical thinking. They found teachers viewed the videos as more useful as the course progressed. Researchers also recognized that not all of the videos should be of the desired instructional practices, as it can appear intimidating for them. Preservice teachers recognized the diversity of the videos amongst them and with their own experiences. Students also were able to compare the different teachers. By viewing videos that contained desired inquiry instruction, it allowed teachers to see how they could implement those practices when they may have originally thought it was not possible. The videos allowed students to view the content as many times as they would like to slow down the happenings in a classroom. Students were also asked to view a single video several times, allowing them to focus on different aspects each time (Yung et al., 2007). Upon interviewing their students after the use of videos for reflection, Yung and colleagues (2007) make several recommendations: use various levels of instruction, not only the desired strategies, reviewing similar teachers can increase the depth of student reflection, and the videos must be implemented with a specific learning goal in mind.

Similarly, Gelfuso (2016) implemented a “Teaching Cycle” where preservice participants preconferenced, taped a lesson, and post conference after the lesson with their teacher educator. During this time they reflected on the recorded lesson. Again, videos offering the opportunity for reflection. The videos allowed for deeper exploration of the lesson rather than relying solely on memory. The post conference was transcribed, and several themes emerged. One major theme was the role of the teacher educator as helping the preservice teachers identify different aspects of their instruction that might have been overlooked. The support of the teacher educator through intentional questioning drew preservice teachers’ attention to inconsistencies in their instruction (Gelfuso, 2016). Although this study was about literacy education, it highlights the support necessary for developing preservice teachers’ reflection.

Another study conducted by van Es, Cashen, Barnhart and Auger (2017) utilized videos for reflection followed by reflection prompts. Through their study, they aimed to focus teachers noticing on “ambitious” mathematics instruction. They selected videos that focused on cognitively demanding tasks to be able to include prompts that focused on student understanding. They showed the clip, followed by the prompts. Teachers were then asked to view the clip a second time and refine their responses to the prompts. Analysis of reflection occurred both over the length of the course and within the reflection times. Qualitative analysis revealed that their noticing practice developed over time, but in varying ways. It was also observed that reflections became more descriptive over the course and that “the course supported candidates in learning to notice classroom instruction in more substantive ways, attending to the details of the mathematics, student thinking, and the ways that classroom discourse and pedagogies for making thinking visible supported in student learning” (van Es et al., 2017, p. 181). Each of these studies, utilizing prompts or frameworks saw a shift in preservice teachers’ focus of reflection.

A slightly different approach used by Sun and van Es (2015), instead of prompts, they used a particular framework, Hiebert’s (2007) *Framework for Analyzing Teaching* and Rodgers’ (2002) *Reflective Cycle* in a teaching cohort when having mathematics preservice teachers analyze videos (as cited in Sun & Van Es, 2015). They compared this group to a cohort that did not use this framework. In comparison to the group that did not participate in the video analysis, the control group had three ways in which they sought responsive instruction. They made space for student thinking by providing time to think and inviting a wide range of ideas and allowing students to share their novel ideas. They also welcomed student ideas, using them for opportunities in class instruction. Lastly, they pursued students’ thinking by asking them to explain or reason through how they arrived at their solution. Participants in the course reached these three categories (making space for student thinking, attending to and taking up novel ideas, and pursuing students' ideas) of responsive teaching at a greater frequency than their non-video analysis cohort. Further analysis of the responses that focused on student thinking showed an emphasis on answers and procedural accuracy over reasoning and conceptual development. This study reveals two important findings: preservice mathematics teachers are capable of increasing their reflection with respect to responsive teaching, but they still need to develop skills to attend to students' reasoning and conceptual understanding (Sun & van Es, 2015). Again, preservice teachers became more responsive, but the researcher still highlights a need for further focus on student learning and understanding.

Benefits of video use for reflection and similar findings have also been found with inservice teachers. Sherin and Han (2004) used video clubs with inservice teachers as a part of a professional development. Participants included four mathematics teachers, two of which video-taped their classrooms for discussion in the video clubs. After transcription and analysis of all of the first seven clubs, a shift in what was discussed and how it was discussed was observed. The video club provided participants with the opportunity to reflect on classroom practices with peers, question strategies, and discuss possible changes. The two most discussed topics were students conceptions and teacher pedagogy. Initially, in the first video club, the four teachers focused mainly on pedagogy, but by the seventh video club, the main focus was on students' conceptions. The participating teachers shifted their focus to making sense of students' thinking. Researchers also prompted participants less in the later video clubs, and the focus continued to remain on students' conceptions. Not only did the focus of the video club change from pedagogy to student conceptions, but the way in which they discussed students' ideas changed. Initially, when discussing students' conceptions, teachers would only state what was said by a student. However, in the last three video clubs, teachers were more likely to generalize and synthesize student thinking. A shift was also observed in how they discussed pedagogical issues. Over the course of the video clubs, less emphasis was placed on what the teacher was doing and more was placed on how what the teacher did affected student thinking (Sherin & Han, 2004). These findings are important as it highlights the impact that research prompts had on teachers focus of reflection over time. It also sheds light on the idea that teachers will maintain this focus and rely less on the prompts, still focusing on student thinking.

Another framework, and a slightly different approach to video usage for reflection was implemented by Santagata and Angelici (2010). Researchers developed a framework based on the differences of novice and expert teachers, recognizing that novice teachers tend to stick to their lesson plans more rigidily and lack in flexibility, attuning to students needs like that of an expert teacher. Davis (2006) distinguishes between productive (connects various aspects of teaching, analytical) and unproductive reflection (aspects of teaching seen as independent, more descriptive in nature). The Lesson Analysis Framework (LAF) focused on four components: classroom lessons as units of analysis, learning goals, impact of teacher decisions on student learning, and proposing and justifying alternative strategies. Prior to working through the LAF, preservice teachers solved the task given to students in the video, were asked to predict student strategies, and were asked to identify other learning opportunities from the task. After watching the video, they then focused on the four component, LAF. In comparison to the group that did not use the LAF, LAF participants' reflections became more productive, providing critical analysis of teachers instruction and provided more detailed explanations for alternatives. Also, "LAF participants thought more deeply about student learning and the relationship between teacher instructional choices and student outcomes" (Santagata & Angelici, 2010, p. 345). Santagata and Angelici (2010) recommend: "These qualitative analyses highlighted the impact that specific prompts have on what preservice teachers attend to and reason about when observing a classroom lesson" (p. 348).

In another study, using the same framework previously mentioned, Santagata and Yeh (2014) used videos of teacher-student interactions, transcripts, and student work examples of lessons in a course with preservice teachers. In this course, they focused preservice teachers' attention with the Lesson Analysis Framework which includes a series of questions to focus their attention. Researchers used videos to help preservice teachers see and attend to student thinking, which was a focus of the course. This also allowed preservice teachers to see how the teacher in the video analyzed and reacted to student thinking. Preservice teachers then recorded their own lessons and reflected on them. To analyze student thinking in videos, preservice teachers were provided with two question prompts, asking for specific examples of each. Responses were coded on three levels: low sophistication (focus was on teacher), medium sophistication (focus was on student, not or minimally linked to learning goals), high sophistication (focus on student and linked to learning goals). Preservice teachers participating in the course made student thinking more visible during their recorded instruction and were able to build on students' thinking during instruction. Additionally, participants were able to analyze their own teaching, using evidence of student thinking with more sophistication:

> Although limited in scope by the small number of participants, this study also suggests that the ability to focus on students during both teaching and analysis is not something PST teachers can develop by simply completing fieldwork experiences (as evidenced by the outcomes of non-LLMT participants). Structured opportunities for developing these abilities in systematics ways need to be embedded in teacher preparation programs. (Santagata & Yeh, 2014, p. 33)

The studies discussed above, centered on the use of video for reflection, provide evidence that intentional reflection can shift the focus of both preservice and inservice teachers. Prompts and resources used must be intentional and centered around a common goal: focusing on student learning and thinking. For studies that did this, the shift in preservice and inservice teachers reflection changed from that of self to their students learning and understanding. Vicarious experiences focused on successful implementation of student-centered mathematics instruction, followed by focused reflection on students' understanding in the video, may provide an opportunity to develop preservice teachers' teaching self-efficacy.

Teacher Self-Efficacy and Reflection

Relationships of reflection and self-efficacy have been explored together before, often looking at how they correlate to one another (Lee & Ertmer, 2006; Noormohammadi, 2014; Phan, 2014; Ross & Bruce, 2007; Tavil, 2014). Reflection can occur through a variety of methods in teacher preparation programs: journals, videos, talk-alouds, debriefing sessions, frameworks, post-experiences, etc (Gabriele & Joram, 2007; Gelfuso, 2016; Sherin & Han, 2004; van Es et al., 2017; e.g.). Noormohammadi (2014) a study of 172 inservice teachers, three surveys were used to measure teacher reflectiveness, self-efficacy, and autonomy. Three areas for self-efficacy were used: student engagement, classroom management, and instructional strategy. Five areas of reflection were measured: practical reflection, cognitive reflection, metacognitive reflection, critical reflection, and learner reflection. When comparing the three areas of teacher self-efficacy with the five areas of teacher reflection, a significant positive correlation was found between the two. Four of the five areas of reflection (not critical reflection) were positively related to all three levels of self-efficacy (Noormohammadi, 2014).

Similarly, in a study conducted by Ross and Bruce (2007), implementation of active teacher learning, classroom examples, collaborative activities modeling desired instruction, reflection, practicing feedback, and focus on the mathematical content resulted in an increase in teacher efficacy. More specifically, following instruction, they used debriefing sessions for teachers to reflect on given prompts to highlight the successes of their peers (vicarious experiences). The results of the study indicate an increase in teacher efficacy, specifically classroom management, which is essential in a student-centered classroom. Many teachers do not feel confident in the implementation of student-centered tasks as it takes the control away from the teacher as the direct instructor, forcing more flexibility in the teachers’ instruction, as students are encouraged to take on more responsibility for their own learning. Acknowledgement of successful implementation and debriefing sessions to critically reflect on instruction were both important aspects in increasing the teachers' efficacy regarding classroom management (Ross & Bruce, 2007). Creating space for teachers to have a time of reflection can provide an opportunity to better understand instructive practices and increase self-efficacy.

Tavil (2014) used eJournals with 42 preservice teachers. Preservice teachers keeping eJournals had greater improvement in their self-efficacy in comparison to preservice teachers who did not keep eJournals over 14 weeks. In the semi-structured interviews, preservice teachers recognized the value of the eJournals on the development of their reflective thinking.

Phan (2014) conducted a short-term, longitudinal study over a two-year time span, collecting data at five different times over the course of four semesters for 269 college students. Looking at the results of students' self-efficacy and levels of reflection, "... the findings indicated the positive temporally displaced effects of self-efficacy on the four categories of reflective thinking…" (Phan, 2014, p. 98). Phan (2014) recognizes the importance of self-efficacy and reflection in the educational process and suggests that there is some evidence of interplay between self-efficacy and reflection, but additional research is needed in the formation of reflective thinking and use of student-centered instruction.

Methodologies in Related Literature

A review of studies examining teacher efficacy and reflection reveals that there are methodological pieces from various studies that can be knit together to target both mathematics teacher self-efficacy and reflection in preservice teachers in hopes of developing use of student-centered instruction. The following methods from each study that will be used in the present study are described in detail below. Smith III (1996) has several recommendations to help preservice teachers develop their efficacy: selecting problems that align with the cognitively demanding standards, predicting students' methods for solving, becoming the facilitator (instead of the direct instructor) of the classroom, and building on students' ideas when appropriate. Also suggested by Smith III (1996) is that focusing on these areas can help teachers in the development of their self-efficacy regarding the implementation of student-centered mathematics. Although researchers have explored this idea with practicing teachers, little work has been done in this area with preservice teachers.

Smith III (1996) analyzes the tension between self-efficacy in traditional mathematics education and student-centered education and the need to develop new foundations in student-centered mathematics for which teachers can base their self-efficacy on. Traditional mathematics efficacy was based on the ability to tell, but "...existing accounts of student-centered practice suggest at least four components of teaching that are promising sites for building and maintaining efficacy beliefs" (Smith III, 1996, p. 396). The four components of teaching considered are choosing problems, predicting student reasoning, generating and directing discourse, and judicious telling (Smith III, 1996).

In a similar fashion, Wilkerson et al. (2018) used an approach that included solving a mathematical task, viewing a vignette of students solving the same task, identifying mathematical and mathematical teaching practices, analyzing student work, and reflecting and connecting to their own practice. Teachers were provided with a recording sheet for each vignette that included four prompts. Of the most interest for this proposed study is the fourth prompt: “How does reflecting on this vignette inform your own practice? What will you take away from this vignette, or what connections can you make to your own teaching or future teaching?” (Wilkerson et al., 2018, p. 366).

In another study, Santagata and Angelici (2010) used the Lesson Analysis Framework (LAF) which “guides teachers to reason on teaching in terms of cause-effect relationships between instructional decisions and learning outcomes in classroom lessons” (p. 339). Participants were asked to solve the task, predict student solutions and difficulties, and discuss other learning opportunities that may arise prior to viewing a video of a teacher implementing the same task. Participants were then asked to reflect on student learning and instructional choices made in the video. These reflections were compared to a group of preservice teachers not implementing the LAF framework. The most significant finding from this study in relation to the present study was that “LAF participants thought more deeply about student learning and the relationship between teacher instructional choices and student outcomes” (Santagata & Angelici, 2010, p. 345). In all three of the studies discussed above, teachers were asked to solve a task and predict student solutions prior to observing either videos or vignettes. The proposed intervention implements the same ideas, but expands on them.

Video reflections have returned positive outcomes for many different scenarios and modes (Santagata & Angelici, 2010; Santagata, Zannoni, & Stigler, 2007; Sun & van Es, 2015; van Es et al., 2017; e.g.). Video reflections also allow for the slowing down and viewing of the same content many times. Santagata et al. (2007) looked at the use of video reflections on preservice teachers' instruction. Throughout the program, preservice teachers were to look deeper into teaching, beyond technical aspects. Projects in this program focused preservice teachers' attention on the "analyses of the content presented in lessons; of cause-effect relationships between teacher actions and student learning; and of students' thinking and understanding of specific concepts and ideas" (p. 126). Despite the short time period, preservice teachers' reflections focused more on the cause-effect of teachers actions and students learning, and they also became more critical throughout their reflections (Santagata et al., 2007).

Another study conducted by van Es et al. (2017) utilized both videos and specific prompts. Researchers selected videos that focused on cognitively demanding tasks and implemented prompts that focused on student understanding. The clip was shown, then followed by prompts. Participants were then asked to view the clip a second time and refine their responses to the prompts. Qualitative analysis revealed that reflections became more descriptive over the course and including attending to student learning. Each of these studies, utilizing prompts or frameworks saw a shift in preservice teachers' focus of reflection. As this study aims to develop the focus preservice teachers' reflections, it is reasonable to use a similar format to shift their focus to student understanding and not self-concern.

Findings from the pilot study conducted with twenty secondary preservice mathematics teachers were similar in the nature of preservice teachers' reflections following the recommended intervention. Specifically, preservice teachers in this pilot study focused more on student thinking and student understanding. The prompts utilized following videos were focused on student understanding while allowing participants to select students from the video to write about in these reflections. Additionally, an increase in *Teachers Sense of Efficacy Scale* (TSES) was observed in mean self-efficacy scores, suggesting the use of reflective prompts may have indirectly increased self-efficacy.

Rationale for Qualitative Data

The studies reviewed above support the use of videos, prompted reflection, and prompts that focus on student learning and understanding to enhance reflection by preservice teachers. Qualitative analysis in Gelfuso (2016), Jacobs et al. (2010), Sun and van Es (2015), van Es et al. (2017), Wilkerson et al. (2018), Yung et al. (2007), e.g. provided insight for researchers to view what teachers were reflecting on initially and after the intervention. In a similar format, qualitative analysis may permit the discovery of what consistencies or inconsistencies preservice elementary teachers may have in viewing a video of teacher and students interacting with a task. Additionally, qualitative analysis of mathematics teacher self-efficacy data can provide insight on how preservice elementary teachers view teaching mathematics. Lastly, qualitative analysis of lesson plans can demonstrate the instructional choices PSTs make prior to and following an intervention.

Gaps in Literature

After synthesizing eleven years of research and looking at self-efficacy study methodologies, Klassen, Tze, Betts and Gordon (2011) recognize an increase in qualitative research of teacher self-efficacy, but still highlight a need for more qualitative and longitudinal studies, as well as more mixed-methods studies. In addition, they suggest case studies could add to this body of literature to deepen understanding about teacher self-efficacy. “Research investigating the sources of teacher efficacy would help explain the process by which teacher efficacy develops and might lead to insights into how to better enhance the self- and collective efficacy of teachers” (Klassen et al., 2011, p. 24). Santagata et al. (2007) also notes the lack of studies that include specific observation frameworks and protocols.

Not only are there areas lacking in qualitative and longitudinal research studies, but there are areas of need regarding what studies are focusing on. Klassen et al. (2011) recognize the importance of researching sources of efficacy, stating: “Insufficient attention has been paid to the sources of teachers’ self- and collective efficacy, and progress in teacher efficacy research has suffered as a result” (p. 31). To address the concerns of teacher focus in reflection and instruction, prompting and focusing questions can guide preservice teachers toward specifics aspects of instruction to focus on, like student learning and understanding (Jacobs et al., 2010; Santagata & Angelici, 2010; Santagata & Yeh, 2014; Sherin & Han, 2004; van Es et al., 2017).

Reflection regarding student-centered mathematics can provide insight for other content areas, but would greatly contribute to the issue of lack of implementation of student-centered instruction. Klassen et al. (2011) suggest to continue research in both general teaching efficacy that can be applied and related to most teaching situations and domain-specific situations. Klassen et al. (2011) also recommend investigations that differentiate on teaching levels can add to literature on how the context can play a role in teacher efficacy beliefs. Smith III (1996) also suggests that research on teacher self-efficacy

> ...should focus on how teacher themselves *see and understand the effects of their teaching practice on students*, not on how others (usually researchers) assess their practice relative to reform principles. The goal of efficacy studies is to characterize teachers' responses to the pedagogical question, 'When am I doing a good job?' Understanding their answers will in turn depend on understanding the kind of evidence they identify and take to be centrally relevant to that question. (p. 399)

Many of the studies discussed above focus on teacher self-efficacy or general self-efficacy with few specifically on mathematics teaching self-efficacy. In a field where instructional styles are encouraged, further exploration is needed, specifically for mathematics teachers.

