October 2020

Teacher Certification Pathway and Mathematical Quality of Instruction

Gail Stewart
University of South Florida

Teacher Certification Pathway and Mathematical Quality of Instruction

by

Gail Stewart

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy in Curriculum and Instruction
with a concentration in Mathematics Education
Department of Teaching and Learning
College of Education
University of South Florida

Major Professor: Sarah vanIngen, PhD
Eugenia Vomvoridi Ivanovic, PhD
Robert Dedrick, PhD
Jennifer Jacobs, PhD

Date of Approval:
October 22, 2020

Keywords: Preparation, teaching, secondary mathematics, teacher perceptions

Dedication

This dissertation is dedicated to my family and my friends and colleagues who are like family to me. Without them, my work would have no meaning.

Acknowledgements

I earned this degree with many others by my side throughout the entire process. I am incredibly grateful for the never-ending support of my committee members, all of whom believed in me even when I doubted my abilities.

To Dr. Sarah van Ingen, thank you for all the wisdom and experiences you shared with me to help me learn and grow. Thank you for setting special time aside for me and making me feel so supported and never alone in the process. You answered my calls, texts, and emails without ever making me feel as if I were bothering you. Your kindness and generosity were so inspiring, and I cannot thank you enough for challenging me and making me a better scholar and person.

To Dr. Jacobs, Dr. Vomvoridi-Ivanovic, and Dr. Dedrick, thank you for all the knowledge you imparted on me throughout my coursework and doctoral candidacy. I admire you all as experts in your field and aspire to teach someone as much as you have all taught me. Your positive and caring natures helped me feel comfortable to ask for help when I needed it. I greatly value your feedback and input which helped me reach my goals and learn an invaluable amount along the way.

To my family, I have always considered myself lucky to have been born into this group of amazing people. Thank you for always supporting me in everything I do. This process would have been impossible without the love, support, and encouragement from you Mom, Leslie, Valerie, Gareth, Grandma, and Scott. Your reassurance during my times of doubt helped me preserve and get to the finish line. Your check-ins via text, calls, and in person made me feel

that you were just as committed to my success as was I. You were always interested in my progress and shared in my excitement as well as lifting me up when I was struggling. I love you all so much.

To my friends, thank you for understanding when I had to say no to social events because of homework, projects, writing, or just being too exhausted to leave the house. Thank you for telling me you were proud of me and acknowledging that this process was a tough one! I appreciate all the love and support, which confirmed that I have an amazing group of friends.

To my doctoral student peers, thank you for answering all my questions and sharing your experiences with me to help me along the way. Thank you for telling me that I am capable and for encouraging me when I felt like I wouldn't make it to the end of the process. Thank you to Keisha, Melanie, Denise, and Andrea for reassuring me that I was on the right path and giving me hope as I reached each new stage in the process. Thank you Annetta for your kindness, compassion, and never-ending support. Going through coursework with you was one of my favorite parts of the process. We had the best conversations about teaching math, and about life in general. You really helped me become a better thinker, learner, and person. Your support was such an integral part of my success and I am so grateful we met. I know we will always be close friends.

Table of Contents

List of Tables

List of Figures

Abstract

The formal documentation of alternative routes to teacher certification programs in the United States began in 1983 (Ludlow, 2011). According to the former US Secretary of Education's Annual Report on teacher quality the high demand for teachers in high needs areas, such as mathematics, has caused growth in alternative certification routes for teachers (Paige, 2002). The many factors that influence teaching quality make it difficult to determine what impact, if any, a teacher's preparation program has on the quality of their instruction. Current research on teacher quality shows varied results, making it hard to reach a conclusion about the effectiveness of any of the preparation program pathways. This study fills in a gap in the literature by attending to the perspectives of the teachers who have matriculated through different pathways. In this study, I juxtaposed teacher scores on the Mathematical Quality of Instruction (MQI) instrument with the same teachers' perspectives on the factors influencing teaching decisions. I asked traditionally and alternatively certified teachers about how their teaching decisions may have been related to their preparation experiences.

I used a multiple case study to examine the relationship, if any, between mathematics teacher certification routes and the quality of mathematics instruction for novice mathematics teachers, according to their score on the mathematical quality of instruction (MQI) instrument. Two alternatively certified mathematics teachers and two traditionally certified mathematics teachers within the first five years of teaching participated in the study. The MQI scores obtained from teachers' mathematics lessons provide quantitative data and semi-structured interviews provided qualitative data to gain insight into mathematics teachers' perceptions about the relation between their certification routes, whether traditional or alternative, and the quality of their mathematics instruction. Qualitative interview data were analyzed through open, axial, and selective coding cycles where codes are used to identify themes within the participant responses and determine a potential relation between the certification route in which mathematics teachers matriculated and the quality of their mathematics instruction.

First, I analyzed each case separately using data gathered from the interviews and the MQI. I used three rounds of coding for each individual case and used situated learning theory as a lens through which to view the interview data. Next, I compared the data within each certification category, identifying similar themes between teachers who matriculated through the same preparation pathways. Finally, I conducted a cross-case analysis to look for commonalities and differences identified in the within case analyses. The common themes identified from traditionally certified teachers' data about rationales for teaching decisions were learning styles, colleagues, and internship experiences. The data from alternatively certified teachers indicated colleagues, learning styles, high stakes testing, and resources as the most common themes influencing rationales for their teaching decisions. The alternatively certified teachers scored higher than their traditionally certified colleagues in the Explanations and Mathematical Sense Making subdomains within the Richness of the Mathematics domain on the MQI. The traditionally certified teachers did not score higher than the alternatively certified teachers in any of the subdomains.

Based on the diversity of teacher experiences both within and between preparation pathways, I recommend that school district induction programs plan experiences for teachers that help fill in the potential gaps that novice teachers have, regardless of the type of teacher preparation program through which they matriculated. A potential area of future research could

focus on improving the method used to evaluate teacher preparation programs in a way that considers the many factors that influence preparation program effectiveness. Evaluation of preparation programs involving an approach that considers using qualitative and quantitative data including teacher insight, could help create a better system for program evaluation while considering these factors. Currently, existing research has tried to determine whether traditional or alternative teacher preparation pathways better prepare mathematics teachers. My study paints a more nuanced picture of the varied experiences in each pathway and the diversity of experiences within those pathways.

Chapter 1: Introduction

Background

Historically, teacher preparation programs offered at institutes of higher learning have been the main source of supplying teacher candidates into education. Traditional teacher preparation programs most commonly prepare teachers by having them complete approximately 120 hours, which is about 40 courses, in the field of education. These programs typically include field experiences where pre-service teachers work with in-service teachers and students in a classroom setting. Prior to graduation, most traditional teacher preparation programs require pre-service teachers to complete an internship where they plan lessons and teach alongside a practicing teacher within the school district. Most traditionally certified teachers matriculate through four-year programs at a college or University.

The formal documentation of alternative routes to teacher certification programs in the United States began in 1983 (Ludlow, 2011). "By the 2009-2010 school year, one in five of all U.S. future teacher graduates came from alternative programs" (Schmidt et al., 2020). Currently, the variation between the many traditional and alternative certification programs that exist make it difficult to explore the effectiveness of each pathway. Teachers are categorized as either traditionally or alternatively certified, yet there are many other smaller categories within those two larger ones. For example, some alternatively certified teachers could have gone through a program specific to mathematics teaching, while others could have gone through a general alternative certification program that prepared teachers to teach any subject. The same is true for traditionally certified teachers. Some may have gone to college and earned a degree in mathematics education, whereas other traditionally certified high school teachers could have a degree in elementary education, but later took and passed their high school certification test and are still considered traditionally certified to teach high school mathematics. With each state offering its own alternative certification routes for teachers, it could be difficult to determine if these programs are preparing teachers, specifically mathematics teachers, to deliver effective instruction to students.

One way for countries to ensure students receive effective mathematics instruction is to provide uniform national standards that outline the mathematics content to be taught by teachers and learned by students at each grade level (Schmidt, 2012). These standards provide direction for teachers including what content to teach, in what sequence, and to what level of depth. In 2010, the Common Core State Standards (CCSS) were created to ensure that all U.S. students graduate from high school with the skills and knowledge necessary to succeed in college, career, and life, regardless of where they went to school. These standards are outlined as learning goals that describe what students should know and be able to do at the end of each grade (CCSM, 2010). In addition to the student learning goals ensued by the CCSS, the creation of these standards also changed the expectations for teachers of mathematics.

The arrival of the Common Core State Standards had an important impact on teacher preparation in the United States. With the implementation of the CCSS came a greater responsibility on teacher preparation programs to adequately prepare mathematics teachers to fulfill the requirements set forth by these standards (Schmidt, 2012; Chelsey and Jordan, 2012). Researchers suggest teacher preparation programs must restructure their content preparation to align with the changes in curriculum being generated in response to the CCSS (Chelsey and Jordan, 2012). One way these requirements might be fulfilled in mathematics teacher preparation is to put policies into place that require additional mathematics courses during teacher preparation which would help prepare teachers to help students meet CCSS requirements (Schmidt, 2012). Writers of the Common Core State Standards used a variety of existing standards and altered them to reflect the skills and knowledge students need to succeed in college, career, and life. In mathematics specifically, the CCSS called for three shifts to existing mathematics standards; greater focus on fewer topics, coherence in linking topics and between grade levels, and rigor to pursue conceptual understanding, procedural skills and fluency, and application with equal intensity. These shifts are important to teacher preparation because the Common Core posits "Understanding how the standards differ from previous standards—and the necessary shifts they call for—is essential to implementing them" (CCSS, 2019). To accomplish this task and fully prepare teachers of mathematics, preparation programs must incorporate exploration of the former mathematics standards, the new CCSS, and the changes that were made between the two.

In addition to the responsibility of college and university preparation programs, responsibility must also lie within individual states to set high standards for teacher certification requirements (Schmidt, 2012). This may mean that states need to raise the bar on certification requirements to ensure that teachers who have acquired certification are able to demonstrate a level of knowledge sufficient enough to teach the CCSS to their mathematics students. The CCSS changed expectations for teachers in the preparation stage as well as for practicing teachers.

One way the expectations for teachers changed is that now, teacher's effectiveness would be evaluated based on how well their students performed on achievement measures based on the CCSS. With the implementation of the CCSS teachers would now be held more accountable based on measures tied to achievement scores (Matlock et al., 2016), which would determine their effectiveness and the quality of their instruction. To further understand the role that the implementation of the standards played on quality of instruction and teacher effectiveness, I will describe both of those phrases in more detail.

Quality instruction can be described by various characteristics that teachers possess, including but not limited to methods of teaching (Berliner, 2005; Strong 2011). Specifically, mathematical quality of instruction refers to a composite of several dimensions including the presence or absence of mathematical errors, mathematical explanation and justification, mathematical representation, and other observable features (Hill et al., 2008).

Effectiveness, however, is a part of quality teaching that refers specifically to student achievement outcomes (Berliner, 2005). Teacher effectiveness is often measured by value-added models based on student outcomes, which are used to determine quality of teaching. While good teaching can occur when standards and norms of the profession are met, effective teaching is tied to student's achievement goals (Berliner, 1987). When students learn what they are supposed to learn in a particular class or subject, the teaching is considered effective (Berliner, 2005). Berk (2005) examined twelve strategies to measure teaching effectiveness and proposed a "unified conceptualization" of teaching effectiveness that consists of evidence collected from a variety of sources. Each source, he posits, can provide valuable and unique information while also containing flaws. Other authors agree with this need for the triangulation of more than one course of evidence in making an accurate determination about teacher effectiveness (Appling, Naumann, and Berk, 2001).

The *Measures of Effective Teaching Project* funded by the Bill and Melinda Gates Foundation has contributed to the research on reliable ways to measure teacher effectiveness

(Muijs and Reynolds, 2017). The goal of the project was to investigate better ways to identify and develop effective teaching (MET Project, 2013). Approximately 3,000 teachers from seven school districts volunteered to participate in the study to help researchers identify and develop measures of effective teaching. The project collected data from classroom observation measures, pupil surveys, and value-added measures calculated using student achievement measures (Figure 1). During the first year of the study, estimates of teaching effectives were produced based on those three measures. Estimates were then adjusted to account for student prior differences. The following year, students were randomly assigned to participating teacher's classrooms (MET Project, 2013). Each analysis allowed MET Project researchers to better understand the impact of the contribution that each data source made to the big picture of effective teaching and how each measure should be implemented to provide the most meaningful feedback. Overall, findings from the MET Project show that it is possible to identify groups of teachers who are more or less effective in effecting student's achievement.

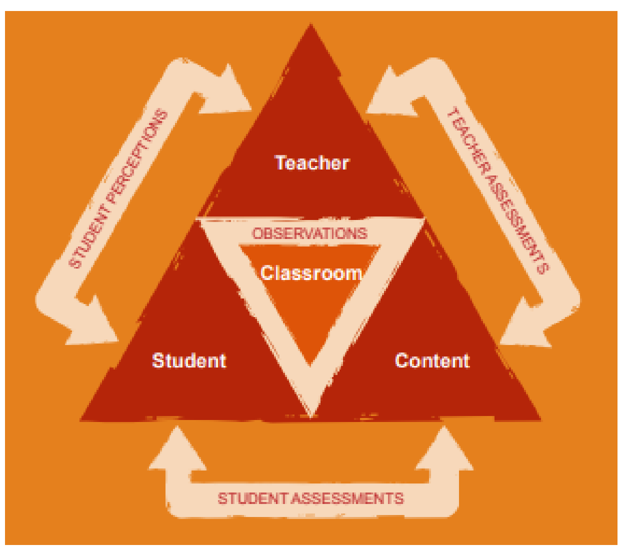


Figure 1. *Multiple Measures of Teaching Effectiveness* (Kane and Staiger, 2012)

The purpose of this dissertation study is to explore the extent to which the preparation pathway in which secondary mathematics teachers' matriculate influences the quality of mathematics instruction that they deliver to students. The current research on alternatively certified mathematics teachers and their instructional performance in the classroom is scant, and this study will add to the literature base comparing traditional and alternative certification routes and their potential impact on mathematics teacher quality of instruction.

Conceptual Frameworks

This research is influenced by two conceptual frameworks: Pedagogical Content Knowledge for Teaching (Shulman, 1986) and Mathematical Knowledge for Teaching (MKT) (Ball, Thames, and Phelps, 2008). The first framework suggests that there is teacher knowledge used in classrooms beyond formal subject matter knowledge, called pedagogical content knowledge. Pedagogical content knowledge describes the specialized knowledge where pedagogy and content knowledge intersect. This type of knowledge goes beyond knowledge of subject matter and focuses on the ways of representing and formulating the subject to make it understandable to others (Shulman, 1986). It also includes understanding the topic of interest well enough to know what makes learning it easy or difficult. In addition, pedagogical content knowledge encompasses an understanding of the conceptions and preconceptions that students bring with them to the learning environment (Ball, Thames, and Phelps, 2008). If students carry any misconceptions with them about a topic, a teacher with strong pedagogical content knowledge can select strategies that are most appropriate to reorganize the learning (Shulman, 1986). Though Shulman's work is not specific to a content area, it has been used as a lens in many content areas to describe the knowledge needed to teach.

The second framework, Mathematical Knowledge for Teaching, is an extension of Shulman's work, and is specific to mathematics. This framework was developed from studies that analyzed what teachers do as they teach mathematics and what they need to know to successfully teach mathematics (Ball, Thames, and Phelps, 2008). The framework consists of subject matter knowledge and pedagogical content knowledge which together represent the mathematical knowledge needed to perform the often repeated tasks of teaching students mathematics.

Though the Pedagogical Content Knowledge for Teaching framework is the original framework, my study refers more to the MKT framework, because of its specificity to mathematics teaching. This is an extension of Shulman's idea of pedagogical content knowledge, which calls for an emphasis on content and the presentation of content through instruction. Deborah Ball and colleagues developed the MKT framework by taking Shulman's ideas and expanding them to apply specifically to mathematics (2008). The MKT framework is comprised of six sections, three that address subject matter knowledge and the other three that address pedagogical content knowledge (see Figure 2). Through ongoing analyses, it has been found that general mathematical ability does not fully account for knowledge and skills that come along with teaching mathematics. Ball et al. (2008) discuss factors that make mathematical knowledge for teaching special, which are as follows: sizing up student errors, know rationales for procedures, meanings of terms, explanation of content, considering what numbers are appropriate to use in examples, and more. They also identify aspects of subject matter knowledge that need to be included in mathematics courses for teachers, which connects to the present study because of the examination of certification pathways and their impact on teacher's performance on the MQI. In this study, the MQI is used as an instrument to help identify what mathematics knowledge matters in teaching.

Another way in which the MKT framework guides this study is because of its influence on and similarity to the MQI. Some of the components of the MQI are similar to specific components of the MKT framework. For example, one of the domains of the MQI is errors and imprecision, which is directly associated with the MKT framework component of sizing up student errors. Each element of the MQI is used to assess one of the following three relationships; teacher-content, teacher-student, or student-content (Gates foundation article). These elements relate to the MKT domains that are categorized by knowledge of students, content, teaching, and curriculum. In addition, previous studies have found significant positive associations between levels of MKT and mathematical quality of instruction as measured by the MQI (Hill et al., 2008).

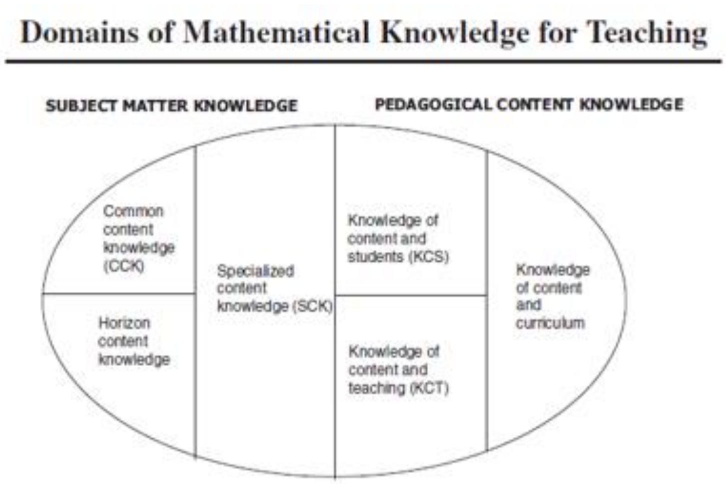


Figure 2. *The Mathematical Knowledge for Teaching Framework* (Ball et al., 2008).

Theoretical Perspectives

In this section, I will discuss the theoretical perspective that guides my study. I will focus on two components of this theoretical perspective and describe what interactions between learners look like based on the components of the guiding theoretical perspective

Situated Learning Theory. Situated learning theory is based on the notion that learning is a highly social, interactive activity that includes collaboration and mentoring. It is comprised of three tenets; authentic context, social interaction, and constructivism (see figure 3 below). The theory originated from cultural studies through which researcher observed learning in a variety of settings. From these studies, Lave and Wenger (1991) came to the conclusion that knowledge transfer is correlated to the social situation and context in which the knowledge is learned.

Community of Practice. Further, within situated learning, learners participate in a community of practice. Wenger (1998) formed the first definition of community of practice as, "a group that coheres through 'mutual engagement' on an 'indigenous' (or appropriated) enterprise, and creating a common repertoire." A community of practice does not imply a co-presence or a well-defined identifiable group, but rather participation at multiple levels of an activity system about which participants share understandings concerning what they are doing and that that means in their lives and communities. A critical aspect of the situated learning model is the notion of the apprentice observing the "community of practice." (Herrington and Oliver, 2000). Wenger's early work on communities of practice focused on identity and the importance of trajectories through the different levels of participation in which one engages within a community and the tensions that could arise for individuals from belonging to multiple communities of practice. As his exploration of communities of practice continued, a new definition was formed (Wenger, McDermott, and Snyder, 2002). The new definition would be more vague and would focus on learning and sharing knowledge, rather than accomplishing a specific task (Cox, 2005). The revised definition of communities of practice is, "Groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis." Though the term 'community of practice' still has varied interpretations, the predominant usage is used to refer to a relatively informal, intra-organizational group specifically facilitated by management to increase learning or creativity (Cox, 2005).

Wenger, McDermott, and Snyder (2002), proposed seven principles for cultivating communities of practice. One of the principles is to create an open dialogue between inside and outside perspectives. They claim that only a member of the community of practice can appreciate the issues within it and know the knowledge that is important to share. This principle relates to my study because insight from teachers about the community of practice in which they participated while preparing to become a teacher could be valuable in determining the affect that their preparation program has on their mathematics teaching. Another principle for cultivating communities of practice that relates to my study is the focus on value. This principle emphasizes the importance of communities creating events, activities, and relationships that help increase their value and encouraging community of practice members to share insights and be explicit about the impact of these insights with other members of the community of practice. This relates to my study because of the impact that teacher performance could potentially have on the planning and implementation of preparation programs.

Legitimate Peripheral Participation. In a community of practice, the social interaction process that occurs between learners who are new to the context and those who are familiar with it is referred to as legitimate peripheral participation (Lave and Wenger, 1991). The authors used legitimate peripheral participation as a way to capture learning as an integral and inseparable aspect of social practice. While novice learners to a particular subject or topic gain knowledge and move closer to the center of the community, they becomes more actively engaged in the culture and learning and eventually take on a mentor role in which he or she can help newer members of the community of practice (Leonard, 2002). This is important to mention because in my study, the acclimation of teachers to the communities of practice within their preparation experiences when they were new and the interactions that they experienced with those who were more familiar could have an impact on their current teaching practices, as measured by the MQI.

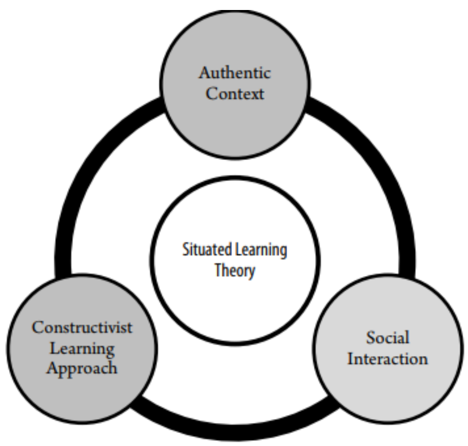


Figure 3. *Tenets of Situated Learning Theory* (Green, Eady, and Anderson, 2018).

Situated Learning Theory in Teacher Preparation

For my study, I choose to view teacher preparation through a situated learning lens. Based on their certification route, traditional and alternatively certified teachers' preparation experiences could vary dramatically. One of the variations could come from the community of practice experiences in which these teachers participated. Some studies suggest that programs informed by elements of situated learning theory, specifically communities of practice, have been shown to be effective when implemented in teacher preparation programs as a method of instruction for preservice teachers (Bell, Maeng and Binns, 2013; Herrington and Oliver, 2000; Mishra and Koehler, 2007; Vannatta, Beyerbach and Walsh, 2001). Some of the programs mentioned in the research that have a foundation in situated learning theory aimed to connect learning to, and position learning within, the classroom environment, encouraging students to apply their knowledge and understanding to this authentic context (Green, Eady, and Anderson, 2018). Other studies posit that programs founded on key tenets of situated learning theory will be more effective than the traditional decontextualized approach when preparing teachers (Bell, Maeng, and Binns, 2013; Green, Eady, and Anderson, 2018).

Gaps in the Research

Surrounding the area of teacher certification routes and their potential impact on teacher quality of mathematics instruction, gaps exist. Few studies exist in this area that are specific to mathematics teachers. These gaps are discussed in more detail in the literature review provided in Chapter 2. The gap I will specifically address in this study is whether there are ways in which a secondary mathematics teacher's preparation pathway affects the quality of his or her mathematics instruction.

Currently, the quality of a teacher's instruction is primarily measured using a value-added approach. Education Value-Added Assessment (EVAAS) Models are currently used by school districts and states across the country to help evaluate the potential impact that districts, schools, and teachers have on student progress (Amrein-Beardsley, 2008). Researchers have examined the validity of these models and have found some shortcomings with using them as the only means to measure effectiveness. One group of researchers discuss the necessity to assess whether teacher who score highly according to EVAAS models are the same teachers who are most effective according to other measure of teacher quality (McCaffrey et al., 2004a). They also discuss the importance of knowing whether teacher scores on these models are contradicted or supported by predictors such as scores on licensure tests, years of experience, and teacher preparation factors such as degree earned and experience in content and pedagogy. Another researcher investigated the validity of the EVAAS model and concluded that the construct of teacher effectiveness was largely oversimplified due to the heavy reliance on student test score gains (Kupermintz, 2003). Another issue with these value-added methods is that the creators have not made the method or calculation of scores completely open for peer review, making it impossible to replicate or conduct confirmatory factor analyses of findings. For these reasons, the EVAAS model is commonly referred to as the "black box" model (Amrein-Beardsley, 2014).

Results from a study conducted by Blazar et al. (2017) indicated that teachers scores varied when evaluated using instruments that were general for teachers of all subjects versus specific to their content area. The researchers concluded that because of these differences, current processes that assess teachers on just one instrument, such as the EVAAS model, are likely to mask important variability within teachers across subject areas. It is clear from the results of this study that integrating general and content-specific tools to measure teacher effectiveness provide a clearer picture of a teacher's performance. My exploratory case study is designed to address this gap in the research around the perceptions of teachers as to how their certification pathway impacts the quality of their classroom instruction.

Multiple case study methodology is appropriate for this study because it can highlight causal links that are more difficult to identify from large-scale studies (Yin, 1994). Case studies are also appropriate in studies where an intervention or method has not clear set of outcomes. In my study, the outcomes of the quality of mathematics teaching based on teacher certification route are not clear, hence why the case study methodology fits. In addition, I will collect and analyze both quantitative and qualitative data. This is appropriate because multiple case studies are designed to bring out the details of participant's viewpoints using multiple sources of data (Tellis, 2007). In this study, it is important that the observational data collected using the MQI is explained by participants through the interview process to highlight possible effects of their preparation program on their mathematics teaching decisions.

Purpose and Research Question

The purpose of this study is to answer the following research question: In what ways, if any, do novice teachers perceive their preparation path (alternative or traditional) as having an impact on the quality of their mathematics instruction as measured by scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI?

Definition of Terms

In this section, I will define the key terms to which I will refer throughout my study. For the purposes of this study, several terms need to be defined: alternative certification, traditional certification, secondary mathematics teacher, and mathematical quality of instruction. In this section I provide operational definitions for these terms that describe how they will be referenced in this study.

Alternative Certification refers to a pathway to teaching that is different from the traditional college of education route. Teachers who possess alternative certification hold degrees in areas other than education. The specific pathway is not important to this study, but it is important to distinguish alternatively certified teachers from traditionally certified teachers. *Traditional Certification* is obtained by teachers who matriculate in a four year college of education program and graduate with a degree in education. *Secondary Mathematics Teacher* is defined in this study as the instructor directly responsible for teaching high school mathematics to students in a traditional public-school setting. *Mathemataical Quality of Instruction* is defined as a composite of several dimensions that characterize the rigor and richness of the mathematics of a lesson, including the presence or absence of mathematical errors, mathematical explanation and justification, mathematical representation, and related observables (Hill et al., 2008).

Limitations

The use of self-reporting in this case study methodology has potential, inherent limitations. Interviews, for example, could result in response bias based on the participant's unwillingness to share their experiences or because of the participant saying what they think the interviewer want to hear (Tellis, 1997). In addition, deeper meanings behind participant answers could be hidden from the interviewer. Another limitation related to the interview process and bias is the use of just one interviewer who is also in the field of education. Because of this, it is difficult to eliminate interviewer bias. Finally, having four participants makes this a small study that represents a small portion of traditionally and alternatively certified teachers.

Chapter 2: Literature Review

The research question in this study involves secondary mathematics teacher's preparation path (alternative or traditional) and the quality of their mathematics instruction as measured by scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI. Because this study looks at differences in Mathematical Knowledge for Teaching between traditionally and alternatively prepared teachers, there are three areas of the literature that are necessary to review. This review of the literature discusses alternative teacher certification, teacher content knowledge, and the Mathematical Quality of Instruction (MQI) instrument.

Alternative Teacher Certification

Existing research on the topic of alternatively prepared teachers is scant, since alternative certification has only existed since the 1980's. This existing research is primarily quantitative and compares aspects of teacher and student achievement based on certification pathway. What we already know is that there are multiple paths to teacher certification, which differ between states and counties. Research and standards specific to preparing mathematics teachers are relatively new and are important to mention when discussing certification routes for mathematics teachers. The Association of Mathematics Teacher Educators (AMTE, 2017) published standards for preparing teachers of mathematics. These standards are guided by five foundational assumptions: (1) ensuring the success of each and every learning requires a deep, integrated focus on equity in every program that prepares teachers of mathematics, (2) teaching mathematics effectively requires career-long learning, (3) learning to teach mathematics requires a central focus on mathematics, (4) multiple stakeholders must be responsible for and invested in preparing teachers of mathematics, and (5) those involved in mathematics teacher preparation must be committed to improving their effectiveness in preparing future teachers of mathematics. The AMTE (2017) standards document also describes what beginning teachers of mathematics should know and be able to do, as well as the dispositions they should develop. These standards can provide direction for teacher educator educators when planning preparation programs of study.

The Teacher Education and Development Study in Mathematics (TEDS-M) includes a study of primary and secondary teacher certification routes (Tatto et al., 2008). The goal of the study was to clearly identify routes of mathematics teacher certification and distinguish how they differ in major aspects such as their structure, curriculum, capabilities and backgrounds of future teachers, and the grade levels and types of schools for which each route prepares future teacher. Researchers conducting the study developed a protocol to analyze curriculum documents from the mathematics teacher education curricula in various programs in participating countries. This protocol was used to examine the relationship between content coverage and performance expectations of courses in the mathematics teacher education programs and the local or national exams for teacher certification. The goal of the protocol was to produce a profile of the knowledge, pedagogy, and dispositions of the intended mathematics teacher curriculum that prospective teachers are exposed to as they learn to teach. The AMTE standards as well as the TEDS-M study indicate the importance of consistency in planning and preparing mathematics teachers.

Definitions of Alternative Certification

Throughout my review of research on alternative certification, I encountered many definitions for the term. Alternative routes to teacher certification are as different from one another as they are from traditional routes (Darling-Hammond, 1990). Variation in programs leaves the term alternative teacher certification with little conceptual value and challenges the ability to compare programs and results from any study (Scribner and Heinen, 2009). Due to these differences, alternative certification is defined by researchers in many ways. Adelman (1986) defines alternative certification as a program that enrolls non-certified individuals with at least a bachelor's degree offering shortcuts, speical assistance, or unique curricula leading to eligibility for a standard teaching credential. Ludlow (2011) presents a similar definition for alternative certification as field based programs designed to recruit, prepare, and license individuals who already had at least a bachelor's degree – and often other careers in fields other than education. Kirby et al. (1989) define alternative certification programs as those designed to increase the potential supply of teachers by preparing them to meet revised state certification requirements for entering teaching. The National Center for Education Information defines alternative teacher certification as referring to a variety of routes to becoming a cerdentialed teacher, from emergency certification to well designed programs (Scribner, 2010). In their article, Zeichner and Schulte (2001) define alternative certification as any alternative to the four year or five year undergraduate teacher education program, including both those programs that have reduced standards and those that hold teachers to the same standards as college and university based undergraduate teacher education. Though these definitions offer more specific examples and qualities of alternative certification, other definitions are more broad.

For example, some researchers claim alternative certification defies standard definition due to the enormous variability of programs (Walsh and Jacobs, 2007). In their article, Walsh and Jacobs (2007) define alternative certifiation as anything but a four-year undergraduate program housed in a school of education. Similarly, Shen (1997) defines alternative certification very loosley, stating that the definition should match the state licensure requirement. Another general definition is offered by Scribner and Heinen (2009) who define alternative certification as a variety of programs designed to train and credential teachers in an expedited fashion. Whitehurst (2002) defines alternative certification as a route to a teaching license that bypasses some of the undergraduate coursework requirements in education. Perhaps the most general definition of alternative certification comes from an article written by Moffett and Davis (2014). They define alternative certification as a variety of options other than a traditional route to becoming licensed to teach. It is important to consider all definitions and the context in which they were created. The multiple definitions of alternative certification reveal the variablity in alternative certification programs and goals, and are all important to consider.

Alternative Certification for Mathematics Teachers

In this section of the literature review, I will focus specifically on empirical articles whose studies address alternative certification for mathematics teachers. I will explore participant characteristics, methodology, data collection and analysis, and results of the studies. Results are categorized based on articles measuring student achievement outcomes, alternatively certified teachers' perceptions, and teacher content knowledge.

Methodology

Among the 15 empirical studies I found within mathematics alternative certification, the methodology was varied, however over half of the articles used quantitative methods. Nine of the studies employed quantitative methodology to conduct the study (Bonner et al., 2013, Boone et al., 2009, Boyd et al., 2010, Evans, 2010, Goldhaber and Brewer, 2000, Kirby et al., 1989, Schmidt et al., 2011, Shen, 1999, Tai et al., 2006) and five employed mixed methods (Brantlinger and Smith, 2013, Evans, 2011, Foote et al., 2011, Scribner and Akiba, 2010, Thomas et al., 2005). Only one of the articles employed solely qualitative methods (Abell et al., 2006).

Data Collection and Analysis

Common themes focused on data collection and analysis emerged from the 15 studies about alternative certification for mathematics teachers, though the type and characteristics of participants varied from study to study. Many of the studies used multiple data collection and analysis methods. In those cases, I referenced the article under each data collection and/or analysis method used, so some of the articles are referenced more than once. The main data collection and analysis themes that emerged from the studies are achievement scores (both of students and teachers), journals, surveys, questionnaires, interviews, observational data, and use of pre-existing national data.

One study compared achievement scores of teachers on a secondary mathematics state licensure test between traditionally and alternatively certified teachers (Bonner et al., 2013). Another used data from a mathematics content knowledge test at the beginning and end of the semester (Evans, 2011). Boyd et al. (2010) used student achievement data as the primary means of data collection, but also used teacher value-added evaluation data from the state department of education.

Over half of the studies used surveys, questionnaires, participant journals, observations, or interviews to collect data (Evans, 2011, Foote et al., 2011, Goldhaber and Brewer, 2000, Kirby et al., 1989, Scribner and Akiba, 2010, Thomas et al., 2005, Boone et al., 2009, Brantlinger and Smith, 2013). Data were collected via these methods about many varying topics and were analyzed in various ways as well. For example, Boone et al. (2009) used surveys to collect data about participant perceptions of the alternative certification program in which they were enrolled as well to analyze changes in participants as they complete the program and start teaching. Another study conducted by Evans (2011) had participants keep teaching and learning journals as a means of data collection as a way to track participants in an alternatively certified mathematics teachers' content knowledge and attitudes over the course of the semester. One study used teacher observations to collect data about prior professional experiences and quality of instruction from mathematics teachers who completed an alternative certification program (Scribner and Akiba, 2010).

Three of the studies used pre-existing national data as a means to answer their specific research question. One study's authors used data from the Teacher Education and Development Study in Mathematics (TEDS-M) and the Trends in International Math and Science Study (TIMSS) to compare teacher preparation programs across the United States (Schmidt et al., 2011). Another source of pre-existing, national data came from the School and Staffing Survey, SASS93. The researcher used this data source to examine the effect of alternative certification programs for mathematics teachers on the teaching force (Shen, 1999). Tai et al. (2006) examined data from both the SASS99 and Teacher Follow up Survey in order to look at the retention rates among alternatively certified mathematics teachers.

Data collection and analysis of the empirical articles that I reviewed were varied yet clearly explained in each article. The same is true for the results sections of these articles, which I explain in the following section.

Results

Student achievement. A study comparing student achievement data based on teacher preparation method showed smaller gains in mathematics achievement for middle school math students taught by teachers prepared in an alternative certification program (Math Immersion) than students taught by traditionally certified teachers (Boyd et al., 2010).

Goldhaber and Brewer (2000) conducted a similar study in which they compared 12th grade mathematics students' achievement based on the type of preparation their math teacher experienced. The researchers found that students of mathematics teachers with alternative certification perform similarly to students of teachers who have traditional mathematics teacher certification, when family background and other schooling characteristics are held constant.

Teacher perceptions. One article collected data from students enrolled in a mathematics alternative certification program about perceived preparation, self-efficacy, and outcome expectancy (Boone et al., 2009). The researchers collected data at six points during the program. Researchers developed the Standards Based Measure of Preparedness Survey (SAMPS) to measure perceived preparedness based on existing state standards for beginning teachers. Items on the survey started with the phrase "how prepared do you feel to…". To measure self-efficacy and outcome expectancy, researchers used a mathematics version of the Science Teaching Efficacy Belief Instrument (STEBI-B). This instrument provides self-efficacy and outcome expectancy measures. Results showed that over time, participants showed an increasingly positive view toward their preparedness for classroom teaching, as well as increased self-efficacy due to the components of the alternative certification program in which they participated. Little change was present, however, in students' outcome expectancy.

In a study conducted by Kirby, Darling-Hammond, and Hudson (1989) the researchers asked teachers from alternative certification programs about their satisfaction with teaching. Their data showed alternatively prepared teachers voiced concerns very similar to those of traditionally certified teachers about the "reality shock" of classroom teaching.

Teacher content knowledge. A study conducted by Bonner et al. (2013) compared scores on a secondary mathematics state licensure test between traditionally and alternatively certified teachers. Approximately seventy five percent of traditionally certified teachers passed the test on their first attempt while 55% of the alternatively certified teachers passed on their first attempt. The results of this study showed the mean values of the exam scores for traditionally prepared teachers to be greater than the mean values of the alternatively prepared teachers for total score as well as within all six domains of the test (Number Concepts, Patterns and Algebra, Geometry and Measurement, Probability and Statistics, Mathematical Processes and Perspectives, and Mathematical Learning, Instruction, and Assessment).

On the contrary, in another study, general results showed teachers who completed the Math Immersion program (an alternative certification program) had stronger academic qualifications, such as SAT and state licensure test scores, than traditionally certified teachers (Boyd et al., 2010).

As described above, the research comparing alternatively prepared mathematics teachers to traditionally prepared mathematics teachers varies in the areas of the size of the sample, participant characteristics, methodology, data collection and analysis, and results based on student achievement, teacher perceptions, and teacher content knowledge. Due to the varied nature, results, and limited number of studies, it is not appropriate to draw conclusions comparing alternative and traditional mathematics teacher preparation programs based on these categories. More research in mathematics alternative certification programs is needed in order to make generalizations and draw conclusions.

Teacher Content Knowledge

Common and Specialized Content Knowledge. In 1986, Lee Shulman proposed a special domain of teacher knowledge that he called pedagogical content knowledge (PCK), which suggested that there is a content knowledge unique to teachers and teaching. Years after Shulman's work gained popularity, it became widely acknowledged that content knowledge is immensely important to teaching and teacher education (Ball, Thames, and Phelps, 2008). These authors elaborated on Shulman's theory of PCK by creating a construct specific to mathematics that they named mathematical knowledge for teaching (MKT). Within this construct, they posit in addition to common content knowledge there is a domain of content knowledge that is unique to the work of teaching mathematics. This, which they named specialized content knowledge, is an area that continues to be explored in order to fully understand the important dimensions of teachers' professional knowledge. The figure below shows Ball, Thames, and Phelps refinement of and additions to Shulman's theory. Though the figure outlines three components of subject matter knowledge and three components of pedagogical content knowledge, I will focus on common content knowledge (CCK) and specialized content knowledge (SCK), which are both categorized under subject matter knowledge.

Specialized content knowledge for mathematics refers to the ability to explain why a procedure works and what it means evaluate student methods for solving problems and be able to determine whether those methods are generalizable to other problems. Other examples of specialized content knowledge for teaching mathematics include unpacking mathematical ideas, explaining procedures, choosing and using representations, and appraising unfamiliar mathematical claims and solutions (Hill and Ball, 2004). This type of knowledge is termed specialized because it is unique to those teaching mathematics to children. Specialized content knowledge is tailored in particular for the specialized uses that appear in the work of teaching and is not commonly used in other professions.

In contrast, common mathematical knowledge of content refers to knowledge of basic skills such as being able to compute a multiplication problem accurately, solving word problems correctly, and so forth. This common knowledge is not unique to teaching, as non-teachers most likely possess the same knowledge. Common content knowledge can be thought of as knowledge that is used in the work of teaching in ways in common with how it is used in other professions or occupations that use mathematics (Ball et al., 2008). Hill and Ball (2004) argue that together, both specialized and common content knowledge compose what teachers need to know in order to teach mathematics, and that teachers of mathematics must possess both types of content knowledge to competently teach mathematics.

Content Knowledge and the MQI

For the purposes of this study, I will be focusing on domains three and four of the MQI, richness of the mathematics and errors and imprecision. I have chosen to focus on these two domains because of the purpose of my study, which is to determine whether the preparation pathway in which secondary mathematics teachers' matriculate has an effect on the quality of mathematics instruction that they deliver to students. Since the study purpose has an emphasis on teacher interaction with the content, I have selected richness of the mathematics and errors and imprecision because they are the two domains that measure the teacher-content relationship. In this section, I will discuss the ways in which each of the components of those two domains relate to either common or specialized mathematical content knowledge.

The purpose of the richness of the mathematics domain of the MQI is to analyze the depth of the mathematics that the teachers offers to the students. The domain is separated into two categories. The first category uses codes that capture the extent to which instruction includes the meaning of mathematical facts and procedures. The codes for the first part of this domain are linking between representations, explanations, and mathematical sense-making.

Linking between representations. To earn the highest score in the linking between representations area, teachers must provide explicit connections about how two or more representations are related and give details and elaboration about the relationship between the two representations while also providing visuals of both representations. The correspondence between the two representations used must be explained to students in a way that focuses on meaning. This dimension of the richness of the mathematics domain is connected to specialized content knowledge because linking representations, as described by the MQI, is knowledge that is unique to individuals engaged in the teaching of mathematics to students (Hill and Ball, 2004). Though a non-teacher may have knowledge about how representations are linked, they would not need to be able to elaborate about the connections or links between such representations.

Explanations. In this area of the richness of the mathematics domain, teachers must provide mathematical explanations that focus on why a procedure works or doesn't work, why a solution method is appropriate or inappropriate, and why an answer is true or not true. An example of this type of explanation is explaining why a formula can be used to find an outcome. To receive the highest score for this code, one or more mathematical explanations must a focus of instruction in the segment. Because this domain requires teachers to explain how and why certain mathematical concepts and procedures work, it requires specialized content knowledge.

Mathematical Sense Making. This code captures the extent to which the teacher or students attend to the meaning or numbers and relationships between them, the relationships between contexts and the numbers or operations that represent them, connections between mathematical ideas, and modeling to determine whether answers make sense. Receiving the highest score in this category requires teachers and students to spend a substantial amount of time during the lesson focusing on meaning. An example of demonstrating mathematical sense making is a teacher explaining to students that dividing the numerator and denominator by the same number, 5 for example, is the same thing as dividing by 5/5, which is the same as dividing by 1, which does not change the value of the fraction. Because this category describes the ability for a teacher to go beyond teaching facts and making sense of the mathematics, it is categorized under specialized content knowledge for teaching mathematics.

The codes for the second part of the richness of the mathematics domain capture the degree to which instruction utilizes key mathematical practices and language. The codes in this section are multiple procedures or solution methods, patterns and generalizations, and mathematical language.

Multiple Procedures or Solution Methods. This area of the domain is also associated with specialized content knowledge for teaching because the skills needed to score high in this category require teachers to possess the ability to discuss and compare multiple procedures or solution methods for efficiency, appropriateness, ease of use, or other advantages and disadvantages.

Patterns and Generalizations. One example of specialized content knowledge for mathematics defined by Hill and Ball (2004) is for teachers to be able to determine whether mathematical methods suitable for solving certain problems are generalizable to other problems. To earn the highest score within this area of the richness of the mathematics domain, the teacher must be able to carefully develop a generalization from examples in detail, summarizing a pattern and describing how it is generated.

Mathematical Language. The last area of the richness of the mathematics domain is the only one that falls under common content knowledge. To earn the highest score in this category, teacher must use mathematical language correctly and fluently. Since mathematical language use is not something specific to teachers of mathematics, it does not require specialized content knowledge but rather is part of the common content knowledge that mathematics teachers need to know.

The second and final domain of the MQI that I am using in this study is errors and imprecision. The purpose of this domain is to capture the extent to which mathematical errors and distortion of the content are made by the teacher. The three codes within this domain are mathematical content errors, imprecision in language or notation, and lack of clarity in presentation of mathematical content.

Mathematical Content Errors. This code is intended to capture events in the teaching segment that are mathematically incorrect. Examples include the teacher solving problems incorrectly, defining terms incorrectly, and equating two non-identical mathematical terms. Since this code scores the lesson segment based on correct or incorrect mathematical content knowledge, it falls under the common content knowledge category. Solving problems incorrectly or making mathematical mistakes is not unique to teaching, making it common content knowledge.

Imprecision in Language or Notation. This code captures problematic uses of mathematical language or notation, such as errors in mathematical symbols, errors in mathematical language, and errors in general language. An example includes use of imprecise phrases such as "multiplication results in bigger numbers" or using the word "reduce" instead of simplify. Since such mathematical language is traditionally learned in teacher training, it is not knowledge that non-teachers would be expected to possess. Therefore, this code is categorized under specialized content knowledge for mathematics teaching.

Lack of Clarity in Presentation of Mathematical Content. The intentions of this code are for it to capture when a teacher's utterances cannot be understood. Some example of this are when a mathematical point is confusing or muddled, or when a teacher neglects to clearly solve or explain the content. A high score in this category would result from the teacher endorsing correct and incorrect suggestions about solving a problem or mentioning key content words without defining them. This code relates to specialized content knowledge because in order for a teacher to avoid lack of clarity, he or she must possess a deep understanding of mathematical concepts and ideas connected to the mathematical point of the lesson segment and be able to make generalizations about examples that would and would not work based on the fundamental skills on that particular mathematical content.

Within the two domains I will be using in this study, evidence of common content knowledge and specialized content knowledge are present. Assumptions about which type of content knowledge teacher possess can be linked to their preparation experiences, specifically whether they were traditionally or alternatively certified. In the next section, I will discuss some common assumptions in the field about this content knowledge.

Assumptions about Content Knowledge

In the past, a majority of the research conducted comparing traditionally and alternatively certified teacher preparation pathways uses student achievement data as a means of comparison. Recently, however, an interest in investigating some of the neglected variables in teacher certification pathway that affect teacher quality has surfaced (Evans, 2001). One of these variables is teacher content knowledge. Results about teacher content knowledge based on their preparation program vary, making it difficult to come to any consistent conclusions about the content knowledge of teachers based on their preparation route. In this section, I discuss the results of studies that examined teacher content knowledge and preparation pathway.

While alternative certification programs have received criticism for a lack of coursework helping teachers improve their pedagogy, traditional teacher preparation programs have been criticized for lacking content-specific experiences and guidance during prospective teacher training (Feuer et al., 2013). A study conducted by Bonner et al. (2013) compared scores on a secondary mathematics state licensure test between traditionally and alternatively certified teachers. Results showed that 75.4% of traditionally certified teachers passed the test on their first attempt while 55% of the alternatively certified teachers passed on their first attempt. The results of this study showed the mean values of the exam scores for traditionally prepared teachers to be greater than the mean values of the alternatively prepared teachers for total score as well as within all six domains of the test (Number Concepts, Patterns and Algebra, Geometry and Measurement, Probability and Statistics, Mathematical Processes and Perspectives, and Mathematical Learning, Instruction, and Assessment).

On the contrary, in another study, general results showed teachers who completed the Math Immersion program (an alternative certification program) had stronger academic qualifications, such as SAT and state licensure test scores, than traditionally certified teachers (Boyd et al., 2010). Results from another study show that alternatively certified secondary mathematics teachers performed better on items measuring algorithmic knowledge of mathematics, that the authors called “rules of thumb,” than they did on items measuring knowledge of the logical foundation of mathematical ideas. In general, they struggles to know how to represent meaning of particular algorithms and did not know how to reason through conceptual problems (McDiarmid and Wilson, 1991).

Hawk and Schmidt (1989) examined the differences in scores on the National Teacher Examination between teachers prepared traditionally and those who were prepared through an alternative certification program and found small differences. The mean score on the math area exam for traditionally prepared participants at the University was 585.11 and the mean score for participants in the alternative certification program was 586.25, showing no statistical difference in the two groups.

The Mathematical Quality of Instruction (MQI) Instrument

The Mathematical Quality of Instruction (MQI) instrument was developed by Heather Hill and her colleagues at Harvard University and the University of Michigan. The purpose for the creation of this instrument was to yield estimates of individual mathematics teacher's instructional quality. The scores could then be used as a guide for teacher reflection and for teachers to examine and potentially alter their practice. The MQI is designed to measure teaching quality, rather than teacher quality (Hill, Charalambos, and Kraft, 2012). The researchers based the MQI on a theory of instruction, existing literature on effective mathematics instruction, and the analysis of many teachers in the United States. The MQI was developed under the premise that classroom mathematical work is separate from other teaching and learning factors such as classroom climate, pedagogical style, and instructional strategies in general. This perspective makes the MQI unique and different from other instruments that measure mathematics instruction. It is important to note that the MQI does not currently have normative scores they recommend using in order to determine what scores a teacher would need to receive in order for the quality of their mathematics instruction to be of low or high quality.

Studies involving the MQI. The MQI was developed and piloted between 2003 and 2012. During those years, the researchers who developed the MQI examined the relationships between teachers' mathematical knowledge for teaching (MKT), MQI scores, and student outcomes. It has also been used to examine the best conditions that need to be present to accurately generalize scores for mathematics teachers.

Several studies involving the MQI have been published to date, according to my search using the University B's library website (Hill, Kapitula, and Umland, 2011; Hill, Umland, Litke, and Kapitula, 2012; Hill, Blunk, Charalamnous, Lewis, Phelps, Sleep, and Ball, 2008; Hill, Charalambous, Blazar, McGinn, Kraft, Beisiegel, Humez, Likte, and Lynch, 2012; Hill, Charalambous, and Kraft, 2012; Kelcey, McGinn, and Hill, 2014). Many of these studies examine the relationship between the level of Mathematical Knowledge for Teaching (MKT) and scores on the MQI. Evidence from these studies shows a positive correlation between a teacher's score on the MQI and their mathematical knowledge for teaching.

In summary, it is clear from the previous studies that there is lack of research that has been conducted on certification pathway as it relates to teacher quality of instruction. Few of the studies have utilized a mixed methods approach, which can offer multiple ways to thoroughly examine the connection between quantitative and qualitative data. The need for such a study is evident based on the analysis of the previous literature. In the next chapter, I describe the methods in which I will engage in order to answer the research question that underlies this study.

Chapter 3: Methodology

This dissertation was a multiple case study that used a mixed method approach to data collection to answer the research question: In what ways, if any, do novice teachers perceive their preparation path (alternative or traditional) as having an impact on the quality of their mathematics instruction as measured by scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI? The purpose of a multiple case study is to examine how the program or phenomenon performs in different environments (Stake, 2006). The mixed methods approach to research provides multiple ways in which a research problem can be addressed, and it is recognized as an accessible approach to research (Creswell, 2017). The rationale for using a mixed methods approach in this study is to attempt to connect the results of the quantitative and qualitative data collected. This study followed the format of quan→ qual, where the quantitative data were collected first in the form of observation using the Mathematical Quality of Instruction Observation Protocol, followed by the qualitative data in the form of interviews with the novice high school mathematics teachers. Within this format, data are to be collected sequentially but no priority is assigned to either orientation.

Johnson et al. (2007) define mixed methods research as "the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the purposes of breadth and depth of understanding and corroboration" (p.123). Tashakkori and Creswell (2007) discuss the importance of researchers keeping in mind that mixed methods research is constantly developing and will continue to do so. They offer a broad definition of mixed methods research as research in which investigator(s) collect and analyze data, integrate the findings, and draw inferences using either quantitative and qualitative approaches or methods. This process is carried out in a single study or program of inquiry. They stress the importance of integration, and so it is my aim in this study to provide a comprehensive integration of the quantitative and qualitative results.

Recruitment

I recruited two traditionally and two alternatively certified novice high school mathematics teachers. For the purpose of this study, the definition of a novice teacher is one who is within their first five years of teaching. My rationale for this number is that it provided a feasible number of teachers for me to observe up to two times and interview two times in depth, and it gave me two cases under each condition to explore. Recruitment occurred through flyers that I placed in teacher mailboxes as well as through personal conversations. As a high school mathematics teacher, myself, I have a professional network with other mathematics teachers in my region in Florida. I used convenience sampling to place flyers in the mailboxes of those colleagues. On the flyer, I explained the purpose and overview of the study and attach the consent form for potential participants to review. I asked potential participants to reply to me via a portion of the flyer that they can return to me or talk to me in person if they are interested in participating in the study. I distributed a follow-up flyer two weeks after the initial flyer is distributed to remind potential participants about the study. I made them aware of my availability to meet with them in person and/or email them to answer any questions they may have. Demographic data gathered included information on the teacher's certification pathway and mathematical teaching experience.

Context

School district. The context of the study was a large school district in the Southeastern part of the United States. The school district is the largest employer in the county, employing a total of 26,000 people. The district educates 220,287 students housed in 270 school sites. Of these school sites, 142 are traditional elementary schools serving grades K through five, 43 are middle schools serving grades six through eight, 27 are high schools serving grades nine through twelve, five of the schools serve grades kindergarten through eight, and 50 are charter schools. According to the 2018-2019 ethnic enrollment report provided by the district, the demographics of the students in this county are as follows; 36% Hispanic, 33% White, 21% Black, 6% Multi-racial, 4% Asian, and less than 1% Indian (https://www.sdhc.k12.fl.us/assets/pdf/SE0016B.pdf). Other demographic characteristics reported by the district include the approximate number of students who fit into specific categories 63% are considered economically disadvantaged, 23% are English language learners (ELL), 19% are enrolled in exceptional student education (ESE), 8% are gifted, 1% are migrant, and 2% are homeless.

School. All the participants in the study teach at Sunshine High School, one of the 27 high schools in the district. Choosing all participants from the same context was a conscious choice made to help reduce the number of outside school related factors that might influence the study such as student demographics or factors related to the inner workings of the school. It allowed me to highlight the contrast between the certification pathways within the same school setting.

The school is a traditional high school serving 2,581 students in grades nine through twelve. According to the 2018-2019 ethnic enrollment report provided by the district, the demographics of the students at Sunshine High School are as follows; 42% White, 33%

Hispanic, 18% Black, 9% Multi-racial, 3% Asian, and less than 1% Indian. Of these students, 51% are considered economically disadvantaged and the minority rate at the school is 59%. The school grade has been a B for the last consecutive four years. The school employs approximately 140 instructional staff which includes teachers of all subjects. Of those, approximately 20 teach mathematics. Mathematics teachers at Sunshine High School teach six out of eight periods each day, have one planning period, and one lunch period. Each period is 47 minutes long. Mathematics teachers teach an average of two courses ranging from Algebra 1 to Advanced Placement Calculus.

Mathematics teachers at Sunshine High School are required to participate in professional learning communities (PLC's) which are comprised of teachers who teach the same course. For example, the school has an Algebra 1 PLC, a Geometry PLC, and Algebra 2 PLC, and so on. During the PLC meetings teachers share resources, lesson plans, assessments, and methodology that has been successful with their students. The goal of the PLC's is to provide a space where teachers can interact with their colleagues, reflect upon their teaching practice, analyze student data, and plan for future lessons. Each PLC has a leader who is one of the members. Their role is to communicate the goals for each meeting and collaborate with members to set goals for future meetings. PLC's are required to meet once a month and turn in a form to administration documenting the goals decided upon at the meeting, as well as a description of what each member needs to collect or bring to the next meeting.

Certification pathway. Though there are many alternative certification programs for prospective teachers, two programs are prevalent in the district in which this study takes place. This district has designed an Alternative Certification Program (ACP) that is in accordance with Florida Statute Section 1012.56, which states:

> *Each school district may provide a cohesive competency-based professional preparation alternative certification program by which members of the school district's instructional staff may satisfy the mastery of professional preparation and education competence requirements specified in … rules of the State Board of Education. Participants must hold a state-issued temporary certificate. Each program must be based on classroom application and instructional performance and must include a performance evaluation plan for documenting the demonstration of required professional education competence*

To qualify for this two-year program, prospective teachers must be non-education majors who hold at least a bachelor's degree. The program is broken down into three parts and they are as follows: (1) demonstration of the Pre-professional Benchmark Level of the Florida Educator Accomplished Practices (FEAPs), (2) teaching experience under the supervision of a trained ACP support team, and (3) professional development components. Upon completion of the program and an electronic portfolio, participants are eligible to seek a professional teaching certificate in the state of Florida (https://www.sdhc.k12.fl.us/docs/00/00/22/42/1819ACP Guidelines.pdf).

Another major alternative certification pathway utilized by prospective teachers in this county is offered at the local community colleges and is called the Educator Preparation Institute (EPI). To participate in this program, prospective teachers must be non-education majors who hold at least a Bachelor's degree in another field. The program consists of seven, three-credit courses for a total of 21 credit hours and a minimum of 30 hours of field experience in live classrooms. The seven courses are Professional Foundations, Classroom Management, Instructional Strategies, Technology, Teaching and Learning Processes, Diversity, Research-Based practices in reading, and Field experience. EPI is designed to be completed in less than one year. Upon completion of the program, participants will be granted an Alternative Preparation Certificate and will be eligible to seek a professional teaching certificate in the state of Florida (https://www.hccfl.edu/academics/educator-preparation-institute).