This study is motivated by a recognition of the obstacles teachers are facing when implementing student-centered mathematics and how to change their perceptions of self-efficacy through prompted reflective practices in order to help them persevere through these known struggles. There are positive implications regarding reflective practices in education settings. However, there is a gap in the literature addressing prompted reflection and its role in vicarious experiences for preservice teachers in mathematics education. Addressing this gap could further our knowledge of how to better prepare preservice teachers in the implementation of student-centered practices that provide the foundation for student-centered mathematics.

Purpose of Study

Ward and McCotter (2004) suggest a need for the identification of lower levels of reflection to provide preservice teachers with the necessary assistance to increase their level of reflection. Ward and McCotter (2004) identified a reflection matrix to assist in the identification of level of reflection. By identifying the level, they believe it is useful in the development of preservice teachers' reflections as they are able understand the expectation of good reflection. They also recognize the usefulness of this matrix as a research tool to identify the level of reflection in varying strategies (i.e. journals, cases, etc.).

The question remains as to why student-centered mathematics is not being implemented by all mathematics teachers. Despite the known challenges teachers face in the initial and following years of teaching such as content knowledge, time availability, resources, workloads, and proper professional development, many teachers continue to struggle with persevering student-centered mathematics teaching (Handal, 2003; Steele, 2001; Yost, 2006; Zeichner & Tabachnick, 1981). As previously mentioned, teachers who completed a student-centered methods course held views and beliefs in their initial years of teaching similar to those held in their teacher preparation programs (Marbach-Ad & McGinnis, 2009). If teachers are able to establish high self-efficacy and teaching efficacy in their preparation programs, hopefully they will continue with student-centered mathematics despite facing the many obstacles of effective teaching (Marbach-Ad & McGinnis). If teachers are able to increase their self-efficacy through student-centered methods courses that offer opportunities for mastery and vicarious experiences followed by reflection, it is necessary to further explore how to create reflections that target student-centered learning in mathematics education.

CHAPTER 3

METHODOLOGY

This study investigated the intervention of prompted reflection focusing on student understanding and assessed preservice elementary teachers' mathematics teaching self-efficacy over the course of eight weeks. The research design used was a qualitative study to investigate the changes in focus of preservice teachers' reflections, mathematics teacher self-efficacy, and nature of lesson plans over the eight-week mathematics methods course, and it is described in detail throughout this chapter. To understand how the focus of preservice elementary mathematics teachers' reflection and their perceptions about mathematics teaching changed over time, a qualitative design was used to investigate these changes.

To begin, the research questions will first be posed followed by a description of the qualitative measures that will be used during this study. Next, a description of participants will be provided. Additionally, to address the concern of coercion, as the researcher was also their teacher, a description of how this was navigated will be included. This will be followed by a brief overview of literature and a detailed description of the intervention that is to take place. Lastly, a discussion will follow the contributions this study has to the field of educating mathematics teachers.

Research Questions

1. What is the nature of preservice teachers' reflections on mathematics lessons over time, as they engage in use of prompted reflections focused on students' understanding of mathematical content?

2. What is the nature of preservice teachers' mathematical teaching self-efficacy over time, as they engage in use of prompted reflections focused on students' understanding of mathematical content?

3. What is the nature of preservice teachers' use of student-centered methods in mathematics instruction after they have engaged in the reflective activities embedded in the intervention, as reflected in their lesson plans?

Participants

Participants included five preservice elementary teachers enrolled in a small, midwestern university in the United States. All preservice teachers were enrolled in an elementary teaching program and were in their third and fourth years of the program. None of the preservice teachers had taken a mathematics methods course prior to this course as this is the only mathematics methods course required for their degree. All preservice teachers enrolled in this course had completed a mathematical content course according to their intended grade level of interest.

All seven preservice teachers enrolled in the course were invited to participate in this study during the fifth week of their elementary mathematics methods course. At this time, participants were asked for the allowance of the use of their class work in this study, as outlined and agreed upon with the University of Northern Iowa Institutional Review Board. Participant consent was gathered by Abby Weiland to ensure preservice teachers did not feel obligated to participate as I, the researcher, was also their instructor.

Only the preservice teachers who read and signed the proposed University of Northern Iowa Institutional Review Board consent form were included in the study. Of the seven preservice teachers invited to participate in the study, five consented. Participants that consented to the study were enrolled in the elementary or early education preservice teacher track. All five participants were white; four participants were female, and one participant was male. Participants were between the ages of 25 to 40.

This particular mathematics methods course covered mathematical content for grades kindergarten through eighth grade and included a variety of activities for preservice elementary and middle level teachers. The course was designed in a way to develop mathematical thinking, focusing on a main area of mathematical content each week. Videos were selected to align with the content discussed in class. For example, the bubble gum task focused on fractions was used during the week fractions and rational numbers were the content focus for the course. To see additional alignment of videos with course content, see Table 1.

Table 1

Video Alignment with Course Content in Intervention

Week	Mathematical Concepts Targeted in Course	Video
1	Introduction to Mathematical Teaching Practices	Donuts (operations and algebraic thinking, counting and cardinality)
2	Mathematical Problem Solving	Addition Strings (number and operations in base ten)
3	Developing Number Concepts Whole Number Concepts	Multiplication Strings (understand properties of multiplication and the relationship between multiplication and division)
4	Fraction Concepts and Computation	Bubble Gum (developing understanding of fractions as numbers)
5	Decimal Concepts and Computation Developing Algebraic Thinking	Counting Cubes (construct a function to model a linear relationship)
6	Developing Algebraic Thinking (continued) Developing Geometric Thinking	Hexagons (construct a function to model a linear relationship)
7	Developing Geometric Thinking (continued) Collecting, Organizing, and Interpreting Data	Half of a Whole (recognize equivalent fractions and understand equivalence as the same size)
8	Sharing Multiplication Lessons	Donuts Triangle (recognize the relationship between the area of a triangle and rectangle, generate the formula for area of a triangle)

Outline of Study

Pre-Intervention

Prior to partaking in the intervention, participants were asked to explain how much they agreed or disagreed with the following statements selected from the *Mathematics Teaching Efficacy Beliefs Inventory* (MTEBI). This instrument was designed and validated to quantitatively analyze elementary teachers' self-efficacy beliefs about mathematics teaching (Enochs et al., 2000). Due to the nature of this study and the proposed research questions, further descriptions and explanations were needed to understand preservice teachers' conceptions about their ability to teach mathematics education effectively. The original MTEBI was designed to have questions regarding both self-efficacy and outcome expectancy (the two components of self-efficacy). Three questions of both types were included in the open-ended questions asked to participants prior to and following the intervention. Questions from the MTEBI (see Appendix A) were asked of participants on the first day of class, prior to partaking in any course activities or video observations. The following is an example of the questions asked: Even if I try hard, I will not teach mathematics as well as I will teach most subjects. (self-efficacy)

Additionally, participants were asked to create a lesson plan on the mathematical concept of multiplication in a grade level of their choice prior to watching the first video. A lesson plan template (see Appendix E) was provided to participants; the lesson plan template was student-centered in nature, based on *Thinking Through a Lesson Plan*

Protocol (Smith, Bill, & Hughes, 2008). Participants were asked questions (see Appendix C) regarding their lesson plans; for example:

How confident are you that this lesson would be effective in helping students understand the mathematical concepts? Please explain your reasoning for your response..

Intervention

This particular elementary mathematics methods course is eight weeks long with each class lasting approximately five hours. During each of the eight classes, participants were asked to do the following. Prior to observing a video, preservice teachers were asked to solve a task and identify possible student solutions, followed by a class discussion of different strategies. Preservice teachers were then asked to observe a video from the National Council of Teachers of Mathematics (NCTM) Toolkit (see Appendix D); videos ranged in content from kindergarten through eighth grade. Videos included students solving a task and interacting with peers and the teacher.

Following the observation of the video, preservice teachers were asked to reflect on the video. Reflection prompts had been adapted from two sources. The first three prompts were adapted from a pilot study conducted with preservice secondary mathematics teachers. Findings indicated a need to specifically address the mathematical concepts targeted in the reflection prompts. The fourth prompt was adapted from a framework used by Wilkerson et al. (2018). In their framework, teachers looked at vignettes; the adaptation made was changing the word vignette to video. These reflections were prompted by questions tailored to each mathematical concept exhibited in the video. See Appendix B for all video reflection prompts; an example of a question is:

Specific to the mathematical concept of ________, how did the student(s) in the video demonstrate their understanding? Provide specific examples. Following individual video reflections, a whole class discussion was held about the video.

Post-Intervention

At the end of the course, participants were asked the same adapted MTEBI questions regarding mathematics teaching self-efficacy (see Appendix A) in the final class, after having partaken in classroom activities and video observations and reflections. Participants were again assigned to create a lesson plan on multiplication to be implemented with an elementary grade level of their choice. Participants were asked the same questions (see Appendix C) regarding their lesson plans that were asked following their initial lesson plan prior to the intervention. Participants also completed an open-ended course reflection. Alignment of the pre-intervention, intervention, and post-intervention data sources are depicted in Table 2.

Table 2

Data Sources Aligned with Intervention

Week 1 (Pre-Intervention)	Weeks 2-7 (Intervention)	Week 8 (Post-Intervention)

• Initial Lesson Plan
• Lesson Plan Reflection Questions
• Mathematics Teacher Self-Efficacy Questions
• Video 1
  ○ Donuts
• Video Reflection Questions
	• Videos 2-7:
	  ○ **2:** Addition Strings
	  ○ **3:** Multiplication Strings
	  ○ **4:** Bubble Gum
	  ○ **5:** Counting Cubes
	  ○ **6:** Hexagon
	  ○ **7:** Half of a Whole
	• Prompted Video Reflection Questions
		• Final Lesson Plan
		• Lesson Plan Reflection Questions
		• Mathematics Teacher Self-Efficacy Questions
		• Video 8/9
		  ○ Donuts
		  ○ Triangle
		• Video Reflection Questions
		• Course Reflections

Contributions to the Field

While NCTM's *Principle to Actions* (2014) standards acknowledge student-centered practices to be the best for students, there continues to be a lack of implementation of these methods (Handal, 2003; Steele, 2001; Zeichner & Tabachnick, 1981). Teachers with higher-efficacy are more likely to implement student-centered and student-centered methods and implement new strategies (Chatzistamatiou et al., 2014; Depaepe & König, 2018; Ross & Bruce, 2007; Zee & Koomen, 2016) Therefore, it is necessary to increase teachers' efficacy in hopes of a wider implementation of student-centered mathematics. Helping preservice teachers develop a strong sense of self-efficacy may help them persevere in facing the encountered obstacles.

Prompting preservice teachers prior to their observations and providing opportunities for reflection could possibly address these issues and increase the implementation of student-centered mathematics in their initial years of teaching. A deeper understanding about the development of preservice teachers' beliefs, can better inform the development of methods courses in teacher preparation programs that contribute to the development of quality mathematics teachers.

Analysis of Data

Each research question will be listed with intended analysis of data to answer the question.

Research Question 1

What is the nature of preservice teachers' reflections on mathematics lessons over time, as they engage in use of prompted reflections focused on students' understanding of mathematical content?

Data was gathered from the weekly, written, prompted video reflections. Reflection responses were compiled and analyzed using open coding and analytic induction to develop codes and sub-codes (Bogdan & Biklen, 1992; Merriam & Tisdell, 2015). Codes were created by looking at the subject of the reflection responses: Students, Teachers, Tasks, and Self (see Appendix F). Sub-codes were then created to capture the different characteristics and aspects within each subject. For example, the initial code may have been Students, but references could have been made to (1) their understanding; (2) their specific solutions to a task; (3) misconceptions, etc. (see Appendix F for additional codes and sub-codes).

The coding scheme was initially developed in the pilot study with the implementation of this intervention. During this process, researchers added new codes to the original coding schemed and also collapsed or deleted any unnecessary codes that did not apply to the video reflections. However, additional sub-codes were added as additional topics of reflection arose. Two researchers separately coded reflections, discussed assigned codes and came to agreement on the coding scheme. This occurred for all pre- and post-intervention video reflections.

Research Question 2

What is the nature of preservice teachers' mathematical teaching self-efficacy over time, as they engage in use of prompted reflections focused on students' understanding of mathematical content?

The written open-ended questions regarding participants' mathematics teaching self-efficacy beliefs prior to and following the intervention were analyzed using open coding within thematic analysis (Braun, Clarke, & Terry, 2014). Thematic analysis as outlined by Braun et al. (2014) focuses on identifying relevant themes across a data set attuned to answering the research questions through six phases.

The six phases of thematic analysis suggested by Braun et al. (2014) are described below. The first phase of thematic analysis is familiarizing oneself with the data through reading and rereading through the data multiple times to begin thinking about what the data means. Following the initial phase is the second phase of creating initial codes for the data. Determining the codes, beginning with the first code of relevance and coding all data, and continuing in this manner until all data in the set has been assigned some code.

Once all data is coded, the third phase includes searching for themes within the coded data. This may include looking for similarities or commonalities, but the main goal is to develop a relationship between the themes that will eventually help tell the story of the data. The fourth phase, reviewing themes, is similar to the previous stage, but differs in examining the already established themes. While the fourth phase is also recursive in nature, more emphasis is placed on whether the themes truly capture the entire data set and are able to tell the story of the data. The fifth phase includes defining and naming the themes previously established. In describing the themes, it is also important during this phase to look at extracts of data that could be used to enhance the understanding of the reader. This may be through quotations or narrating the data in a way for the reader to understand and make meaning of the data. The final phase of this analysis is producing the report to share findings from the data (Braun et al., 2014).

Research Question 3

What is the nature of preservice teachers' use of student-centered methods in mathematics instruction after they have engaged in the reflective activities embedded in the intervention, as reflected in their lesson plans?

Written lesson plans will be gathered at the last class. Upon gathering them, analysis of the characteristics of the lesson plans and responses to the written questions will be done. Lesson plans may provide insights about participants' focus of instruction and use (or lack of) student-centered instruction. Written questions regarding the lesson plans may provide insights on participants confidence in implementing a mathematics lesson and their judgement criteria for student learning.

Reflection responses to lesson plans, videos, responses to mathematics teaching efficacy, and interviews will be compiled separately and analyzed using open coding in thematic analysis. Thematic analysis of this data aligns with the data gathered in this study as it is exploratory in nature. Similar to the second research question, this research question, too, is explorative in nature, thus thematic analysis was used to interpret the data (Braun et al., 2014).

The thematic analysis method is fitting for this study as it allows for themes to be representative across multiple data sources that are relevant to the second and third research questions. As the research questions are explorative and experiential, the flexibility of thematic analysis is insightful on the experiences and shared meanings within the data.

CHAPTER 4

RESULTS

Introduction

The results following an intervention are described below. The intervention included utilizing reflective prompts focused on student understanding and the role of the teacher in the development of students' understanding following the observation of a video. The intervention included videos demonstrating student-centered mathematics and student-teacher interaction within small group or whole-class discussion. Reflective prompts given after the video observation were used to focus PSTs on the students' understanding and the role of the teacher in the development of this understanding in weeks two through seven of the course. The video reflections referred to in the results section are responses to general prompts utilized prior to and following the intervention in weeks one and eight.

Following the intervention, changes were observed in the focus of PSTs' video reflections, lesson plans, lesson plan reflections, and in responses to both mathematics self-efficacy and outcome expectancy questions following the intervention. The shift in these responses and reflections were reiterated in PSTs' overall course reflections. Course reflections provided insight about what PSTs valued in the course and how they felt their conception of mathematics teaching changed over the course.

Findings aligned with the research questions are organized vertically within Figure 1: video reflection themes in column two, mathematics teaching efficacy in column three, and lesson plans in column four. The research questions are tied to and align with the overarching themes within the data, as depicted in Figure 1. They will be described in detail below.

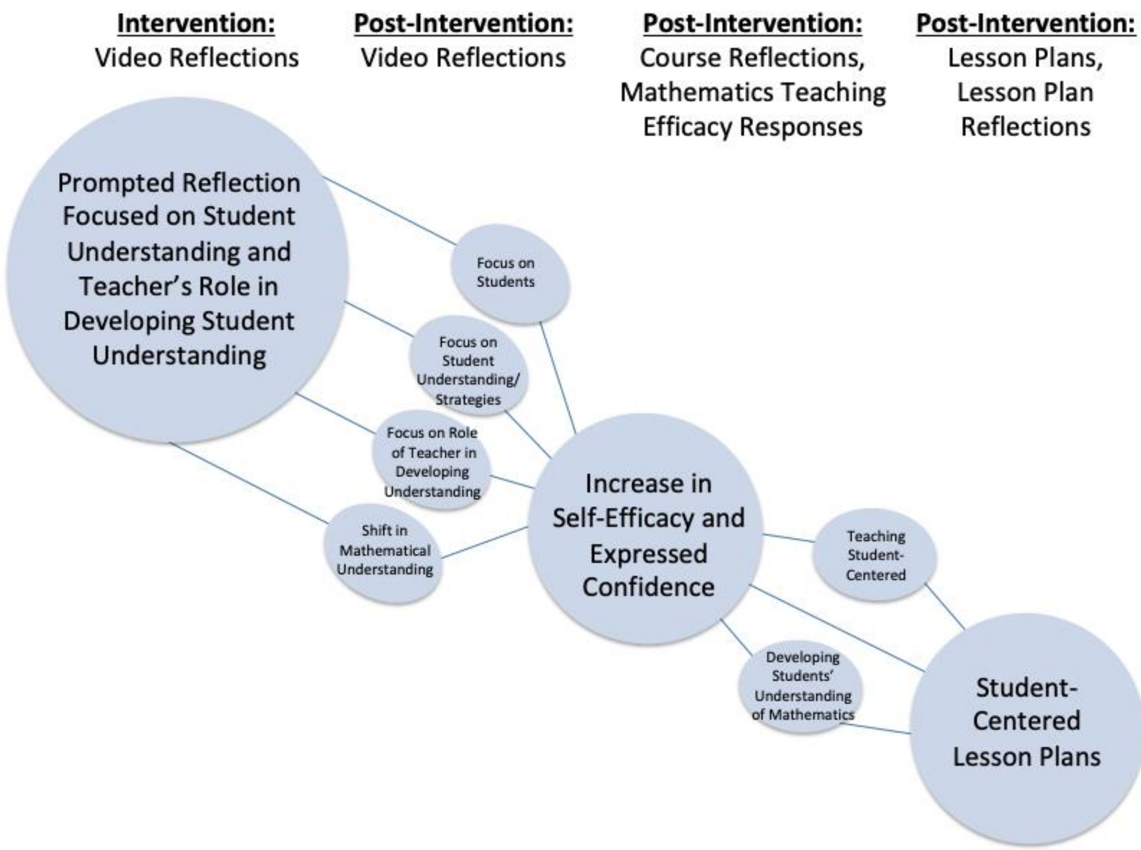
As thematic analysis emphasizes the importance of theme order, the first three themes are ordered sequentially in column two: “focus on students” (specifically strategies and understanding), “focus on the role of the teacher,” and “shift in what it means to instruct for and demonstrate mathematical understanding.” These themes aligned across all data sources, but specifically align with video reflections, answering research question one.