Quantitative Data Collection

The Mathematical Quality of Instruction (MQI) Instrument. As discussed in Chapter 2, the Mathematical Quality of Instruction (MQI) instrument was developed by Heather Hill and her colleagues at Harvard University and the University of Michigan. The purpose for the creation of this instrument was to measure individual mathematics teacher's instructional quality. The scores were intended to be used as a guide for teacher reflection and for teachers to examine and potentially alter their practice. The MQI was developed to provide a multidimensional yet balanced view of mathematics instruction.

The MQI is comprised of the following five domains; common core-aligned students' practices, working with students and mathematics, richness of the mathematics, errors and imprecision, and classroom work that is connected to mathematics. For the purposes of this study, I will be focusing on domains three and four, richness of the mathematics and errors and imprecision. I have chosen to focus on these two domains because of the purpose of my study, which is to determine whether the preparation pathway in which secondary mathematics teachers' matriculate has an effect on the quality of mathematics instruction that they deliver to students. I have selected richness of the mathematics and errors and imprecision because they are the two domains that measure the teacher-content relationship (See Figure 4 below). In the next section, I will describe the two domains that I have selected in further detail.

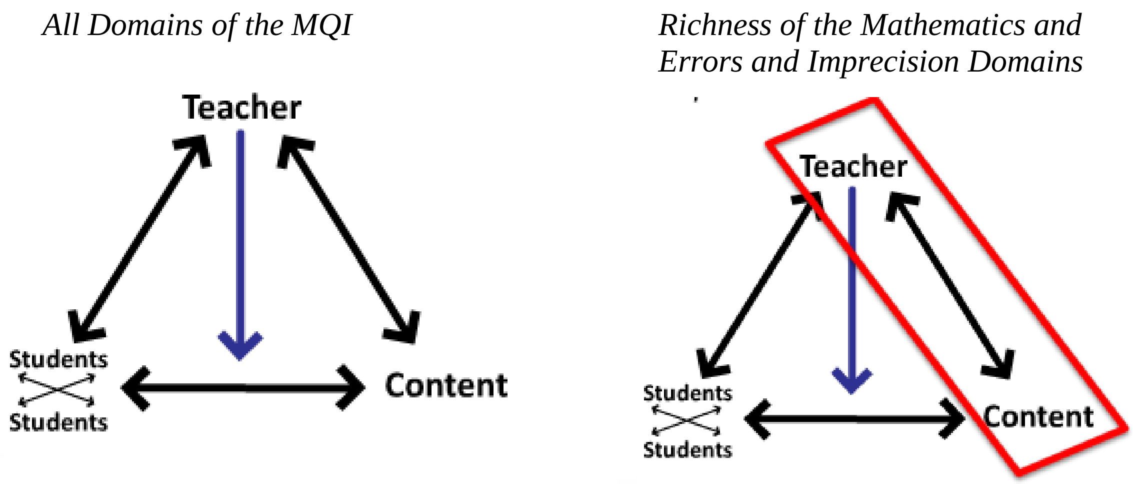


Figure 4. *MQI Dimensions and Interactions* (Cohen, Radenbush, and Ball, 2003).

Richness of the mathematics: This domain attempts to analyze the depth of the mathematics that the teacher offers to the students. The codes within this domain are grouped into two categories. The first category uses codes that capture the extent to which instruction includes the meaning of mathematical facts and procedures and is broken down into three areas, each of which are scored as not present, low, mid, or high. For the purposes of my study, I used a Likert scale to assign a numerical value to each scoring category (not present = 0, low = 1, mid = 2, high = 3). For this domain, it is favorable to obtain scores on the high end of the scale and the higher the score, the better the mathematical quality of instruction for this domain. The following points describe each of the three areas in the meaning of mathematical facts and procedures part of the Richness of the Mathematics domain.

- *Linking Between Representations:* This code refers to the explicit linking and connections between different representations of a mathematical idea or procedure presented by the teacher and the students.

- *Explanations*: This code refers to mathematical explanations that focus on why a procedure works or doesn't work, why a procedure is appropriate or note appropriate, and why and answer is true or not true.

- *Mathematical Sense-Making*: This code refers to the extent to which the teacher or students attend to the meaning of numbers, the relationship between numbers, the relationships between contexts and the numbers or operations that represent them, connections between mathematical ideas or representations, give meaning to mathematical ideas, use modeling and answers to determine sense-making

The second category focuses on codes that capture the degree to which instruction utilizes key mathematical practices and language and is broken down into the following three areas, each of which are scored using the Likert scale equivalents discussed in the paragraph above.

- *Multiple Procedures or Solution Methods:* This code refers to the extent to which different mathematical approaches to solving a problem are taken and discussion is had about how to solve a word problem using two different strategies.

- *Patterns and Generalizations:* This code intends to capture instruction during which the class first examines instances or examples, then uses this information to develop or work on a mathematical generalization in order to notice, extend or generalize a mathematical pattern.

- *Mathematical Language:* This code refers to the teacher and students' ability to use mathematical language and also whether or not the teacher supports students' mathematical language use.

Errors and Imprecision: This domain captures the extent to which mathematical errors and distortion of the content are made by the teacher. This does not, however, include errors that are noticed and later corrected by the teacher. There are three codes within this domain, each of which are scored as not present, low, mid, or high. For the purposes of my study, I used a Likert scale to assign a numerical value to each scoring category (not present = 0, low = 1, mid = 2, high = 3). For this domain, it is favorable to obtain scores on the low end of the scale and the lower the score, the better the mathematical quality of instruction for this domain. The following points describe each code in this domain.

- *Mathematical Content Errors:* This code captures events in the segment that are mathematically incorrect, including but not limited to solving problems incorrectly, defining terms incorrectly, forgetting a key condition in a definition, or equation two non-identical mathematical terms.

- *Imprecision in Language or Notation:* This code refers to the extent to which problematic mathematical language or notation are used. Examples include errors in notation which includes mathematical symbols, errors in mathematical language and general language including definitions, and appropriate use of terms and in distinguishing everyday meanings from their mathematical meanings.
- *Lack of Clarity in Presentation of Mathematical Content:* This code intends to capture instances where a teacher's utterances cannot be understood such as when a mathematical point is muddled, confusing, or distorted. Other examples include when a teacher's launch of a task or activity is unclear or problematic, and when a teacher neglects to clearly solve problems or explain content.

Observation procedures. I collected two 45-minute long videos of each of the four teachers teaching mathematics lessons. The rationale for collecting data via video-taped lessons was as a means of analyzing the mathematical quality of instruction of traditionally and alternatively certified teachers in a way that is consistent with the recommendations of the researchers who created the MQI instrument, which I used to assess the lessons. The creators of the MQI describe it as a standardized instrument for assessing the mathematical quality of instruction with a focus on mathematics and teaching of mathematics, rather than general pedagogy or climate. They say that because it is standardized, raters learn and adopt their way of thinking about mathematics instruction and use their defined methods for collecting and interpreting data, which is through watching videotaped lessons of teachers teaching.

I met with participants to show them how to use the camera equipment, then collaborated with participants to determine a convenient time for them and set up the recording equipment prior to their teaching of the lessons to be recorded. The participating teacher started the recording at the beginning of the lessons they taped. The developers of the MQI have established a protocol for using the instrument, through which I was trained using their online modules and video library containing sample lessons and scoring practice exercises (https://hu.sharepoint.com/sites/ GSE-CEPR/MQI-Training/Pages/aspx).

After data were collected, I used the protocol suggested by the developers of the MQI which is as follows: Each recorded lesson will be divided into equal-length segments (approximately 7.5 minutes) for scoring. Prior to data collection, I trained one other rater using the videos provided on the MQI training site. The other rater rated 20% of the videos. The other rater and I independently gave each segment a score for each of the selected domains of focus. We recorded our ratings on the MQI scoring rubric tool that I created (Appendix B). After each of us independently rated the videotaped lessons, we met to discuss and compare our results. We discussed until we came to a consensus and determined the appropriate rating for each category of the two domains of focus. I used the MQI scores to influence the interview questions that I asked each participant.

Qualitative Data Collection: Multiple Case Study

I chose the case study methodology because it can illuminate causal links that are otherwise difficult to discern from large-scale correlational research (Yin, 1994). Specifically, I was interested in the causal links between certification pathway and mathematics teaching quality.

One advantage of case study is that it "allows the researcher to focus on individuals in a way that is rarely possible in group research" (Mackey and Gass, 2005, p. 171). This method creates a specific focus by placing the researcher in the field so they may gain insightful explanations from personal views (Yin, 2014). Large scale studies often cannot take into account the contextual factors associated with the phenomenon of study. Case study is an appropriate methodological choice for this dissertation study because it allows me to investigate phenomena in participants' current, real-life environments (Yin, 1994). As a research methodology, case study provides an opportunity for in-depth exploration leading to a thick, rich description of each case (Geertz, 1973), which allows me to gain an understanding of how teacher's visualize a connection between pathway and their current teaching practice. For these reasons, case study was appropriate for this dissertation study.

In addition, the multiple case study methodology has been used in other studies involving the Mathematical Quality of Instruction (Hill et al., 2008) to examine the quality of instruction of multiple teachers who all teach mathematics, in order for comparisons and conclusions to be drawn. The case study methodology is aligned with my research question, which aimed to examine the mathematical quality of instruction of two traditionally certified and two alternatively certified teachers and identify similarities and differences between the cases. In my study each participant's data, both their scores on the MQI and their interview data about their perceptions, were collected and interpreted separately, making the case study methodology appropriate.

I used a semi-structured interview protocol to interview participants two times throughout the study. I conducted individual interviews with participants at the school in a room convenient for participants, ensuring their privacy was respected. I used digital recording equipment to record the interviews and used a speech to text website online to transcribe the interviews. The first interview occurred at the beginning of the study when participants were recruited and before their lessons were recorded. During the first interview my questions related to participants' general preparation pathway and the tenets of situated learning theory (Appendix C). The goal of this initial interview was to gain insight into participant's experiences in their preparation program including the structure and timeline of the program.

After the quantitative data were collected**,** I conducted a second interview with each participant, through which I hoped to gain insight into participants' perceptions of the potential impact that their preparation program had on the quality of their mathematics instruction, specific to the videotaped lessons. This interview included questions related to the two domains of the MQI (Richness of the Mathematics and Errors and Imprecision) and the relation between those domains and participant's teaching decisions as observed in the videotaped lessons. Prior to the second interview, I emailed each participant a copy of the scoring rubric tool that I used to rate each of their lessons using the MQI. I also emailed them the videos they recorded so they had a chance to re-acclimate themselves with the lessons they taught, given that there was time between the date that they recoded the lessons and the day of the interview. At the beginning of the second interview, I explained to each participant how the MQI works, and gave them examples from the scoring guide in each subscale.

I planned some general questions about the certification route in which each participant matriculated, as well as some questions and probes based on the participant's scores on the MQI. For example, I asked open ended questions like "I noticed when students gave a wrong answer you (insert what the participant did). What was your rationale for making that decision?" connected to the type of certification pathway. The probes were specific to each participant's lesson, therefore it was difficult to write them before viewing the video-taped lessons (Appendix C).

My rationale for including interviews in the study was to gain insight into participant's perceptions about the effect, if any, of their teacher preparation pathway on the scores on the MQI. According to Cohen and Crabtree (2006), semi-structured interviews are often preceded by observation and provide opportunities for the researcher to gain insight about participant perceptions by allowing them freedom to express their thoughts in their own terms. The interviews were crucial in determining the connection, if any, between teacher perceptions of their certification pathway and its potential effect on their instructional decisions in their mathematics classroom. I used components of situated learning theory to gain deeper understanding of how participants involvement in their respective teacher preparation program, whether traditional or alternative, possibly had an impact on their preparation experiences as well as their experiences in their induction years of teaching. To do this, I asked the participants questions related to the three tenets of situated learning theory: authentic context, social interaction, and constructivist learning approach, and the role that each played in their preparation program. Example of these types of questions can be found in Appendix C.

Using the information participants provided on the recruitment flyer, I researched about the program through which each participant matriculated by visiting the website of each program. This helped me gain an understanding of the types of courses and experiences in which participants engaged during their preparation program. The information from each program was also used for stimulated recall during the interviews to learn more about the possible ways in which preparation experiences, as documented by the program guides online, affected the quality of mathematics teaching.

Coding Protocol: After collecting the interview data from both interviews, I transcribed each interview using an online speech to text website. After reviewing the transcriptions provided by the website, I listened to the recordings again and edited the transcriptions to ensure accuracy. The qualitative analysis procedures I used were influenced by the frameworks developed by Strauss and Corbin (1990), Merriam (2009), and Creswell (2012). Below, I describe the steps I will take to analyze the interview data I collected in more detail.

Strauss and Corbin's (1990) framework includes three stages of coding, each which help the researcher narrow in on themes produced by the interview data. The stages of coding in this framework are open coding, axial coding, and selective coding. The first step in the framework is to use open coding while initially reading the interview data. Open coding is defined as the analytic process through which concepts are identified and their properties and dimensions are discovered (Strauss and Corbin, 1990). The goal of open coding is to open the text in order to uncover, name, and develop concepts found within the interview data. Within this step, any piece of data considered relevant will be coded. The goal in this step is to generate categories and properties within those categories with the goal of determining how the categories are similar or different. When I read the transcribed interview data, I wrote notes, thoughts, and connections in the margins (Merriam, 2009). I uploaded the transcriptions into a coding program which I used to organize the open codes I discovered as I read through the transcripts of the interview data.

The second stage of the coding process is axial coding. The purpose of axial coding is to begin reassembling data that were separated during open coding (Strauss and Corbin, 1990) and relate categories and properties identified during open coding (Merriam, 2009). During axial coding, I related the categories from the open coding process to subcategories to form more precise and complete explanations about the phenomena being studied. Through the process of axial coding, I gained an understanding of how the categories identified in open coding related to each other. Through the axial coding process, I looked at the categories identified in the open coding process to uncover relationships among those categories. I made a master list of codes that I identified in the axial coding stage. I used the master list to sort the rest of the data and revised the list by expanding or collapsing categories as necessary according to the data (Merriam, 2009).

The final coding stage, selective coding, is more analytic and involves refining the codes previously identified. In this stage, categories are organized around a central concept, which in the case of this study is situated learning theory, as discussed earlier in this paper. This theory is the lens through which I make meaning of the codes. It is in this stage where I eliminated excess information and identified other information to fill in poorly developed categories. Finally, I validated codes by comparing them to the data one more time, and by asking participants for their reactions to the themes identified and developed throughout the coding process (member checking). It is important to know that though all aspects of the themes might not fit each case specifically, the larger concepts should apply (Strauss and Corbin, 1990). After I completed the three stages of coding with the interview data, individual case findings were used to identify and interpret across case findings.

Across Case Analysis: Stake (2013) claims "researchers have an obligation to provide interpretation across the cases." He goes on to posit one goal of cross case analysis is to give the binding concept, theme, issue, or phenomenon that strings the cases together. The across case analysis process allowed me to see similarities and differences between participant's quality of mathematics instruction based on their preparation program experiences. I used constant comparative methods to look across the cases and across the codes and themes about preparation experiences from the first interviews. Next, I used constant comparative methods to look across codes and themes from the second interviews to find similarities and differences in the ways that participant's preparation experiences may have influenced the mathematical quality of their instruction, according to their MQI scored. I used the tenets of situated learning theory to make sense of the themes across cases.

Trustworthiness. Triangulation and member checking are two strategies to ensure the trustworthiness in qualitative research (Lincoln and Guba, 1986). In this section, I discuss the ways in which I use triangulation and member checking in this dissertation study.

Cohen and Crabtree (2008), describe triangulation as "using multiple data sources in an investigation to produce understanding." These understandings should be "rich, robust, comprehensive, and well-developed." Furthermore, the aim of triangulation is to confirm the validity of the research process (Tellis,1997) and assure that the picture is as clear as possible with as little researcher bias as possible (Stake, 2013). Similarly, Leech and Onwuegbuzie (2007) emphasize the importance of utilizing more than one type of analysis, triangulation, in order to understand phenomenon more fully.

Data triangulation, investigator triangulation, and method triangulation are all types of triangulation that can be used to increase trustworthiness (Lincoln and Guba, 1986). In this study, I use all three types of triangulation. Data triangulation refers to the use of multiple data sources including persons of interest. In this study I collected data from observations, interviews, lesson plans, and transcripts and from four participants, thus employing triangulation of data. Investigator triangulation refers to the use of more than one researcher to make coding and analysis interpretation decisions. In this study I used a second coder to strengthen the findings and make the research process more robust. The role of the second coder is to examine the interview transcripts and code them using the same process used by the researcher. The second coder reviewed the codes identified by the researcher to ensure they are the same as or similar to their codes. If similar themes emerge from the data from different coders, the validity of the study increases. I looked for agreement on the coding of themes between the two raters and establish interrater reliability. If coding disagreements emerged, we discussed our rationale behind the codes we each assigned to the data and come to an agreed upon conclusion. Method triangulation, the final type of triangulation, means using multiple methods to collect data. In this study, I used method triangulation by collecting quantitative data as measured by the MQI and qualitative data through the analysis of interview data and information from each participants' preparation program.

Another form of triangulation used in this study to increase trustworthiness is called member checking. Member checking, according to Lincoln and Guba (1986) is defined as, "The process of continuous, informal testing of information by solidifying reactions of respondents to the investigators reconstruction of what he or she has been told or otherwise found out" (p.77). When participants member check they have the opportunity to confirm or deny the researchers interpretations of the data, which adds trustworthiness to the interview data and credibility to the study (Lincoln and Guba, 1986; Stake, 1995). After interview data are collected, I summarized my researcher notes and compiled them in a format appropriate for participants to review. I distributed them to participants and give them an opportunity to ensure that I fully and correctly captured their perceptions on the ways in which, if any, their preparation pathway had an impact on the quality of their mathematics instruction as measured by scores on the MQI. I asked participants for feedback indicating whether they agree with my interpretations of their perceptions and ask them to clarify if they disagreed.

Data Storage and Protection

Pseudonyms were given for the name of the school and each participant in the study. Any identifiers of the participants were removed to ensure privacy. I collected all consent forms and stored them in a locked cabinet in my major professor's office. I used a speech to text online website to transcribe the interviews. When creating and analyzing codes, I uploaded the transcriptions into a coding program which I used to organize the codes. All digital data were stored on my password protected computer.

Role of the Researcher

Having taught mathematics for fifteen years, I am qualified to view recorded mathematics lessons and analyze aspects of teaching and learning within classrooms. In addition to my mathematics teaching experience, I was selected to participate in a five-year Master Teacher Fellowship program which provided me opportunities to refine my practice as well as mentoring other mathematics teachers in doing the same. Specific to the Mathematical Quality of Instruction (MQI) tool, I completed the online training modules provided by the writers of the tool in order to ensure my accurate use of the tool to score the videotaped lessons of participants teaching mathematics lessons. The online training modules consisted of thorough explanations of each domain of the MQI along with videos of mathematics teachers teaching, providing practice scoring opportunities within each domain. At the completion of the training, I took a test to ensure accurate scoring of all the domains.

I understand that I may have personal and professional relationships with some of the participants in this study because we were colleagues for four years at Sunshine High School. Prior to this study, I have not had experiences watching the participants teach or analyzing any aspects of their teaching. As a researcher, my role will be to focus on the mathematical experiences that are categorized under the two domains of the MQI that I am using to analyze data collected in the videos (Richness of the Mathematics and Errors and Imprecision) and will not be affected by my possible previous collegial relationship with any participants.

In addition, I must be aware of any potential bias based on my own teacher preparation experiences. I earned my Bachelors and Masters degrees in education, matriculating through a traditional teacher preparation program at a University that has a large college of education. I learned about alternative certification pathways to teaching when I began teaching and met some colleagues who did not experience the same type of preparation that I did. Working alongside and collaborating with mathematics teachers who experienced alternative certification pathways helped me learn about the various certification pathways available to teachers of mathematics.

Now that I have described my role as the researcher, in the following section I describe the rationale for collecting the quantitative data for my study. Next, I describe the quantitative data collection and analysis procedures I used in this study. Then, I describe the rationale for collecting the qualitative interview data for my study, followed by the qualitative data collection and analysis procedures that utilized. This section concludes with a discussion of the research question guiding the study and a summary of the data analysis plan to address the question.

Ethical considerations

Ethical issues related to human subject participation will be addressed by following all regulations within the University B and school-district IRB processes. It is important that participants in the study are aware that the results of the study will not be used in an evaluative method in terms of their teaching career. The methods, procedures, and results of this study will not influence or affect participant value added scores, which are determined by a process identified by the county in which they teach.

This is a minimal risk study. The interviews were conducted in person at a time convenient to participants. Their names nor the specific programs in which they participated were shared. In addition, no experimental procedures were performed. Participants participated in two interviews, one focused on their perceptions of their preparation program and the other on the extent to which their teaching decisions related to their scores on the MQI. One indirect benefit to subjects participating in this study is the potential for teachers to gain some insights into their own teaching. In addition, results from the study could help benefit the future preparation of teachers alternatively and traditionally certified.

Chapter 4: Findings

In this chapter, I present each of the four cases individually. Each case begins with background information about the participant's preparation program experiences, including a table that lists the courses taken and practicum experiences. I provide this information in Table 1 below and describe each participant's background in more detail within the description of each case.

Table 1
Participants

	Traditionally Certified		Alternatively Certified	
	Allison	Cindy	Jessica	Stephanie
Current Year of Teaching	5	4	4	4
Courses Taught	Algebra 1 Algebra 2	Geometry Liberal Arts Math	Algebra 1 Geometry	Geometry Math for College Readiness
Degree Area	Bachelors in Secondary Math Education	Bachelors in Secondary Math Education	Bachelors in Computer Science, Masters in Business Administration	Bachelors in Sociology
Former Career			Software Engineer	Secretary

Following the general preparation program information for each individual case, I provide the information obtained from part one of the first interview in which I asked questions about participant's perceptions of their preparation experiences. Next, I include information gained from part two of the first interview in which the questions I asked were related to the three tenants of situated learning theory which are: the extent to which participants perceive their experiences to have taken place in an authentic context, the perceived role of social interaction within their preparation program, and the extent to which the constructivist learning approach was present in their preparation program.

Following the information from the first interview, I provide an overview of lesson one including the topic taught, objective, information about the students in the class, and the standards addressed. Four tables follow the overview. The first table lists the scores on the MQI for the Richness of the Mathematics domain for lesson one. In the second table, I used a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3) to assign a total score to each category within the domain. In the Richness of the Mathematics domain is it favorable for scores to be higher on the scale, as higher scores indicate higher Richness of the Mathematics. The third table lists the scores on the MQI for the Errors and Imprecision domain for lesson 1 and is followed by a fourth table in which I used a Likert scale equivalent as described above. In this domain, however, it is favorable for scores to be lower on the scale, as lower scores represent less error. Next, I provide an overview of lesson two including the standards addressed, followed by four tables like those presented for lesson one.

Following the tables, I include information gained from the second interview during which I asked questions about each participant's perception of the impact of their preparation pathway experiences on the quality of their mathematics instruction, as measured by their scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI. I conclude each case with a summary.

Case 1: Allison

Allison is in her fifth year of teaching. During the 2019-2020 school year she taught Algebra 1 and Algebra 2 at Sunshine High School. She completed her final internship at this school and has taught here for all 5 years of her career. She earned a bachelors degree in Secondary Mathematics Education from University A and is therefore a traditionally certified mathematics teacher.

Description of Preparation Program. To gain acceptance into the Teacher Education Program, students must have a grade-point average of at least 3.0 at the end of their sophomore year when they complete their undergraduate general curriculum requirements. They also must pass all sections of the Test of General Knowledge to be continue in the secondary mathematics program.

There are a series of five formal clinical experiences in the Secondary Education Programs that begin during student's sophomore year and continue throughout their senior year. Students must take the Mathematics 6-12 subject area exam during practicum III. If they do not pass, they must retake the exam and obtain a passing score by the end of their final internship. A final requirement of the program is for students to earn a minimum of accomplished rating on the Practicum I teaching evaluation tool and Progressing or better on the Practicum II and III Danielson teaching evaluations used in the surrounding school district. The courses and practicum experiences total 136 credit hours. The table below shows the courses required to obtain the undergraduate degree in Secondary Mathematics.

Table 2

University A: Secondary Mathematics Education Courses (6-12)

Content Courses	Pedagogy Courses	Field Experience
College Geometry	Foundations of American Education	Pre-Education Practicum
Calculus I	Philosophy of Education and Teacher Learner Relationships	Practicum I
Calculus II	Secondary Classroom Assessment	Practicum II (ESOL)
Calculus III	Secondary Classroom Management	Practicum III
Intro to Higher Mathematics	Methods of Secondary Instruction	Final Internship Practicum IV
Probability and Statistics	Teaching Mathematics in the Secondary School	
Differential Equations	Technology in Education	
Linear Algebra or Modern Abstract Algebra	Teaching Reading in the Secondary Content Areas	

Interview 1 – Part 1: Preparation Program Perceptions

The first interview was separated into two parts. During the first part I asked participants general questions about their preparation pathway experiences.

Overall Perceptions: During the initial interview, I started by asking Allison general questions about her preparation experiences. The first thing she mentioned when I asked her to describe her preparation experience from start to finish were three of her practicum experiences. She recalled her first practicum experience which was comprised of observations at a K-8 school once a week for two hours. She then discussed another practicum experience where she went to a high school twice a week for four hours each time. Finally, she told me about her final internship where she was at a high school every day for an entire semester. She told me that all of these experiences were accompanied by coursework. Her perceptions of the coursework revealed that a major factor in determining whether the classes were useful or not was based on the professor and types of assignments. She said, "some of the classes were awesome based on the professor. Some of them were a little weird, they wanted everything to be project based, which is very hard to do with math" (Interview 1).

Perceived Strengths of Preparation Program: Allison identified lesson planning as a strength of her preparation program. She described the amount of detail that was expected from her professors when turning in lesson plans as being helpful in terms of preparing her to teach on her own. She also described the amount of lesson plan feedback given by her professors as a helpful tool in her preparation experience. Because of these experiences, she discussed lesson planning being a lot more work that she initially thought. She said,

> They made us write down every single detail of every single thing that we would say, do, and everything, which made me realize how long an actual class period is. Going in, I was like Oh I can just explain, Oh I'm going to do linear functions. Well what exactly was a linear function? What do I need to go over? And they almost made us like script it, which made me be like, this is a lot longer than I thought it was going to be. (Interview 1).

Perceived Weaknesses of Preparation Program: Allison identified the project-based learning that she mentioned earlier in the interview as an area of the preparation program that was not helpful. She said,

> when you're doing like geometry you can do different fun things with like area and volume and all that stuff because you're working with shapes but not as much when you're doing algebra. So that kind of stuff I wasn't really too fond of (Interview 1).

Another area that she perceives as a weakness from her preparation program is the lack of specificity to mathematics teachers in some of the coursework. She recalled that the pedagogy courses contained secondary education majors in various subject areas, not just mathematics.

She saw this as a weakness in the preparation program and thought it would be more useful if the pedagogy courses were specific to mathematics teaching and learning, rather than general for prospective secondary teachers of all subject areas. She said,

> The classes were kind of combined, which was really hard because how you teach math is totally different than how you're going to teach English and how you're going to teach reading and how you're doing to teach science. Some of the methods are the same, but you still have to apply them differently (Interview 1).

In addition, Allison identified the lack of mathematics teaching experience of the professors of her pedagogy courses as an area of weakness. She recalled,

> None of the ed professors were math teachers ever, which makes it really hard. Because they don't understand that math classes run differently. Like you can't not do notes in a math class. If you don't do notes, you're not going to have any idea what to do. I feel if there was a specific teacher or person that could have been more like, okay, this is how a math classroom is structured, I think that would have been a lot more beneficial (Interview 1).

Perceived Missing Areas of Preparation Program. I asked Allison think about her experience teaching and reflect back on her preparation program experiences to identify any possible aspect of in service teaching that were missing from her program. She answered,

> The hardest part was figuring out how to fill out all the paperwork that we have to do. Like planning notes for IEP's and stuff. I had never seen those before in my life. I feel like I wasn't prepared enough for that kind of stuff (Interview 1).

Factors Influencing Choice of Preparation Program. I asked Allison about the factors that influenced her decision to enroll in the secondary mathematics education program at the

University A. She started by telling me that she always wanted to be a teacher and wanted to teach mathematics because it was something that always came easy to her. She did not identify any specific factors that made her choose the preparation program she did. She described.

> When I was in high school, I realized I wanted to teach math because it was just something that came easily to me and I was always the person that they always stuck helping others in class. I was like, oh, I'm actually good at this. So I decided to be a teacher and when I transferred into UT it just kind of fell into place and it worked out. I knew they have a very good ed program (Interview 1).

After her response to this question, I moved into part two of the first interview, during which I asked questions about Allison's the extent to which her preparation program experiences may relate to situated learning theory.

Interview 1 – Part 2: Preparation Program Experiences and Situated Learning Theory

Perceived Portion of Preparation Experiences in an Authentic Context. I asked Allison about the extent to which her preparation program experiences did or did not take place in an authentic context. She revisited the practicum experiences that she mentioned earlier in the interview.