The fourth overarching theme, “shifts in mathematics teaching efficacy”, drew upon the three previous themes as PSTs displayed their confidence and mathematics teaching efficacy from these focal points. PSTs expressed confidence in their ability to instruct using student-centered approaches and develop students’ mathematical understanding (as the teacher), aligning with Research Question 2. This is displayed in the third column of Figure 1, as PSTs expressed their confidence and efficacy from these main themes.

Similarly, the shifts observed in lesson plans focused on student-centered instruction and ability to develop student understanding of mathematics, demonstrating their ability to depict student-centered instruction, aligning with Research Question 3. PSTs’ focus on students, the role of the teacher, and shift in what it means to demonstrate mathematical understanding are evident in their final lesson plans, aligning the final research question with the holistic themes across the data sources. First, a description of results will be aligned with the three research questions and corresponding data sources, followed by a holistic view of results aligned with themes across all data sources.

Figure 1

Shifts Observed Across Data Sources Following the Intervention



Research Question 1: Video Reflection Results

Following the intervention, a shift observed in content of video reflections was observed PSTs were asked to reflect on videos observed prior to and following the intervention. Four main shifts were observed in video reflections. First, PSTs focused more on students in video reflections following the intervention in comparison to before the intervention, specifically reflecting on student understanding and students' specific solutions and strategies to the task versus general engagement of the students. With this shift in focus on students, a slight decrease was observed in video reflections focused on the teacher following the intervention. Second, with respect to the PSTs' teacher observations, there was an increase in their focus on what the teacher was doing in the video to address or further student understanding rather than general facilitation of the classroom. Third, when comparing reflections on the same task (Donuts), prior to and following the intervention, PSTs reflected more on task concerns and made specific references to the underlying mathematical concepts inherent in the task following the intervention. Finally, with respect to self-concerns, PSTs completed fewer video reflections that voiced self-concerns; for example, they referred to aspects of the videos that they "liked" or "disliked". Their self-concerns in video reflections following the intervention focused more on students and inferences drawn about student understanding; PSTs made more inferences about the students and their level of understanding in the video. Examples of student reflections will be provided below, aligned with the overarching themes of the data.

A noteworthy aspect of PSTs' course reflections is that all PSTs mentioned the use of videos/tasks in their course reflections as something they valued in the course. PSTs referenced their use in challenging their thinking and developing their understanding. For example, Adam (participants' names have been replaced with pseudonyms), referring to the videos said, "Another aspect of the class, that I felt changed my thought process, was watching the other teachers perform in the classroom." Another PST, Bonita said,

> Having a task-based lesson was something new to me so seeing it in action in a variety of different ways was the key to me understanding the importance of using it in a classroom. I enjoyed watching the videos from class to see how they can be played out in elementary classes.

A different PST, Claire, expressed their enjoyment of this aspect of class as they felt challenged as learners, too:

> These [tasks] were a great way for us to actively think about student strategies and the steps they would take to solve these. I struggled my way through them almost every week, but I enjoyed this part of class the most.

All PSTs referenced the videos/implementation of tasks, valuing different aspects. Additional examples of observed shifts in reflection focus will be located within overall themes.

Research Question 2: Mathematics Teaching Efficacy

PSTs were asked six questions from the *Mathematics Teaching Efficacy Beliefs Inventory* (MTEBI) before and after the intervention: three questions pertaining to outcome expectancy and three questions pertaining to mathematics teaching efficacy. When PSTs were asked questions specific to their mathematics teaching efficacy and outcome expectancy, changes were observed in responses gathered before and after the intervention.

With respect to outcome expectancy written responses, two main themes emerged. Prior to the intervention, PSTs expressed many outside variables as playing a significant role in students' understanding in response to outcome expectancy questions; after the intervention, PSTs expressed the importance of the teachers' role in developing student understanding. Along with this shift in the role of teachers, PSTs also articulated a shift in the type of classroom environment conducive to mathematics teaching. PSTs were more specific, making more detailed statements after the intervention, in the type of learning environment they thought teachers should create for effective mathematics instruction.

Two main themes emerged from an examination of the mathematics efficacy questions. PSTs were more confident in their teaching ability and ability to facilitate a mathematics classroom environment in their mathematics efficacy responses following the intervention. Secondly, PSTs related what they believe they personally can do in their own classrooms with future students to develop future students' understanding of mathematics.

Additionally, PSTs expressed confidence in course reflections, specifically referencing confidence in their ability to instruct using student-centered methods and in their ability to develop student understanding of mathematics. Both efficacy and expressed confidence will be described in detail within theme four below.

Research Question 3: Lesson Plans

All PSTs created lesson plans prior to the intervention using the lesson plan template (see Appendix E) aligned with *Thinking Through a Lesson: Successfully*

Implementing High-Level Tasks (Smith, Bill, & Hughes, 2008). Lesson plan templates include a launch, explore, and summary of a mathematical task. Following the intervention, four main shifts in the content and focus of lesson plans were observed: 1) Lesson plans became more student-centered; 2) More lesson plans utilized a task that allowed for multiple solutions; 3) PSTs were able to articulate how their lessons allowed for the exploration of the mathematical concept; and 4) Lesson plans assessed student understanding through questioning and written work throughout the lesson in addition to at the end of the lesson.

Prior to the intervention, all PSTs demonstrated some sort of teacher modeling of mathematics during the launch or explore phase. Additionally, all PSTs were incomplete in their lesson plans, missing one or more sections of the template. Only two of the five PSTs completed the rationale for how their task allowed exploration of the mathematical concept. However, these were not explanations for how the task allowed exploration of the mathematical concept; instead, both described how the task aligned with the content standard, omitting how it provided an opportunity for exploration. Additionally, in the initial lesson plans, none of the PSTs included questioning unique to possible student thinking. All questioning in the lesson plans prior to the intervention focused on questions regarding procedural computations, with the goal seeming to be to funnel students towards the exact way the teacher wanted the problem solved. To see a complete example of one PST's lesson plan prior to and following the intervention, see Appendix H.

Shifts were also observed in PSTs' reflections on their lesson plans created prior to and following the intervention. PSTs wrote lesson plans on the mathematical concept of multiplication in elementary grades three through five. Prior to the intervention, PSTs were more general in their responses about the effectiveness of their lesson, viewing student understanding as exhibited through written work and summative assessments. They expressed confidence in their own understanding of the mathematical concept in their lesson plans. Two main shifts were observed following the intervention; 1) PSTs expressed more confidence and specific examples of how they would teach their lessons for student understanding, providing specific examples of how they would check for understanding through formative and summative assessments, students' explanations, and the allowance of multiple strategies and; 2) PSTs also shifted their understanding about what it meant to teach the lesson effectively, focusing more on their flexibility in implementation, and the need to meet multiple students' needs. Lesson plan reflection responses following the intervention were less about the specific content of mathematics in their lesson plans and more about the facilitation of the classroom to develop student understanding. Specific examples and changes are provided below.

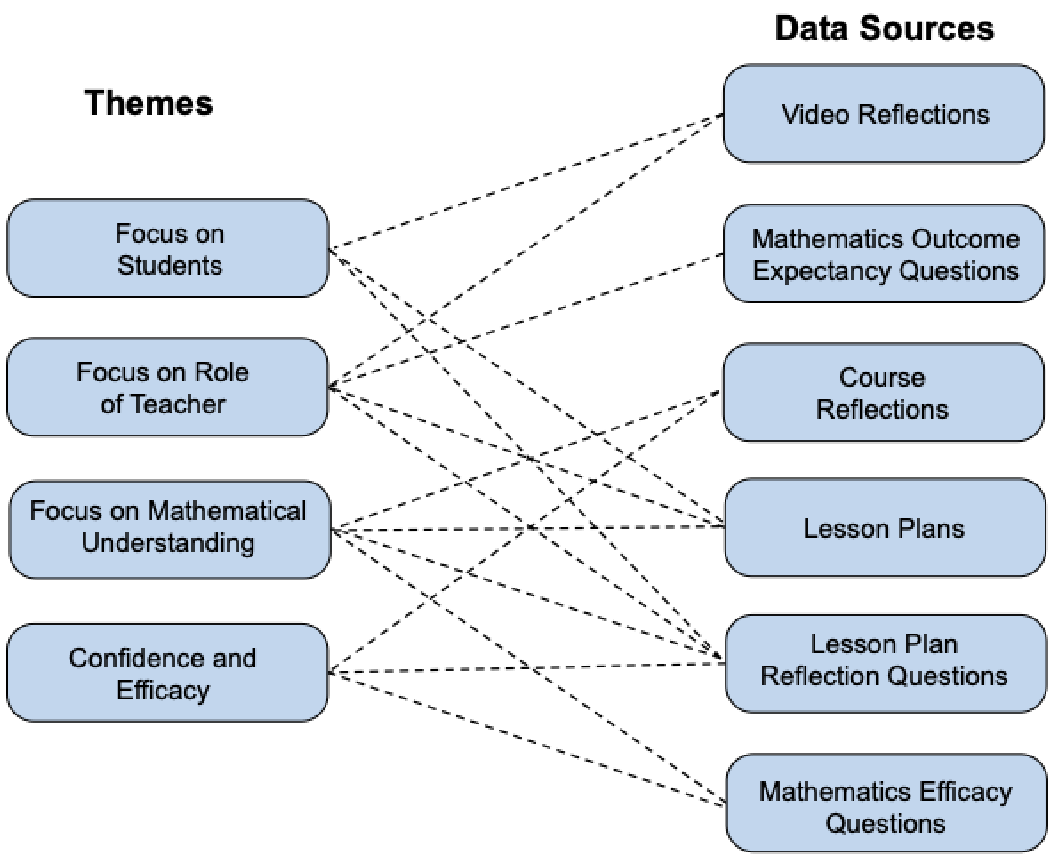
The overarching themes holistically representing all data sources will now be described in detail below.

Main Themes Across All Data Sources

The four main themes from an analysis of all sources of data were: shifting from a focus on oneself to a greater focus on students, a change in the perceived role of the teacher in mathematics education, a shift in understanding of mathematics and mathematics education, and an expressed increase in confidence of mathematics teaching ability following the intervention. The relationships among the four main themes and each set of data is represented in Figure 2. Each theme reflects all data sets holistically. Within each of the four overarching themes, the analyses revealed sub-themes which are described in detail below.

Figure 2

Visual Relationship Between Four Holistic Themes and Individual Data Sources



Theme 1: Shift in Focus on Students

The shift in focus on students was observed in video reflections, lesson plans and lesson plan reflection questions. In all three data sources, a greater emphasis was placed on students following the intervention. The specific changes in focus on students will be described in detail below, aligned with the three sub-themes: greater attention paid to the development of student understanding, references made to specific strategies, and PSTs drawing more inferences about student understanding.

Shift in focus on students: Focus on student understanding. There appeared to be a greater focus on students and student understanding following the intervention. For example, following the intervention, PSTs reflected more on students (43.1% of video reflections) in comparison with prior to the intervention; regardless of whether PSTs viewed the same video they had previously seen (21.9% of video reflections) prior to the intervention or a different one (35.4% of video reflections), the percent of their reflections that focused on students increased. A shift in the focus of these student-related video reflections was also observed as PSTs focused more on the development of students' understanding.

Fewer video reflections focused on student understanding prior to the intervention; most video reflection comments about students referred to general engagement of students. For example, Denise said, "The students were excited and engaged in the learning." Another PST, Claire, referring generally to student engagement said, "Multiple students were able to come to the front of the class and be an active part in the learning of this lesson." The focus of these video reflections was on students' overall engagement in the lesson versus their individual understanding of the content. As previously mentioned, a shift to reflecting on student understanding was observed in video reflections following the intervention with the same video.

The same participant, Claire, watched the video following the intervention, focusing on student understanding, specifically referencing two student methods exhibited in the class: “I think the students were able to grasp the concept. Students used counting on to show that either way the problem was written, the answer would be the same.” Adam referred to student understanding through their verbal responses: “The students were verbal with their understanding of the concept and explained their thinking when asked too.”

This shift in focusing on students’ understanding in video reflections was also observed in reflections after a different video following the intervention; PSTs reflections more frequently focused on student understanding. For example, Bonita said, “Once the students were able to see the visual representation on the board. I believe that some of the students who may have been struggling could see how each of the two formulas worked for this given problem.” Another PST specifically referenced students who understood and students who did not understand the concept, Eleanor stated, “I feel like the students were basically saying the same things, repeated from one student to another. Only 3 students really grasped the topic, while one was completely lost.” Video reflections shifted from more general statements about student understanding to often providing more specific examples and explanations of student understandings in videos.

Similarly, shifts in the focus on students were to student understanding was also observed in lesson plan reflection questions. PSTs articulated how they would assess student understanding, which changed in lesson plan reflection questions following the intervention. Similar to video reflections, PSTs described the role of students' verbal explanations to demonstrate understanding following the intervention. When asked about how they would know if students understood the mathematical concepts in their lesson plans prior to the intervention, all participants said that they would observe student understanding through written performance and correct answers via homework, worksheets, exit tickets, and observation of writing in group work. Claire said, "The "exit ticket" assessment piece of this lesson will show me if students are successfully understanding this concept." Another PST, Adam, said, "Students will be able to identify the operation used through rewriting new story problems. TTW [The teachers will] be able to look at their written work and through discussion if the students are able to find the product." Similarly, Denise referenced the exact strategy they would model: "The students are able to compute the answer and show their work by using the new strategy." All participants made use of a summative evaluation to indicate the level of student understanding at the end of the lesson.

In contrast to the lesson plan reflection questions prior to the intervention, following the intervention, PSTs were specific in how they would know students understood the mathematical concept of their lesson through multiple means: formative assessment, explanation and justification, and allowance of the use of multiple strategies. Many PSTs reference a "task," or problem they used to engage students with the targeted mathematical concept. Tasks are to allow for multiple strategies and solutions with the intent of students exploring mathematical concepts rather than being provided with a single method used to solve. One PST, Eleanor, referenced the use of an exit ticket (a written response to a problem to do a quick check for understanding), but also showed value for what was happening throughout the lesson:

> The exit ticket is the grand summation of the lesson, but it's at the end. I would walk around during the explore phase to see which of my students was A) understanding the information and B) using the different strategies. The basic to more complex strategies offers some insight into student understanding and helps me know where I need to funnel my emphasis for later.

Similarly, Bonita said,

> The variety of different assessments I add to the lesson will show if they are understanding the concept. Discussion and explanation of their strategies is where I will learn the most about their understanding during the lesson and the exit ticket will show me that they can take what they learned and apply it to a similar problem.

Both PSTs still used an exit ticket, but relied on other modes of assessment to check for student understanding. Another PST (Adam) specified the use of students explaining their reasoning to them to check for understanding throughout the lesson:

> The worksheet allows the students to see the different ways the task can be written but does not force them to make choices. As the students are completing the task, they are to bring their "cards" back to me to check their learning. This is

> a oral and visual assessment that allows me to see if they understand how to explain their thinking.

PSTs focused more on student understanding and how it was demonstrated following the intervention.

Shift in focus on students: Focus on student strategies. PSTs referenced specific student strategies used to demonstrate students' understanding of mathematical concepts. For example, prior to the intervention, only one PST, Bonita, in a single video reflection comment generally referred to students' strategies: "I thought it was great to have three different forms of visual representation to allow all different learners to understand the task." This comment generally addresses the multiple strategies shown in the video. The same PST reflected on the same video following the intervention, stating, "Students were able to explain their thinking with a written equation, as well as with manipulative and visual representation." Other PSTs were even more specific about students' strategies in video reflections, referencing specific students and examples from the video. Eleanor stated the following in their video reflection after the intervention:

> I like how the teacher asked Cooper how he knew the answer was 7. He was ready to give a response, Claire was quick to agree that it just got switched around, and the teacher was on it and used her terminology that the numbers "Just got switched around," which is what the point of her lesson basically was.

A similar observation was made for video reflections following the intervention when observing a different video and task. For example, when observing a different video following the intervention, Claire said:

> They thought it was a 1 when looking back and comparing with previous strategies. Most students were able to connect that finding the area of a square and dividing it by two will give them the area of a right triangle.

PSTs specifically referred to students, recounting strategies exhibited in the video, in video reflections following the intervention.

Attention to student strategies was also demonstrated in lesson plans following the intervention. Prior to the intervention, not a single PST predicted possible student solutions, instead, demonstrating only a single way to solve; this is in contrast to following the intervention, as all five PSTs described how they would facilitate a discussion centered around students' strategies. All PSTs were able to articulate questions that both advance and assess student understanding of a particular strategy versus procedural questions aligned only with the PSTs' way of thinking. All participants selected the order in which they would have students share their strategies and why they would sequence them to tie together different representations of solutions. The various strategies predicted were aligned with questions to assess student understanding with respect to their unique thinking. Student understanding was assessed through questioning in addition to a written or verbal assessment following the whole group discussion.