> So last semester was the entire semester full time (in a classroom). And then we did two other internships on top of that. So probably not as much as you probably need but more than other schools do. So first semester junior year was the first time I stepped in and I was just purely observing. The first time I taught was first semester senior year and it was like one day of the week I would teach and then the other day I would observe. And at the end of that we were teaching both days (Interview 1).

I wanted to learn about how her coursework experiences were or were not delivered in an authentic context, so I asked her how her experiences as a student were similar or dissimilar to experiences that she provides for her students. In response to this question she started to discuss her content classes during her preparation experience.

> In my math classes at UT, that made more of how I would run my classes because its, you explain it, you do practice, you explain something, you do practice, like the I do, we do, you do method. They didn't do that much in my education classes, but I know that that's like what most math teachers do (Interview 1).

Perceptions of Social Interaction in Preparation Program. I asked Allison about the role of social interaction in her preparation program and experiences. She recalled a lot of social interaction throughout the program and described experiences collaborating with other students throughout the program, specifically in her content focused mathematics courses.

> So we had a lot of group projects and there were some group projects where we did like, two math teachers wrote a lesson together or wrote a unit plan together. But then we also did one where it was a group project where you'd have one English, one math, one history, one science, and you'd have to teacher all four curriculums in one unit. There was a lot of social interaction (Interview 1).

Based on her responses, I asked if she felt that the social interactions were forced. She replied,

> Yes. It was always partnered. They'd choose it. Math classes, we could work with whoever we wanted pretty much. But for ed classes it was always picked for us. Now by the time we got into our junior and senior year, it was the same 15 to 20 kids that were in all of your classes. So you knew everyone and you were comfortable with them (Interview 1).

When I asked her to clarify if she thought that was a good thing she said,

> I do. Because you kind of knew who they were, how their style teaching is, all that kind of stuff. Whereas, if it was a huge class and you got stuck with someone new every single time, it would be hard to adjust because when you're writing unit plans, what we did was each person would write their subject area…but then we had to make it look like one person wrote the entire thing. So fitting four different styles of writing into one thing gets hard when you don't know the person but once you get to know each other, you can kind of make it easier (Interview 1).

Perceptions of the Constructivist Learning Approach in Preparation Program. In the final part of the interview I asked Allison to describe any experiences within her preparation program in which she constructed her own learning of a topic or idea and to what extent the new information was linked to prior learning. She started discussing a recycling project that she was assigned to create. She said, "I figured out something with bringing in random shapes from home, different containers and stuff and then doing a geometry project and finding the area, surface area, volume, and all that stuff depending on what figure they brought in" (Interview 1). I probed further by asking if she could recall a topic that she didn't really know about initially but was able to construct her own learning around eventually. She replied,

> Accommodations for ESL kids I would say, because there's so many kids here that English isn't their first language. So just the accommodations on figuring out okay do they want the dictionary or how to work it that way. We were just told every time to partner them and give them a dictionary. Guess that works for some kids but not for all of them. So figuring out those new methods was I would say something that we kind of…we did work together as a cohort (Interview 1).

I then asked her about the extent to which the new information she learned connected to prior learning. She discussed experiences in both her content and pedagogy classes.

> I will say a lot with calc. Everything goes back to Algebra. If you are not good in your algebra skills then you can't do it. So finally piecing together all those parts and doing differential equations…it was finally like, okay this makes sense as why this happens, and this happens and all this. So that happened in math. I know my ed classes built upon each other, but I don't remember right now the extent of what we learned in one class was used in the next class. I remember doing that because I remember going back to previous books and stuff and using it but I can't think of what (Interview 1).

Probing deeper, I asked about any connections she may have experienced in terms of learning prior to her starting the preparation program. She had some general memories such as,

> I mean I guess like when you're sitting in a classroom you've kind of watched your teachers anyways so you're seeing, okay, Im doing a lot of the same things in all the math classes, I'm doing a lot of the same things in all the English classes. So I guess seeing the reason why we're doing those things getting put into place in the ed program worked out (Interview 1).

Perceptions of Opportunities for Reflection in Preparation Program. Finally, I asked her to describe any opportunities she had to reflect within her preparation program. She was able to describe some reflection experiences and told me how helpful they were in her preparation. She said,

> First semester senior year we had to make until plans and lesson plans…and then we also had to present them. After we did the lesson part of the grade was a reflection grade. So we had to fill out this whole big thing and it was like okay, what did you do good? What

would you do different now? Go back, watch your video. What did you notice you did more of? What did you notice you didn't do enough of? That type of thing. So it kind of brought me to think of it as the student while I'm also teaching it. (It was) extremely helpful. Because there's things that I never knew that I did. So, I used to wear a hairband on my wrist and I would play with it the entire time I was teaching. Now I don't wear a hairband on my wrist when I teach because I don't want to sit there and play with it and have my students pay attention to it (Interview 1).

Videotaped Lesson 1: Solving Exponential and Logarithmic Equations (Algebra 2)

Overview of the Lesson. The topic of this lesson is solving exponential and logarithmic equations. The objective is, "Students will be able to solve exponential and logarithmic equations." Allison taught this lesson in her second period Algebra 2 class. This class consists of a total of 26 students in 10^{th}, 11^{th}, and 12^{th} grade.

This lesson addresses two standards:

- MAFS.912.A-SSE.2.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
- MAFS.912.F-LE.1.4 For exponential models, express as a logarithm the solution to $ab\ ct$ $= d$ where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.

Table 3

MQI Ratings for Richness of the Mathematics in Lesson 1 (Allison):

Lesson Title: Solving Exponential and Logarithmic Equations (Algebra 2)		
Category	Video Segment	Rating
Linking Between Representations	S1	NP
	S2	NP
	S3	NP
	S4	NP
Explanations	S1	NP
	S2	L
	S3	NP
	S4	L
Mathematical Sense Making	S1	NP
	S2	L
	S3	NP
	S4	L
Multiple Procedures Or Solution Methods	S1	NP
	S2	NP
	S3	NP
	S4	NP
Patterns and Generalizations	S1	L
	S2	L
	S3	L
	S4	M
Mathematical Language	S1	M
	S2	M
	S3	M
	S4	L

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 4

Total Scores for Richness of the Mathematics in Lesson 1 (Allison)

Category	Total Points Earned	Decimal
Linking Between Representations	0/12	0.00
Explanations	2/12	0.17
Mathematical Sense Making	2/12	0.17
Multiple Procedures or Solution Methods	0/12	0.00
Patterns and Generalizations	5/12	0.42
Mathematical Language	7/12	0.58
Total	16/72	0.22

Note. Higher scores are favorable in this subdomain

Table 5

MQI Ratings for Errors and Imprecision in Lesson 1 (Allison):

Category	Video Segment	Rating
Mathematical Content Errors	S1	NP
	S2	NP
	S3	NP
	S4	NP
Imprecision in Language or Notation	S1	NP
	S2	L
	S3	L
	S4	L
Lack of Clarity in Presentation of Mathematical Content	S1	NP
	S2	L
	S3	L
	S4	L

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 6

Total Score for Errors and Imprecision in Lesson 1 (Allison)

Category	Total Points Earned	Decimal
Mathematical Content Errors	0/12	0.00
Imprecision in Language or Notation	3/12	0.25
Lack of Clarity in Presentation Or Mathematical Content	4/12	0.33
Total	7/36	0.19

Note. Lower scores are favorable in this domain

Videotaped Lesson 2: Radians, Degrees, and Angles of Rotation (Algebra 2)

Overview of the Lesson. The topic of this lesson is converting between degrees and radians and angles of rotation. The objective is, "Students will be able to convert between degrees and radians and will be able to draw angles of rotation on a coordinate plane. The lesson addresses the following standard:

- MAFS.912.F-TF.1.1 Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle; Convert between degrees and radians.

This lesson was recorded using Zoom during the last nine weeks of school when students and teachers participated in elearning from home due to COVID-19. Allison held live zoom lessons each week and recorded and posted them for students to watch later if they were unable to attend the live zoom. This lesson was recorded for her Algebra 2 students to watch before completing the assignments that were associated with the video.

Table 7

MQI Ratings for Richness of the Mathematics in Lesson 2 (Allison):

Lesson Title: Radians, Degrees, and Angles of Rotation (Algebra 2)		
Category	Video Segment	Rating
Linking Between Representations	S1	NP
	S2	L
	S3	NP
	S4	NP
Explanations	S1	M
	S2	M
	S3	L
	S4	L
Mathematical Sense Making	S1	L
	S2	L
	S3	L
	S4	L
Multiple Procedures Or Solution Methods	S1	NP
	S2	NP
	S3	NP
	S4	NP

Table 7 (continued).

Patterns and Generalizations	S1	NP
	S2	L
	S3	L
	S4	NP
Mathematical Language	S1	M
	S2	M
	S3	M
	S4	L

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 8

Total Scores for Richness of the Mathematics in Lesson 2 (Allison)

Category	Total Points Earned	Decimal
Linking Between Representations	1/12	0.08
Explanations	6/12	0.50
Mathematical Sense Making	4/12	0.33
Multiple Procedures or Solution Methods	0/12	0.00
Patterns and Generalizations	2/12	0.17
Mathematical Language	7/12	0.58
Total	20/72	0.28

Note: Higher scores are favorable in this domain

Table 9

MQI Ratings for Errors and Imprecision in Lesson 2 (Allison):

Category	Video Segment	Rating
Mathematical Content Errors	S1	NP
	S2	NP
	S3	L
	S4	NP
Imprecision in Language or Notation	S1	L
	S2	L
	S3	NP
	S4	L
Lack of Clarity in Presentation of Mathematical Content	S1	NP
	S2	NP
	S3	NP
	S4	NP

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 10
Total Score for Errors and Imprecision in Lesson 2 (Allison)

Category	Total Points Earned	Decimal
Mathematical Content Errors	1/12	0.08
Imprecision in Language or Notation	3/12	0.25
Lack of Clarity in Presentation Or Mathematical Content	0/12	0.00
Total	4/36	0.11

Note. Lower scores are favorable in this domain

Interview 2: Perceptions of Preparation Pathway's Effect on MQI Scores

After collecting the quantitative data**,** I conducted a second interview with each participant, though which I hope to gain insight into participants' perceptions of the potential impact that they preparation program had on the quality of their mathematics instruction specific to the videotaped lessons. This interview included questions related to the two domains of the MQI (Richness of the mathematics and errors and imprecision) and the relation between those domains and participant's teaching decisions as observed in the videotaped lessons. My rationale for including interviews in the study is to gain insight into participant's perceptions about the effect, if any, of their teacher preparation pathway on the scores on the MQI. Before the second interview I sent the MQI rating documents to Allison so she had a chance to look at the scored before the interview.

I started with some general feedback about her scores. I told her that her scores on the first lesson were strong in explanations and mathematical language and asked her how she learned these skills of explaining and using mathematical language. She replied,

> The first time I ever taught logs it was a disaster. So I actually ended up having to reteach it because it was just so bad. So I pulled from other teachers and came up with this log roll idea. Well, another teacher, I don't remember. I think it was Kim who showed this to me. And once I started using the log roll thing it became so much easier and them I've just been doing that year after year and it works so well (Interview 2).

Her second lesson also scored well in the explanations and mathematical language categories of the Richness of the Mathematics component of the MQI. I asked her to think back to her preparation experiences and explain how she learned to provide thorough explanations while teaching mathematics concepts. She said,

> I definitely remember learning that in a course previously. I don't remember if it was when I learned it for the first time when I was in algebra 2 in high school or if I learned it in college. But just kind of reiterating it to them that okay you have to remember to put it over one, kind of reinforcing things they do already know, but that they sometimes forget because they're trying to get to the solution as quick as possible instead of learning the process to get through it (Interview 2).

I asked a clarifying question. "So could I interpret that as you're wanting them to understand the reasons why things are the way they are not just memorizing the steps to doing it?" To which she replied, "Correct. Yeah. Perfect" (Interview 2).

Next I asked her how she determined how many examples to explain and what type of examples to explain. She answered,

> So I always start off with the easiest, which is like the same base. So that way it gives them the basic idea of okay cool, this is how it works out. Whenever I have two numbers raised to an exponent, if they have the same base, I just set the exponent equal to each

> other. So then I always make it just a little harder with each type. So that's why I then went to where you have to change them to have the same base. Then the last part was where you can't change them. So it progressively gets more difficult along the way (Interview 2).

I asked her if the way she taught this lesson to her Algebra 2 class was consistent with the way she learned the concept and she didn't really remember. I moved on to the next section of the rubric about sense making and asked Allison why she used the specific type of modeling that she did in this lesson. She said,

> So when I learned how to teach they always taught us to explain and visualize. Because if you just say oh look these two numbers are different, they're not going to exactly know which two numbers. So that's why I circle and color code things because it helps kids realized, oh that's what she's talking about in red, or whatever color I choose to use for that. And kids actually do that in their notebook so when they go back to study, they actually see oh hey that's what she did there. That's why this changed to this. I'm trying to remember, but I definitely wasn't given a shortcut or anything and I've never seen it (log roll) in a book or anything but that's just how I guess important it is to work with other teachers, because you learn things along the way at work (Interview 2).

I asked if that strategy was something she learned in her college of education classes to which she replied, "Oh yeah. I don't remember specifically which course or which teacher, but definitely learned that there" (Interview 2). To address the multiple procedures or solutions scores I asked her if she thinks there were other possible methods that she could have used to explain the logs to her students. She said,

> Oh absolutely. But like I said earlier, this was the method that I've always had the most success with so that's why I always choose this one. And I feel like it's the most user-friendly, the kids understand it the most because it's not overly technical (Interview 2).

The last question in the richness of the mathematics area that I asked was about her use of mathematical language. This was the section in which she scored highest for the first lesson. I asked her the reasoning behind using the mathematical language as well as asking her if she naturally uses this language when she explains concepts to students or if it is something she has to consciously remind herself of while teaching. She replied,

> I usually always use those types of words as much as I can…Its just that when they repeat the word or hear it again and again and again it sinks in. So I mean there's really only…you can't call an exponent anything else besides an exponent unless you want to say raised to this power, but then it just gets to be too much. So I guess just repetition helps them remember what its called so that way they have the voacb (Interview 2).

I continued by asking if she uses certain strategies or methods to encourage students to use mathematical language in her classroom. She said,

> Well when they ask questions if they don't use the vocab I don't know what they're saying. So I kind of enforce the using that along the way so that way it gets them familiar with the word but it also helps them and their fellow students realize like, okay she's actually wanting us to learn some voacb here (Interview 2).

I transitioned to the second component of the MQI, Errors and Imprecision. I explained to Allison what would count as an error or imprecision. I told her that using the "log roll" would be considered in the gray area of imprecision, but since she used it multiple times it was considered imprecision. I asked her to elaborate on that explanation and also to explain why she chose to use that term to explain the mathematics to her students. She answered,

> So I believe I write it out before I show them the log roll, I show them the equation in log form and then I also show it to them in exponential form. And I use the same letters to show them that you can rewrite it. And them I'm like well the textbook wants you to memorize and this is how they want us to teach it to you guys and you just have to memorize where these things go. But I have this little trick that's going to help you remember where you start at the base, roll around the outside of the equal sign, and end on what's inside. So that way you can do your log roll and then you just write it in the order that you touch the numbers in. Then you know that the second number that you touch is your exponent. I learned in my internship that you don't have to teach everything the way the book wants you to, sometimes you need to explain it in a way that is different so the students will understand it. Exactly like the log roll versus memorizing how to do it (Interview2, GV).

Summary of Case 1: Allison is a traditionally certified teacher who attended a traditional four-year preparation and earned a degree in Mathematics Education. She is in her fifth year of teaching and teaching has been her only career. She recalls her internships and practicums as being the most useful part of her preparation program, and also identified the social interaction experiences as helpful throughout her preparation. When asked about missing components of her preparation program, she identified more math specific professors and math teaching strategies. Allison also discussed some logistical aspects of the job as missing from her preparation program, such as learning how to complete ESE paperwork. She thought the mathematics courses in her preparation program were more aligned with how she currently teaches. On the two videotaped lessons she taught, she scored highest in the following areas of the MQI; Explanations, Patterns and Generalizations, and Mathematical Language, which are all subdomains of the Richness of the Mathematics domain. She discussed several reasons when I asked her the reasoning for her teaching decisions as shown in the videos. One reason was based on learning she gained from her colleagues. She also made connections to learning she gained in her preparation program, specifically when describing why she explained things the way she did.

Case 2: Cindy

Cindy is in her 4th year of teaching. During the 2019-2020 school year she taught Geometry and Liberal Arts Math. She completed her final internship at this school and has taught here her entire career. She earned a bachelors degree in mathematics education from University B and is therefore a traditionally certified mathematics teacher.

Description of Preparation Program. Students must earn a C or higher in all courses to remain in the program and earn at least a 2.5 grade point average for their core and specialization courses. All courses, aside from senior seminar, must be completed prior to the final internship. In addition, all sections of the General Knowledge Test must be passed prior to the final internship. Students have until the end of their final internship to pass the Mathematics 6-12 Subject Area Exam as well as the FTCE Professional Education Test. The program consists of 120 credit hours. The chart below shows the courses required to obtain the undergraduate degree in Secondary Mathematics.

Table 11
University B: Mathematics Education Courses (6-12)

Content Courses	**Pedagogy Courses**	**Field Experience**
Calculus III	Schools and Society	Practicum
Discrete Mathematics	Human Development and Learning	Final Internship
Bridge to Abstract Math	Measurement for Teachers	
Linear Algebra	Integrating Exceptional Students	
Elementary Number Theory	ESOL Competencies and Strategies	
Geometry	Content Area Reading	
Early History of Mathematics	Classroom Management	
Introduction to Statistics	Schools and Society	
	Middle School Methods	
	Senior High School Methods	
	Technology for Teaching Math	

Interview 1 – Part 1: Preparation Program Perceptions

Overall Perceptions. I started the interview by asking Cindy to give some overall perceptions about her preparation program and experiences. She immediately discussed her internship and practicum experiences.

> So that (internship) was definitely like the most experience to get. And I remember thinking during that time like they should definitely make us do more than just the practicum and the internship. It would have been nice to have more of that hands on interaction (Interview 1).

Based on her answer, I knew the internship had a positive impact on her preparation experiences. Later, she went into more detail about its usefulness and positive impact on her as an inservice teacher.

Perceived Strengths of Preparation Program. Although it was clear that she identified the internship experience as a strength of her preparation program, I asked Cindy to elaborate on any other strengths of her program. She discussed the classes, specifically those offered through the college of education. She said, The classes were good. I'm trying to think of like what projects we did, because I know I had to do a unit write up in college and I didn't really know how to do that. I was kind of just making notes on each section and like, oh yeah this would be a test. And I don't know it was completely different than actually being a teacher and actually different ways to present material and practice material (Interview 1).

Perceived Weaknesses of Preparation Program. I asked Cindy if there were any aspects of her preparation program that were not helpful. She answered,

That's hard because I really enjoyed all the classes I took because you know math nerd like Oh Geometry, this is how it works. The numbers, 'Im sure it helped train my brain on how to think and follow things through and procedural type just kind of math logic brain. But the teacher side of things, definitely don't use that. Now the education class is, I think that was more based off of like what professor you had. Some professors are more like story-based so that was kind of like only, that cool that's there's scenarios (Interview 1).

Perceived Missing Areas of Preparation Program. When I asked Cindy about any aspects of the program that were not helpful she started talking about things she wished were included in her preparation program. She started by talking about exposure to technology;

I think it would have been helpful if we did a word seminar class or something like that like how to operate word. We did technology in the classroom but that was programs with geometry or like algebra. But even just knowing word shortcuts and like typing up worksheets and tests, that's something I actually learned during my internship, but I find the most helpful in my everyday life (Interview 1).

She also talked about having access to some of the logistical parts of teaching. She said, "It would've been nice if we were to have access to the email system…but you don't know what district you're going to be in" (Interview 1). I asked her if there were any other aspects of her preparation program that she believes were missing, now that she has been teaching for a few years. She said,

> The words stuff. Also just like exposure to different types of students. Because I feel like a typical college kids was like an honor student and only were exposed to honors and like AP classes. Whereas in my practicum I realized, oh no every student really cares about learning and cares about math. And that would have been nice just to kind of have that exposure earlier on (Interview 1).

Factors Influencing Choice of Preparation Program. I asked Cindy what factors influenced her decision to enter the secondary mathematics preparation program at University B. Her primary reason seemed to be because of her family, as she said,

> Really just, I think my family like my dad and my mom went to University B and as a kid I always went to University B football games and I just always pictured myself there. Then my brother ended up going and I wasn't the type of student or I guess person that wanted to get away from family. I wanted to stay local (Interview 1).

I asked her specifically why she chose the teaching preparation program for secondary mathematics offered at University B. She said, "My dad. From a very young age he inspired me to be a math teacher. I thought it was cool. I used to want to grade his papers and stuff" (Interview 1). After her response to this question, I moved into part two of the first interview, during which I asked questions about Cindy's the extent to which her preparation program experiences may relate to situated learning theory.

Interview 1 – Part 2: Preparation Program Experiences and Situated Learning Theory

Perceived Portion of Preparation Experiences in an Authentic Context. I asked Cindy to tell me about the aspects of her preparation program experience that took place in an authentic context. She seemed a little confused, so I clarified by explaining more about the meaning of authentic context, asking her which parts of her preparation program provided experiences similar to those she currently provides her own students. She didn't recall many experiences that she considered similar to those that she provides her students, but rather started explaining what she thought would have been more authentic and useful. She said,

> I would have found it more useful if they showed us maybe like Kagan strategies or different ways to present material because especially it seems like there was this transition in the last less than ten years, where a math teacher used to be like okay this is the section were doing, we're taking these notes, you're going to do these problems in the book…so I would have appreciated more, just opportunities to practice different structures of activities and lessons and things like that. I remember they had us make like posters. They had us make the unit outline (Interview 1).

At this point it seemed like she was describing more part of her preparation program that were missing. I asked her what portion of her preparation experiences took place in an actual school setting.

> The practicum, I think I only had to go twice a week at the most. I did (a tutoring program) through University B. If you were a college of education major then you could apply to be a tutor and they would assign you schools and you would go to the schools and pull students out of the class and help them with their homework , so that was a good experience. Just that did expose me to like more students. But that wasn't part of the

> education program. That was more of like a job. So having that experience was good (Interview 1).

She then recalled more experiences in an authentic context within her program and I asked her to elaborate.

> Oh I did I did do observations. There was a class where, I don't remember which class that we had, I was in a kindergarten room. I was like this is not where I'm wanting to be. Because at that point I knew it was going to be high school, I didn't want (to teach) little kids. So that would have been probably better to like place us where we would be. But maybe they were just trying to show us more, maybe break us out of our box. But I remember I had to observe (Interview 1).

I asked her to recall in what ways, if any, were her preparation experiences similar or not similar to the experiences that she provides for her students. She made a connection between the education courses in her preparation program and the methods she currently uses to teach mathematics because they were activities within the classes rather than just lecture. She said,

> I think the education courses are closer to what I'm doing here because they weren't, so I'm going to lecture, you're going to take notes and be quiet the whole time and listen to me. That was the math courses. But in education they definitely, there was definitely lectures but there was others where it was a more interactive day, your group would like make a poster or brainstorm. It wasn't always just lecture. So I mean I think it compares to my students because there are days where I do present new information and I have the notes set up, and it is a little but more lecture based (Interview 1).

Perceptions of Social Interaction in Preparation Program. Next I asked Cindy about the role that social interaction with other prospective teachers played in her preparation program and experiences. She described,

> I think that we were all just like excited to be math teachers and we were all kind of in the same boat of being naïve to it all. In hindsight out interactions were positive, and there was never anyone like why are we doing this. Or we were all excited and ready to have our own classrooms and do our own thing (Interview 1).

I continued asking about social interaction within her preparation program, specifically whether the program provided opportunities for her to interact with peers. She recalled several group projects and assignments in which she was asked to work collaboratively with her peers, and also described opportunities where she met up with peers to collaborate, even when it wasn't required. She said,

> Oh yeah, we had group projects and stuff. So a lot of group projects and that forces us to like get together and work on things together, and what are you going to do for this part…I mean, I definitely made friends and we would work on things together like meet up and go to the library and maybe it wasn't group work, but we both had the same paper to write or the same questions to answer (Interview 1).

I followed up with a question about whether she thought those experiences had any impact on the teacher that she is now in terms of social interaction with her peer teachers. She answered,

> Yes, it's harder when you become a teacher because there's so many different levels of teachers and experiences. So like when I was in college, none of us knew anything. We were just figuring out together. Whereas when you become a teacher, you have that 20 year teacher who might be just tired of people and don't really want to help you. Or

> you'' have the novice teacher who is like oh yea let's do this and just bounce ideas off each other. So I mean, I think it's just more kind of survival. Like you can kind of vibe out and figure out who you're going to work well with and just try and help each other with that (Interview 1).

She went on to describe experience with her cooperating teacher during her final internship,

> Like (my cooperating teacher) and I, we are always bouncing ideas back and forth and it helps because she was my intern teacher. So we bonded pretty quick. Just always collaborating, always trying to pick each other up like Oh I tried this, you should try it, and just training. I don't know what I would do if I didn't have people that were willing to work together (Interview 1).

Perceptions of the Constructivist Learning Approach in Preparation Program. During the final part of the first interview, I asked Cindy if she could recall any experiences in her preparation program in which she constructed her own learning of a topic or idea. She said,

> Yeah. I remember I had one teacher that was vague. We had out project and it was, I remember everyone had all these questions and she was just saying I do not want to limit creativity and we were like okay but what do we do? Do I don't remember what the project was on. I think we had to…I remember it was geometry. We had to present like quadrilaterals or something. So, it wasn't like okay read about this chapter in the book and present or anything. I think it was more coming up with a lesson (Interview 1).

Next I asked her how much she does or doesn't think that the new information was linked to prior information. She answered,

> In math, they definitely expected you to know everything you've ever been taught. Maybe one of my calc teachers would be like oh year I Remember that now its like this.

> But yea, math was mostly just okay, follow along. Education, I feel like it was more of a connection to their own life, like oh this happened to me once, it might happen to you in the future. Which again, I appreciate the scenarios, but it would have been nice to just kind of learn more specific things. I don't even know what I would have rather learned, but not really sit there and listen to stories (Interview 1).

Perceptions of Opportunities for Reflection in Preparation Program. During the last part of the first interview I asked Cindy to reflect upon experience within her preparation program where I asked her to reflect on specific learning or experiences. She was able to recall several instances where she was prompted to reflect. Specifically, she discussed the reflections she did after an observation from a lesson she videotaped then watched.

> They had us record ourselves doing and lesson and then reflect on it, which that was helpful. It's definitely nerve wracking at the time. You've never really taught before in front of people, now you're recording yourself. So that was kind of intense, and then we had to go watch it with professors, so uncomfortable, but I got through it and it was…I would call that a learning experience because they did give feedback that was useful. It wasn't like oh you should have spent longer on this like number two, it was teaching styles and critiques (Interview 1).

I asked her if she felt that the reflection opportunities were helpful. In addition to thinking they were helpful, she also expressed a desire to have had more opportunities for reflection. She said,

> Yea, I did. Any maybe even doing more of that…So definitely just kind of advocating for yourself and just trying to absorb as much as you can. I mean…this is what I knew I always wanted to do and I wanted to be good at it so… (Interview 1).

Videotaped Lesson 1: Arcs and Inscribed Angles (Geometry)

Overview of the Lesson. The topic of this lesson Arcs and Inscribed Angles. The objective is, "Students will be able to determine the measure of arc and inscribed angles within circles." Cindy taught this lesson in her first period Geometry class which contains of a total of 25 students in 9th, 10th, 11th, and 12th grades.

This lesson addresses the following standard:

- MAFS.912.G-C.1.2 Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.

Table 12
MQI Ratings for Richness of the Mathematics in Lesson 1 (Cindy)

Lesson Title: Arc and Inscribed Angles (Geometry)		
Category	Video Segment	Rating
Linking Between Representations	S1	NP
	S2	NP
	S3	NP
	S4	NP
Explanations	S1	NP
	S2	L
	S3	L
	S4	M
Mathematical Sense Making	S1	L
	S2	L
	S3	L
	S4	M
Multiple Procedures Or Solution Methods	S1	NP
	S2	NP
	S3	NP
	S4	L
Patterns and Generalizations	S1	NP
	S2	NP
	S3	NP
	S4	NP

Table 12 (continued).