For example, following the intervention, the same PST, Denise, asked the following assessing questions with respect to one solution strategy:

> Why did you add 12 each time? Walk me through your thinking.
>
> Why did you stop when you got to 96?
>
> How did you get 8 as an answer by solving this way?

A similar questioning pattern unique to five other possible solutions strategies was provided. The other four PSTs provided assessing questions to determine student understanding as well.

Similar to shifting the focus from the PSTs' strategy to that of the students, all participants used predicted student solutions in lesson plans to orchestrate a discussion following the exploration of the mathematical concept, and they were able to articulate why they chose to present strategies in the provided sequence. For example, Bonita wrote the following:

> 1) I would address the student who makes an array of five groups of eight plants. This will give the class a visual representation of the problem and how the array consists of both rows and columns. I would use this strategy to make sure all students recall the difference in meanings between a column and a row
> 2) I would then have the student who used repeated subtraction present next. This strategy can relate back to the previous strategy by using the visual representation from the array to show how subtracting by 5 until all plants are gone is another solution to the problem.
> 3) I would have the student who used skip counting strategy to present next. This strategy shows the opposite concept from the previous subtraction but still shows how to break down the total of 45 into smaller pieces to form 5 rows of 9 plants.
> 4) Together with the previous strategy the student who used the number line will present their work and tie it back together with skip counting since both students are essentially doing the same things.

> 5) To wrap things up the final strategy I would have presented would be the student who used a multiplication equation to solve the problem. The student wrote on their paper 5x__=45

A change in what it means to demonstrate mathematical understanding and how it should be orchestrated by the teacher to develop that understanding shifted from initial to final lesson plans. Lesson plans following the intervention were more student-centered in the tasks provided, questions asked, and strategies shared in the class to develop student understanding, relative to those produced prior to the intervention.

Shift in focus on students: Drawing inferences about student understanding. With a greater focus on student understanding and specific student strategies, PSTs drew more inferences about student understanding following the intervention. Prior to the intervention, PSTs focused more on what they "liked" or "disliked" in the videos with reference to what the teacher was doing, rather than focusing on how the teacher was or was not developing student understanding. Following the intervention, a decrease in self-concern related video reflections was observed (i.e. likes, dislikes, interests, how to alter instruction, inferences). Prior to the intervention, almost half (46.9%) of the reflections pertained to self-concerns. Following the intervention, a slight decrease in self-concern video reflections was observed when viewing both the same video and a different video, changes in the focus of self-concern related reflections was observed, as PSTs drew more inferences about student understanding.

A specific case of one teacher across all video reflections shows the shift in PSTs' focus on students' level of understanding. Claire stated the following in her video reflection prior to the intervention, “I really enjoyed how the teacher got all the students involved in the learning.” Following the intervention, the same PST stated the following when watching the same video, “I like that students were asked to repeat a student’s response so everyone understood where her answer was coming from.” The same PST focused on both the teacher and students, drawing inferences about student understanding when reflecting after a different video, stating,

> I think students were confused while they were explaining their strategies. The teacher just kept asking, "how do you know?". I do like that she connected the strategies and let students create their own equations, but the presentation of the lesson was confusing and I don't think many students "got it."

Following the intervention, an increase in inferential video reflections was observed. Prior to the intervention, only one PST made an inference about students’ understanding in the video. Following the intervention, two PSTs made inferences when observing the same video and all five PSTs made inferences about student understanding when observing a different video. Inferences focused on the level of student understanding. For example, Bonita said, “I thought students were struggling with the idea of making formulas to solve the problem.”

Prior to the intervention, one PST, Claire made a general claim about students in the video showing understanding, stating,

> I believe the lesson went well. The students were very engaged. What stood out for me the most was how excited the teacher was when the students were able to come up with a correct answer. I think this makes students excited about learning!

The same PST made an inference about the specific level of student understanding when watching the same video, providing a specific example, stating, "I think the students were able to grasp the concept. Students used counting on to show that either way the problem was written, the answer would be the same." Other PSTs made more specific references to students in the videos after the intervention, making inferences about student understanding. For example, Eleanor stated,

> I feel like the students were basically saying the same things, repeated from one student to another. Only 3 students really grasped the topic, while one was completely lost. For the teacher to say "If you haven't participated, help me out," the students who don't have a clue, weren't paying attention, or are wrong and don't want to show it, that could be detrimental to them.

Video reflections that were inferences drawn from PSTs shifted to more specifications about the level of student understanding following the intervention.

In summary, following the intervention, video reflections, lesson plans, and lesson plan reflection questions demonstrated a shift in focus on students and specifically, focusing more on students and their level of understanding. Greater emphasis was placed on student understanding and how it would be demonstrated in the classroom. Not only did the quantity of student-focused video reflections increase, but differences were also observed in attention paid to student understanding and specific student strategies. Overall, PSTs focused more on students following the intervention; even when reflections were on the teacher following the intervention, they were more focused on the role of the teacher in developing student understanding. Additionally, more reflections focused on specific student strategies and more inferences were drawn about student understanding through the assessment of verbal and written work following the intervention, as demonstrated across multiple data sources, relative to those observed prior to the intervention

Theme 2: Shift in the Role of Teachers in Student Understanding

Across multiple data sources: outcome expectancy question responses, video reflections, lesson plans, and lesson plan reflections, a shift in the described role of the teacher was observed. PSTs focused more on the teacher's role as the facilitator of the classroom and as the developer of student understanding. PSTs focused on the teacher in approximately the same proportion of video reflections prior to and following the intervention, regardless of which video was observed. Although there was only a small difference in the quantity of teacher-focused reflections, differences in PSTs' focus within those reflections were observed. Two sub-themes from all data sources will be described below: a shift in the role of the teacher in mathematics instruction and the ability of the teacher to develop students' understanding.

Shift in the role of teachers: Teachers' role in mathematical instruction. Following the intervention, PSTs views of the role of the teacher in mathematics were different in comparison to before the intervention. For example, in outcome expectancy question responses, PSTs expressed their belief in a teacher's role in developing a mathematical learning environment to have a role in students' attitudes, learning, and understanding of mathematics. Following the intervention, Adam stated: "Yes, many times math has a negative stereotype. Great teaching can knock those boundaries down and make it an inclusive learning environment for all students." One participant (Claire) expressed their belief in the ability of one teacher to change students' mathematical mindset:

> Students need that connection. If they didn't do well in math and that was their mindset throughout school, all it takes is one teacher to change their perspective. Allowing students to have fun and make those connections to prior knowledge gets them excited about learning.

Prior to the intervention, when asked about grades of students improving due to teachers finding an effective teaching approach, Bonita responded,

> I agree. I think students would obviously improve their learning if a more suitable learning and teaching technique was implemented. This isn't to say that it may also have to do with the math topic being discussed as well. Just as any other subject there will be different subgroups that come easier to students.

This PST's comment was more general, similar to the other four PSTs, lacking connections to their own practice. PSTs referred to effective mathematics teaching when talking about student understanding, but they lacked a specification of what this meant or looked like. For example, Claire said, "It would be harder for students to succeed in mathematics if the teacher isn't able to teach the concepts effectively."

In contrast, PSTs were able to more specifically define the role of the teacher after the intervention. When responding to outcome expectancy questions following the intervention, PSTs referred specifically to how they would teach mathematics in order to overcome students' lack of understanding. For example, one PST (Denise) stated about the process of mathematical learning: "There are so many strategies to solve math problems so if we can provide students opportunities to use multiple strategies and teach them multiple ways to solve problems--the students will hopefully connect with one that works for them.” Another PST, Adam, emphasized flexibility of mathematics teaching and the impact it has on students, stating, “Yes, as a teacher it is your job to assess and understand your students! The more prepared you are for your students learning the more success your students will have!” Eleanor referred to the flexibility of mathematics teaching, stating, “Motivation and outside factors also relate to the student's achievement, but an effective teacher, one who is willing to be flexible in the teaching methods, can also boost a student's achievement.” PSTs referenced specific classroom contexts and environments and how it related to student understanding in their outcome expectancy responses following the intervention.

A change in understanding of the role of the teacher in mathematics instruction was also observed in lesson plans. Prior to the intervention, PSTs described the teacher’s role as more central, and a modeler of the mathematics students were intended to replicate. Three teachers modeled the expectations for problem solving before students engaged with the task/explore. For example, Claire modeled the desired concept in the launch, saying, “Provide a simple multiplication and division problem using the same numbers. Model how you can change a division problem into a multiplication problem to make the division problem easier to solve.” This was followed by a game during the explore phase practicing the concepts modeled in the launch. Denise launched a task, assuming students knew multiplication, and used the explore phase as a way for the teacher to model one strategy and have students practice that single strategy, stating, "The strategy for solving multiplication by 8 is the double, double, double strategy. The teacher will use 6 x 8 for example. We take the factor (that is not 8) and we are going to double it." Eleanor did not use a task at all, instead assuming students already knew how to multiply, reviewed by modeling, and used the explore phase as a review game.

Two participants used an initial task that allowed for multiple strategies, but then proceeded to funnel instruction toward a single strategy during either the launch or explore phased of the lesson plan. Bonita asked students to look for a pattern in repeated multiplication problems, stating, "Students will turn and talk with their partners to see what they think is similar with these problems and what patterns they were finding." This was followed by the teacher instructing students how to do a single strategy that should be used: "As a class the teacher will have students use the sketch strategy to draw out the problem." This strategy was then modeled on another, similar problem. Adam used an open-ended task, followed by demonstrating a strategy left on the board for students to refer to while solving the task in the explore phase: "The students will have the example posted on the board that was done as a class during the launch activity." Both PSTs who utilized a task that could allow for multiple solution paths scripted for teachers to demonstrate a single way of solving, followed by expectations for students to do the same, instead of allowing the students to have multiple strategies. Initial lesson plans were written with the teacher as the central focus of instructing, having the teacher demonstrate the modeling of the mathematical concepts in the lesson plan. As demonstrated in these examples, PSTs viewed the teacher as the central component of mathematics instruction.

Following the intervention, this role shifted; teachers became more of a "facilitator" with lesson plans taking on a student-centered approach. Lesson plans following the intervention were more student-centered in nature, as detailed below. Four of the five PSTs utilized tasks that allowed for multiple student strategies of a new mathematical concept for students, and all PSTs were complete in their lesson plans, following the intervention. One PST used a game for computing multiplication factors rather than exploring this concept through a task that allowed for multiple solution strategies.

Following the intervention, PSTs developed lesson plans, and in the launch phase, not a single PST modeled the mathematical concepts necessary to solve the task in the explore phase. For example, Claire even specified the lack of modeling or funneling:

> To clarify the task, the teacher will make sure that students understand the concept of fundraising, in this case, cookie dough. The teacher will make sure students understand that they must show their work for each step of the task and read the problem completely. Students will engage in the task individually of selling cookie dough, but will not be guided along the way.

Eleanor also clarified that no modeling would be provided for students, stating, "...but will not be prompted with methods of doing this."

A specific example of how one PST, Claire, demonstrated this shift in the teachers' role prior to and following the intervention. Claire described the actions of the teacher after having students discuss a picture model of a multiplication problem prior to the intervention:

> Circle the multiplication and division equations and rewrite them on the board stacked on top of each other. Explain that today they will review the inverse relationship of multiplication and division to help solve future word problems. Define inverse operation as an operation that reverses the effect of another operation. With multiplication and division, if you multiply to get a product, you cnc use division to reverse the operation by dividing the product and vice versa. The product is the answer when two or more numbers are multiplied together. Provide a simple multiplication and division problem using the same number. Model how [you] can change a division problem into a multiplication problem to make the division problem easier to solve.

In this example, Claire is scripting exactly what the teacher will do to model the content standard for students to replicate following the introduction of the lesson rather than allowing students to explore the concept for themselves.

Following the intervention, lesson plans were more student-centered and four of five PSTs centered lesson plans around a task that allowed for multiple solutions. In contrast, the same PST launched her lesson in the following way after the intervention:

> The teacher will ask, "Have you ever sold anything for a fundraiser?"
>
> Students will respond with examples.
>
> The teacher will ask, "how do you calculate your customers' total if they buy more than one of the same products?"
>
> Allow students to respond.

> The goal is to get students to understand that if you sell multiples of the same item you can use multiplication to calculate the total.
>
> After consensus is reached, the teacher will say, "I need some help figuring out how many tubs of cookie dough students sold during their fundraiser. (At this time the task will be projected on the board as well as given to each student).
>
> Students will understand that their goal is to use a strategy to find out how many tubs of cookie dough each student sold.

Here, although the desired method is multiplication, it is not modeled, and students are still able to use any strategy to solve the task.

All of the four PSTs who used a task allowing for exploration of a mathematical concept provided multiple student strategies. Aligned with this more student-centered approach, the role of the teacher shifted to develop students' strategies and their understanding of the mathematical concepts. All PSTs included questions to advance and assess students' understanding aligned with a variety of possible student strategies (see Appendix G for Denise's questions). The only modeling discussed by the PSTs was done at the end of the lesson in the summary phase. All PSTs used student strategies to guide the discussion instead of using a single strategy provided by the teacher. Additionally, four of the five PSTs utilized a task that allowed students to explore the mathematical concepts in the explore phase of the activity.

As noted across the data sources, the role of the teacher as described by PSTS changed over the course, following the intervention. PSTs focused more on the teacher's role as a facilitator of the students' discussions as opposed to the role of modeling the procedural mathematics for students to replicate.

Shift in the role of teachers: Focus on developing student understanding. PSTs also referred to the teachers' role in the development of student understanding of mathematical content. For example, in outcome expectancy question responses, prior to the intervention, PSTs were unsure of their answers to the outcome expectancy questions, both agreeing and disagreeing or hesitating with their responses. Bonita, for example, responded, "Agree and Disagree because I think its a mixture of the effectiveness of the teacher and the skills that the student has on the subject area as well." When asked about students' achievement in mathematics being directly related to their teacher's effectiveness in mathematics teaching, Eleanor stated, "Not entirely either. Outside factors can play into a student's achievements and this must be understood." PSTs were not definitive and expressed uncertainty in their responses about the role of the teacher in the development of students' understanding.

Additionally, prior to the intervention, when answering questions about outcome expectancy, PSTs attributed students' success or lack of, not only to teachers, but to other outside variables that can inhibit their understanding of mathematics. For example, Adam stated, "Teaching is only one aspect of a student's learning experience." Other PSTs made reference to these other variables as well; one PST (Bonita) described outside factors as obstacles, stating: "I have mixed feelings on this. I think students can overcome certain obstacles that are associated with the students' previous math classes. But, there may also be issues that will follow them their entire career…" PSTs placed more emphasis on outside variables as inhibiting students' math performance in response to outcome expectancy questions prior to the intervention. Following the intervention; PSTs made specific references to how they (the teacher) can impact students' understanding in video reflections. For example, Claire stated:

> I think students grades improve in math and any other subject when they understand the content and get excited about learning. Allowing students to explore tasks lets them use prior knowledge to complete it and hopefully helps that information stick.

In contrast to responses before the intervention, PSTs unanimously agreed that teaching can change students' understanding of mathematics. When asked whether "The inadequacy of a students' mathematics background can be overcome by good teaching," all PSTs agreed that it can. One PST, Bonita, stated,

> Agree because most likely the student has been told they are not good at math and they know have that mindset at all times. I believe that all students in a classroom can participate and find a way to understand content therefore building confidence which in turn will reduce the inadequacy of the student.

Another PST, Eleanor, said, "Agree! If the teacher makes it interesting, helps bring the lesson to the student's level and needs as a learner, the student's inadequacies can be decreased to a great degree by good teaching."

Similarly, in video reflections, prior to the intervention, no reflections focused on the teachers' role in developing student understanding. Instead, video reflections were primarily focused on the teacher's actions and their general facilitation of the classroom prior to the intervention, with only one video reflection pertaining to something else. For example, Adam stated:

> I thought the teacher did a great job highlighting the value of the donuts that were used for the problem. She allowed the lesson to be student driven and had the students reflecting on their thinking during the lesson. I felt that the teacher could have highlighted how the objects could have been different on the projector. Their chips on their desk were multi-colored but the screen was strictly using black objects.

Following the intervention, the focus of video reflection on teachers shifted to teachers focused on students' understanding, teachers questioning students, and teachers furthering students' understanding. For example, the same PST (Adam) stated the following when observing the same video,

> The students were verbal with their understanding of the concept and explained their thinking when asked too. The teacher highlighted several strategies that the students used and the class acknowledged their understanding of those strategies. "Switched around, moved down here, and teacher assisted counting on."

This particular PST no longer focused on overall, general facilitation of the classroom, instead more specifically focusing on specific students and students' understanding, highlighting what the teacher did to notice students' specific understanding in the video.

In summary, following the intervention, PSTs' view of the teacher in mathematics instruction appeared to be different than before the intervention. In addition, a greater focus was placed on their role in the development of student understanding of mathematics. This shift in the role of the teacher was observed across three data sources: outcome expectancy questions, lesson plans, and video reflections.

Theme 3: Shifts in Mathematical Understanding

Changes were observed in PSTs' own understanding of mathematics and mathematics teaching. Two sub-themes were noted: a shift in what it means to teach mathematics and in what it means to develop students' mathematical understanding. Similar to observed shifts about the role of the teacher and a greater focus on students as outlined above, a change was observed in PSTs' understanding of mathematics and mathematics teaching and understanding across four data sources: mathematics teaching efficacy question responses, course reflections, lesson plans, and video reflections.

Shifts in mathematical understanding: What it means to teach mathematics. A shift was observed in PSTs' articulation of what it means to teach mathematics. In addition to the observed changes in PSTs' view of the role of the teacher and student understanding, changes were observed in how they viewed mathematics instruction. For example, PSTs focused more on the specific content of mathematics in their mathematics teaching efficacy responses prior to the intervention, showing their hesitation with their ability to teach mathematics. When asked if they understand mathematics well enough to be effective in teaching elementary mathematics prior to the intervention, all PSTs' responses referred to mathematical concepts/content. For example, Denise referenced the specific grades, stating: "Yes, for the lower grades I do but there are so many different strategies that I would want to practice and try--especially for upper grades." Claire expressed their confidence, again referring to mathematical concepts, stating: "Agree. I am very familiar with mathematics concepts of many different grade levels." Another PST displayed hesitation, expecting to learn elementary mathematical content in the course. Adam stated, "I feel like I should understand elementary mathematics but I am certain I need a deep refresher!" All of these mathematics teaching efficacy responses reference specific concepts of mathematics.

However, PSTs expressed their confidence and willingness to learn and grow with mathematics teaching when answering mathematics teaching efficacy questions following the intervention. When asked if they know how to teach mathematics concepts effectively, Denise said, "It's a work in progress but I am feeling more confident with math tasks and possible points of entry." Another PST (Adam) acknowledged a development of their own understanding of mathematics teaching over time, and said, "I do feel with additional practice that my math concepts will grow and understanding how students think will help me develop as an effective teacher."

As seen in some of the previous quotes from participants, PSTs focused more on their confidence in the learning environment they would provide for students rather than knowing all of the mathematical content of elementary mathematics when answering self-efficacy questions, shifting their focus from mathematical content to the context of learning mathematics. Other examples include: "Agree. I may not know every formula, but my classroom will provide an environment where students are learning from each other and learning concepts effectively." The same participant (Claire) also stated: "I really have enjoyed learning how to set up math lessons to provide students with challenging tasks to allow students to explore individually before bringing the class together. Students learning from students is one of my favorite things!"

PSTs also made more translations to their own teaching and classroom, providing specific examples, and how it would impact their students following the intervention when responding to mathematics teaching efficacy questions. For example, Denise referred to their future classroom, stating: "Absolutely, again, a work in progress, but I understand the purpose of a high quality math task and will want to do that in my future classroom." Another PST, Eleanor, referred to how they would engage with curriculum and what it means for student understanding, stating: "I look forward to not using the predetermined curriculum for the launch, explore, and assessment pieces, if possible. If math were taught like this in my classroom now, I believe more students would understand it." The same PST specifically referenced their gender and the opportunity they have in their future classroom, stating: "Disagree! I like math and will try very hard to make it as exciting as other subjects. Especially knowing female students are easily discouraged by mathematics, being female, I will help to improve their image of math in school (Eleanor)." PSTs also talked about student learning and understanding when discussing effective teaching of mathematics. Claire expressed her change in her own understanding, stating, "Setting up lessons like we have has changed my whole outlook on student learning in mathematics." PSTs expressed a shift in their understanding of teaching mathematics and their own practices in math teaching through mathematics teaching efficacy responses following the intervention.

Similarly, when PSTs were asked in lesson plan reflection questions, “How confident are you that you could successfully teach this lesson? Please explain your reasoning for your response.” Prior to the intervention, all participants expressed confidence in their lesson plans and their personal, general understanding of the mathematical concept. For example, generally referencing the topic, Adam stated, “I feel very confident in teaching this lesson. The material will be covered by following the standards and accessing the students prior knowledge.” Eleanor referenced a specific grade level and mathematical concept: “Very confident, as I've already taught a variation of this lesson while subbing once in 3rd grade.” The reflections on implementing lesson plans prior to the intervention were general in their confidence of a particular mathematical concept.

Following the intervention, responding to the same question, participants expressed that they were confident and focused less on mathematical concepts and more about the facilitation of classroom through flexibility upon implementation and preparation to meet multiple students’ needs, shifting their understanding of teaching mathematics. Denise described what it means to teach mathematics to develop students’ understanding in response to the efficacy questions following the intervention:

> I feel very confident if I were to teach this lesson. I feel the task is cognitively demanding but as we have learned-- we want students to struggle. I came up with similar problems as a formative assessment and would want students to grasp the concept of division as an unknown multiplication factor. I believe I set up assessing and advancing questions to benefit students’ understanding.

Similarly, another PST in response to efficacy questions following the intervention, Eleanor, referenced the need for flexibility in their instruction,

> I feel I could confidently teach the lesson, but know I will have to adapt it in some ways afterwards... Knowing very few classrooms (if any) have students of all one ability, I would need to accommodate my lesson for those students.

The focus, following the intervention, shifted to the facilitation of mathematics instruction and how it would relate to multiple learners versus focusing on their own understanding of the mathematical concept.

Mathematics instruction as described by preservice teachers in lesson plans became more student-centered. Four of five PSTs centered lesson plans around a task that allowed for multiple solutions, and used predicted student solutions to orchestrate a discussion following the exploration of the mathematical concept. Four of the five PSTs were able to articulate why their task allowed exploration of the mathematical concept. One PST generally referred to their task as providing the opportunity for exploration, but the other four were able to specifically articulate how it allowed for exploration with respect to the task and the content standard.

<u>Shifts in mathematical understanding: What it means to develop mathematical understanding.</u> As PSTs reflected on the course, four of the five PSTs referenced a difference in their own understanding of mathematics teaching and education. For example, Claire stated, “After completing this course, my view on mathematics has changed significantly.” Another PST (Adam) stated, “This course has changed my perspective on the true content of math being taught at the elementary level.” With this

shift in perspective, Eleanor expressed her change in mindset to focus on students: "It took quite a few weeks to finally turn the emphasis onto student learning instead of the teacher's performance." PSTs recognized how they felt their own views had changed over the course.

In lesson plans, PSTs showed a shift in their expectations for what it means for students to demonstrate understanding. All questioning included in lesson plans prior to the intervention focused on questions of procedural computations, scaffolding students to the exact way the teacher wanted the problem solved. For example, Denise wrote in her lesson plan (see Appendix G for context):

> The strategy for solving multiplication by 8 is the double, double, double strategy.
>
> The teacher will use 6 x 8 for the example.
>
> We take the factor (that is not eight) and we are going to double it.
>
> What do I mean by double? (TTW [The Teacher Will] pull popsicle stick).
>
> Students may say 6 x 2 or 6 + 6 (Since working with multiplication, try to stick with that when modeling, but either will work).
>
> 6 x 2 = 12.
>
> Now what is double 12?
>
> 12 x 2 = 24.

The above scripts the single method, she, the teacher would demonstrate for students. In contrast, following the intervention, all five PSTs were able to articulate questions that advance and assess student understanding with multiple predicted strategies. The focus was on questioning unique strategies rather than funneling students to a single strategy as demonstrated above. In contrast, following the intervention, Denise asked the following questions with respect to one student strategy she predicted. Questions were also developed for five other possible student strategies in addition to this one, following a similar format.

Advancing Questions:

- Is there another strategy you could think of to solve this problem?
- What if there were 24 kids in the group, how many eggs could each kid find?

Assessing Questions:

- How did you solve this?
- Why did you add 12 each time? Walk me through your thinking?
- Why did you stop when you got to 96?
- How did you get 8 as an answer then by solving this way?
- For error: How could you check your work by using another strategy?

Questions asked of students following the intervention focused more on students' level of understanding (see Appendix G for remaining questions and complete lesson plans for Denise prior to and following the intervention). These questions did not direct students toward a single method of solving, instead they aligned with potential student solutions. What it means to develop students' understanding of mathematics shifted after the intervention: from replicating the teachers' methods to attending to and assessing students' understanding of their particular method.

Similarly, in video reflections, when observing the same video, there were more task-related reflections following the intervention. Prior to the intervention, only one of the five PSTs referred to the actual task being implemented in the video. This was a more general statement about the possibility of multiple strategies the task allowed. Bonita stated, “I thought it was great to have three different forms of visual representation to allow all different learners to understand the task.” Following the intervention, observing the same video, four of the five PST mentioned the task, specifically, focusing on the mathematical concept underlying the task.

Prior to the intervention, no PSTs mentioned the underlying mathematical concept in the task/lesson/video and students’ understanding. Following the intervention, four of five PSTs specifically referenced the mathematical concept the students were trying to learn when observing the same video. For example, one PST said,

> The teacher highlighted many different opinions throughout the classroom and those students either discussed or led their thinking at the front of the classroom. The teacher never discussed the idea of the commutative property but the students highlighted the idea of the concept through their ideas. (Adam)

Another PST specifically referenced the mathematical concept along with the inferred level of student understanding: Eleanor stated, “Overall, I feel the students understood the commutative property and counting on from 3 or 4 to get to 7. I feel they understood the idea that "it's just switched" and that all addition problems work this way.” More participants specifically referenced the underlying mathematical concept in their video reflections on the same video following the intervention.

Theme 4: Expressed Self Efficacy and Confidence

Expressed confidence was observed with more references to confidence from different sources such as course reflections, lesson plan reflection questions, and mathematics teaching efficacy questions, following the intervention. Two sub-themes presented themselves when examining the shift in PSTs' expressed confidence and efficacy prior to and following the intervention: expressed confidence in student-centered mathematics instruction and in expressed confidence developing students' understanding of mathematics.

Expressed self efficacy and confidence: Confidence in student-centered instruction. PSTs expressed more confidence in student-centered instruction following the intervention. Two PSTs specifically referenced an increase in their confidence about teaching mathematics after the course in course reflections: Eleanor said, "...I feel much more confident teaching math after taking this course…" and Adam said, "I feel much more confident about how to engage the class in their learning experience." When talking about exploration and launching cognitively demanding tasks, the same PST claimed, "...I can say I feel truly confident in that teaching style!" Another PST, Claire, expressed their excitement: "I can't wait to get into the classroom and try this method of teaching."

Additionally, PSTs expressed more confidence in their mathematics efficacy question responses with respect to self-efficacy following the intervention. Prior to the intervention, participants exhibited indecisiveness in responses and lack of confidence in their mathematics teaching ability. For example, when asked if they know how to teach mathematics concepts effectively, Eleanor stated, "Ha! Maybe, maybe not." Adam said, "I know how to write lesson plans…" displaying their lack of confidence in teaching mathematics concepts effectively.

In contrast, following the intervention, PST were more definitive in their responses to mathematics teaching efficacy questions, agreeing or disagreeing. Although they may not know every mathematical concept in potential grades they might teach, PSTs expressed their confidence in their ability to teach mathematics from other sources, beyond content knowledge. For example, the same PST from above, Eleanor expressed, "Agree, I feel more confident teaching them now. I know it will be hard during the first few years of teaching, but I have resources to look to for guidance."

Prior to the intervention, PSTs expressed confidence in their own understanding of the mathematical concepts. This confidence shifted following the intervention, reflecting more on their ability to implement and facilitate a mathematical lesson, similar to their shifts in what it means to teach and understand mathematics. For example, one PST, Eleanor, reflected on their experiences with the particular mathematical concept prior: "Very confident, as I've already taught a variation of this lesson while subbing once in 3rd grade. " Following the intervention, the same PST focused not on their own experience with the mathematical concept, but how they would adapt the lesson to meet the needs of the students:

> I feel I could confidently teach the lesson, but know I will have to adapt it in some ways afterwards… Knowing very few classrooms (if any) have students of all one ability, I would need to accommodate my lesson for those students. I also feel that I need to increase the excitement in the lesson.

Similarly, Denise referenced their experience with the mathematical concept prior to the intervention, stating, “I am fairly confident because I have taught this lesson while subbing 4th grade before. This helps students with figuring out their x8 math facts.” Following the intervention, the same PST expressed confidence, specifically reference how her task would engage students with the mathematics, and their role in developing student understanding:

> I feel very confident if I were to teach this lesson. I feel the task is cognitively demanding but as we have learned-- we want students to struggle. I came up with similar problems as a formative assessment and would want students to grasp the concept of division as an unknown multiplication factor. I believe I set up assessing and advancing questions to benefit students' understanding.

Although both confident prior to and following the intervention, the confidence in their ability to teach mathematics came from different sources, focusing more on their ability to instruct with student-centered practices versus their content knowledge of mathematics.

Expressed Self Efficacy and Confidence: Confidence in Improving Student Understanding. Similarly, prior to the intervention, participants lacked specificity in their responses about the effectiveness of their lesson plans in developing students’ understanding when asked “How confident are you that this lesson would be effective in helping students understand the mathematical concepts? Please explain your reasoning for your response.” PSTs made general claims about it being an effective lesson, for example Claire, “I believe this lesson would be effective in helping students understand this mathematical concept;" Eleanor, "Fairly confident that the students could understand the activity/multiplication concepts using the 'Circle and Stars' method (but using x's because some students can't make stars yet)." PSTs made more general statements about "being effective" without providing specific examples of developing students' understanding.

Following the intervention, with respect to the same questions, PSTs provided explanations of why they could teach their particular lesson for student understanding, exhibiting more confidence and emphasizing the role of the teacher. Denise expressed their confidence as well as how the task they chose would allow for student understanding: "Very confident. The task I provided allowed for multiple entry points and multiple strategies to be represented. I also would teach the lesson for students to understand that division can be solved by using multiplication." Another participant specifically referenced the instructional strategies they would use to increase student understanding:

> I feel, in third grade, students may be able to understand 3 of the strategies I explained, maybe 4. I'm not sure I would teach all of them at one time, but implement one strategy per day or two. I think the general idea behind my lesson would be effective, but I would gauge my student's understanding via their discussion, questions, and overall attentiveness in the classroom. After looking at it, I would probably offer manipulatives of some kind (cubes, possibly) right at the start to increase their attentiveness, but also help them see the different groups of whole numbers. (Eleanor)

Prior to the intervention, all participants expressed confidence in their lesson plans and their personal, general understanding of the mathematical concept. As previously mentioned, participants generally referenced the content of mathematics in their lessons. For example, Adam said, “I feel very confident in teaching this lesson. The material will be covered by following the standards and accessing the students prior knowledge.” The reflections on implementing lesson plans prior to the intervention were general in their confidence of a particular mathematical concept. The same PST following the intervention mentioned their confidence, despite their confusion with the mathematical concept, stating,

> I feel confident in teaching this lesson to a class. As I began to write the lesson, I felt confused about exactly what was supposed to be taught throughout the lesson. As I continued to dive into the concept, I found ways/strategies I felt the students would connect to. The idea/concept of my lesson is to interpret multiplication problems in different formats, IE identifying different variables. (Adam)

Following the intervention, responding to the same question, participants expressed that they were confident and focused less on mathematical concepts and more about the facilitation of classroom and development of students’ understanding. One PST specifically stated how they would not only prepare, but how they would move the lesson forward and develop student understanding:

> I believe since I took the time to write out each angle of the lesson I would be able to teach this lesson. Knowing the possible strategies students will bring to the table is key to being prepared for conversation and collaboration at the end of the

> task. Also I now know the right type of questions to ask to keep students moving upward and onward. (Bonita)

PSTs focused more on how they would develop student understanding following the intervention, expressing their confidence in this rather than in the mathematical content itself.

In summary, an expressed confidence was present in course reflections, lesson plan reflection questions, and teaching efficacy question responses. PSTs expressed their confidence in their ability to instruct mathematics using student-centered strategies versus relying solely on their content knowledge of mathematics as they did prior to the intervention. PSTs also expressed confidence in their ability to develop students' understanding of mathematics.

Summary of Results

Changes were observed in all sources of data following the intervention: video reflections, lesson plans, lesson plan reflections, and in responses to both mathematics self-efficacy and outcome expectancy questions. These shifts in reflections and responses were reiterated in PSTs' overall course reflections.

Following the intervention, differences were observed in PSTs' focus on students as they focused more on students' level of understanding, use of specific strategies, and drew more inferences about the level of student understanding as demonstrated through various forms of work. With this change in focus on students, a shift in the focus on the role of the teacher was observed. PSTs' view of the role of the teacher changed from that of a modeler of mathematics to that of a facilitator of students' thinking. With this, PSTs also focused more on the teachers' role in developing student understanding in mathematics. These two shifts complemented the change in PSTs' views about what mathematical understanding is and how it is demonstrated. PSTs' views of what it means to teach and instruct mathematics changed, with more emphasis placed on effective mathematics instruction versus mathematical content knowledge following the intervention, and shifts in what it means to develop mathematical understanding from leading students to the "right" answer to allowing students to demonstrate mathematical understanding across multiple modes. Lastly, PSTs' expressed an increase in confidence over the course in both their ability to implement student-centered instruction and their ability to develop student understanding of mathematics.

CHAPTER 5

DISCUSSION

Interpretation of Results

The results of this study revealed that following an intervention, changes occurred in PSTs' understanding of effective mathematics teaching and an expressed increase was observed in PSTs' mathematics teaching efficacy. Additional research can explore the relationship between the intervention and these observed changes. Comprehensive results will be provided and interpreted, aligned with each theme as outlined in Chapter Four, followed by an interpretation aligning with each of the three research questions.

Theme 1: Shift in Focus on Students

Changes were observed in the focus placed on students; specifically, a greater focus was placed on student understanding, specific student strategies, and inferences drawn about student understanding following the intervention. A need for further exploration in shifting focus of PSTs has been expressed as Chamoso et al. (2012) recommend need for further research in the use of focusing reflection to transition the focus to that of the students. These results provide insight into changes that occurred following the intervention of prompted video reflections.

Similar to prior research (Chamoso et al., 2012; Wilkerson et al., 2018), a lack of focus on students and student understanding by PSTs was observed prior to the intervention. Specifically, PSTs rarely focused on student understanding, student strategies, or drawing inferences about student understanding, as evidenced in their video reflections, lesson plans, and lesson plan reflections. Instead, a greater emphasis was placed on teachers and their ability to model mathematics for students. However, following the intervention, PSTs focused more on specific student strategies and how they demonstrated students' understanding of the desired mathematical concepts. These are noteworthy as the *Principle to Actions* Eight Mathematics Teaching Practices (NCTM, 2014) emphasizes the use of student-generated strategies and representations as well as using evidence of student thinking to guide mathematics instruction.

As discussed above, student-centered mathematics instruction is often different than the experiences PSTs have had (Handal, 2003; Paolucci, 2015), so a greater focus on students following the intervention is notable. The PSTs were able to shift their focus from primarily on the role of the teacher and teacher-centered mathematics to that of the student and their level of understanding of the desired mathematics. This finding echoes those of Jacobs et al. (2010), where they found an increased focus on student understanding and student strategies when viewing a collection of student work or viewing teaching videos. Sherin and Han (2004) also found a shift in focus to making sense of participants' thinking after participating in video clubs. Video clubs included the observation of a whole class discussion of a mathematical task, followed by discussions of the teachers and researcher. These discussions were more focused on pedagogy and teachers' moves in the initial video club discussion, but as the club progressed, participants focused more on student thinking.