Mathematical Language	S1	L
	S2	L
	S3	L
	S4	M

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 13

Total Scores for Richness of the Mathematics in Lesson 1 (Cindy)

Category	Total Points Earned	Decimal
Linking Between Representations	0/12	0.00
Explanations	4/12	0.33
Mathematical Sense Making	5/12	0.42
Multiple Procedures or Solution Methods	1/12	0.08
Patterns and Generalizations	0/12	0.00
Mathematical Language	5/12	0.42
Total	15/72	0.21

Note. Higher scores are favorable in this domain

Table 14

MQI Ratings for Errors and Imprecision in Lesson 1 (Cindy)

Category	Video Segment	Rating
Mathematical Content Errors	S1	NP
	S2	NP
	S3	NP
	S4	NP
Imprecision in Language or Notation	S1	L
	S2	L
	S3	L
	S4	L
Lack of Clarity in Presentation of Mathematical Content	S1	NP
	S2	NP
	S3	NP
	S4	NP

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 15
Total Scores for Errors and Imprecision in Lesson 1 (Cindy)

Category	Total Points Earned	Decimal
Mathematical Content Errors	0/12	0.00
Imprecision in Language or Notation	4/12	0.33
Lack of Clarity in Presentation Or Mathematical Content	0/12	0.00
Total	4/36	0.11

Note. Lower scores are favorable in this domain

Videotaped Lesson 2: Writing Quadratic Equations (Algebra 1B)

Overview of the Lesson. The topic of this lesson is writing quadratic equations by identifying roots. The objective is, "Students will be able to write quadratic equations in standard form by identifying roots from a graph." Cindy taught this lesson in her second period Algebra 1B class. This class consists of a total of 18 students, all in 10^{th} grade. The lesson addresses the following standard:

- MAFS.912.F-IF.3.8: Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.

Table 16
MQI Ratings for Richness of the Mathematics in Lesson 2 (Cindy)

Category	Video Segment	Rating
Linking Between Representations	S1	M
	S2	L
Explanations	S1	M
	S2	L
Mathematical Sense Making	S1	M
	S2	L
Multiple Procedures Or Solution Methods	S1	NP
	S2	NP
Patterns and Generalizations	S1	NP
	S2	NP

Table 16 (continued)

Mathematical Language	S1	M	
	S2	L	

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 17
Total Scores for Richness of the Mathematics Lesson 2 (Cindy)

Category	Total Points Earned	Decimal
Linking Between Representations	3/6	0.50
Explanations	3/6	0.50
Mathematical Sense Making	3/6	0.50
Multiple Procedures or Solution Methods	0/6	0.00
Patterns and Generalizations	0/6	0.00
Mathematical Language	3/6	0.50
Total	12/36	0.33

Note. Higher scores are favorable in this domain

Table 18
MQI Ratings for Errors and Imprecision in Lesson 2 (Cindy)

Category	Video Segment	Rating	Notes
Mathematical Content Errors	S1	NP	
	S2	NP	
Imprecision in Language or Notation	S1	NP	
	S2	NP	
Lack of Clarity in Presentation of Mathematical Content	S1	NP	
	S2	NP	

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 19

Total Scores for Errors and Imprecision in Lesson 2 (Cindy)

Category	Total Points Earned	Decimal
Mathematical Content Errors	0/6	0.00
Imprecision in Language or Notation	0/6	0.00
Lack of Clarity in Presentation Or Mathematical Content	0/6	0.00
Total	0/18	0.00

Note. Lower scores are favorable in this domain

Interview 2: Perceptions of Preparation Pathway's Effect on MQI Scores

I started with some general feedback about her scores. I told her that her scores on the first lesson were strong in explanations and asked her how she learned these skills of explaining. She replied,

> I don't' remember how I was taught it. I just remember my internship because my internship was geometry. So I really absorbed a lot then and took (my cooperating teacher's) lead. This was the first year I didn't use her packets. So I made my own little notebook and did that, but definitely with the whole highlight and just understanding the concept, I would say its more from my internship just how to explain things. But also just understanding math in general, I guess, and trying to think of how to tell kids in the most basic way how to do things (Interview 2).

Next I asked her how she decided to use those same explanatory processes in her own classroom. She said,

> Because I thought that they reached out to other types of learners. For me, I personally wouldn't need to highlight, but for maybe visual people or just trying to make connections, I just stuck with it and it makes it kind of fun. You're not just writing with the same pen the whole time (Interview 2).

Later in the interview she talked more about using highlighters and referenced learning how to do that in her internship. She added,

> So, I pretty much always do it whenever I can. So, basically whatever theory I'm teaching that day or concept, property, whatever, try to color coordinate as best as possible. So with the arcs, I would highlight the angle and maybe even the sides of the angle to try to show that its opening up to this specific are and highlight that arc. So just trying to connect that all of those have a relationship and something's going on there, because there's a lot to look at, especially with circles. It's not just an angle anymore…so definitely learned that from (my cooperating teacher). I don't really remember highlighting in high school or even in college (Interview 2).

She went on to recall an experience from her preparation program related to explanations.

> My geometry class in college was insane…I had to figure out my own thing for that. So, the highlighting…I don't know…I just try to make…I don't want to make it too complicated. Sometimes we get up to three, four colors, but I try to stick to one or two colors and ust whatever the property is saying. If it's opposite angles are equal to 180, I'll highlight the opposite angles the same color and be like, these are the ones that go together (Interview 2).

The next area that I brought up within the sub category for the Richness of the Mathematics scale is called Multiple Procedures or Solution Methods. I reminded Cindy about how she showed the students two different ways to find a missing angle and asked her how she decided which methods she would show her students. She replied,

> That's a hard one because the math nerd in me wants to show them every little trick and the teacher in me is like don't confuse them. So, I try to be as straightforward with them

> as possible. I'm like okay for you guys are little mathematicians out there. You could so this, but if this is going to confuse you, then ignore me right now. Just stick to what you know (Interview 2).

To find out more about her explanations and multiple solution methods. I asked her if she was able to make any connections between the way she did those things in these lessons and the way that she learned to teach or the way that she learned math. She said,

> I would definitely say that it's just from teachers that I've had throughout my whole life, even back to elementary school. I would pay a lot of attention to my gifted math teacher. She was always so excited and had these cute little songs and it would just get me really into it. So maybe I think of her. In college I had this adorable little Asian man progressor and he would get so excited. He'd be like, tell me, tell me, tell me. He would just want us to interact with him (Interview 2).

I asked her to clarify if she was referring to one of the professors from her preparation program. She said, "Yeah. This was elementary number theory, the most mundane, ridiculous math class, but he was so adorable that I was excited to go. Definitely didn't learn how to teach math in college" (Interview 2). The next area that I brought up within the sub category for the Richness of the Mathematics scale is called Mathematical Language. I told her that she scored on the higher end of the MQI in this area because she used a lot of mathematical language as she was teaching both lessons. I reminded her of some of the terms she used and asked her if she had any particular strategies that she used related to mathematical language in terms of her use or her students use. She said,

> I really just try and use the mathematical terms as much as possible instead of saying this thing over here, like actually call it what it is. And hopefully that would translate into

> their lingo. Also just being pretty straight forward with them. Every chapter usually we have basically a vocab lesson where you're teaching them the new parts of different shapes and I'm like you've got to learn these words to know what we're talking about. This is going to be our language…each year I try to think of new ideas, like how can I make them be more accountable for the words…I remember my first year of teaching, Mr. Scott evaluated me and he said I really love how you call everything what it is. You didn't just say this line. You called it a secant. Or if it was a tangent, you called it a tangent. That kind of stuck with me (Interview 2).

I asked her if there were any connections she could make between her preparation program and the mathematical language strategies that she used in these two lessons. She described a particular education course and a group project she did. She answered,

> So we each had our own little part of the unit to present to the class. Then one of my partners said something like this triangle-ish picture and we got so many points taken off because he said ish instead of the specific term. So that definitely had an impact on me. But also it was a good point. You can't just say…slang words or colloquialism or whatever. Just call it what it is and teach them what it is (Interview 2).

We moved on to Errors and Imprecision next. I asked her about a part of the video where she wrote one half right next to a number without using a parenthesis or symbol of any kind and asked her to explain her rationale for writing it that way. She explained,

> Oh yeah. I always tell them fractions are division. That's a thing I say a lot. I do something uses parenthesis. I don't know why I didn't there. I don't know if kids just don't…I mean, obviously they don't have the same experience I had in school but sometimes I'll use parenthesis and they're like Why are you putting those there? I'm like

just to group it, its multiplication. But I probably should have put them because then they might think it's a mixed number (Interview 2).

Next I transitioned the interview questions to focus on the second video about quadratic graphs and equations. I told her that the scores in the Explanations sub category were high on the MQI scale and were similar to those in the first lesson. When I first asked her about the lesson plan she said, "I totally stole that from Teachers Pay Teachers" (Interview 2). Then I asked her more specifically if there were any connections between the way she taught this concept and the way she learned it. She discussed the way she learned it in high school

> Yeah probably connected to how I learned it in high school, because college doesn't really teach…It just dives deeper into math. So I feel like a lot of the math that I learned in college really can't apply to my teaching. I mean, sure, I have a deeper conceptual understanding for everything theoretically, I guess. I guess in high school I was told that its just the opposite…so I remember before I taught this lesson I actually watched a video on why it's the opposite because I just always accepted the fact that it is (Interview 2).

To clarify what she said, I asked if it was correct to say that she doesn't recall ever understanding the why behind writing quadratic equations based on a graph and she said, "Yeah. Because I knew I wanted to be a math teacher so I was like okay learn all the tricks, all the things. So that was a trick that I was taught. It wasn't really like oh its…" (Interview 2). For the final part of the second interview I asked Cindy if she had anything else to add about her teaching methods from her two videotaped lessons in terms of any perceptions about a possible connection to her preparation program. She said,

> The main thing I feel like I learned in college was to always be aware of diversity and that everyone is different. I felt like every education class was like, is it okay to be

> different? Yes. Accept everyone. So even though I probably didn't teach different methods of doing it, because a lot of times it is pretty straight forward…I feel like whenever I go around to each kids I'm definitely just aware that they might not get it as fast or they need you to say it again. Especially if they were listening during the lesson…just being aware that everyone's brain is different, and they don't all work the same. So I definitely took that from college, just being equitable and just making sure that you get it across to everyone (Interview 2).

I asked her if she was referring to learning about different learning styles such as visual, auditory, etc and she replied,

> Yea for sure. That's definitely why I've stuck with the highlighting because like I said for me highlighting doesn't really do anything…but I've stuck with it for those kids that maybe they see the connection like oh all the green things are related and all the pink things add up to 90…definitely just trying to keep in mind that everyone learns differently. I love when we do volume and surface area because then I pass around all the prisms and its very tactile (Interview 2).

Since she mentioned using tactile learning methods in her classroom I asked her if she remembers doing anything similar in her preparation experiences. She answered,

> We had to do teaching math in middle school and teaching math in high school. I'm pretty sure they were two different courses. And those were pretty intense, trying to learn the different methods of teaching. And then there was this other class I took and we learned about all the different education philosophers and what they studies and what they got out of it. So that was interesting like Vygotsky and all that (Interview 2).

I asked her if any of that learning has any impact on what she does in her classroom. She said,

> I mean, I'm definitely not like Oh Vygotsky's method, let's do that today. But just definitely having your eyes opened up to the different ways of thinking, different philosophies on how to learn. That was for sure interesting. I Remember we did a debate and one half of the room was one philosopher and the other half was the other and we would debate on which one was better…If I could go back I would totally read every textbook and try to take in as much as possible (Interview 2).

After her last comment I agreed but said it is hard because you really don't know what teaching is like until you are in a classroom. She said,

> I remember my practicum was really eye opening just because that was my first time in a lower level class because throughout college they had you complete hours. So I dd a few hours in a kindergarten class or a middle school class and I'm like this is pointless, I'm definitely never going to teach these kids. But in my practicum I was in a liberal arts class and I had to do x amount of hours. It was a lot more. It was almost half of an internship. And I was like oh wow this is real life, okay. Because in high school it was all honors and AP for me, so I never really got to see the other half of the world. So that was pretty major (Interview 2).

To clarify, I asked if she thought those practicum experienced helped with her expectations about what she might encounter when she started teaching on her own. She answered, "Oh definitely. I definitely saw students that didn't care to learn, that just didn't care about math. It was very eye opening for sure" (Interview 2).

Summary of Case 2. Cindy is a traditionally certified teacher who attended a traditional four-year preparation and earned a degree in Mathematics Education. She is in her fourth year of teaching and teaching has been her only career. She recalls her internships and practicums as being the most useful part of her preparation program, and also identified the social interaction experiences as helpful throughout her preparation. When asked about missing components of her preparation program, she identified the want for exposure to different types of learners. She also identified some logistical aspects of the job, such as learning how to use word processing systems or district email. Her perception of the most authentic context in which she participated was her college of education classes, and she stated that she thinks they are most like the way she currently teaches her own mathematics classes. On the two videotaped lessons she taught, she scored highest in the following areas of the MQI; Explanations, Mathematical Sense Making, Mathematical Language, which are all subdomains of the Richness of the Mathematics domain. When asked to describe the rationale for some of her teaching decisions in the two videotaped lessons, she recalled making those decisions based on learning she gained from her internship. She also identified several specific instances of learning from some of her preparation program coursework. She also credited her program with helping her become aware of the need to address diverse learning styles to accommodate all students' ways of learning.

Case 3: Jessica

Jessica is in her 4th full year of teaching. She started teaching in February of 2016 at another high school in the district. During the 2019-2020 school year she taught Algebra 1 and Geometry at Sunshine High School. She earned a bachelor's degree in mathematics with a minor in computer science and a masters degree in Business administration with an emphasis on information systems. She earned both of these degrees at a traditional four-year university. She earned her teaching certification by completing the district's Alternative Certification program at the beginning of her teaching career. Before becoming a teacher, Jessica was a software engineer for 15 years. She managed a software development group with Verizon. When I asked her why she decided to make a career change and become a teacher she answered:

> I had become more of a manager director and I was more doing budgeting and layoffs. I was like this is horrible. I had to lay off like 60 people the week of Thanksgiving and I was like I can't do this. I really can't. I'm going to lay off like 59 people and I'm out the door. Then I took a break and said I was just going to have the holidays with my family and then I said okay, what did you want to do when you were little? You wanted to be a teacher. Let's see what that does. And when you call up (the county) and say hey how do you be a teacher, they get you in the classroom really fast. So, I was a teacher like by February, which was crazy. I started ACP in the fall (Interview 1).

Description of Preparation Program. In the fall of her first full year of teaching, Jessica enrolled in the district's Alternative Certification Program (ACP). "The (ACP) philosophy is based on a deep commitment to student achievement by providing high-quality professional development for teachers through a quality competency-based program. The goal of ACP is to train non-education majors in pedagogy so they can make a positive impact on student achievement and provide quality educational opportunities for children. To qualify for ACP, teachers must hold a bachelor's degree and meet the state requirements that allow them to apply for a professional teaching certificate upon completion of the program. The ACP Program is comprised of three parts:

1. Demonstration of the Pre-professional Benchmark Level of the Florida Educator Accomplished Practices (FEAPs).
2. Teaching experience under the supervision of a trained ACP support team.

3. Professional development components designed to provide participants with quality training opportunities while demonstrating mastery of the FEAPs.

Teachers enrolled in the ACP program have three years to complete the requirements which include submission of a portfolio containing 11 artifacts demonstrating knowledge of the FEAPS. These artifacts must be accompanied by written verification from the ACP support team of successful comprehensive competency demonstration. In addition, the portfolio must include written verification of successful completion of teaching experience to include pre-planning, post-planning and a minimum of 180 days of teaching under the supervision of the ACP support team as evidenced by the principal's signature. Verification of successful completion of required professional development components by course instructors are also required for teachers to successfully complete the program. ACP instructor approval of electronic portfolio activities demonstrating mastery of the FEAPs is also required. Finally, ACP teachers must submit of a passing score on the appropriate Subject Area Exam (SAE), General Knowledge Test (GKT) and Professional Educator Test (PET) to the ACP office. All of these requirements must be completed by the end of the ACP teachers third year of teaching, upon which they qualify to earn a permanent teaching certificate for the state of Florida. Below is a chart showing the eight courses teachers in the ACP program must complete. The courses are not subject specific and are offered after school, on the weekends, and in the summer. The total amount of hours combined for the courses is 189. The table below shows the courses required in the county's Alternative Certification Program.

Table 20
County Alternative Certification Program Coursework

Content Courses	Pedagogy Courses	Field Experience
	Thinking Maps Teacher Induction Transition into Teaching Effective Teaching Strategies Effective Classroom Management Integrating Technology into Education Reading to Learn Educating Students with Disabilities	

Interview 1 – Part 1: Preparation Program Perceptions

The first interview was separated into two parts. During the first part I asked participants general questions about their preparation pathway experiences.

Overall Perceptions. I asked Jessica to give me a rough timeline of her preparation program including her overall perceptions. She discussed completing the program quickly based on her personal life circumstances and had some positive perceptions of her experiences. She said,

> So I did (the program) in about a year and a half. I started in September and then I was done by…it's a two-year program but I ended up doing it in a year and a half. And I had kind of expedited because I got pregnant. So in the midst of me starting out as a teacher I surprise got pregnant. That kind of made my scheduling off a bit. But I took the majority of my classes at the ISC and they were in the evenings after school. I had a lot of good instructors. My instruction that did the classroom management class was especially good. I remember him quite a bit. I think the technology class felt a bit weak, but I come from a technology background so…(Interview 1).

Perceived Strengths of Preparation Program. I asked Jessica if there were any parts of the ACP program that she perceives as particularly helpful to her as a teacher. She said,

> The classroom management class was actually quite good because I didn't know anything about how to manage 30 teenagers. It helped me realize that you couldn't just expect them to be grown up and to act reasonable. You had to put limits and controls around them, and how to do that from day one and not give them a lot of slack really. That was very useful to me. All in all it was a good program. It definitely helped me because I had no education background other than I had been a student many times (Interview 1),

Perceived Weaknesses of Preparation Program. Next I asked her to reflect on her first couple years of teaching and identify any potential missing aspects from the ACP program that she thinks would have helped her as a teacher. She said,

> Some of the classes felt a little bit repetitive…It would have been nice to have something that was more discipline-tailored, so like more that was specific to a math teacher. There was a reading strategies class that I had to take, but there was no math strategies class (Interview 1).

Perceived Missing Areas of Preparation Program. When I asked Jessica if there were any parts of her preparation program that she perceived as missing, she reiterated the need for more math-specific coursework, as she mentioned above.

> It would have been nice if there was a way to have some sort of like elective component to ACP that said okay if you're teaching English or social sciences, take this class. If you're teaching math or science, take this class. Because there's different strategies on how to present math and formulas and processes that I've picked up along the way, but it would be been nice to have that actually in the class (Interview 1).

Factors Influencing Choice of Preparation Program. I asked Jessica about the factors that influenced her decision to join the ACP program once she began teaching. She named several factors:

> So it was cheap. I mean I don't think I paid very much for it at all. It was convenient and that it was at the ISC (Instructional Services Center) and so all the classes were tailored to fit around a teacher's schedule. And it was quick. I did get it done fairly quickly. So, kind of checked all the boxes (Interview 1).

Interview 1 – Part 2: Preparation Program Experiences and Situated Learning Theory

Perceived Portion of Preparation Experiences in an Authentic Context. I asked Jessica about the extent to which her preparation program experiences did or did not take place in an authentic context. She said,

> My ACP classes were in a classroom environment, but it was all professionals working together, going over material and learning it. There wasn't really any hands-on component to being in a classroom. We were in a classroom, they gave us lots of examples. We did a lot of role-playing (Interview 1).

She went on to discuss some experiences she had during her first year of teaching while in the preparation program.

> I had a TTD (teacher talent developer) at my school. I shadowed a couple of her classes and she shadowed my class a few times in the beginning and that really helped. So having more of an observation and shadowing program I think would be useful (Interview 1).

I asked her to describe the ways in which her preparation experiences were similar or not similar to those she provides for her students currently. She remembered learning getting the information in her preparation program all at the beginning and then going through it in more detail in small chunks. She said she does not do that with her students because it would overwhelm them. She described what she thinks is more successful with her students, which is teaching them a concept and then giving them some time to practice. She described,

> I really hesitate on giving students packets. I kind of feel like it shuts them down a bit. A lot of it depended on us doing reading outside of class and coming to the course prepared to discuss it. I have a lot of trouble doing that with high school kids. So I try to give them a little bit of homework. I strongly feel that whole memory curve and they need to practice just a little bit. But I can't really expect them to process things overnight and come back ready (Interview 1).

Next I asked Jessica about her instructors in the ACP program and whether they created experiences similar to those she might encounter in her own classroom. She said,

> There was one where we had to act like goofball kids. Like how are you going to react in this situation? The teacher tells you to do this, how are you going to react? What are you going to do, what are some expected things, and then how would you deal with them? (Interview 1).

After she described those experiences in her preparation coursework I asked her if she perceived those experiences to be helpful or not. She answered, "They were because within our groups we were able to see what some of the other teachers have come up against and then help them sort of debug how you could deal with that in the future" (Interview 1).

Perceptions of Social Interaction in Preparation Program. Her thoughts about her preparation experiences in an authentic context led well into the next question about social interaction, since she had already described several instances related to social interaction. I asked Jessica about the role of social interaction in her preparation program and experiences. She described social interaction as one of the most memorable parts of the program because of the ability to connect with others experiencing the same types of situations. She said,

> I think that was actually some of the highlight of it, was interacting with others. Teachers that were in my same situation and maybe having my same struggles. And not just commiserating but helping each other and using the instructors also to figure out how we can do things better or solve problems (Interview 1).

She went on to discuss social interactions in terms of group assignments. She said,

> We would do jigsaws to make it through an article and read all the material, and that sort of thing. We did a lot of gallery walks and things like that…I think every single class we were in groups and we were interacting with each other. We were doing group work and jigsaws and all sorts of…the different group interactive roles. We were definitely working with each other all the time (Interview 1).

Perceptions of the Constructivist Learning Approach in Preparation Program. In the final part of the interview I asked Jessica to describe any experiences within her preparation program in which she constructed her own learning of a topic or idea. She recalled,

> We did some lesson planning and I had different rubrics that we learned to use for lesson planning, like the one that has the map and all the grids, and then other ones that were for differentiating and fitting in ESL supports and things like that (Interview 1).

I rephrased the question and asked her if there were any experiences, she could remember in which she was coming up with her own ideas, rather than following specific directions. She said,

> Yeah, we definitely did a lot of brainstorming on things. Or like those gallery walk things where we would post things around the room and everybody would go piece by piece and write their own ideas. Then we would all share what our ideas were. That was definitely a big part of it in pretty much all the classes. I can't think of any of them where it was all just spoonfed…it was interactive, it was pretty good (Interview 1).

Next I asked Jessica to what extent, if any, her preparation program experiences linked to prior information she gained. She mentioned that none of her peers in the program had teaching experience, but they relied on the experiences they had each day with their own students as well as those they can remember from being students themselves. She said,

> We did a lot of discussion around issues we would be having or problems we needed to have addressed. But I remember the instructors made it very well we can modify this and talk about your problem right now, today if we need to, as opposed to just like going through the text. None of us really had any past education experiences to pull from, other than when we were in class and when we were students ourselves (Interview 1).

Lastly, I asked Jessica if she remembered any experiences in her preparation program in which she was asked to reflect. She recalled an experience using a journal to reflect.

> I had to keep a journal for one of them. There was one where I had to keep a journal of questioning. We were talking about questioning strategies. That's one of my weakest things is questioning in class. Other than, how'd you get to your answer. Especially in math, its hard to get to that level where you're asking them good questions. Do we had to keep a journal of what questioning strategies we used, how we could've done better, that sort of thing. That was a good reflection I did (Interview 1).

I asked her if any of those experiences with reflection in her preparation program translated to her current teaching practice. She said, "Especially around questioning…I'm constantly thinking about how I could have done better with asking questions and…or getting the students to ask me questions. That's my biggest struggle honestly" (Interview 1).

Perceptions of Opportunities for Reflection in Preparation Program. Finally, I asked Jessica about her perception of the opportunities provided in her preparation program for reflection. She recalled a specific aspect of one of her classes in which she had to keep a journal. She said,

> I had to keep a journal for one of them. There was one where I had to keep a journal of questioning. We were talking about questioning strategies…so we had to keep a journal of what questioning strategies we used, ho we could've done better, that sort of thing. That was a good reflection I did (Interview 1).

Videotaped Lesson 1: Intersecting Chords, Secants, and Tangents (Geometry)

Overview of the Lesson. The topic of this lesson is intersecting chords, secants, and tangents. The objective is, "Students will be able to identify congruent chords and arcs and solve equations to find their values." Jessica taught this lesson in her 4th period Geometry class. This class consists of a total of 28 students in 9th, 10th, 11th, and 12th grades.

This lesson addresses the following standard:

- MAFS.912.G-C.1.2 Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.

Table 21

MQI Ratings for Richness of the Mathematics in Lesson 1 (Jessica)

Lesson Title: Intersecting Chords, Secants, and Tangents (Geometry)		
Category	Video Segment	Rating
Linking Between Representations	S1	NP
	S2	NP
	S3	NP
	S4	NP
Explanations	S1	L
	S2	M
	S3	M
	S4	L
Mathematical Sense Making	S1	L
	S2	M
	S3	M
	S4	L
Multiple Procedures Or Solution Methods	S1	NP
	S2	NP
	S3	L
	S4	NP
Patterns and Generalizations	S1	NP
	S2	NP
	S3	NP
	S4	NP
Mathematical Language	S1	H
	S2	M
	S3	M
	S4	L

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 22

Total Scores for Richness of the Mathematics in Lesson 1 (Jessica)

Category	Total Points Earned	Decimal
Linking Between Representations	0/12	0.00
Explanations	6/12	0.50
Mathematical Sense Making	6/12	0.50
Multiple Procedures or Solution Methods	1/12	0.08
Patterns and Generalizations	0/12	0.00
Mathematical Language	8/12	0.67
Total	21/72	0.29

Note. Higher scores are favorable in this domain

Table 23

MQI Ratings for Errors and Imprecision in Lesson 1 (Jessica)

Category	Video Segment	Rating
Mathematical	S1	L
Content Errors	S2	NP
	S3	NP
	S4	NP
Imprecision in	S1	L
Language or Notation	S2	L
	S3	L
	S3	L
Lack of Clarity in	S1	NP
Presentation of	S2	NP
Mathematical Content	S3	NP
	S4	NP

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 24

Total Scores for Errors and Imprecision in Lesson 2 (Jessica)

Category	Total Points Earned	Decimal
Mathematical Content Errors	1/12	0.08
Imprecision in Language or Notation	4/12	0.33
Lack of Clarity in Presentation Or Mathematical Content	0/12	0.00
Total	5/12	0.41

Note. Lower scores are favorable in this domain

Videotaped Lesson 2: Writing and Graphing Equations of Circles (Geometry)

Overview of the Lesson. The topic of this lesson is writing and graphing equations of circles. The objective is, "Students will be able to write the equation of a circle given a graph and graph a circle given its equation." This lesson addresses the following standard:

- MAFS.912.G.6.6 Given the center and the radius, find the equation of a circle in the coordinate plane or given the equation of a circle in center-radius form, state the center and the radius of the circle.

This lesson was recorded using Zoom during the last nine weeks of school when students and teachers participated in e-learning from home due to COVID-19. Jessica held live zoom lessons each week and recorded and posted them for students to watch later if they were unable to attend the live zoom. This lesson was recorded for her Geometry students to watch before completing the assignments that were associated with the video.

Table 25
MQI Ratings for Richness of the Mathematics in Lesson 2 (Jessica)

Writing and Graphing Equations of Circles (Geometry)		
Category	Video Segment	Rating
Linking Between Representations	S1	NP
	S2	L
Explanations	S1	M
	S2	M
Mathematical Sense Making	S1	M
	S2	M
Multiple Procedures Or Solution Methods	S1	NP
	S2	NP
Patterns and Generalizations	S1	NP
	S2	NP
Mathematical Language	S1	M
	S2	M

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 26
Total Scores for Richness of the Mathematics in Lesson 2 (Jessica)

Category	Total Points Earned	Decimal
Linking Between Representations	1/6	0.17
Explanations	4/6	0.67
Mathematical Sense Making	4/6	0.67
Multiple Procedures or Solution Methods	0/6	0.00
Patterns and Generalizations	0/6	0.00
Mathematical Language	4/6	0.67
Total	13/36	0.36

Note. Higher scores are favorable in this domain

Table 27
MQI Ratings for Errors and Imprecision in Lesson 2 (Jessica)

Category	Video Segment	Rating	]
Mathematical Content Errors	S1	NP	
	S2	NP	
Imprecision in Language or Notation	S1	L	
	S2	L	
Lack of Clarity in Presentation of Mathematical Content	S1	NP	
	S2	NP	

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 28

Total Score for Errors and Imprecision in Lesson 2 (Jessica)

Category	Total Points Earned	Decimal
Mathematical Content Errors	0/6	0.00
Imprecision in Language or Notation	2/6	0.33
Lack of Clarity in Presentation Or Mathematical Content	0/6	0.00
Total	2/18	0.11

Note. Lower scores are favorable in this domain

Interview 2: Perceptions of Preparation Pathway's Effect on MQI Scores

I started with some general feedback about Jessica's scores. I told her that her scores in the explanations subcategory in the Richness of the Mathematics Domain were a mix of low and mid. I reminded her of some of the explanations that she gave during the first lesson and asked her if she had a rationale for those explanations. She replied,

> That was sort of tying back to lessons we had previously done, to try to make breaking down…and some of those circle diagrams, they just don't even know where to start…so you have to kind of make them remember what they already know (Interview 2).