These studies, taken collectively, are consistent with results observed in the present study. The use of prompted reflective questions following a video encouraged PSTs to focus more on students, specifically on their strategies and level of understanding, a quality that is integral in student-centered mathematics instruction. As student-centered mathematics is rooted in constructivism, suggesting students construct their knowledge by relating it to their prior knowledge (Piaget, 1973), a greater focus on student thinking, strategies, and level of understanding is crucial to this type of mathematical instruction. With this shift in focus on students, a shift in focus on teachers and their role in mathematics instruction was also observed and will be described below.

Theme 2: Shift in the Role of Teachers in Student Understanding

A shift in the role of teachers in both mathematics instruction and their role in the development of student understanding was observed following the intervention across multiple data sources. Specifically, prior to the intervention, PSTs focused more on the teachers' actions and their modeling of mathematics for students. This is similar to findings found by Chamoso et al. (2012), as PSTs focused more on teaching and methodology rather than on student learning.

PSTs expressed the ability of the teacher to develop student understanding despite factors and variables outside of their control following the intervention in responses to outcome expectancy questions. This is an important finding as Manouchehri (2003) found that teachers who utilized student-centered instructional practices in mathematics all (participants that were interviewed) felt that they were able to control what their students learned in mathematics versus outside factors.

This is problematic as student-centered mathematics shifts from the teachers as the holder and teller of knowledge to that of a facilitator of the classroom and students' thinking. In *Principles to Actions* Eight Mathematics Teaching Practices (NCTM, 2014), teachers are not to model the mathematics for students, instead they are to use and connect students' strategies and representations, facilitate discourse, pose purposeful questions, and use evidence of student thinking.

According to Smith III (1996), teachers with high self-efficacy feel that they can help students construct their knowledge rather than providing students with knowledge, and this then allows them to adopt student-centered teaching methods. Thus, the shifts in the role of the teachers as observed in this study, following the intervention, are promising. When PSTs focused on the teacher following the intervention, it was more on the role of the teacher in student-centered mathematics instruction and how they were able to develop students' understanding. Specifically, PSTs expressed belief in their ability to develop student understanding and how to use evidence of student thinking and strategies in their teaching to develop understanding of the mathematical concepts. This aligns with student-centered instruction, as teachers must be able to develop students' understanding of mathematical concepts through the strategies they choose; thus, a belief in their ability to do so is valuable.

Theme 3: Shifts in Mathematical Understanding

Prior to the intervention, PSTs primarily viewed mathematics understanding as their own understanding of the mathematics content they aimed to teach. This shifted following the intervention; PSTs focused more on how they would facilitate instruction and do so to develop student understanding to draw on for their beliefs about their ability to teach mathematics. This was a somewhat unexpected but noteworthy finding, as PSTs drew on confidence in their ability to use student-centered practices rather than their content knowledge for their sense of confidence in their ability to teach mathematics.

PSTs views of what it means to develop mathematical understanding shifted following the intervention. As previously mentioned, changes were observed with respect to both teachers and students following the intervention. PSTs were able to articulate what it meant to develop mathematical understanding and the role of the teacher in developing this understanding. Again, as the Eight Mathematical Teaching Practices as outlined by *Principles to Actions* (NCTM, 2014) emphasize student-centered approaches and the development of conceptual understanding for students through the use of tasks, student thinking, student strategies, and connection of student representations, this is an important finding. PSTs were able to not only shift their understanding of what it means to teach mathematics, but what it means to develop students’ understanding of mathematics.

In Briley’s study (2012), PSTs’ beliefs about the nature of mathematics had a statistically significant relationship to PSTs’ mathematics teaching efficacy, as PSTs with stronger mathematics efficacy beliefs had more sophisticated beliefs about mathematics. As PSTs in this study demonstrated a shift in their understanding of mathematical instruction and students’ understanding of mathematics, as well as an expressed increase in mathematics teaching efficacy, prompted reflections focused on student understanding as an intervention is worthy of further exploration.

Theme 4: Expressed Self Efficacy and Confidence

Results from this study may provide insight into gaps in research about self-efficacy, specifically mathematics teaching efficacy. Smith III (1996) noted that development of teachers' beliefs about their capabilities of instructing with student-centered methods deserves further exploration, and these findings contribute to a desired need for research in this area. Exploration of reflective thought has also been linked to self-efficacy in teacher preparation courses and professional development (Noormohammadi, 2014; Phan, 2014; Ross & Bruce, 2007; Tavil, 2014), but as Santagata et al. (2007) suggest, there is a lack of research on the use of specific observation frameworks and protocols. Klassen et al. (2011), in a synthesis of eleven years of self-efficacy studies, point out the need for additional qualitative studies. As previously mentioned, many studies focus on teacher self-efficacy or general self-efficacy, so the findings of this study, specific to mathematics teaching efficacy are informative for understanding the development of PSTs mathematics teaching efficacy following the use of prompted reflections following the observation of a video. Figure 1 depicts the shifts observed following the intervention and the increase in PSTs' efficacy about teaching using student-centered instructional practices and their ability to develop student understanding of mathematics. The shifts in mathematics teaching efficacy as observed in this study will be further interpreted below.

Following the intervention, PSTs expressed confidence in their ability to implement student-centered instruction as well as their ability to improve student understanding of mathematics. In terms of self-efficacy, Bandura (1977) notes that if the person being observed in vicarious experiences is successful, it is more likely to change the observers behavior. As quoted in the introduction, “Modeled behavior with clear outcomes conveys more efficacy information than if the effects of the modeled actions remain ambiguous” (Bandura, 1977, p. 197). Videos allowed PSTs to view a successful student-centered mathematics task, and prompts focused PSTs to the desired outcome: development of student understanding. Prompts focused PSTs to students’ understanding, how it was demonstrated in the video, and the role of the teacher in this development. The outcomes desired were clear.

With respect to instruction, Lotter et al. (2018) also note if teachers are or have experiences with unsuccessful inquiry-based instruction, they are less likely to implement these methods in their own classrooms. Video selection usage allowed PSTs to view successful student-centered instruction and see the role of the teacher in the development of students’ understanding through these methods. Videos also provided an opportunity for PSTs to focus on reflection rather than being overshadowed by focusing on their own actions. Following the intervention, PSTs expressed more confidence in both instructing mathematics using student-centered methods and in their ability to develop students’ understanding of mathematics.

As the teachers in selected videos demonstrated successful implementation of student-centered mathematics, it is reasonable that PSTs expressed mathematics teaching efficacy and confidence in their ability to instruct student-centered mathematics to develop student understanding shifted following the intervention. This is desired as increasing efficacy can increase the likelihood of integrating student-centered instructional methods (Depaepe & König, 2018; Temiz & Topcu, 2013; Zee & Koomen, 2016) and willingness to implement new strategies and persist in the face of struggle (Chatzistamatiou et al., 2014; Ross & Bruce, 2007; Zee & Koomen, 2016). Additionally, increasing efficacy with PSTs in particular is important, as Hoy and Spero (2005) recognize that teaching self-efficacy may be most malleable in preservice years, with teachers typically keeping the same beliefs as they continue to teach, making them more difficult to change. With this, a focus on increasing teaching self-efficacy which is more fluid, specifically mathematics teaching self-efficacy, may provide an opportunity to change the more stable, general self-efficacy. Further interpretation of results in response to each research question will be outlined below.

Research Question 1

Research Question 1 asked, "What is the nature of preservice teachers' reflections on mathematics lessons over time, as they engage in use of prompted reflections focused on students' understanding of mathematical content?"

Prior to the intervention, PSTs focused more on the teacher in their initial video reflections, similar to findings in previous literature (Chamoso et al., 2012; Gelfuso & Dennis, 2014; Seung et al., 2014; Sherin & Han, 2004). The issue with a teacher-centered focus is that it lacks focus on students, which is in direct conflict with the goal of effective mathematics being student-centered to develop deeper, conceptual knowledge. PSTs also focused more on specific mathematical content knowledge, or lack thereof, to judge their evaluation of the effectiveness of mathematics teaching.

Following the intervention, video reflections still focused on the teacher with only a slight decrease in percentage, but the shift observed was to a greater focus on the teachers' role in developing student understanding, as targeted by the specific prompts in weeks 2 through 7. With this, the greatest change in video reflection focus observed was the focus on students. PSTs provided more specific examples of student understanding in both video reflections and projected understanding of students in lesson plan reflection questions.

Again, this is a valuable finding as it suggests that PSTs are capable of shifting their focus of reflection with intentional, focused reflection prompts, to student understanding; a central aspect of student-centered instruction. Prompted reflective questions focused PSTs on student understanding and the role of the teacher in the development of this understanding, but allowed for PSTs to select their own examples from videos to depict this.

With respect to the specific prompts following video reflections in weeks 2 through 7, PSTs were able to provide examples of their choices. As recommended by Lee and Ertmer (2006), prompts did not too narrowly focus PSTs, limiting their reflections; instead, PSTs were allowed to process the information for themselves and select examples they felt demonstrated student understanding. Additionally, prompts were too general in the pilot study conducted, so prompts were altered to focus on students' understanding of the targeted concept in the video. Although prompts focused on student understanding and the teachers' role in this development during the intervention, prompts did not direct PSTs to a specific example within each video, allowing PSTs to select their own. Prompts of this nature, not too narrowly focused, but with direction towards mathematical concepts, allowed PSTs to select their own interpretations of student understanding, facilitating a shift in the focus of reflection, similar to findings in the pilot study and other literature.

The PSTs' responses to the use of prompts suggests that they are able to shift their focus of reflection to better understand where students are in solving a problem or task. Specifically, shifting from more general statements about student understanding to providing specific examples of student understanding of mathematical concepts through cognitively demanding tasks as exhibited in the video. As mentioned in the introduction above, Dewey (1933) states, "But while we cannot learn or be taught to think, we do have to learn *how* to think well, especially *how* to acquire the general *habit* of reflecting" (p. 35). In this study, PSTs were able to develop their reflection with intentional prompts throughout a mathematics methods course. PSTs were able to develop their reflection to focus on the level of student understanding through the use of intentional, focused prompts following a video observation.

<u>Research Question 2</u>

Research Question 2 asked, "What is the nature of preservice teachers' mathematical teaching self-efficacy over time, as they engage in use of prompted reflections focused on students' understanding of mathematical content?"

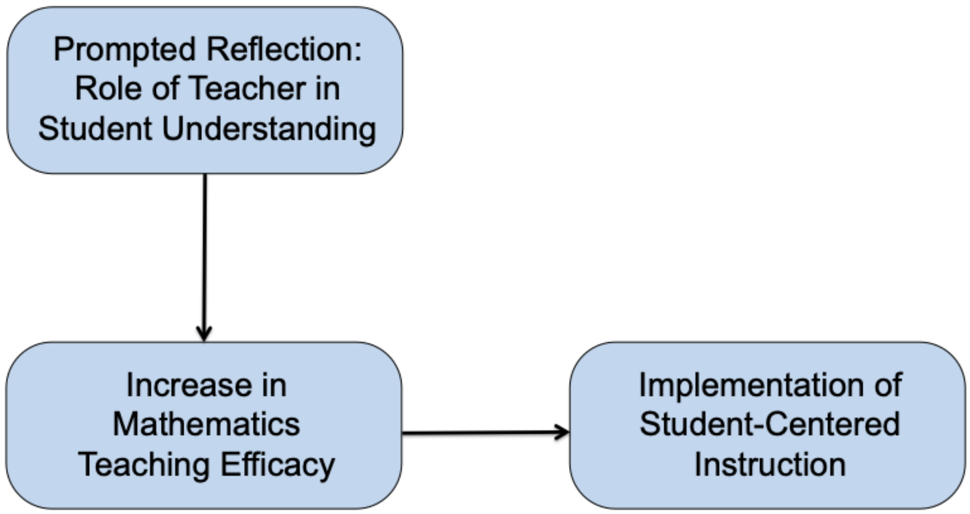
With respect to PSTs mathematics teaching efficacy, confidence was expressed in both course reflections and mathematics teaching efficacy responses, suggesting a possible indirect increase in mathematics teaching efficacy following the use of focused reflection prompts. Similar to prior literature (Handal, 2003; Paolucci, 2015), in course reflections, PSTs expressed they had never learned or experienced mathematics in a student-centered approach. Despite this, following the intervention, PSTs expressed confidence in their ability to instruct mathematics in a student-centered way. This is a valuable finding as it suggests regardless of having no experience with student-centered mathematics, PSTs were able to develop confidence with an approach different from their own learning experience.

Prior to the intervention, PSTs expressed confidence in their mathematics teaching ability as it related to specific concepts and content areas, as demonstrated by several quotes referring to specific mathematics content. An interesting finding was, following the intervention, their expressed confidence was centered on how they would be able to facilitate a mathematics classroom rather than their own content knowledge. In contrast to the pilot study, the open-ended mathematics teaching efficacy and outcome expectancy provided insight into PSTs' sources of efficacy. PSTs drew on their ability to predict, tie together student strategies, and orchestrate discussions versus directly modeling procedural methods to develop understanding.

This is a valuable finding as teachers with greater self-efficacy are more likely to persevere as they encounter struggles and more willing to try new strategies (Chatzistamatiou et al., 2014; Ross & Bruce, 2007; Zee & Koomen, 2016), specifically student-centered strategies (Depaepe & König, 2018). As PSTs may not have experience with student-centered mathematics, these findings suggest that prompted reflections focused on students' understanding may facilitate the development of PSTs efficacy in effective mathematics teaching in a methods course (see Figure 3). Mathematics teaching efficacy is valuable to develop in PSTs as it may increase the likelihood of implementing student-centered practices.

Figure 3

Indirect Relationship Between Prompted Reflections and Student-Centered Instruction



With the shift in PSTs' confidence of mathematics teaching, PSTs also expressed a greater emphasis on the role of the teacher and the ability to develop students' mathematical learning and understanding in outcome expectancy questions following the intervention. PSTs expressed that other variables may inhibit student understanding of mathematical concepts prior to the intervention, but their expressed belief in the role of the teacher following the intervention was that teachers had the ability to develop this understanding despite those factors previously mentioned.

This finding is interesting as it suggests PSTs may be able to overcome beliefs about their role as a teacher in the mathematics classroom. This finding is also valuable as PSTs may be placed in field experiences that do not exhibit student-centered mathematics. Despite not being exposed to student-centered mathematics in a physical classroom setting, PSTs are able to experience student-centered mathematics through video observations and still develop their thinking and beliefs in their teaching abilities. Additionally, in contrast to field experience placements, videos allowed PSTs to focus on reflecting about the classroom and students rather than their own pedagogy. PSTs specifically mentioned the use of videos and tasks as valuable to their understanding of mathematics instruction in the course.

Research Question 3

Research Question 3 asks, “What is the nature of preservice teachers’ use of student-centered methods in mathematics instruction after they have engaged in the reflective activities embedded in the intervention, as reflected in their lesson plans?”

Despite being provided with a template that aligns with student-centered instruction in a mathematical lesson plan protocol as outlined by Smith et al. (2008), PSTs’ initial lesson plans followed a teacher-centered approach, with the teacher modeling the mathematics to be learned. All participants followed a similar approach prior to the intervention. Only one PST provided students with a problem to explore, but then provided a single strategy desired for all students to use. Although the lesson plan template modeled student-centered learning (see Appendix E), PSTs still wrote lesson plans that were not explorative in nature. All five PSTs were also incomplete in their initial lesson plans (see Appendix H for Denise's pre-intervention lesson plan), demonstrating a lack of understanding of the vocabulary and format of a student-centered lesson plan and effective mathematics instruction as outlined by the Eight Mathematics Teaching Practices as described by *Principles to Actions* (NCTM, 2014).

However, following the intervention, all five PSTs' lesson plans utilized multiple student strategies to demonstrate the mathematical concepts versus a single strategy provided by the teacher. Additionally, four of the five PSTs included a mathematical task that allowed for exploration of a mathematical concept in the launch and explore phases in contrast to the initial lesson plans. The role of the teacher changed from the center of the lesson plans to a facilitator of the discussion after exploration of mathematical concepts. This aligns with the instruction modeled in the observed videos of the intervention.

Further, in final lesson plans, all PSTs provided questions they (the teacher) would ask to both assess and advance student understanding of a variety of potential strategies. Additional questions and comments were provided on how they would connect strategies to summarize the targeted mathematical concept of the lesson. The use of student strategies, posing of purposeful questions, and orchestrating discussions based on student thinking are practices desired and outlined in *Principles to Actions* Eight Mathematics Teaching Practices (NCTM, 2014). This demonstrates PSTs' ability to target students' understanding, and as a teacher, how to develop student understanding from their current level of understanding. This is a necessary component in student-centered instruction of mathematics as teachers must be able to focus on, and develop students' understanding.

These findings suggest PSTs were able to develop not only an understanding of what effective mathematics is as mentioned in their course reflections, but they were able to depict how they would implement a student-centered lesson through their lesson plans. In contrast to their initial lesson plans, PSTs all included multiple strategies for how students might solve a task, articulating how they would present and connect student strategies versus only sharing a single strategy modeled by the teacher as was the case in their initial lesson plans. Allowing students to explore and the sharing of multiple strategies is a valuable aspect of student-centered instruction. This is noteworthy as it demonstrates PSTs' ability to transfer their learning and understanding of mathematics instruction to their own planned instruction. It is also noteworthy that they expressed confidence in their ability to instruct utilizing these student-centered instructional methods and in their ability to develop student understanding of targeted concepts when reflecting on their lesson plans.

Limitations

There are several limitations of this study that must be noted. First, although a small sample size allowed for an in-depth analysis of these PSTs, only five participants of relatively homogenous ethnic and socio-economic backgrounds limits the applicability of findings to other PSTs and settings. Additionally, other factors outside of the intervention may have played a role in the development of PSTs' mathematics teaching efficacy and use of student-centered instruction in lesson plans. In this course, other activities such as patterns of questioning, examination of student work, and readings also focus on student understanding. The main difference between these activities and the video reflections and intentional prompts are that videos and prompts explored the relationship between students' understanding and the teachers' role in developing student understanding. Therefore, because of the presence of these other activities and no control group to compare to, causal conclusions about the effects of the intervention on PTS' understanding of student-centered instruction in mathematics as well as their self-efficacy cannot be drawn. Notwithstanding this limitation, all PSTs expressed the value of tasks/videos in the development of their personal understanding in the course as demonstrated in PSTs quotes at the beginning of Chapter Four, and thus, it would be worthwhile to explore the role of these tasks in future research.