Next I asked if she made any connections to other mathematics in the first lesson. She replied,

> Yeah, we hit that a lot in the circles unit where I tried to make them go back to what we knew from studying angles back in September and October where we did linear pairs and vertical angles and saying look guys, you've got a circle, but you actually already know how to do a lot of this, right? Break the diagram down, look at what you know (Interview 2).

I asked her next if the way she taught the first circles lesson to her class was consistent with the way she learned the concept. She said,

> No, I have no memory. I took geometry, this level of geometry…I remember my geometry teachers, but it was seventh grade. So I don't remember…I can picture the

classroom but I can't recall how it was taught to me. I remember doing a lot more proofs than we do now. I remember that seventh grade geometry, we did prove something…I don't think this is how I learned it. I think I learned it more, here are facts, here are relationships, write a proof (Interview 2).

Then I asked her about the multiple procedures or solution methods sub category within the Richness of the Mathematics domain of the MQI. I reminded her of one instance where she showed students two methods to solve for a missing arc length by either subtracting from 360 degrees or using the equation she previously showed them. I asked her to talk more about the reasoning behind her decision to show multiple solution methods. She explained,

> Some of them don't see the semicircles and some of them just immediately see the semicircles so that's kind of…You can always go back to 360. But if you see the semicircle, use it. The other thing I often do is because they hate fractions, a lot of the multiplying by two, versus dividing by two when you set up your equations I usually try to show them both ways that way. (Interview 2).

This description helped me understand her rationale behind showing the students multiple ways to set up or solve a problem, and showed that she used the knowledge of her students to guide her instructional decisions. Next I asked Jessica if there were any connections she could make between her preparation program and the way she explained the concepts in the lessons. She was able to make a connection between what she learned in her program about different types of learners, and the importance of awareness of how students learn. She said,

> I'm always trying to be aware that people are coming at you from different levels and with different ways of learning. And so in ACP, there was a lot of discussion about people who are visual learners versus auditory learners versus oral learners. So I try to

> respect that and how they might be processing the information I'm giving. Many students just blindly transcribe what you write and then they need time to go back and look at it and process it. So I do try and incorporate that time into the lesson (Interview 2).

I asked her to explain more about her rationale behind the highlighting strategy that she used during both lessons. She said,

> That's actually…because that's not something I really ever did until I was a teacher, was that sort of highlighting of things and color coding. That's not something I personally need to do so it is something I've kind of learned to do for the kids (Interview 2).

The next area that I brought up within the sub category for the Richness of the Mathematics scale is called Mathematical Language. I told her that she scored on the higher end of the MQI in this area because she used a lot of mathematical language as she was teaching both lessons. I reminded her of some of the terms she used and asked her if she had any particular strategies that she uses related to mathematical language in terms of her use or her students use. She said,

> I do try not to dumb it down…I do a lot of Kagan activities in class. I know I didn't that day, but I do Kagan activities where I make them do sage and scribe and that sort of thing where they have to speak to each other and the other one writes it and then switch roles. Do a lot of vocab in their notebooks where they have to write down sentences, like write your answer using proper vocab, that sort of thing (Interview 2).

I asked Jessica to elaborate upon how she learned those strategies that she uses to explain concepts to her class. She said,

> So I did a Kagan training. (The school) was an achievement school when I was there and I took the Kagan five day cooperative learning training. (My department head) was all

> about Kagan. So from day one, she was helping me kind of try to find ways to get my classroom engaging and then she's the one who sent me to Kagan, which is great. So yeah, we do a lot of sage and scribe a lot…because getting them to talk it, to actually use the words, not just hear me using them (Interview 2).

I asked her if there were any connections between the strategies she described and what she learned in her preparation program. Again, she referenced the Kagan models and made a connection between them and one of her preparation classes. She said,

> Well the actual activities are Kagan models but I did do a reading to learn class with ACP and I remember in the reading to learn class it talked about how students process new vocab and how they have to use it in order to maintain it. So, I do remember that being a focus in that class (Interview 2).

Next I asked her a question based on the Errors and Imprecision domain of the MQI. I pointed out some of the small imprecisions in her lessons and asked her if she was aware of them as she was teaching. She said,

> Absolutely. Big arc minus little arc divided by two instead of one half of the major arc minus the minor arc..yes…I mean, that kind of stuff its kind of coming up with catchy little things that they might remember. So big arc minus little arc divided by two, yeah that's definitely imprecise, but if they remember it in the midst of all of those formulas in circles… (Interview 2).

Next I focused my questions on the second lesson, which Jessica delivered via zoom about writing the equations of and graphing circles. Specifically, I asked her about the first subcategory of the Richness of the Mathematics domain, linking between representations. I asked Jessica to describe why she used the representations she did to connect the equations to the graphs. She described another lesson she previously taught and made a connection from that lesson about lines to this lesson about circles. She emphasized that she broke it down into steps the way she saw that done on a computer program she used in the past. She said,

> At the beginning of it I tied it to a line. I started by saying hey here's the equation of a line and what information do we get from this question and how would we graph it. Well guess what? We can also do this with circles too. So, I tried to start off with something that they knew and that is something that we had practiced weekly…I had been using the (computer program), and they broke it down into such easy steps where they had four skills on this…So I was trying to make it so that it would be easy enough for them to walk through those skills and just master this and do well with it (Interview 2).

For the final part of the second interview I asked Jessica if she had anything else to add about her teaching methods from her two videotaped lessons in terms of any perceptions about a possible connection to her preparation program. She said,

> I mean, it was like a few years ago now…so I think it's more just the broad strokes of recognizing the different types of learners and using the vocab, having high expectations, now lowering your bar and giving them the opportunity to sort of rise up to it (Interview 2. KC).

Summary of Case 3. Jessica is an alternatively certified teacher who earned her certification through the district's ACP (alternative certification program). She is in her fourth year of teaching and teaching is her second career. Prior to teaching she was a software engineer. She recalls the classroom management course as the most useful part of her preparation program, and also identified the social interaction experiences as helpful throughout her preparation. When asked about missing components of her preparation program, she identified the want for more mathematics-specific experiences within the coursework. On the two videotaped lessons she taught, she scored highest in the following areas of the MQI; Explanations, Mathematical Sense Making, Mathematical Language, which are all subdomains of the Richness of the Mathematics domain. When asked to describe the rationale for some of her teaching decisions in the two videotaped lessons, she recalled several specific instances of learning from some of her preparation program coursework, such as the need to teach in a variety of ways to accommodate for student's different styles of learning. She also made references to colleagues from whom she learned, as well as references to her own learning experiences as a student.

Case 4: Stephanie

Stephanie is in her 4th year of teaching. During the 2019-2020 school year she taught Geometry and Math for College Readiness. She earned a bachelors degree in sociology with a minor in nursing at a traditional four-year University. She earned her teaching certification by completing and alternative certification program offered by the district, called the PATH program, at the beginning of her teaching career. Before becoming a teacher, Stephanie worked in corporate American and in a school in a secretarial position.

Description of Preparation Program. The Program to Attract and Train High (PATH) quality exceptional teachers for students with disabilities provides non-education majors with a bachelors degree an opportunity to become teachers. Before they can start teaching, applicants must take five pre-service courses that are each approximately 20 hours, pass the subject area exam, exceptional student education certification test, and all subsections of the General Knowledge Mathematics test. They are also required to shadow in a school and screen before a district committee. Upon completion of the program, participants would be hired in a high needs school and begin teaching. Project PATH was a grant funded program that no longer exists in the district. As part of the grant, participants received a scholarship in the amount of $2,250 to cover the cost of the ACP program. Another inventive of $680 was given to participants to reimburse them for passing each state certification exam upon them reporting a passing score. The chart below shows the pre-service courses required in the PATH program.

Table 29
Path Program Coursework

Content Courses	**Pedagogy Courses**	**Field Experience**
	Basic Teaching Pedagogy Classroom Management Resume Skills Disability Awareness	Shadowing Teachers at a School Site

Once participants complete the PATH program requirements and they are hired at an approved school site, they are enrolled in the Alternative Certification Program (ACP) where they continue to take courses while teaching.

The ACP Program is comprised of three parts:

1. Demonstration of the Pre-professional Benchmark Level of the Florida Educator Accomplished Practices (FEAPs).
2. Teaching experience under the supervision of a trained ACP support team.
3. Professional development components designed to provide participants with quality training opportunities while demonstrating mastery of the FEAPs.

Teachers enrolled in the ACP program who first went through the PATH program have one year to complete the requirements which include submission of a portfolio containing 11 artifacts demonstrating knowledge of the FEAPS. These artifacts must be accompanied by written verification from the ACP support team of successful comprehensive competency demonstration. In addition, the portfolio must include written verification of successful completion of teaching experience to include pre-planning, post-planning and a minimum of 180 days of teaching under the supervision of the ACP support team as evidenced by the principal's signature. Verification of successful completion of required professional development components by course instructors are also required for teachers to successfully complete the program. ACP instructor approval of electronic portfolio activities demonstrating mastery of the FEAPs is also required.

Table 30
County Alternative Certification Program Coursework

Content Courses	**Pedagogy Courses**	**Field Experience**
	Thinking Maps Teacher Induction Transition into Teaching Effective Teaching Strategies Effective Classroom Management Integrating Technology into Education Reading to Learn Educating Students with Disabilities	

Interview 1 – Part 1: Preparation Program Perceptions

The first interview was separated into two parts. During the first part I asked participants general questions about their preparation pathway experiences.

Overall Perceptions. Overall, Stephanie's perceptions of her preparation program were positive. She credits the program with her success and decision to remain a current inservice teacher at Sunshine High School. She briefly discussed the positive experiences with the training and mentoring in the program, as well as the support system at the school and from the program. She said, “I just feel like I had such a great support system. They’ve been there to pick you up…(the trainers) were amazing. They were so good. I can’t think of one that wasn’t beneficial or didn’t help me in some way” (Interview 1).

Perceived Strengths of Preparation Program. I asked Stephanie to describe any aspects from her preparation program that she thought were particularly helpful. She discussed resources and mentoring.

> I mean I think I got more information than I could possibly ever utilize as far as every section we went through, we were getting more texts and things like that. Not just notes that we were doing for the course itself, but they would give us like a book…Like you’re first year in the classroom, and all these different self-help and teacher help books to teach you different strategies. Resources. They would give you these resources. So I have an entire library of stuff that I got. It was great having all those resources given to us (Interview 1).

I asked her if there was anything else from her preparation experiences that stood to her as being helpful to her when she started teaching and she recalled experiences working with mentors.

> I would say the mentors that we had on campus they were the ones that we would meet with or they would come and do observations. They were very good at fiving constructive criticism without making you feel like you were being judged. And they wouldn’t just say, Okay you could have done this better. They would say this is what I would do or maybe try this. They would give you examples. Because Im a type of person, it’s like show me what that looks like. You can talk in all these acronyms and al

these things but it's like what does that look like in the classroom. And they were very helpful with that (Interview 1).

Perceived Weaknesses of Preparation Program. I next asked Stephanie to describe any perceived areas of weakness within her preparation program. She recalled thinking there were not many instructor or coursework specific to mathematics. She said,

> None of the instructors that I had did high school math…and so a lot of times it was difficult for me to try and translate what they were wanting you to do. And if they were teaching a certain strategy…They were always talking about reading strategies and not that there's not any reading in math, but they were talking so much about the language and reading and especially when we were learning about ELL students and how to work with them. I was like, ok how does this work in math? So that was kind of hard. I didn't have a lot of math background people (Interview 1).

During the second interview Stephanie brought up the perceived weakness of her preparation program again in relation to the lack of specificity in math. She said, "It was frustrating during training because of the emphasis on language arts. I would always wonder how do I translate this to math" (Interview 2).

Perceived Missing Areas of Preparation Program. Next I asked Stephanie to reflect back upon her first few years of teaching and describe any areas that may have been missing from her program. When I asked if there were any aspects of the program that she thought may have been missing she couldn't think of any. She said, "I really don't. As far as the environment, I was very at ease and used to that" (Interview 1).

Factors Influencing Choice of Preparation Program. I asked her what factors influenced her to join the PATH program and become a teacher. She answered;

> Just because I'm later in life and just commuting to school and having to do that, like trying to figure out hours that would work for me. I had kids of my own at the time there were, one was still in high school, one was in college, and one was about to go to college. So it was just the way they presented it was like they were intentionally trying, they were recruiting people because there was such a shortage of ESE teachers. And I think they did everything they could to make it as accessible and easy for you to complete the coursework. And they put that carrot out there that okay you don't have to pay for any of this unless you leave the program. Then you have to reimburse us however much money it was. And it was not a small chunk of change. It was like a few thousand dollars or a couple thousand dollars (Interview 1).

Interview 1 – Part 2: Preparation Program Experiences and Situated Learning Theory

Perceived Portion of Preparation Experiences in an Authentic Context. Next, I asked Stephanie to describe any experiences within her preparation program that took place in an authentic context where the instructors set up experiences similar to those she would use with her own students. She discussed the connections that the instructors made to their own experiences and some of the assignments. She said,

> I think the instructors were very open about sharing their experiences, their good and their bad days and what had happened in their classroom. We had a lot of, it wasn't just doing reading and worksheets and things like that I mean, we had videos, training videos. We also were expected to like I said shadow. You had to do at least two days of shadowing, but you could do as much as you wanted to (Interview 1).

Perceptions of Social Interaction in Preparation Program. I asked Stephanie about the role that social interaction played throughout her experiences in the PATH program. She described her interactions with her peers in the program as positive and helpful in her preparation. She described the social interaction experiences as an extra resource and even said she still keeps in touch with some of her peers, which indicated the role of social interaction in her preparation program had a positive impact on her experience. She said,

> We were in our cohort so you always had the same group of people. We would share what we had gone through that week or we'd even say I had this happen, did you every have this happen? What did you do? How did you handle it? It was nice to get another opinion like what did your administration tell you to do or how did…it was just, it was really good. It was another extra resource. We could keep in touch during the week, even when we weren't in training together, and I still keep in touch with a couple of them. So it was nice (Interview 1).

She went on to describe some specific experiences of sharing information with her peers in the PATH program;

> I had such a good support system here at (school). My ESE specialist is so good. Some of them, they weren't grasping it, I don't even know how to do x, y, z. And I was like didn't your ESE specialist show this to you? And they're like no. So we would help each other wherever there seemed to be holes or to see what each person needed. But it was nice. It was great networking (Interview 1).

Next I asked her if the instructors provided any specific opportunities for participants in the ACP program to interact with their peers, related to assignments or activities. She said,

> Yea we often had activities built into the training where you had to…I mean when we were learning different strategies, like think pair shares and things like that, we would do it on each other or they would send us off into groups and we had to work as a team and

things like that. So kind of showing you a little bit how you would work with PLC's and that kind of thing (Interview 1).

Perceptions of the Constructivist Learning Approach in Preparation Program. I asked Stephanie about the constructivist learning approach and specifically if there were any experiences in her preparation program where she constructed her own learning of an idea or topic. She relied,

> I mean, again, that goes back to a lot of the strategies seemed to be surrounding reading and language. So I would have to tweak things to make it work for math. And when they were teaching us things like tiered worksheets or whatever it was, or graphic organizers, so much of the training seemed to be surrounding reading and language and you just had to modify it in such a way that it would fir or work in a math problem setting (Interview 1).

Perceptions of Opportunities for Reflection in Preparation Program. Finally, I asked Stephanie about the opportunities, if any, that her preparation program provided to reflect upon learning or experiences within the program.

> Oh constantly. Constantly. They would emphasize how reflection is what you should be doing constantly to think back, did that lesson go well? If it did, why? If it didn't, why? And what would you maybe do different or not do different? And I mean, I do that every period it seems like. But no, they emphasize that a lot. And at the end of every course, its just like any other training course we take. You do the evaluation thing and it asks you to do that reflection (Interview 1).

Videotaped Lesson 1: Congruent Chords and Arcs (Geometry)

Overview of the Lesson. The topic of this lesson is congruent chords and arcs. The objective is, “Students will be able to identify congruent chords and arcs and solve equations to find their values.” Stephanie taught this lesson in her 6th period Geometry class. This class consists of a total of 12 students in 10^{th} and 11^{th} grades.

This lesson addresses the following standard:

- MAFS.912.G-C.1.2 Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.

Table 31

MQI Ratings for Richness of the Mathematics in Lesson 1 (Stephanie)

Lesson Title: Congruent Chords and Arcs (Geometry)		
Category	Video Segment	Rating
Linking Between Representations	S1	L
	S2	NP
Explanations	S1	M
	S2	M
Mathematical Sense Making	S1	M
	S2	M
Multiple Procedures Or Solution Methods	S1	NP
	S2	NP
Patterns and Generalizations	S1	NP
	S2	NP
Mathematical Language	S1	M
	S2	M

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 32

Total Scores for Richness of the Mathematics in Lesson 1 (Stephanie)

Category	Total Points Earned	Decimal
Linking Between Representations	1/6	0.17
Explanations	4/6	0.67
Mathematical Sense Making	4/6	0.67
Multiple Procedures or Solution Methods	0/6	0.00
Patterns and Generalizations	0/6	0.00
Mathematical Language	4/6	0.67
Total	13/36	0.36

Note. Higher scores are favorable in this domain

Table 33

MQI Ratings for Errors and Imprecision in Lesson 1 (Stephanie)

Category	Video Segment	Rating
Mathematical Content Errors	S1	NP
	S2	NP
Imprecision in Language or Notation	S1	L
	S2	L
Lack of Clarity in Presentation of Mathematical Content	S1	NP
	S2	NP

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 34

Total Scores for Errors and Imprecision for Lesson 1 (Stephanie)

Category	Total Points Earned	Decimal
Mathematical Content Errors	0/6	0.00
Imprecision in Language or Notation	2/6	0.33
Lack of Clarity in Presentation Or Mathematical Content	0/6	0.00
Total	2/18	0.11

Note. Lower scores are favorable in this domain

Videotaped Lesson 2: Cube Roots (Math for College Readiness)

Overview of the Lesson. The topic of this lesson is cube roots. The objective is, "Students will be able to simplify cube roots." Stephanie taught this lesson in her 4th period MCR class.

This class consists of a total of 12 students in 10th, 11th, and 12th grades. The lesson addresses the following standard:

- MAFS.912.A-SSE.2.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

Table 35

MQI Ratings for Richness of the Mathematics in Lesson 2 (Stephanie)

Lesson Title: Cube Roots (Math for College Readiness)		
Category	Video Segment	Rating
Linking Between Representations	S1	L
	S2	NP
	S3	NP
	S4	NP
Explanations	S1	M
	S2	M
	S3	L
	S4	L
Mathematical Sense Making	S1	H
	S2	L
	S3	M
	S4	M
Multiple Procedures Or Solution Methods	S1	H
	S2	L
	S3	M
	S4	M
Patterns and Generalizations	S1	NP
	S2	NP
	S3	NP
	S4	NP
Mathematical Language	S1	M
	S2	M
	S3	M
	S4	M

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 36

Total Scores for Richness of the Mathematics in Lesson 2 (Stephanie)

Category	Total Points Earned	Decimal
Linking Between Representations	1/12	0.08
Explanations	8/12	0.67
Mathematical Sense Making	8/12	0.67
Multiple Procedures or Solution Methods	0/12	0.00
Patterns and Generalizations	1/12	0.08
Mathematical Language	8/12	0.67
Total	26/72	0.36

Note. Higher scores are favorable in this domain

Table 37

MQI Ratings for Errors and Imprecision in Lesson 2 (Stephanie)

Category	Video Segment	Rating
Mathematical Content Errors	S1	NP
	S2	NP
	S3	NP
	S4	NP
Imprecision in Language or Notation	S1	NP
	S2	NP
	S3	NP
	S4	NP
Lack of Clarity in Presentation of Mathematical Content	S1	NP
	S2	NP
	S3	NP
	S4	NP

Using a Likert scale equivalent (Not present = 0, Low = 1, Mid = 2, High = 3), each category was assigned a total score in the table below. I then converted the total points earned in each category to a decimal.

Table 38

Total Scores for Errors and Imprecision in Lesson 2 (Stephanie)

Category	Total Points Earned	Decimal
Mathematical Content Errors	0/12	0.00
Imprecision in Language or Notation	0/12	0.00
Lack of Clarity in Presentation Or Mathematical Content	0/12	0.00
Total	0/36	0.00

Note. Lower scores are favorable in this domain

Interview 2 Part 2: Perceptions of Preparation Pathway's Effect on MQI Scores

I started with the first subcategory within Richness of the Mathematics, Linking Between Representations. I reminded Stephanie that in lesson 1 she used a ruler to show her students how two chords within a circle could be of equal lengths. I asked her how she chose to use that representation and what made her show that representation. She answered,

> I had seen it used before. I believe it was in a video that I had watched. I don't think it was during any of the trainings. I think it was just I was looking for ways to teach the concept. It probably was when I was first doing geometry. And certain concepts, they come easy to me, but I was trying to, based on how I knew they struggles on certain things and how they needed to have different ways to have the lightbulb go off. A lot of times I'll just go online. If I think that's something that really would benefit a lot of my kids, I try using it to see if it works. So it was probably something I found in my first or second year (Interview 2).

Next I informed Stephanie that her scores in the Explanations subcategory were high and asked her if the way that she explained the content was consistent with the way she learned it. She had a hard time recalling specifically, but did discuss her math teachers from high school. She mentioned the importance of her former teachers demonstrating information rather than just telling. She also talked about the lasting impact her teachers had on her because of the way they explained concepts using multiple methods. When describing her learning experiences, she said,

> I always remember having really good math teachers when I was in high school. I mean, generally speaking, to me, they were good math teachers because they just didn't speak it. They showed you. They were not just giving you verbal information. They would give you a lot of visuals. They would do multiple examples of problems but present them

in different ways so that maybe the first go around when you explain it, maybe half the kids will be like oh okay I get it and the other kids are lost. It helped me. So I do teach I think, a lot of ways very visually because I know how it helps me. And it seems to help them a lot (Interview 2).

She went on to give a specific example from the lesson,

> So looking at word problems, or looking at something in a textbook saying Okay this is the definition of perpendicular bisector. They would read that and go, huh? But if I visually show them or have them on a paper, like I want you to take this ruler and I want you to draw a circle with your compass. Take this ruler, draw a chord, draw a diameter, things like that. I just feel that visual things, kinesthetic things appealed to me as a learner (Interview 2).

I asked her if she was able to identify any connection between what she learned in her PATH program coursework or experiences and what she did in her lesson in terms of explanations. She said,

> Yeah for sure. I mean I still have a lot of documents and notes that I keep from when I went through that. Because my training was running concurrently with my first year as a teacher, when we would meet every Saturday for our trainings and our sessions it was great because you would lean on and go to those teachers that were also high school, that were also doing math. You would share your notes and see what worked for them and what didn't work. And so there was a lot of good just sharing of ideas in those Saturday classes. And even some of the teachers that didn't teacher math, just as far as classroom management and managing certain behaviors, it was really, really helpful to listen to them. And plus it made you feel like, okay, it's not just me (Interview 2).

I then told Stephanie that she scored high on the last subcategory within Richness of the Mathematics, Mathematical Language. I asked her to identify any strategies or methods that she used to ge ther students to use mathematical language as well as if she is aware that she is using that language as she explains concepts. She explained,

> I'm consciously aware of trying to reinforce the math vocabulary because when they're tested on it, they need to understand what it means. But I'm also constantly aware of the fact that they are low readers. They have comprehension issues. And is geometry especially because there's so much vocabulary that they've never seen before. And so what I try to do when I'm introducing all these words, and there were some lessons where we spent an entire day just doing a glossary of words. But then when I would use those words, if they didn't seem to quite understand what they would be asked to do I try to use more simple terms (Interview 2).

She went on to explain how some of her students see mathematical language are immediately think it means that the mathematics is too hard for them. She then made a reference to her preparation program experiences,

> I had an article…I had to do it for a homework assignment. I don't remember what section of training it was but there was an article that talked about how our society and out schools have made it acceptable for people to say I can't do math, I'm terrible at math. And everybody's just like, oh yeah me too. But do you ever hear anybody say I can't read? Its like we feed that. Its acceptable to say Miss I don't get math (Interview 2).

I asked her about the connection, if any, to her usage of mathematical language and her preparation program. She didn't make a connection between the two and said,

> No, I wouldn't say so. I just know that that's something that when we are evaluation, I know that its important to make sure that we are doing out best to help them learn the vocabulary of the subject. It (the PATH program) wasn't math specific at all (Interview 2).

She had a similar answer when I asked about possible connections between the strategies that she used while teaching the lessons and her preparation program experiences. She said,

> I've just done a lot of looking around for good ideas. Teachers Pay Teachers, looking for people who present things in different ways. And I look for stuff that maybe mentioned things like differentiation or working with ESE students or ELL students to give me some ideas of a little bit more simplified presentation of concepts that makes it easier for them to grasp. I did go to him (another teacher) a couple times with some of the concepts just to ask him how he presented certain things because there were times when he and I have co-taught Algebra 1 that I really really liked the way he explained certain concepts. So I have stolen stuff from him. Like I said just looking for stuff on my own online (Interview 2).

I reminded her about what she said in the first interview about having an entire library of resources that she gained from her preparation program and asked her if she has used any of those resources. She said,

> I have referred back to it mainly for ESE behavior type things. I had some real tough nuggets this year. Some kids that I was just trying to reach or trying to get to. So I referee back to those references a lot, like how do you try and coach the uncoachable, kind of stuff (Interview 2).

I asked her to expand on how she learned about the strategies and methods she used in these lessons, and if they were learned on her own, seen from other teachers or online, or learned in her preparation program. She said,

> I would say in the program, I mainly used stuff from the program that were beneficial across all curriculum. It didn't matter what subject area, it was things that were more related to ESE and behaviors and how to work with low readers. So that's what I primarily got from the training. And then for subject are math related stuff that I get a lot more from just researching online and talking to my co-teachers and others teachers too (Interview 2).

Summary of Case 4. Stephanie is an alternatively certified teacher who earned her certification through the district's PATH (Program to Attract and Train High quality exceptional teachers for students with disabilities) program. She is in her fourth year of teaching and teaching is her second career. Prior to teaching she worked in corporate America and was a secretary. She described the amount of resources she collected as well as her work with the mentors provided as strengths of the program. She also identified the social interaction experiences as helpful throughout her preparation. When asked about missing components of her preparation program, she identified the want for more mathematics-specific experiences within the coursework and perhaps more instructors who had mathematics teaching experience. On the two videotaped lessons she taught, she scored highest in the following areas of the MQI; Explanations, Mathematical Sense Making, Mathematical Language, which are all subdomains of the Richness of the Mathematics domain. When asked to describe the rationale for some of her teaching decisions in the two videotaped lessons, she made references to colleagues from whom she learned, as well as references to her own learning experiences as a student. She also discussed experiences she recalled from her own learning as a student. Finally, she told me that she looks online for resources that will help her explain mathematical content to her students in a variety of ways.

Conclusion

In this section, I presented each case individually. I included information on each participant's preparation program, their perceptions of their preparation experiences, and the extent to which their experiences relate to the three tenants of situated learning theory. Next, I provided an overview of each video lesson followed by a table presenting the MQI scores assigned to those lessons. Following the tables, I include information gained from the second interview during which I asked questions about each participant's perception of the impact of their preparation pathway experiences on the quality of their mathematics instruction, as measured by their scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI.

In the next section, I present the within-case analysis where I use the data to draw conclusions between each pair of teachers, Allison and Briana who are traditionally certified, and Jessica and Stephanie, the alternatively certified teachers.

Within Case Analyses

By conducting this case study, my intention was to determine the ways, if any, in which novice teachers perceive their preparation pathway (alternative or traditional) as having an impact on the quality of their mathematics instruction as measured by scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI. I used open coding while initially reading each participant's first interview and used the tenants of Situated Learning Theory (authentic context, social interaction, constructivist learning approach) as a lens through which to analyze the perceived preparation path experiences of each participant. I used the same process to code the second interview, with a focus on connections made between each participant's scores on the MQI for the two lessons they recorded and the ways, if any, their preparation path impacted the teaching decisions they made to earn those scores.

The within case analysis process allowed me to see similarities and differences between participant's quality of mathematics instruction based on their preparation program experiences. I used constant comparative methods to look across the cases and across the codes and themes about preparation experiences from the first interviews. Next, I used constant comparative methods to look across codes and themes from the second interviews to find similarities and differences in the ways that participant's preparation experiences may have influenced the mathematical quality of their instruction.

In this part of the chapter, I provide several interpretations within the cases with the goal of identifying the binding concept, theme, issue, or phenomenon that strings the cases together (Stake, 2013). I present the information by first analyzing the cases of the two traditionally certified teacher participants. Next, I analyze the cases of the two alternatively certified teacher participants. Finally, I compare themes between the pairs of teachers, traditionally versus alternatively certified.