Another benefit of the videos was the allowance of PSTs to focus on student understanding and the role the teacher was playing without worrying about other factors, such as classroom management. As mentioned previously, videos allow for PSTs to experience student-centered mathematics in their preparation programs despite the possibility of not seeing them at all in their field experiences. This makes the type of intervention used in this study well-suited to preservice teacher education or professional development for inservice teachers.

Recommendations

Recommendations for Scholars

A recommendation for scholars in studying the nature of PST reflections is to select a video that PSTs likely have content knowledge of to ensure a lack of content knowledge is not taking away from the focus on student understanding. A lack of content understanding may interfere with the PSTs' ability to focus on student understanding due to their own lack of understanding. Two videos were viewed following the intervention. One video was the same as the initial video shown prior to the intervention to compare the focus of reflections with respect to the same mathematical concept. The second video used was to explore the nature of reflections following a video they had not previously observed. Shifts in reflection between the two videos were similar in nature. Two PSTs did struggle with their own misconceptions of the mathematical content as observed in the second video reflections. Although their reflections were still focused on students, their own misconceptions inhibited their reflections on how the teacher developed student understanding.

Recommendations for Mathematic Teaching Educators

The selection of student-centered instruction exhibited in videos is recommended as PSTs may have little to no experience with mathematics instruction of this nature. Videos for this intervention were selected to align with mathematical concepts targeted in a course for elementary PSTs. With this in mind, videos were selected to develop the complexity of mathematical concepts throughout the course, aligning with course content. Videos should be selected to align with course content and objectives to allow for mathematical understanding to develop naturally from course conversations.

Lastly, prompts should not focus PSTs too narrowly as recommended by Lee and Ertmer (2006); they also should not be too general as observed in the pilot study with participants not focusing on student understanding as specifically demonstrated in the video. Prompts should focus on the targeted mathematical concept demonstrated in the video and students' understanding, as well as the teachers' role in the development of students' understanding of the targeted mathematical concept as outlined in Appendix B. With this in mind, PSTs should be allowed to select examples of their choice to provide insight to their view of developing students' understanding.

Future Research

To explore reflection as a possible source for developing mathematics teaching efficacy in a mathematics methods course, three recommendations are advised in future research: the use of a control group, a larger sample of PSTs, and a longitudinal study to determine if mathematics teaching efficacy is maintained. Each of these recommendations would provide insight about the development and maintenance of mathematics teaching efficacy as well as the use of student-centered mathematics instruction following a methods course that incorporates focused reflective prompts.

Control Group

Future studies that include control groups may be able to determine whether the intentional reflections and video observations caused the changes observed in mathematics teaching efficacy. Control groups would allow for comparisons to be made in changes of mathematics teaching efficacy between groups that received prompted video reflections as an intervention and those that did not. With the remaining course activities and tasks being the same, more conclusions would be able to be drawn about the relationship between the reflective prompts focused on student understanding and PSTs' mathematics teaching efficacy.

Larger Sample

Further, a quantitative study employing a larger sample of participants on mathematics teaching efficacy may be able to help identify perceived sources of efficacy and changes over the duration of a mathematics methods course. With a larger sample of participants, the original *Mathematics Teaching Efficacy Beliefs Inventory* (MTEBI) could be used in full instead of qualitatively focusing on a smaller number of questions. An increased sample size would provide more accurate data regarding the targeted research questions. Additionally, it would also provide insight if any of the findings with limited support were outliers or a theme that is worthy of more exploration.

The pilot study previously mentioned focused on secondary mathematics teachers; it would be beneficial to explore the nature of mathematics teacher efficacy in secondary PSTs in addition to elementary PSTs. With secondary mathematics PSTs, it may be worth exploring to see the similarities and differences in nature of reflections (in terms of content and focus) and mathematics teaching efficacy. A study of qualitative nature may provide insight on the sources in which secondary mathematics PSTs draw on for the development of their mathematics teaching efficacy, similar to the findings in the present study.

Longitudinal Study

Additionally, a longitudinal study allows for follow up on the use of student-centered mathematics instruction after completing a mathematics methods course. A longitudinal study may provide insight on the retainment of PSTs' perceived mathematics teaching efficacy after encountering many of the previously mentioned obstacles for the first time and their own personal use of student-centered practices. This would be insightful as it could possibly demonstrate the importance of developing mathematics teaching efficacy in teacher preparation programs to provide PSTs with the skills to overcome challenges and implemented desired, student-centered instruction.

Conclusion

The shifts in PSTs' video reflections, lesson plans, lesson plan reflections, and mathematics efficacy and beliefs responses suggest the implementation of focused prompts on student understanding may be worthy of implementation in mathematics methods courses in teacher preparation programs, and this may be explored in future research. A shift in mathematics teaching self-efficacy, beliefs responses and self-expressed confidence in course reflections following the intervention may provide insight on the development and possible sources for PSTs' mathematics teaching efficacy. Increasing mathematics teaching efficacy is important as it may increase teachers' willingness to try new instructional strategies, such as student-centered mathematics (Chatzistamatiou et al., 2014; Ross & Bruce, 2007; Zee & Koomen, 2016). This study lends support to the idea that watching videos of a teacher implementing student-centered instruction followed by prompts focused on students' understanding and the role of the teacher in that development is a promising way to develop PSTs' mathematics teaching efficacy, thereby increasing the likelihood they will implement student-centered mathematics instruction. However, this study was exploratory, and needs to be replicated with a larger number of PSTs and diverse populations.

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APPENDIX A

MATHEMATICS TEACHER SELF-EFFICACY QUESTIONS

Read the statement and describe whether you agree or disagree and explain why.

1. Even if I try hard, I will not teach mathematics as well as I will teach most subjects. (self-efficacy)

2. When mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach. (outcome)

3. I know how to teach mathematics concepts effectively. (self-efficacy)

4. The inadequacy of a students' mathematics background can be overcome by good teaching. (outcome)

5. I understand mathematics concepts well enough to be effective in teaching elementary mathematics. (self-efficacy)

6. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching. (outcome)

APPENDIX B

VIDEO REFLECTION PROMPTS

Video Reflection Prompts Weeks 1 and 8:

1. Please reflect on the lesson you just observed.

2. How do you think the lesson went today? What stood out for you?

Video Reflection Prompts Weeks 2-7:

1. Specific to the mathematical concept of **________**, how did the student(s) in the video demonstrate their understanding? Provide specific examples.

2. What did the teacher say or do to develop student understanding of **______**? Provide specific examples.

3. What could the teacher do, additionally, to increase student understanding of **______**?

4. How does reflecting on this video inform your own practice? What will you take away from this video, or what connections can you make to your own teaching or future teaching?

APPENDIX C

LESSON PLAN QUESTIONS

1. What are the mathematical concepts you are teaching in this lesson?

2. How confident are you that this lesson would be effective in helping students understand the mathematical concepts? Please explain your reasoning for your response.

3. How will you know that students understand the mathematical concept targeted in your lesson?

4. How confident are you that you could successfully teach this lesson? Please explain your reasoning for your response.

APPENDIX D

VIDEO TASKS

National Council of Teachers of Mathematics (NCTM) Toolkit Videos/Tasks (Grades K-8):

- Addition Strings
- Donuts
- Half of a Whole
- Bubble Gum
- Multiplication String
- Triangle
- Hexagon
- Counting Cubes

APPENDIX E

LESSON PLAN TEMPLATE

Grade Level: Identify the grade level for your lesson.

MATHEMATICAL GOALS AND OBJECTIVES

Outline 1-2 goals for the lesson. Remember the 4 Ms when writing your learning goals (Made First, Manageable, Measurable, and Most Important). For Most Important, consider the conceptual math understanding you intend to develop in this lesson. Your goals must address these concepts.

IOWA CORE STANDARDS

Identify the main Iowa Core Standards that are being targeted during the lesson.

MATERIALS

Materials List:
List the materials/manipulatives/technology you and/or your students will be using while teaching this lesson.

PREREQUISITE KNOWLEDGE

About the Math:
IMPORTANT: This section of the plan should describe the mathematics any student must already know before beginning this lesson in order to be successful. Statements such as "This lesson assumes students already know ..." are desired. Statements such as "Most of the students in this class already know how to add and subtract fractions" or "The students have been working on adding fractions recently" are not acceptable.

The *Iowa Core State Standards* can help you complete this section. For example, if your lesson addresses 2.OA (2nd grade Operations and Algebraic Thinking) for grade 2, what does K.OA and 1.OA for grades K and 1 say that is related to the ideas in your lesson? Or, if your lesson addresses 3.G (3rd grade Geometry) for grade 3, what else does 3.G say students should know about the big idea in your lesson?

Also, using the phrase "must have a basic understanding of the concept of …" is not very clear – state exactly the particular sub-concepts that the student must know.

About the Task/Context:
Describe the important ideas related to the context (if there is one) of the task that students need in order to engage in the task. This includes making sure they are familiar with the real-world context, vocabulary related to the context, etc. Do not include ideas/skills that students will develop as part of working on the task.

Launch/Before (estimated time: _____)

The entire launch should take no more than 5-10 minutes.

LAUNCH ACTIVITY

Within the boxes below, you should answer the following questions. You should include s**pecific questions** you will ask students, manipulatives you will use, etc. during this part of the lesson.

Teacher Activity
Write a launch that will ensure students have enough information to solve the task, but does NOT lower the cognitive demand of the task. Some questions to consider (answer those that are relevant to your task(s)): • What will you say/do to ***introduce*** the context and/or the explore task(s)? • What questions are you going to ask the students to find out what they know or understand *about the context* (if there is one)? • What will you say/do to launch the explore ***task*** itself in an interactive way with your students? • What questions are you going to ask the students to find out what they know *about the mathematical ideas important for the task (i.e., their prior knowledge),* if necessary? • How are you going to help students develop a common language to work on the explore task?

RATIONALE OF LAUNCH ACTIVITY

Describe why you think this launch activity does the following: (1) fits the learning goal(s) of this lesson, (2) helps students understand the context (if there is one); (3) talks about the relevant key mathematical ideas; (4) develops a common language; and (5) maintains the cognitive demand of the task. D**raw on readings to support your rationale.**

Explore/During (estimated time: _____)

The explore part of the lesson should be about half of the class period length.

EXPLORE TASK

• Write the exact task you will present to your students using exactly the words you will use when you pose the task. (Attach the task in the appendix, if necessary.) • Discuss what materials you will have available for students while they try to solve the problem.

RATIONALE OF EXPLORE TASK

• Describe why this task fits the learning goals (including the numbers chosen for this task). • How does this activity connect to and build upon prior knowledge? • Provide a rationale for the materials that you decided to let students use during the Explore Task. In particular, describe how the materials will support students' thinking and learning within this task. • **Draw on readings to support your rationale.**

ANTICIPATED STUDENT RESPONSES (ASR) FOR MONITORING DURING EXPLORE

You should complete a monitoring chart and attach it as an appendix to this lesson plan. This chart should have significant detail – I actually want to see you work out how students will solve your exact problem. For example, simply stating "students will use base-10 blocks" is not good enough – *how* will they use them? See example lesson for what I mean here.

MONITORING DURING EXPLORE

During the Explore part of the lesson, you will monitor students working and will keep track of which students are using which strategies to determine what they are learning. In the boxes below, you should provide specific **questions/talk moves** in case any of the following scenarios might happen during the Explore part of the lesson.

Event	Anticipated Teacher Move
To Understand Students' Work	Write what you will ask/say/do to (a) help you/others understand what the student/group is doing/ thinking, (b) probe to deepen/extend the student/group's understanding or elicit connections, (c) draw the student/group's attention to some misconception that has arisen. The goal is to keep students thinking, rather than telling them what to do or think.

Stuck	Write what you will ask/say/do to help students who might be stuck get unstuck so they can work on the task.
Done Early	Write what you will say/do to get students who are "done early" working on math again? What extending question might you pose, or how will you redirect the student/group to rethink their work?

ASSESSMENT #1 FROM THE EXPLORE

You should use the monitoring chart you create as an informal assessment of your students. Here you should describe how the monitoring sheet will allow you to measure your learning goals and informally assess your students at this point of the lesson.

Discussion/After (estimated time: _____)
The discussion part of the lesson should be about half of the class period length.

ORCHESTRATING THE DISCUSSION

During the Discussion part of the lesson, you will select certain groups of students to share their strategies (**not all students need to share their work, but you should have at least 3**). ***This means that you only need to select a subset of your anticipated strategies.*** Moreover, you will sequence which strategy will present first, which will present second, and so on. The rationales for why you select and sequence particular groups of students to share (and not others) should be connected to your learning goal(s).

***You can use your monitoring chart instead of using this table, but please be sure to write specific questions for each of the solution strategies you want to share.

Strategy/Presenter(s)	Discussion Questions/Probes
ASR 1 Copy and paste one Anticipated Student Response (ASR) from the Monitoring Chart. This is the ASR that you expect to share **first** during the Discussion.	• Write **specific** questions/comments/probes you intend to use during the discussion. • Include how you will bring students into the discussion.
ASR 2 Copy and paste a second Anticipated Student Response (ASR) from the Monitoring Chart. This is the ASR that you expect to share **second** during the Discussion.	• Write **specific** questions/comments/probes you intend to use during the discussion. • Include questions that emphasize similarities/differences among the strategies and note when you expect to raise those. • Include how you will bring students into the discussion.
ASR 3	• Write **specific**

Copy and paste a third Anticipated Student Response (ASR) from the Monitoring Chart. This is the ASR that you expect to share **third** during the Discussion.	questions/comments/probes you intend to use during the discussion. • Include questions that emphasize similarities/differences among the strategies and note when you expect to raise those. • Include how you will bring students into the discussion.
ASR 4 If necessary, copy and paste a fourth Anticipated Student Response (ASR) from the Monitoring Chart. This is the ASR that you expect to share **fourth** during the Discussion.	• Write **specific** questions/comments/probes you intend to use during the discussion. • Include questions that emphasize similarities/differences among the strategies and note when you expect to raise those. • Include how you will bring students into the discussion.

RATIONALE FOR SEQUENCE

Why would you have students share their responses in this order? Be sure to discuss:

1. why you want to discuss the misconceptions where you suggest (if you address any)
2. what connections you want students to take away from the strategies you want students to share
3. whether you ordered them based on level of mathematical thinking (concrete to abstract) or some other reason

DISCUSSION SUMMARY/CLOSURE

Script exactly what you want said/done to tie up the discussion and make the mathematical ideas clear. Outline the important ideas that need to come together so that students will have the kind of "residue" (take away) from your lesson that reflects the learning goals.

FINAL ASSESSMENT

Describe what you will use to assess individual student thinking at the end of the lesson. This could include:

1. An exit ticket.
2. A homework assignment.
3. A quiz
4. Some other way

APPENDIX

****Attach all necessary appendices here. This includes the task, your monitoring chart, your final assessment, etc.

Example:

Monitoring Chart

Anticipated Student Responses	Questions/Probes	Student/Group with Strategy	Sequence
	Advancing Questions: **Assessing Questions:**		
	Advancing Questions: **Assessing Questions:**		
	Advancing Questions: **Assessing Questions:**		
	Advancing Questions: **Assessing Questions:**		
	Advancing Questions: **Assessing Questions:**		

APPENDIX F

VIDEO REFLECTION CODE BOOK

Label	Code	Definition/Criteria	Example Quote
Student Focused: The focus of the reflection is on the student.			
S.1	Student focused: explanation of task/approach to task	This code is meant to capture descriptions of students explaining how they solved the task, explaining steps in the process, or justifying their reasoning. This may include comparison of approaches between students.	"I recall a point in the video when one student explained what Arden (name?) was trying to say when he explained his ideas, rather than Arden doing it himself."
S.2	Student focused: confusion/misconception/lack of understanding	This code is meant to capture descriptions of students that are puzzled or confused by a question from their peers or teacher or by the task. This code is meant to capture discussion that acknowledges students' misconceptions regarding the task.	"However, there was confusion on what n represented in each of the equations respectively, until at the end when another student pointed out how both of the equations are correct because the two different equations have a different representation for n." "The second group had a misconception about how the first groups solution worked so the teacher asked them to compare how they were the same and how they were different."
S.4	Student focused: engagement	This code is meant to capture reflections that included reference to the level (low/high) of student engagement in the video and with the task.	"The students were all engaged in the presenters' explanations and looked for similarities and differences in their representations."
S.5	Student focused: understanding	This code is meant to capture reflections in which student understanding is the focus.	"This allowed students to explain their reasoning and understand RHA a variable can represent many things."
S.6	Student focused: discussion	This code is intended to capture any reference to student discussion, this may be whole class, student to student, or student to teacher. The discussion may also be implied by the writer of the reflection.	"The students opened up in discourse and a lot of kids shared their insights." "...that the students were able to resolve it with out the teacher getting overly involved."

Label	Code	Definition/Criteria	Example Quote
S.8	Student focused: action	This code is meant to capture the description of actions of students in the video. This may include verbal or physical actions.	"The students were the ones who ran the classroom."
Teacher Focused: The focus of the reflection is on the teacher.			
T.1	Teacher focused: questioning	This code is meant to capture descriptions focused on teacher questioning (ask/prompt/probe) to students or the entire class.	"The teacher asked what the equations meant and guiding questions to get them to think about the next step."
T.3	Teacher focused: focus on students' current understanding	This code is meant to capture when teachers are focused on students' understanding. This may include teachers summarizing or targeting students' understanding.	"With the last student, the teacher worked on the student's explanation, to assess the student's understanding of the task."
T.4	Teacher focused: furthering understanding/challenged thinking	This code is meant to focus on the teacher furthering students' understanding. This differs from T.3 as that is focused on teachers looking at/understanding students' understanding, and this code focuses on what teachers are doing to further, challenge, or deepen students' understanding.	"Then she asked the student to think about another plan that could be used, to further the student's thinking and understanding of the task."
T.5	Teacher focused: actions	This code is meant to capture the description of actions of teachers in the video. This may include verbal or physical actions.	"The teacher barely talked throughout the whole video."
T.6	Teacher focused: listening to student	This code is meant to capture descriptions of teachers listening to students explanations, descriptions, conversations, etc.	"Instead, she listened to their thinking and see whether or not they could justify that it would always work."
T.8	Teacher focused: corrected student	This code is meant to capture a description of a teacher correct a single student or a group of students in their mathematical thinking.	"The only thing she did correct them on was the mathematics that they said aloud like .12 cents."
T.10	Teacher focused: addressing student misconceptions	This code is meant to capture when a teacher directly targets a student misconception by addressing it directly or indirectly with the student.	"Since the student had a working model she encouraged the student to find another way while drawing on the student's misconception that a dollar was the only thing less then 2 dollars."