Within Case Analysis of Traditionally Certified Teachers – Part 1: Perceptions of Preparation Program

In this section, I used the tenets of situated learning theory as a lens through which to analyze the data gathered from the first interviews about preparation program experiences from the two traditionally certified teachers in my study, Allison and Cindy.

Authentic Context: Situated learning theory posits that "learning is most effective when it is situated both within supportive social and authentic contexts (Bell, Maeng, and Binns, 2013). This theory recognizes that knowledge must be learned in an authentic context similar to how it might be used (Orgill, 2007). In the first interview I asked participants to what extent their preparation experiences took place in an authentic context. The two traditionally certified teachers had differing opinions on what experiences were most aligned to their current teaching situation. Allison felt that her classes in the math department were most similar to how she teaches math to her students. She said,

> …In my math classes at UT, that was more of how I would run my classes because it's, you explain it, you do practice, you explain something, you do practice like the I do, we do, you do method. They didn't do that much in my education classes, but I know that that's like what most math teachers do. I would say that they didn't really show us... Like I said earlier, how to teach Math (in the education classes). It was more of like, here are strategies to teach. And I feel if there was a specific teacher or person that could have been like, okay, this is how a Math classroom is structured, I think that would have been a lot more beneficial (Interview 1).

In contrast, Cindy felt that her education classes were more authentic to how she facilitates mathematical learning in her classroom. She said,

> I think the education courses are closer to what I'm doing here because they weren't, so I'm going to lecture, you're going to take notes and be quiet the whole time and listened to me. That was the math courses. The professor would just get up and write on the board and talk the whole time. There was never fun activities or anything like that. But in education they definitely... there was definitely lectures, but there was others where it

was a more interactive day. It wasn't always just lecture. So I mean I think it compares to my students because there are days where I do present new information and I have the notes set up, and it is a little bit more lecture based. But there are a lot of days where I tried to do like activities and just kind of mix it up, not the same thing every day (Interview 1).

As you can see these two participants, though their preparation program experiences were similar, had varied opinions on which aspects of their respective preparation programs took place in an authentic context. One similarity they both discussed in their interview was the authenticity of their practicum experiences where they were in classrooms with students and the positive impact those experiences had on their teaching. After Allison discussed her practicum and internship experiences, I asked her if she considers those as a helpful component of the program. She replied, “Yes I do! The internships and practicum were the most helpful things we do” (Interview 1). Cindy referenced the various practicum experiences that she had in her preparation program and how they helped prepare her for teaching. She said,

> I remember my practicum was really eye opening just because that was my first time in a lower level class, because throughout college, they had you complete hours. I was in a liberal arts class and I had to do X amount of hours. It was a lot more. It was almost half of an internship. And I was like, "Oh wow, this is real life. Okay." Because in high school, it's all honors and AP for me, so I never really got to see the other half of the world. So, that was pretty major (Interview 1).

In addition to much discussion about their practicum experiences, both Allison and Cindy agreed that they could have benefited from more practicum experiences, as those were they most authentic of the preparation experiences. Cindy said, “…that was definitely like the most experience to get. And I remember thinking during that time like they should definitely make us do more than just the practicum and the internship" (Interview 1). Allison agreed that she could've benefited from more practicum or internship experiences as well. When I asked her about the portion of her preparation experiences that took place in a school setting she recalled her placements and then said, "So probably not as much as you probably need" (Interview 2).

Social Interaction and Constructivism: The second and third tenants of Situated Learning Theory are social interaction and constructivism. Group work and peer reflections to encourage collaborative learning through social interactions are examples aspects of a preparation program that incorporate social interaction and constructivism (Owen-Pugh, 2002; Riveros, Newton and Burgess, 2012). Both traditionally certified teacher participants easily recalled experiences within their preparation program involving social interaction. The experiences each recalled were very similar and were centered on group projects in their coursework.

Allison said,

> We had a lot of group projects and there were some group projects where we did like, two Math teachers wrote a lesson together or wrote a unit plan together. But then we also did one where it was a group project where you'd have one English, one Math, one History, one Science, and you'd have to teach all four curriculums in one unit. There was a lot of social interaction. It was always partnered. They'd choose it. Math classes, we could work with whoever we wanted pretty much. But for ED classes it was always picked for us (Interview 1).

Similarly, Cindy also discussed group projects when I asked her about her perceptions of social interaction in her preparation program.

> We had group projects and stuff…so a lot of group projects and that forced us to like get together and work on things together, and what are you going to do this part? And this part we're going to compile it and make it cohesive and kind of brainstorm different... it was a lot of like education theory (Interview 1).

In addition to the discussion of group projects, both traditionally certified teachers talked about getting to know their peers within their preparation program and becoming comfortable with them. Allison said,

> By the time we got into our junior and senior year, it was the same 15 to 20 kids that were at all of your classes. So you knew everyone and you were comfortable with them. (It was a good thing) because you kind of knew who they were, how their style teaching is, all that kind of stuff. Whereas, if it was a huge class and you got stuck with someone new every single time, it would be hard to adjust because when you're writing unit plans, what we did was each person would write their subject area, which makes sense (Interview 1).

Cindy had similar perceptions about getting to know her peers and by her responses, it is evident that her program included social interaction experiences. She said,

> I think that we all just like excited to be math teachers and we were all kind of in the same boat of being naive to it all. In hindsight our interactions were positive, and there was never anyone like why are we doing this? So like when I was in college, none of us knew anything. We were just figuring out together…or we were all excited and ready to have her own classroom and do our own thing. I mean I definitely made friends and we would work on things together like meet up and go to the library (Interview 1).

Helpful Components of the Program: To gain insight into participant's perceptions of the components of their preparation program that were helpful, I asked them to describe experiences within their program that stand out them as being particularly helpful in terms of preparing them to teach mathematics on their own. Both the traditionally certified participants, Allison and Cindy, mentioned various aspects of their preparation programs that were helpful, but agreed that their practicum experiences and internships were the most helpful aspects of their preparation programs. Allison also discussed creating lesson and unit plans as a helpful part of the program. Allison said,

> We did a lot of lesson plan and unit plans. And they kind of tore us apart along the way and made us write down every single detail about every single thing that we would say, do and everything, which made me realize how long an actual class period is. Because going in I was like, Oh I can just explain, "Oh I'm going to do linear function." Well what exactly was the linear function? Do I need to go over? And they almost made us like script it, which made me be like, holy crap this is a lot longer than I thought it was going to be (Interview 1).

She then started discussing the internships and practicum and described them to be the most helpful aspect of the program. I asked her to elaborate on the reasoning behind her statement. She said, "The internships and practicum were the most helpful things we did. Seeing the day to day and implementing all of the practice" (Interview 1). When I asked Cindy about the most helpful aspect of the program she starting by mentioning the classes but then talked about the field experiences, naming them as the most helpful experience within her preparation program. She said, I really enjoyed all the classes I took because you know math nerd like Ooh, geometry, this is how it works. The numbers, it's Sally's work but I don't use it every day. I'm sure it helped train my brain on how to think and follow things through and procedural type, just kind of math logic brain (Interview 1).

She stared talking about her internship and practicum experiences at the beginning of the first interview and mentioned that they were helpful, so I asked her to tell me more about what she mentioned earlier and she recalled,

Yes I would say the internships were most helpful. The experience of being in the classroom is incomparable. I learned how to actually teach and manage a classroom all at the same time. It also validated my desire to be a teacher, interacting with the kids and teaching the content. I wish I could have had those experiences sooner in the program (Interview 1).

Based on their responses, it is apparent that the authentic context of being in a classroom was valuable and memorable to both traditionally certified teachers, as it stood out as being the most helpful part of their preparation programs. Their perceptions these participants about the helpful nature of the classroom experiences during their preparation align with the research of Green, Eady, and Anderson (2018) about preparing quality teachers which states, “Programs built on a foundation of situated learning strive to connect learning to, and position learning within, the classroom environment, encouraging students to apply their knowledge and understanding to this authentic context.

Missing Components of the Program: Though Allison and Cindy’s perceptions of the most helpful components of their preparation program were very similar, their perceptions of the aspects of their preparation program that were missing were not as similar, but still showed a common theme. One small similarity about what was missing from their program was that they both mentioned an aspect of teaching not related to mathematics teaching but related to the paperwork component of the job. The other aspect of their programs that they both identified as missing was related to strategies. Allison felt that her program was general and lacked specific strategies related to mathematics teaching while Cindy would have liked her program to incorporate more strategies for differentiating instruction for different types of learners.

In regards to the paperwork component of teaching, Allison thought it was difficult to figure out how to fill in paperwork related to students with Individualized Education Plans whereas Cindy felt it would have been more helpful to have had experience learning how to use computer software such as word to help with the creation of lessons. These two missing aspects that these traditionally certified participants identified are similar because they are not related to the instructional aspect of mathematics teaching. Allison said,

> I think the hardest part was figuring out how to fill out all the paperwork that we have to do. Like, planning notes for IEPs and stuff. I had never seen one of those before in my life. When I started here I was like, I don't know what this means, I don't know what any of this means. And I feel like I wasn't prepared enough for that kind of stuff (Interview 1).

The non-instructional aspects of teaching Cindy thought were missing from her preparation program were exposure to Microsoft word at to the email system she would be using as a teacher. She said,

> I think it would have been helpful if we did a word seminar or like class or something…like how to operate word. But even just knowing word shortcuts and like

typing up worksheets and tests, that's something that I actually learned during my internship, but I find the most helpful in my everyday life (Interview 1).

Specific to instructional aspects of teaching, Allison and Cindy both identified strategies as a missing component to their preparation programs. Allison wished her program had more math specific learning. She said,

> I wish that there was... So there wasn't a lot of specifically math ed majors. I think there was only a few of us. So the classes were kind of all combined, which was really hard because how you teach math is totally different than how you're going to teach English and how you're going to teach reading and how you're going to teach science. They don't understand that math classes run differently. Like you can't not do notes in a math class. If you don't do notes, you're not going to have any idea what to do. I just wished there was more math ed and there was a specific math ed class (Interview 1).

Cindy's perceptions were similar to Allison's in that she felt her preparation program lacked specific experiences that would help her teach math to her students. However, her perceptions of what was missing were not specifically related to teaching math content, but teaching strategies in general. She said,

> Just like exposure to different types of students. Because I feel like a typical college kid was like an honor student and only were exposed to honors and like AP classes. Whereas in my practicum I realize, Oh not every student really cares about learning and cares about math. And that would have been nice just to kind of have that exposure earlier on.
>
> I would have found that more useful if they showed us maybe like Kagan strategies or different ways to present material…so I would have appreciated more, just opportunities to practice different structures of activities and lessons and things like that (Interview 1).

Summary of Within Case Analysis for Traditionally Certified Teachers: Part 1

In the previous two sections, I compared the data collected from Allison and Cindy, the two traditionally certified teachers. I used the tenets of situated learning theory as a lens through which to analyze the data gathered from the first interviews about preparation program experiences. My analysis revealed differences in each participant's perception on the extent to which their preparation experiences took place in an authentic context, though they agreed that the internship and practicum experiences were most useful. In terms of social interaction and constructivist approaches to learning, both recalled similar experiences about working with peers often during their preparation program, specifically on group projects. When they identified components of their preparation programs that were helpful, Allison discussed the lesson planning experiences and Cindy mentioned her mathematics courses. Despite those differences, they agreed that their internship and practicum experiences were the most helpful aspect of their preparation programs overall. They had different perceptions of the components of their preparation programs that were missing. While Allison would have liked more instruction on how to complete IEP paperwork and would have liked her education coursework to be more math-specific, Cindy would've liked to learn about computer programs she would use as a teacher and would have liked more exposure to different types of students.

Within Case Analysis of Traditionally Certified Teachers – Part 2: Perceptions of Preparation Program Impact on MQI Scores

In the second interview, which I conducted after watching each participant's two recorded lessons, I asked questions to each participant about their perceptions of the impact of their preparation pathway (alternative or traditional) on the quality of their mathematics instruction as measured by scores on the Richness of the Mathematics and Errors and

Imprecision domains of the MQI. In this section, I discuss the analysis from the information gathered from the second interview and each participant's scores on the MQI . While analyzing the data collected from Allison and Cindy, the two traditionally certified teachers, some trends in the MQI data and several themes emerged. First, I describe the trends in the MQI data. I report their scores as a percentage that represents the earned points added from both observations divided by the total points for both observations. This was calculated for each category on the MQI for both traditionally certified teachers. Then, I describe each of the themes identified from the interview data related to the MQI scores.

MQI Data: Each teacher's videos were scored using two domains of the MQI; Richness of the Mathematics and Errors and Imprecision. The Richness of the Mathematics domain consists of six subdomains and the Errors and Imprecision domain consists of three domains. I looked at the scores from all subdomains for both traditionally certified teachers, Allison and Cindy, to identify trends in the data. I selected subcategories which had a difference of 15% or less. The trends that emerged within this category from the Richness of the Mathematics domain were found within the Explanations, Multiple Procedures or Solution Methods, and Mathematical Language subdomains. The trends that emerged within this category from the Errors and Imprecision domain were found within the Mathematical Content Errors and Imprecision in Language or Notation subdomains. The table below shows the scores from those subdomains for the two traditionally certified teachers, Allison and Cindy.

Table 39

Subdomain Scores for Traditionally Certified Teachers

Teacher	Allison	Cindy
Linking Between Representations*	4%	17%
Explanations*	33%	39%
Multiple Procedures or Solution Methods*	0%	6%
Mathematical Language*	58%	44%
Mathematical Content Errors**	4%	0%
Imprecision in Language or Notation**	25%	22%

Note. * indicates a higher score is favorable, **indicates a lower score is favorable

I asked both traditionally certified participants questions about their perceptions of the impact of their preparation program on their teaching decisions within these subcategories. From their answers, I identified three themes described by teachers as having an impact on the quality of their mathematics instruction as measured by the Richness of the Mathematics and Errors and Imprecision domains of the MQI; Learning Styles, Colleagues, and Internship. Below I will describe each theme.

Theme 1: Learning Styles

When I asked Allison and Cindy their rationale for using the teaching strategies they did in their recorded lessons, one theme that emerged was their discussion of multiple learning styles. The both referenced learning about the need to use a variety of strategies when teaching mathematics in order to reach all learners in the class in their preparation programs or internship experiences. When I asked Allison if there were any connections between the note-taking strategy she used with her students and her preparation program she said,

> So when I learned how to teach they always taught us to explain and visualize. Because if you just say, "Oh, look, these two numbers are different," they're not going to exactly know which two numbers. So that's why I circle and color code things because it helps kids realize, "Oh, that's what she's talking to in red," or whatever color I chose to use for that. And kids actually do that in their notebook. So when they go back to study, they

> actually see, "Oh, hey, that's what she did here. That's why this changed to this. Oh yeah. I don't remember specifically which course or which teacher, but definitely learned that (in college) (Interview 2).

When asking Cindy about the note-taking strategies she used in her videotaped lessons she talked about highlighting information on the geometric figures as a means to address the visual learners in her class. Her responses were similar to Allison as she referenced the importance of reaching learners with varied learning styles, a skill that she learned in her preparation program. I asked her how she learned to do that and she said,

> …for me highlighting doesn't do really anything. I'm just very, "Okay. I know that those things add to 180 and that will do that," but I've stuck with it just for those kids that maybe they see the connection like, "Oh, all the green things are related and all the pink things add up to 90." So I definitely stick with that. I definitely took that from college, just being equitable and just making sure that you get it across to everyone (Interview 2).

Cindy was able to recall more specific instances of learning about teaching strategies in her program. She went on to say,

> because we had to do teaching math in middle school and teaching math in high school. I'm pretty sure they were two different courses. And those were pretty intense, just trying to learn the different methods of teaching. And then there was this other class I took and we learned about all the different education philosophers and what they studied and what they got out of it. So, that was interesting, like Vygotsky and all that" (Interview 2).

Theme 2: Colleagues

The second theme that emerged from the interview data was seeking help and information from colleagues. Allison scored 33% in explanations and Cindy scored 39%. I asked both of them how they learned to explain the content they taught in their lessons. When answering these questions, the both referred to learning from their colleagues. Allison said,

> The first time I ever taught logs, it was a disaster. So I actually ended up having to reteach it because it was just so bad. So I pulled from other teachers and came up with this log roll idea…I think it was Kim who showed this to me. And once I started using the log roll thing, it's became so much easier. And then I've just been doing that year after year and it worked so well (Interview 2).

Cindy described more general experiences when discussing the importance of collaborating with colleagues within the mathematics department. She referenced a specific teacher and said,

> (My cooperating teacher) and I, we are always bouncing ideas back and forth… Just always collaborating, always trying to pick each other up like oh I tried this, you should try it, and just training. I don't know what I would do if I didn't have people that were willing to work together (Interview 1).

Theme 3: Internship

During the second interviews, when I asked Allison and Cindy to describe how they learned to explain concepts the way they did in the videotaped lesson, they both talked about their field experiences and identified those as being the most helpful for enhancing the quality of their mathematics instruction. I asked Allison if her perception of her ability to explain things had any relation to her internship experiences, to which she replied, "I learned in my internship that you don't have to teach everything the way the book wants you to, sometimes you need to explain it in a way that is different so the students will understand it" (Interview 2). This was her rationale for explaining the concepts of logarithims and radians the way she did in the videos. She then added, "The internships and practicum were the most helpful things we did" (Interview

2). When I asked Cindy specifically how she learned to explain content the way she did in the videotaped lessons she referenced her internship and cooperating teacher when she said,

> …definitely learned that from (my cooperating teacher). I don't really remember highlighting in high school or even in college. I just remember my internship because my internship was geometry. So I really absorbed a lot then and took (my cooperating teacher's) lead. I would say the internships were most helpful. The experience of being in the classroom is incomparable. I learned how to actually teach and manage a classroom all at the same time. It also validated my desire to be a teacher. Interacting with the kids and teaching the content. I wish I could have had those experiences sooner in the program (Interview 2).

Summary of Within Case Analysis for Traditionally Certified Teachers: Part 2

In this section, I identified three themes that emerged from Allison and Cindy's perceptions of the influence of their preparation program on their teaching decisions evident in the videotaped lessons. These themes were learning styles, colleagues, and internship. Within these themes, these traditionally certified teachers described decisions influenced by their preparation program experiences, as well as by experiences they have had in their current teaching context. In the next section, I follow the same process with the two alternatively certified teachers.

Within Case Analysis of Alternatively Certified Teachers – Part 1: Perceptions of Preparation Program

In this section, I used the tenets of situated learning theory as a lens through which to analyze the data gathered from the first interviews about preparation program experiences from the two alternatively certified teachers in my study, Jessica and Stephanie.

Authentic Context: Both alternatively certified teachers experienced a preparation program that took place simultaneously with their first couple years of teaching. Jessica's program started during her second semester of teaching while the structure of Stephanie's program required teacher candidates to take a couple classes in the summer before they taught, but the majority of preparation coursework took place during their first year of teaching.

As I stated earlier in the traditional certification section above, situated learning theory states that learning is most effective when it takes place in an authentic context of how it might be used. Because of the structure of these alternative certification models, the extent to which their preparation programs took place in an authentic context was high since they were teaching in a classroom everyday throughout the program. When taking classes on the weekend, both alternatively certified teachers then had an opportunity to practice their learning the very next week with students. When I asked Jessica and Stephanie to explain the parts of their program that took place in an authentic context, the experiences they described were similar. Since both of their preparation programs took place while they were actually teaching in a mathematics classroom, their learning was often tailored to the specific experiences that they encountered daily, along with the experiences of others in their respective programs. When I asked Jessica to describe the extent to which her preparation experiences took place in an authentic context, she said

> My ACP classes were in a classroom environment, but it was all professionals working together, going over material and learning it. We were in a classroom, they gave us a lot of examples. We did a lot of role-playing… within our groups we were able to see what some of the other teachers have come up against. And then help them sort of debug how you could deal with that in the future (Interview 1).

Stephanie recalled experiences within her preparation program that included actual classroom experiences as well. She said,

> You were like learning on the go. I was like you would have your classes that week and then you'd go to training on the weekend, and that was a great opportunity for all of us to bounce things off. You're not going to believe what happened to me this week. You could ask questions and it was in context with, okay, today we're going to be talking about such and such. Tell me about something that you saw this week where you were, and it was nice. We often had activities built into the training where you had to ... I mean, when we were learning different strategies, like think pair shares and things like that, we would do it on each other or they would send us off into groups and we had to work as teams and things like that. So kind of showing you a little bit how you would work with PLCs and that kind of thing (Interview 1).

From their answers to my questions related to authentic context, it is clear that Jessica and Stephanie had similar experiences within their preparation programs and share the perception that much of their learning took place in an authentic context.

Social Interaction and Constructivism: Both alternatively certified teachers had similar experiences with social interaction in their preparation programs. They both credited the social interactions with peers in their programs for much of the learning that they gained. In addition, both Jessica and Stephanie identified the ability to interact with others in their same situation as one of the highlights of their preparation program. When I her them what role social interaction played in their preparation program, Jessica said,

> I think that was actually some of the highlights of it, was interacting with others. Teachers that were in my same situation and maybe having my same struggles. And not

> just commiserating but helping each other and using the instructors also to figure out how we can do things better or solve problems (Interview 1).

Similarly, Stephanie said,

> It was great because you would lean on and go to those teachers that were also high school, that were also doing co-taught, that were also doing math. You would share your notes and see what worked for them and what didn't work. And so there was a lot of good just sharing of ideas in those Saturday classes. And even some of the teachers that didn't teach math, just as far as classroom management and managing certain ESE behaviors, it was really, really helpful to listen to them. And plus it made you feel like, okay, it's not just me (Interview 1).

In addition to both alternatively certified teacher's positive experiences interacting with others in their preparation program, they each also described group assignments through which social interaction was required and strategies for collaboration were taught and practiced. Jessica recalled,

> I think in every single class we were in groups and we were interacting with each other. We were doing group work and jigsaws and all sorts of... the different group interactive roles. Yeah, we were definitely working with each other all the time. We would do jigsaws to make it through an article and read all the material, and that sort of thing. We did a lot of gallery walks and things like that (Interview 1).

Helpful Components of the Program: I asked Jessica and Stephanie to identify components of their preparation programs that were most helpful to them in their teaching practice. The one common theme that emerged from both participant interviews when I asked about helpful components of their preparation program was the instructors. Both alternatively certified participants talked about the knowledge they gained from their instructors. Jessica described her perceptions of her instructors by saying,

> I had a lot of good instructors. My instructor that did the classroom management class was especially good. I remember him quite a bit…I remember the instructors made it very, "Well we can modify this and talk about your problem right now, today if we need to, as opposed to just like going through the text." I had a couple that were very interactive where they didn't mind kind of going down bunny trails to talk about issues we were having (Interview 1).

Stephanie had similar perceptions about her instructors' methods of helping the teachers within the alternative certification preparation program. She said, "I think the instructors were very open about sharing their experiences, their good and their bad days and what had happened in their classroom" (Interview 1). In addition to the instructors, each alternatively certified participant identified some other helpful aspect of their preparation program. Jessica discussed one specific course that was most helpful to her, in addition to the helpfulness of the ability to socially interact with other teachers in similar situations, as mentioned above. Stephanie, on the other hand, identified the amount of resources collected and the mentors as the most helpful component of the program. When describing her most helpful class, Jessica said,

> The classroom management class was actually quite good because I didn't know anything about how to manage 30 teenagers. It helped me realize that you couldn't just expect them be grown up and to act reasonable. You had to put limits and controls around them, and how to do that from day one and not give them a lot of slack, really. That was very useful to me (Interview 1).

In addition, she referenced the social interaction, specifically the role playing, and identified the opportunities to talk with other teachers in the same preparation program as being a helpful component of the ACP program in which she participated. She said, “they were (helpful) because within our groups we were able to see what some of the other teachers have come up against. And then help them sort of debug how you could deal with that in the future” (Interview 1). Stephanie’s perception of the most helpful aspects of her preparation program were different from Jessicas. She thought the amount of resources she received as well as the mentors provided by the program were the most helpful components. She said,

> I mean I think I got more information than I could possibly ever utilize as far as every section we went through, we were getting more texts and things like that. Not just notes that we were doing for the course itself, but they would give us like a book that was written by so-and-so, like Your First Year in the Classroom, and all these different self-help and teacher help books to teach you different strategies. Resources. They would give you these resources. That was part of what we got too. So I have an entire library of stuff that I got. Yeah. And like I said, I have things that now I go back, I'm like, "Oh God, I forgot I had that," because you just get so focused on one thing and you're like, oh what do I do for this, and you forget that you have some of these things. But it was great, having all those resources given to us as well (Interview 1).

She also identified the mentors provided by the program as the most helpful component of her preparation program. She said,

> I would say the mentors that we had on campus, they were the ones that we would meet with or they would come and do observations. They were very good at giving constructive criticism without making you feel like you were being judged. And they

> wouldn't just say, "Okay, you could have done this better." They would say, "This is what I would do, or maybe try this." They would give you examples. Because I'm a type of person, it's like show me what that looks like. You can talk in all these acronyms and all these things that you, titles, different strategies, but it's like what does that look like in the classroom? And they were very helpful with that (Interview 1).

It is important to note that neither Jessica nor Stephanie discussed anything specific to mathematics as being the most helpful component of their preparation program. Perhaps because both of their programs were general for alternatively certified teachers and therefore were not subject specific. In the next section about missing components of the program, however, both alternatively certified participants mentioned the lack of math-specific content as a weakness of their preparation programs.

Missing Components of the Program: In the final part of the first interview, I asked Jessica and Stephanie to consider what they know now about effective mathematics teaching and determine if there were any components of their preparation programs that they perceived to be missing. They identified a common missing component, the lack of specificity of their preparation program to mathematics teaching. Jessica said,

> It would have been nice to have something that was more discipline-tailored, so like more that was specific to a math teacher…there was no math strategies class. And it would have been nice if there was a way to have some sort of like elective component to that ACP that said, "Okay, if you're teaching English or social sciences, take this class. If you're teaching math or science, teach this class." Because there's different strategies on how to present math and formulas, and processes that I've picked up along the way, but it would've been nice to have that actually in the class (Interview 1).

Stephanie echoed Jessica’s perceptions about the major missing component of her alternative certification preparation program. Stephanie said,

> …and so a lot of times it was difficult for me to try and translate what they were wanting you to do. And if they were teaching a certain strategy…they were always talking about reading strategies, and not that there's not any reading in math, but they were talking so much about the language and reading…and I was like, "Okay, but how does this work in math?" You know what I mean? So that was kind of hard. But they were really good at helping you to interpret how you could do it, what it would look like. But I didn't have a lot of math background people (Interview 1).

Summary of Within Case Analysis for Alternatively Certified Teachers: Part 1

In the previous two sections, I compared the data collected from Jessica and Stephanie, the two traditionally certified teachers. I used the tenets of situated learning theory as a lens through which to analyze the data gathered from the first interviews about preparation program experiences. My analysis revealed similar perceptions from Jessica and Stephanie about the extent to which their preparation experiences took place in an authentic context. They both recalled experiences where instructors asked them to use situations from the teaching experiences they encountered at the time of the coursework to learn and practice strategies. In terms of social interaction and constructivist learning experiences, both credited the ability to socialize with their colleagues for much of the knowledge they gained and identified social interaction with peers as one of the highlights of their preparation programs. When they identified components of their preparation programs that were helpful, Jessica and Stephanie both mentioned their instructors, but also mentioned different components of their preparation programs they found helpful. Jessica mentioned specifically the classroom management course she took as well as the ability to learn from others in the program. Stephanie's perceptions of the most helpful components in her program were the resources she received as well as the mentors with whom she worked. They had very similar perceptions of the components of their preparation programs that were missing. Both Jessica and Stephanie would have liked their preparation program to include more coursework, strategies, and experiences specifically related to mathematics teaching. Both of their programs, though different, were general for prospective teachers of all subjects and they felt they would have benefited more from more exposure to mathematics specific experiences.

Within Case Analysis of Alternatively Certified Teachers – Part 2: Perceptions of Preparation Program Impact on MQI Scores

In the second interview, which I conducted after watching each participant's two recorded lessons, I asked each participant questions about their perceptions of the impact of their preparation pathway, in this case alternative, on the quality of their mathematics instruction as measured by scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI. In this section, I will discuss the analysis from the information gathered from the second interview and each participant's scores on the MQI .

When I analyzed the data collected from Jessica and Stephanie, the two alternatively certified teachers, some trends in the MQI data and several themes emerged. First, I will describe the trends in the MQI data. I report their scores as a percentage that represents the earned points added from both observations divided by the total points for both observations. This was calculated for each category on the MQI for both traditionally certified teachers. Then, I will describe each of the themes identified from the interview data related to the MQI scores.