Label	Code	Definition/Criteria	Example Quote
T.12	Teacher focused: facilitation	This code is meant to capture attention to or focus on what the teacher is doing to facilitate the task/lesson.	"...the teacher didn't tell either group that they were right or wrong."
Tasks: The focus of the reflection is on the mathematical task used in the video.			
TA.1	Task: description of task	This code is meant to capture the description of the mathematical task used in the video.	
TA.2	Task: solutions	This code is meant to capture descriptions of solutions to the mathematical task used in the video. This does not include student or teacher descriptions as observed in the video.	"This video showed how their can be multiple correct answers to the same problem/task, and that it is important to use multiple approaches as a learning experience for everyone in the classroom (both students and teachers)."
TA.3	Task: underlying mathematical concept	This code is meant to capture reference to or descriptions of the mathematical concept targeted with the task.	"The teacher never discussed the idea of the commutative property but the students highlighted the idea of the concept through their ideas."
Classroom: The focus of the reflection is on the classroom.			
CR.1	Classroom: description	This code is meant to capture descriptions of the classroom; this may include descriptions of the physical space.	"The classroom was oddly quiet while she was helping the students which to me means that they aren't discussing mathematics at their tables."
Self Concern: The focus of the reflection is how the person reflecting felt about the lesson.			
SE.2	Self concern: likes	This code is meant to capture descriptions that are liked by the writer of the reflection.	"I also like how she does little scaffolding and expects students to do most of the work."
SE.3	Self concern: dislikes	This code is meant to capture descriptions that are not liked by the writer of the reflection.	"I didn't like that the students weren't interacting with each other during the video and hearing limited discussion even though they were in groups makes me uncomfortable."
SE.4	Self concern: something interesting	This code is meant to capture things that the writer of the reflection found to be interesting.	"I thought it was interesting on how the kids came up with different equations based on how they deciphered the shape of the figure."

Label	Code	Definition/Criteria	Example Quote
SE.5	Self concern: how to change/alter instruction	This code is meant to capture things that the writer of the reflection would change about the instruction or mathematical task observed in the video.	"I would have made it more of a whole class discussion where everyone was participating and understanding what was being talked about."
SE.6	Self concern: Inference	This code is meant to capture when the writer of the reflection makes an observation and interprets it, making an inference.	"The classroom was oddly quiet while she was helping the students which to me means that they aren't discussing mathematics at their tables."
SE.7	Self concern: Wonderment	This code is meant to capture questions or things that the write wonders about the video.	"I want to know where the lesson started out or how the activity was launched with them to provide more feedback on the video."
SE.8	Self concern: Lack of content knowledge	This code is meant to capture when the writer of the reflection makes a mistake in assessing the task or incorrectly solves the task.	"The teacher then moved rather suddenly into a different formula that was too quick for me to grasp."
SE.9	Self concern: content appropriateness	This code is meant to capture when the writer of the reflection refers to the appropriateness of the content for the level of the students	" I don't think this is a good Kindergarten lesson, it feels a little too "in-depth", but my understanding of K is a few years old."

APPENDIX G

PRE-INTERVENTION LESSON PLAN (DENISE)

*Note, text in red has been added to show areas that were incomplete.

Grade Level: 4th grade
Name: Denise

MATHEMATICAL GOALS AND OBJECTIVES

The student will be able to solve multiplication facts (2-9) x 8 by using the double, double, double strategy.

IOWA CORE STANDARDS
Operations and Algebraic Thinking

4.OA.B.4 Find all factor pairs for a whole number in the range 1–100. Recognize that a whole number is a multiple of each of its factors. Determine whether a given whole number in the range 1–100 is a multiple of a given one–digit number. Determine whether a given whole number in the range 1–100 is prime or composite.

MATERIALS

Materials List: White boards Markers Multiplication worksheet

PREREQUISITE KNOWLEDGE

About the Math: This lesson assumes students already know how to solve a multiplication using a strategy.
About the Task/Context: Incomplete

Launch/Before (estimated time: _____)

LAUNCH ACTIVITY

Within the boxes below, you should answer the following questions. You should include s**pecific questions** you will ask students, manipulatives you will use, etc. during this part of the lesson.

Teacher Activity
• 6x8 will be written on the board • The students will be asked to solve the problem on their white boards. • TTW encourage students to use any strategy they know to solve it. • TTW will walk around the room and see how students are solving. • TTW have a discussion and ask students to share out strategies.

RATIONALE OF LAUNCH ACTIVITY

This activity will give students an opportunity to use a strategy to solve a multiplication problem. This will also provide an opportunity for the teacher to assess the students knowledge.

Explore/During (estimated time: _____)

EXPLORE TASK

• We have been working on multiplication facts and we are getting much quicker at those but I want to introduce a strategy to help you with your multiplication facts by 8. Skip counting by 8 can be a little trickier than our other numbers. • The strategy for solving multiplication by 8 is the double, double, double strategy. • The teacher will use 6x8 for the example • We take the factor (that is not eight) and we are going to double it. • What do I mean by double? (TTW pull popsicle stick) • Students may say 6 x 2 or 6 + 6 (Since working with multiplication, try to stick with that when modeling but either will work) • 6 x 2 = 12 • Now what is double 12? • 12 x 2 = 24 • It is called the double, double, double strategy because we have to double three times • 24 x 2 = 48 • 6 x8 =48 • TTW remind students that these math facts will come quick eventually and maybe they already do but we are going to work on this strategy today. • TTW will have students practice on white boards and show their work on their white board using the double, double, double strategy. • 3 x 8

RATIONALE OF EXPLORE TASK

This activity will provide students a new strategy to help solve multiplication by 8 problems.

ANTICIPATED STUDENT RESPONSES (ASR) FOR MONITORING DURING EXPLORE

Incomplete

MONITORING DURING EXPLORE

Incomplete

Event	Anticipated Teacher Move
To Understand Students' Work	
Stuck	
Done Early	

ASSESSMENT #1 FROM THE EXPLORE

Incomplete

Discussion/After (estimated time: _____)

ORCHESTRATING THE DISCUSSION

Strategy/Presenter(s)	Discussion Questions/Probes
ASR 1 Incomplete	
ASR 2	
ASR 3	
ASR 4	

RATIONALE FOR SEQUENCE

Incomplete

DISCUSSION SUMMARY/CLOSURE

Incomplete

FINAL ASSESSMENT

Incomplete

APPENDIX H

POST-INTERVENTION LESSON PLAN (DENISE)

Multiplication: Easter Egg Task

Grade Level: 3rd grade
Name: Denise

MATHEMATICAL GOALS AND OBJECTIVES

1. TSWBAT solve a story problem with two-digit numbers using a variety of strategies; including division as an unknown factor problem.
2. NCTM: Students will apply and adapt a variety of strategies to solve problems
3. NCTM: Students will be able to communicate mathematical thinking coherently and clearly to peers, teachers, and others.

IOWA CORE STANDARDS

Understand properties of multiplication and the relationship between multiplication and division (3.0A.B)

- Understand division as an unknown-factor problem. For example, find 32 ÷ 8 by finding the number that makes 32 when multiplied by 8. (3.0A.B.6) (DOK 1,2)

MATERIALS

Materials List:

- Counters
- White board/markers
- Paper/pencil
- Document camera
- Exit ticket
- Assessment checklist

PREREQUISITE KNOWLEDGE

About the Math:

This lesson assumes students know how to read and solve story problems by using multiplication and division within 100 by using equal groups, arrays, and can solve for an unknown number by using drawings and equations. (3.OA.A.3)

The lesson also suggests that students already know how to interpret whole-number

quotients of whole numbers. Students know that the largest number is what needs to be shared evenly; interpret 56 ÷ 8 as the number of objects in each share when 56 objects are partitioned equally into 8 shares, or as a number of shares when 56 objects are partitioned into equal shares of 8 objects each. *(Iowa Core* 3.OA.A.2). This lesson also assumes that students know that a division problem can be set up as a multiplication problem with an unknown whole factor relating three whole numbers. *(Iowa Core* 3.OA.A.4)
About the Task/Context: To clarify the task, the teacher will make sure that students understand what an Easter egg hunt is and how the eggs hold candy, but we want to make it fair, so everyone will get the same amount.

Launch/Before (estimated time: 5 minutes)

LAUNCH ACTIVITY

Within the boxes below, you should answer the following questions. You should include specific questions you will ask students, manipulatives you will use, etc. during this part of the lesson.

Teacher Activity

- TTW ask, "Have you ever participated in an Easter egg hunt?"
- TTW allow for students to respond
- Have you ever done an Easter egg hunt where one kid gets a lot of eggs and another kid only gets one or two? Is that fair?
- TTW allow students to respond
- How can I make an Easter egg hunt fair?
- The goal is to get students to understand that every child should be able to find the same number of eggs and there should be the same amount of candy in each egg to make it fair.
- After students understand that we want an Easter egg hunt to be fair, I will discuss my dilemma. "I am planning the town's Easter egg hunt. The kids will be split into age groups. There are 96 eggs hidden for each group. There are only 12 kids in the first group. How many eggs should we tell each child to find?
- Students will understand that there are only 96 eggs to split evenly among 12 kids.

RATIONALE OF LAUNCH ACTIVITY

1. This task fits the learning goal because they have to be able to solve a story problem using two-digit numbers using a variety of strategies including division as an unknown factor problem.
2. By relating the task to an Easter egg hunt, the students will understand the goal of the task and understand why it's important for kids to get the same amount.
3. The key mathematical ideas are to solve a division problem as a multiplication problem with an unknown factor. The students will understand this at this method

at the end of the activity.

4. Students will understand what each number means in the equation. There are 96 eggs and 12 kids—how many eggs does each kid get? The students will also be able to effectively communicate their strategy by using common math vocabulary—multiplication, division, factor, unknown factor, solve, equal, etc.
5. The task is cognitively demanding for students. Multiples of 12 will be challenging for the students as they have focused primarily on single digit multiples up until now. The teacher will focus on student strategies and the thinking behind them rather then the answer. It is a cognitively demanding task as they will have to show their work and explain their thinking anyway they know how to solve the problem. The teacher is not to step in but just understand student thinking.

Explore/During (estimated time: 20 minutes)

EXPLORE TASK

- Task: There are 96 eggs hidden for each age group. If there are 12 kids in the first group, how many eggs can each child find so they each get the same amount?
- Students will get a handout of the task as well as the task being projected on the screen.

RATIONALE OF EXPLORE TASK

This task fits the learning goals of the lesson as the students will use what they know about multiplication to help solve this problem. This task assumes that third graders already know multiplication and division problems as three whole numbers.
This task builds on their previous knowledge of understanding division as unknown factors in multiplication problems by drawing arrays or other drawings. Students will be provided with the task, individual white boards and markers or paper and pencil to allow each student to work through the task and show their work.

ANTICIPATED STUDENT RESPONSES (ASR) FOR MONITORING DURING EXPLORE

*See Monitoring Chart (Appendix A)

MONITORING DURING EXPLORE

Event	Anticipated Teacher Move
To Understand Students' Work	
Stuck	What do you know? What are you trying to figure out? Imagine you are one of the 12 friends at the Easter egg hunt. How can you split up the 96 eggs evenly? What do you need to

	do?
Working Unproductively	What is the task? What do you know? Where are you going to start? Show your work.
Done Early	What method did you use? Explain to me your reasoning for solving it this way. What if each child were to get 3 eggs each—how many kids would have to find the 96 eggs, so each child had the same amount? There were 16 kids in the second group—how many eggs could each child find in that group? What if I only had 72 eggs, how many eggs could each child find then?

ASSESSMENT #1 FROM THE EXPLORE

As students are working on the task, the teacher will assess the students by using a formative assessment checklist. The teacher will make notes on each student/ group and the strategy they are using. This information will help the teacher rank the strategies used, clear up common misconceptions, and will help when students are asked to share their strategies under the document camera to the class and participate in whole group discussion.

Discussion/After (estimated time: 15 minutes)

ORCHESTRATING THE DISCUSSION

*See Monitoring Chart (Appendix A)

RATIONALE FOR SEQUENCE

1. A) I would first share the misconception, only if others are also making similar mistake. To clarify the problem, I would have students reread the problem and highlight what they know and underline what the are trying to figure out. I would ask students to repeat to a partner to ensure everyone understands the problem.
   B) I would then have students who solved the problem by drawing a picture, array, or table share first. All students could connect to this thinking as we have worked with arrays in the past. All students could clearly understand the problem and clear up misconceptions if seeing it displayed as a visual representation.
2. Next, I would share the student strategy of skip counting/ addition. This strategy ties well to the array as they are counting each row in the array.
3. I would have the group who solved using division go next because they broke it up using smaller numbers to help solve. Although they kept the problem as division

they could have easily set it up by using multiplication and an unknown factor which is what we will focus on. I would come back to this strategy of breaking up numbers after we discuss the unknown factor strategies in 4 & 5.

4. I would have the group that used the guess and check method go next because they did set it up with an unknown factor in a multiplication problem; but used guess and check because they didn't know the unknown factor.
5. Last, I would have the students who knew that 12 x 8 =96 go last because they set up their division problem by using the unknown factor in a multiplication problem which is what we want to focus on. I would then go back to strategy 3 and show how division and multiplication can both help solve the same problem.

DISCUSSION SUMMARY/CLOSURE

TTW lead the class in discussion asking the following questions: What was the most popular strategy among the class? Would any of you choose a different strategy now that you've seen what your classmates did? What do you think was the most efficient way to solve this problem? TTW allow students to respond.

TTW then lead the class through a similar problem, to focus on solving a division problem using multiplication with an unknown factor. The next group had 16 kids participating for the 96 Easter eggs. How could we solve this? This will allow the teacher an opportunity to focus on this strategy for students to practice on their white boards. TTW ask "What do we know? What do we need to figure out? How do you know?" TTW allow for students to walk her through the problem to solve using step by step directions. TTW stop and ask other classmates to repeat/ rephrase classmate's thinking to ensure everyone understands. Where did Johnny get that number? What's the next step? Where does the number 16 come from? What does 96 represent? What do you mean equal?

FINAL ASSESSMENT

The following exit ticket will be used to assess student thinking. The exit ticket will provide the teacher with a good indication whether the student knows how to set the problem up with an unknown factor in a multiplication problem.

Exit Ticket: I have a bag of 32 pieces of candy. If I put 4 pieces of candy in each egg, how many eggs can I fill with one bag of jelly beans?

Appendix A

Monitoring Chart

Anticipated Student	Questions/Probes	Student/ Group with	Sequence

Responses		Strategy	
Possible Error: Solved the problem as multiplication 96 x 12 = 1,1,52 Possible Error: Used 12 kids and assumed each kid got 12 eggs	Advancing Questions: ● For error, you are saying you are giving each child 96 eggs—but you do you have that many eggs to give to each person?... ● Let's read the problem again and highlight what we know and try to figure out what we are trying to solve. Assessing Questions: ● How did you get that number? ● Walk me through your thinking.		1 A)*share error if only others are making similar misconceptio n first
Solved using unknown factor in multiplication problem 12 x ___ = 96 Guess and check 12x 5 = 60 12x 10=120 12x8=96 Possible Error: Starts at one and tries all until gets to 8.	Advancing Questions: ● What if there were 16 kids in the group? How many eggs would they each get? ● Would you solve the same way? Assessing Questions: ● Why did you start with guessing with those numbers? ● How did you know to set up the problem like this? (unknown factor)		4
Solved by skip counting/ addition 12+ 12= 24 24 +12=36 36+12=48 48+12=60	Advancing Questions: ● Is there another strategy you could think of to solve this problem? ● What if there 24 kids in the group, how many eggs could each kid find? Assessing Questions:		2

60+12=72 72+12=84 84+12=96 Possible Error: Didn’t count the first 12/ wrong addition	● How did you solve this? ● Why did you add 12 each time? Walk me through your thinking? ● Why did you stop when you got to 96? ● How did you get 8 as an answer then by solving this way? ● For error: How could you check your work by using another strategy?		
Solved by drawing an array—and counting by ones XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX Possible Error: Miscounted when drawing the array.	Advancing Questions: ● Is there a multiplication problem you could use to help solve this? What would that look like? ● Try solving using another strategy. Assessing Questions: ● How did you solve this problem? ● How did you know you needed 12 in each row? ● How did you figure out that there were 8 rows? ● For error: How many columns do you have? How many rows? What do those numbers represent		1. B)

Solved by division, making smaller numbers 96 ÷ 12 = 8 96 ÷ 2 = 48 48 ÷ 12 = 4 (I know 12 goes into 48 4 times so then 12 can go into 96 8 times) Possible Error: 96 ÷ 2 = 48 48 ÷ 2 = 24 24 ÷ 2 = 12 Student then adds the 2's to get 6	Advancing Questions: ● What if I only had 72 eggs, how many eggs could each child find, so each child has the same amount? ● For error, how could you double check your work? ● For error, try another strategy to see if you get the same answer. Assessing Questions: ● Walk me through your thinking here. ● Why did you divide 96 by 2? ● How did you know you could break up 96 into a smaller number? ● For error: How did you know to set the problem up like this? ● How did you come up with 6—what is your thinking?		3
Solved using unknown factor in multiplication problem using a variable 12 x a = 96 Possible Error: Student knew when multiplying the 2 (in 12) it had to equal a 6 (of 96). Student tried 3 and then tried 8 (knowing 8 x2 =16)	Advancing Questions: ● What if I only had 72 eggs, how many eggs could each child find, so each child has the same amount? ● Would you solve using the same strategy? Assessing Questions: ● How did you know to set the problem up like this? ● How did you come up with 8—what is your thinking?		5
Other possible ideas:			

Standard long division algorithm Number Line			