MQI Data: Each teacher's videos were scored using two domains of the MQI; Richness of the Mathematics and Errors and Imprecision. The Richness of the Mathematics domain consists of six subdomains and the Errors and Imprecision domain consists of three domains. I looked at the scores from all subdomains for both alternatively certified teachers, Jessica and Stephanie, to identify trends in the data. I selected subcategories which had a difference of 15% or less. The trends that emerged within this category from the Richness of the Mathematics domain were found within all of the subdomains (Linking between Representations, Explanations, Mathematical Sense Making, Multiple Procedures or Solution Methods, Patterns and Generalizations, and Mathematical Language). The trends that emerged within this category from the Errors and Imprecision domain were found within the Mathematical Content Errors, and Lack of Clarity subdomains. The chart below shows the scores from those subdomains for the two alternatively certified teachers, Jessica and Stephanie:

Table 40

Subdomain Scores for Alternatively Certified Teachers

Teacher	Jessica	Stephanie
Linking Between Representations*	6%	11%
Explanations*	56%	67%
Mathematical Sense Making*	56%	67%
Multiple Procedures or Solution Methods*	6%	0%
Patterns and Generalizations*	0%	6%
Mathematical Language*	67%	67%
Mathematical Content Errors**	6%	0%
Lack of Clarity**	0%	0%

Note. * indicates a higher score is favorable, **indicates a lower score is favorable

The main trend I noticed in the MQI scores from Jessica and Stephanie's videotaped lessons was that they both scored the highest in the same three subdomains of the Richness of the Mathematics domain of the MQI. Those three subdomains are Explanations, Mathematical Sense making, and Mathematical Language. I focused the second interview questions around these three areas and asked Jessica and Stephanie questions about their teaching decisions related to these categories and their perceptions of how their preparation experiences influenced those teaching decisions.

As compared to the traditionally certified teachers, they had less in common and identified other factors that contributed to their teaching decisions, not necessarily factors related to their preparation programs. During the analysis while looking for commonalities, I discovered very little of what they identified as factors that contributed to their teaching decisions were related to their preparation program, but rather more of what they identified as influencing their teaching decisions were factors from their current context.

From their answers, I identified four themes described by alternatively certified teachers as having an impact on the quality of their mathematics instruction as measured by the Richness of the Mathematics and Errors and Imprecision domains of the MQI, even though their reasons for discussing these factors were not always related to their preparation program. The four themes I will describe in the following section are colleagues, learning styles, high stakes testing, and resources.

Theme 1: Colleagues

The first theme I identified while looking for commonalities between Jessica and Stephanie was their mention of the impact of colleagues on their teaching decisions. At first glance, they seemed to discuss some colleagues from their preparation programs as having an impact on their teaching decisions. As we progressed throughout the interview however, it became clear that Jessica referenced a former colleague and credited her for influencing her current teaching methods, especially related to explanation. Stephanie, on the other hand, referenced current colleagues and said she learned to explain the concepts she taught in these lessons from them.

I started each of the second interviews by telling Jessica and Stephanie that they scored particularly well in the Explanations subdomain of the Richness of the Mathematics domain of the MQI. I asked them questions about how they learned to explain the mathematics they taught in the videotaped lessons and specifically if they learned any of those skills in their respective preparation programs. Jessica immediately referenced her former department head and said,

> (My department head) at (my school)…from day one she was helping me try to find ways to get my classroom engaging…so I do a lot of Kagan activities in class. I make them do sage and scribe and that sort of thing, where they have to speak to each other and the other one write it and then switch roles (Interview 2).

Stephanie, on the other hand, referenced other colleagues in her current context as having an impact on her teaching decisions from the videos. She said,

> I did go to (Tom) a couple times with some of the concepts…just to ask him how he presented certain things because there were times when he and I have co-taught algebra one that I really, really liked the way he explained certain concepts. It seemed to get more kids to understand it more quickly. And he would just kind of tell them, "Don't look at the textbook right now. We're not worrying about that. Just I'm going to show you a really simple way to do this." And I love that. I like stuff like just show me the shortcut, show me the simple ways. Just show me what works. So I have stolen stuff from him (Interview 2).

Theme 2: Learning Styles

The second theme I identified from the interview data provided by Jessica and Stephanie was their mention of the need to accommodate for different types of learners and learning styles. When describing the way they learned to explain concepts they both referenced knowing the importance of providing multiple types of explanations in order to reach all learners in their classrooms. Though Jessica made a direct connection to what she learned in her preparation program, Stephanie credited her former teachers from her experience as a student for her knowledge of presenting material in various forms.

Jessica started by discussing the learning she gained from her preparation program about types of learners and then described her rationale for using the specific strategy of highlighting she used when explaining arcs and angle measures in one of her lessons. Jessica said,

> In ACP, there was a lot of discussion about people who are visual learners versus auditory learners versus oral learners. So, I try to respect that and how they might be processing the information I'm giving. Some of them might... Many students just blindly transcribe what you write and then they need time to go back and look at it and process it. I took from (ACP) how to structure a lesson and give time for student practice and differentiation. So I do try to incorporate that time into the lesson…because (highlighting is) not something I really ever did until I was a teacher, was that sort of highlighting of things and color coding. That's not something I personally need to do, so it is something I've kind of learned to do for the kids. In (ACP) it's more just the broad strokes of recognizing the different types of learners (Interview 2).

During the second interview with Stephanie, I referenced a part of one of her teaching videos where she drew a figure on the board and used rulers to explain the difference between a diameter and a chord in a circle. When I asked her to describe her rationale for that explanation she said,

> I always remember having really good math teachers when I was in high school. I mean, generally speaking, to me, they were good math teachers because they just didn't speak it.

> They showed you. They were not just giving you verbal information. They would give you kinesthetic delivery. They give you a lot of visuals. They would do multiple examples of problems but present them in different ways so that maybe the first go around when you explain it, maybe half the kids will be like, oh, okay, I get it. And other kids are lost. So I had teachers that would say, "Well, let's try looking at it this way." And they would just do it a little differently. So I guess it was just something... I don't know. It helped me. So I guess that's just kind of ingrained (Interview 2).

She went on to describe the way she learns and how she uses that knowledge within her teaching decisions. She explained,

> I guess I'm a very visual learner. I'm like, okay, I kind of get what you're explaining to me in words, but show me what that means. So I do teach, I think, a lot of ways very visually because I know how it helps me. And it seems to help them a lot…I just feel that visual things, kinesthetic things appealed to me as a learner (Interview 2).

Theme 3: High Stakes Testing

A third theme that emerged from the second interview with Jessica and Stephanie was the connection of their teaching decisions based on the importance of high stakes testing. Jessica discussed testing when describing why she connected their current learning to prior learning, while Stephanie described her decisions to emphasize mathematical language as important because of testing. Though the notion of high stakes testing was only mentioned once by each alternatively certified teacher, I deemed it important to discuss, especially since neither of the traditionally certified teachers mentioned high stakes testing.

Jessica and Stephanie both also scored high (and had the exact same scores) in the mathematical language subdomain within the Richness of the Mathematics domain on the MQI.

During our second interview, I told them both that they scored high in this area and I gave them some examples of the mathematical language they used in their videotaped lessons. I asked them to explain their rationale for using that language in addition to how they learned to do so. Though they had different explanations for the reason they used the mathematical language that they did in their lessons, they both referenced the need to prepare students for high stakes testing. Jessica made a connection between the importance of teaching mathematical language and her preparation program, while Stephanie discussed the importance of her students knowing the vocabulary to help them be successful on high stakes tests. Jessica said,

> I tried to start off with something that they knew and that is something that we had practiced weekly since January, because I had a bee in my bonnet that when they took the EOC, they were all going to be able to write the equation of a line (Interview 2).

When I asked Stephanie about her rationale for using mathematical language during her videotaped lessons she made a connection to the importance of preparation students for high stakes testing. She recalled, “I'm consciously aware of trying to reinforce the math vocabulary because when they're tested on it, they need to understand what it means” (Interview 2).

Theme 4: Resources

The fourth theme I identified between the alternatively certified teachers is related to their use of resources. Jessica discussed resources from her preparation program as well as those she has found on her own as being part of the reason she made teaching decisions she did during the videos. Stephanie, on the other hand, referenced mathematical resources she has found on her own throughout her teaching experience and credited those as having an influence on why she explained concepts the way she did.

Jessica made a connection between her rationale for using mathematical language and one of the courses she took in her preparation program. She said,

> I did do a reading to learn class with ACP. And I remember in the reading to learn class, it talked about how students process new vocab and how they have to use it in order to maintain it…so I do remember that being a focus in that class. And that class, I was very much trying to find ways to apply it to math because reading to learn, a lot of that content in that ACP class, is structured towards reading and language arts and social studies even, but not so much math. So I remember thinking, stretching ways that I would apply this and the vocab obviously came up quite a bit, getting them to actually read and talk math and write math as opposed to just doing calculations (Interview 2).

In addition, she discussed the structure of her lesson in connection with an online resource she had successfully used in the past called IXL. She said,

> I chose to tie it to linear equations first. For that unit, I had been using the IXL tool…and in IXL, they broke it down into such easy steps where they had four skills on this. And the first skill was just, find the center of the circle, where they just had to find the coordinates of the center of the circle. Then the second skill was like, find the radius. And then they took that and then the next step, they broke it down into plugging those into the formula for the circle and it just kind of baby stepped them through it and I was like, that is such an easy way to do it. So I was trying to make it so that…. it would be easy enough for them to walk through those skills and just master this and do well with it (Interview 2).

When I asked Stephanie to explain the rationale behind the way she explained concepts during her chords and arcs lesson, she referenced learning that method of explanation from a video she found on the internet years prior. She said,

> I had seen it years before. I believe it was in a video that I had watched. I don't think it was during any of the trainings. I think it was just I was looking for ways to teach the concept. It probably (was) when I was first doing geometry. And certain concepts, they come easy to me, but I was trying to, based on how I knew they struggled on certain things and how they needed to have the light bulb go off…a lot of times I'll just go online. If I think that's something that really would benefit a lot of my kids, I try using it to see if it works (Interview 2).

Summary of Within Case Analysis for Alternatively Certified Teachers – Part 2

In this section, I identified four themes that emerged from Jessica and Stephanie's perceptions of the influence of their preparation program on their teaching decisions evident in the videotaped lessons. These themes were colleagues, learning styles, high stakes testing, and resources. Within these themes, these alternatively certified teachers described decisions influenced by their preparation program experiences, as well as by experiences they have had in their current teaching context. In the final sections of Chapter 4, I discuss the cross-case analysis of the two traditionally certified teachers and the two alternatively certified teachers.

Cross Case Analysis of Traditionally and Alternatively Certified Teachers – Part 1: Perceptions of Preparation Program

In part 1 of the cross case analysis, I start by examining the first interviews, where I asked participants to describe their preparation program experiences and their perceptions based on the tenants of situated learning theory, as well as what was most helpful and what was missing from their programs. I discuss the commonalities between the traditionally and alternatively certified teachers' program structure as well as the differences. Then I discuss the commonalities and differences between the traditionally and alternatively certified teachers' perceptions of their experiences within their respective programs.

Commonalities in Program Structure: Though all four teachers matriculated through different preparation programs, there was one commonality between all of the programs. I gathered information about each program, including the courses, expected timeline, and length of the programs and looked for similarities. The only similarity I identified was in the coursework of the programs. Both the traditional and alternative certification programs contained a course about classroom management, a reading course, a technology course, and one or more courses about different types of learners. That was the only commonality I identified between all four programs.

Differences in Program Structure: While looking across the programs for differences, several emerged. The first difference in the programs is the context. Both traditional certification programs took place at four-year Universities and the participants were full time students. Both alternative certification programs were offered through the county and participants took courses concurrently as they were teaching, mostly on the weekends.

The second difference in the two types of preparation was the coursework. The traditional programs were both four-year programs consisting of between 16 and 20 courses in the college of education and mathematics department as well as practicum and internship experiences in classrooms. Their coursework contained mathematics content courses, mathematics teaching methods courses, courses on assessment, and practicum and internship experiences. Both alternative programs consisted of eight courses, none of which were specific to teaching mathematics. The alternative programs included some shadowing, but no formal practicum or internship experiences. The alternative preparation programs both contained a course intended to help teachers transition into the field, since many participants would be second career teachers.

A final difference in the preparation programs was the timeline, credentials and outcome. Both teachers in the traditional preparation programs needed a high school diploma to start their programs, completed their programs in four years, and earned a bachelors degree and a permanent teaching certificate at its conclusion. The teachers in the alternative certification program needed a bachelors degree in any field to enter the program, completed the program in two years, and earned a temporary teaching certificate at its conclusion.

Commonalities in Teacher Program Perceptions: While looking for commonalities across the cases, I identified three general themes discussed by all four teachers. All four teachers agreed that their preparation programs took place in an authentic context, specifically referencing the courses they took, though those courses were different. A second commonality was that all four teachers were able to recall many instances of social interaction throughout their preparation experiences and agreed that social interaction was an important part of their preparation. The third commonality all four teachers mentioned was the opportunity their preparation program provided for reflection.

Differences in Teacher Program Perceptions: The major differences between the perceptions of the traditionally and alternatively certified teachers emerged when discussing the most helpful parts of their preparation program as well as the parts they perceived as missing from their preparation programs. Both traditionally certified teachers agreed that their practicum and internship experiences were the most helpful, while the alternatively certified teachers identified their instructors and mentors as being most helpful. When describing the missing components of their program, the traditionally certified teachers identified more logistical components about paperwork and computer programs while the alternatively certified teachers both stressed the desire for more learning specific to mathematics teaching, as their programs were both non-subject specific.

Summary: In this section, I presented a cross case analysis of traditionally and alternatively certified teachers' program structure and their overall perceptions on their preparation program. I discussed one commonality in all four of the program structures which was found in the general categories of coursework that each provided. I went on to discuss the differences in the structure of the two types of programs, which included the context of the programs, specific coursework required, timeline, credentials, and outcome of the programs. Next, I described commonalities in teacher's perceptions of their preparation experiences. I identified three themes from the first interview data that were similar across both groups of teachers. These themes were authentic context, social interaction, and opportunities for reflection. Finally, I discussed the differences in teacher's perceptions of their preparation experiences across the groups. The two themes that emerged as differences across the groups were related to the parts of their preparation programs that each group of teachers perceived as the most helpful, as well as what parts of the program they perceived as missing. In the next and final section of Chapter 4, I present part two of the cross-case analysis, which described the teacher's MQI scores as well as commonalities and differences between the two groups of teachers rationale's for their teaching decisions in the video data collected.

Cross Case Analysis of Traditionally and Alternatively Certified Teachers – Part 2: Perceptions of Preparation Program on MQI Scores

In this section of the cross case analysis, I use each teacher's MQI scores and second interviews to look across the data from the traditional and alternatively certified teachers and identify commonalities and differences in perceptions of the extent to which their preparation pathway has an impact on the quality of their mathematics instruction as measured by the MQI. I focused on the three subdomains from the Richness of the Mathematics domain and one subdomain from the Errors and Imprecision domain because those are the subdomains in which participants data was most populated (see table 40 below). I structured the second interview questions around these subdomains and asked teachers to identify the rationale for their teaching decisions in these areas. Below I describe the commonalities and differences in their answers across groups.

Table 41

Most Populated Subdomains of MQI Data

Teacher	Allison(T)	Cindy(T)	Jessica(A)	Stephanie(A)
Explanations*	33%	39%	56%	67%
Mathematical Sense Making*	25%	44%	56%	67%
Mathematical Language*	58%	44%	67%	67%
Imprecision in Language/Notation**	25%	22%	33%	11%

Note. * indicates a higher score is favorable, **indicates a lower score is favorable

Commonalities in Rationales for Teaching Decisions: One commonality between the rationales for teaching decisions between the traditionally and alternatively certified teachers was their identification of the importance of addressing different learning styles during their instruction.

Differences in Rationales for Teaching Decisions: One main difference I identified in the difference between traditionally and alternatively certified teacher's rationales for their teaching decisions was the extent to which traditionally certified teachers credit experiences from their preparation program, specifically their internships, as having an impact on the quality of their mathematics teachers. During the second interviews, the traditionally certified teachers made more references to experiences from their preparation programs than the alternatively certified teachers.

Summary: In the final section of this chapter 4, I discussed commonalities in perceptions of the groups of teachers based on the data collected from their teaching videos and scored using the MQI. Both groups of teachers discussed the importance of accommodating different styles of learners in their classrooms. Next I discussed the differences in the two groups of teacher's rationales for their teaching decisions. Overall, the traditionally certified teachers made more references to their preparation program when they discussed their rationales for teaching decisions than did their alternatively certified peers.

Conclusion

In Chapter 4, I presented my findings from the data collected in this study. I started by providing a description of each participant individually, including information about their preparation program. Following the general preparation program information for each individual case, I provided the information obtained from part one of the first interview in which I asked questions about participant's perceptions of their preparation experiences. Next, I included information gained from part two of the first interview, during which I asked questions related to the three tenants of situated learning theory.

In the next part of presenting each participant's individual case, I described an overview of their first videotaped lesson followed by the MQI ratings assigned to that lesson using two domains of the MQI, Richness of the Mathematics and Errors and Imprecision. I did the same for each participant's second video. Following the descriptions of that data, I described the data collected from the second interview with each participant, during which I asked questions about teacher's perceptions of their pathway's effect on the MQI scores of their videotaped lessons.

Next, I presented a within case analysis of the traditionally certified teacher's cases where I identified themes between their perceptions of their preparation programs using the three tenants of situated learning theory as well as the parts of their programs they identified as most helpful and as missing. In the second part of the within case analysis of traditionally certified teachers, I identified common themes between the data from the second interviews, during which I asked teachers about their perceptions of their preparation programs with respect to the impact the program experiences may have had on the quality of their mathematics teaching as reported by the MQI. I repeated this two-part process for the two alternatively certified teachers at the end of the section.

After the within cases analysis, through which I compared data between the two traditionally certified teacher, then between the two alternatively certified teachers, I presented a cross case analysis of traditionally and alternatively certified teachers in two parts. In the first section, I identified commonalities and differences between the program structure between the two groups. Then I identified commonalities and differences of the teacher program perceptions between the two groups. Finally, in the last section of Chapter 4, I presented the second part of the cross-case analysis, in which I described the perceptions of two groups preparation program's impact on the quality of their mathematics teaching as scored by the MQI. In this final section I described the two groups MQI Scores, the similarities in rationales for their teaching decisions, and the differences in rationales for their teaching decisions.

In the next Chapter, I present a summary of the findings from my study followed by a section in which I revisit the research discussed in my literature review. I present implications for teacher education programs to consider in both traditional and alternative certification preparation programs, as well as some questions for school district induction programs to consider. I discuss possible connections between my study's findings and two sets of standards that guide teacher preparation. Finally, I present some recommendations for further research.

Chapter 5: Discussion

Introduction

In this chapter, I start by presenting an overview of this study and a summary of the findings. Next, I revisit some of the existing literature presented in my literature review and identify areas in which the findings from my study fit in, discussing areas where the findings are similar and different. Then I discuss implications for teacher preparation programs and recommendations for future research. I end with a conclusion in which I highlight my insights and reflections from conducting the study.

This multiple case study aimed to capture the ways in which novice mathematics teachers perceived their preparation pathway as having an impact on their teaching decisions. The following question guided my research: In what ways, if any, do novice teachers perceive their preparation path (alternative or traditional) as having an impact on the quality of their mathematics instruction as measured by scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI? The current research on alternatively certified mathematics teachers and their instructional performance in the classroom is scant, and this study added to the literature base by comparing teacher perceptions of traditional and alternative certification routes and their impact on the mathematical quality of instruction.

I collected and analyzed both qualitative and quantitative data in order to have multiple sources of data to identify connections between teachers' perceptions of their preparation program and its potential impact on their teaching decisions. In the first interview, I asked participants questions to gain general information about their preparation program. I also asked questions informed by the tenets of situated learning theory, the framework guiding my study. I collected two video-taped lessons from each participant and scored them using the Mathematical Quality of Instruction instrument (MQI). Finally, I interviewed each participant a second time, asking questions related to their scores on the MQI and the rationale for their teaching decisions in the videotaped lessons. I coded the interview data and identified themes within and between cases, as well as making comparisons to the MQI scores. In the next section, I present a summary of my findings.

Summary of Findings

In this section, I present the summary of findings for the within case analyses first, followed by the summary of findings for the cross-case analysis.

Summary of Within Case Analysis for Traditionally Certified Teachers: I used the tenets of situated learning theory to analyze similarities and differences in each participant's perceptions of the context of their preparation experiences. Both traditionally certified teachers agreed that the internship and practicum experiences were most useful, and both recalled similar experiences about working with peers often during their preparation program, specifically on group projects. They had different perceptions of the components of their preparation programs that were helpful, Allison discussed the lesson planning experiences and Cindy mentioned her mathematics courses. They also had different perceptions of the components of their preparation programs that were missing. While Allison would have liked more instruction on how to complete IEP paperwork and would have liked her education coursework to be more math-specific, Cindy would've liked to learn about computer programs she would use as a teacher and would have liked more exposure to different types of students. They expanded on these perceptions during the second interview, which included analysis of their scores on the MQI.

The three themes that emerged from the second interview with the traditionally certified teachers were based on perceptions of the influence of their preparation program on their teaching decisions evidenced in the videotaped lessons. These themes were learning styles, colleagues, and internship, and were referenced most often by the traditionally certified teacher participants when explaining their rationales for teaching decisions they made during their videotaped lessons that influenced their scores on the MQI.

Summary of Within Case Analysis for Alternatively Certified Teachers: I repeated the same protocol used with the traditionally certified teachers and used the tenets of situated learning theory to analyze the perceptions from Jessica and Stephanie about their preparation experiences. They both recalled experiences where instructors asked them to use situations from the teaching experiences they encountered during coursework to learn and practice effective teaching strategies. Both credited the ability to socialize with their current colleagues for much of the knowledge they gained and identified social interaction with peers in their preparation programs as one of the highlights. When they identified components of their preparation programs that were helpful, Jessica and Stephanie both mentioned their instructors, but while Jessica mentioned specifically the classroom management course she took as well as the ability to learn from others in the program, Stephanie cited the resources she received as well as the mentors with whom she worked as most helpful. Their perceptions of the missing components of their program were almost identical, as both would have liked their preparation program to include more coursework, strategies, and experiences specifically related to mathematics teaching.

Four themes emerged from Jessica and Stephanie's perceptions of the influence of their preparation program on their teaching decisions evident in the videotaped lessons. These themes were colleagues, learning styles, high stakes testing, and resources, and were referenced most often by the alternatively certified teacher participants when explaining their rationales for teaching decisions they made during their videotaped lessons that influenced their scores on the MQI. These teachers also used these themes to describe experiences they have had in their current teaching context.

Summary of Cross-Case Analysis: Three general themes emerged from the discussion of the general preparation programs perceptions of all four teachers. All four teachers agreed that their preparation programs took place in an authentic context in which experiences provided were like those that they would provide for their own students. They also agreed that their preparation programs included social interaction experiences deemed by both groups as important throughout their preparation experiences and provided opportunities for reflection. The major differences between the perceptions of the traditionally and alternatively certified teachers emerged when they discussed the most helpful and the missing parts of their preparation programs. Both traditionally certified teachers agreed that their practicum and internship experiences were the most helpful, whereas the alternatively certified teachers identified their instructors and mentors as being most helpful. The traditionally certified teachers identified more logistical components about paperwork and computer programs as missing from their program, while the alternatively certified teachers wish their programs had more learning experiences specific to mathematics teaching, as their programs were both non-subject specific.

When asked about their rationales for the teaching decisions they made during their videotaped lessons, all four teachers referenced the importance of accommodating the different learning styles of students in their classes and the importance of learning from and collaborating with other colleagues. The differences in their rationales were seen when traditionally certified teachers credited their internship experiences as their rationale for teaching decisions while the alternatively certified teachers more often referenced resources they found on their own, the need to prepare students for high stakes testing, or their own former K-12 and college teachers as the rationales for their teaching decisions.

MQI Scores Summary: When comparing their scores on the Richness of the Mathematics and Errors and Imprecision domains of the MQI, some trends emerged. The two alternatively certified teachers scored higher than their traditionally certified colleagues in the Explanations and Mathematical Sense Making subdomains within the Richness of the Mathematics domain. The traditionally certified teachers did not score higher than the alternatively certified teachers in any of the subdomains. In all other subdomains of the Richness of the Mathematics domain as well as the Errors and Imprecision domain, the two groups of teachers had either similar or mixed results. Despite these apparent trends, it is important to note that in a qualitative study, it is not appropriate to generalize to the entire groups of teachers prepared this way. However, the interview findings gave insight into the different factors that may have influenced teacher decision making during their videotaped mathematics lessons. The performance of these four teachers based on their MQI scores defies some of the assumptions already established in the field about the impact of teacher preparation experiences on the quality of mathematics instruction.

Revisiting the Literature Review

In this section, I remind the reader of some of the existing research that has been conducted comparing types of teacher certification pathways that I discussed in my literature review in chapter two. I then identify how the findings from my study fit into this existing research, identifying areas where the findings are similar and different.

Most studies comparing alternatively and traditionally certified teachers used quantitative methods to compare teachers based on a number of factors such as student achievement, teacher SAT scores, licensure test scores, content knowledge, and attitudes (Bonner et al., 2013, Boone et al., 2009, Boyd et al., 2010, Evans, 2010, Goldhaber and Brewer, 2000, Kirby et al., 1989, Schmidt et al., 2011, Shen, 1999, Tai et al., 2006). These studies showed varied results, making it hard to reach a conclusion about the effectiveness of any of the preparation program pathways. My study helped fill in the gaps as it used teacher perceptions and scores on the MQI to gain knowledge about the factors influencing teaching decisions made by traditionally and alternatively certified teachers related to their preparation experiences.

Research on Pedagogical Content Knowledge for Teaching (Shulman, 1986) suggests that there is teacher knowledge used in classrooms beyond formal subject matter knowledge and implies effective teachers possess a strong sense of pedagogical content knowledge. This type of knowledge goes beyond knowledge of subject matter and focuses on the ways of representing and formulating the subject to make it understandable to others (Shulman, 1986). In order to possess a strong sense of pedagogical content knowledge, one would assume that a teacher would learn these skills in their preparation program, specifically in the courses which focus on teaching methods.

More specific to my study is a framework that is an extension of Shulmans work called Mathematical Knowledge for Teaching (MKT). This framework was developed from studies that analyzed what teachers do as they teach mathematics and what they need to know to successfully teach mathematics (Ball, Thames, and Phelps, 2008). The framework consists of subject matter knowledge and pedagogical content knowledge which together represent the mathematical knowledge needed to perform the often repeated tasks of teaching students mathematics. In the articles referenced in my literature review, “mathematical knowledge for teaching” means “not only the mathematical knowledge common to individuals working in diverse professions, but also the subject matter knowledge that supports that teaching, for example why and how specific mathematical procedures work, how best to define a mathematical term for a particular grade level, and the types of errors students are likely to make with particular content” (Hill et al., 2008).

Ball, Thames, and Phelps (2008) discuss factors that make mathematical knowledge for teaching special. Many of these factors are similar to those measured in the Richness of the Mathematics and Errors and Imprecision domains of the MQI. These factors include sizing up student errors, knowing rationales for procedures, meanings of terms, explanation of content, considering what numbers are appropriate to use in examples, and more. That study also asserts that knowing and being able to use the mathematics required inside the work of teaching is what seems most important. This implied that teachers who can perform these tasks while teaching were prepared in programs that included learning and experiences specific to the teaching of mathematics, an idea that is not true for the alternatively certified teachers in my study.

The findings of my study challenge these assumptions as the alternatively certified teachers scored either higher, just as higher, or similarly as did their traditionally certified colleagues in the areas of the MQI where pedagogical content knowledge may be displayed. For example, in two of the subdomains under the Richness of the Mathematics domain, Explanations and Multiple Procedures or Solution Methods, the two alternatively certified participants scored higher than the traditionally certified participants. Within the Explanations the subdomain teachers are expected to explain why a procedure works or doesn’t work, why a solution method is appropriate or inappropriate, and why answer is true or not. All these skills fall under mathematical knowledge for teaching and if the assumption were true, the traditional certified teachers would be expected to score higher in this subdomain. The same is true for the Multiple Procedures or Solution Methods subdomain of the MQI. Within this category, teachers are expected to use multiple solution methods for a single problem and take different approaches to solving mathematical problems. These skills, like those housed in the Explanations subdomain, fall under mathematical content knowledge and therefore, one would assume the traditionally certified teachers would have scored higher in that subdomain.

Similarly, in the Errors and Imprecision domain of the MQI, two of the subdomains represent knowledge that could be categorized as Mathematical Knowledge for Teaching. Since part of the definition provided by Hill et al. (2008) for MKT implies teachers ability to explain why and how mathematical procedures work, we can assume that the Mathematical Content Errors and Imprecision subdomains relate to this specified knowledge. The Mathematical Content Errors subdomain is intended to capture events that are mathematically incorrect, such as forgetting a key condition in a definition or solving a problem incorrectly. The Imprecision domain captures errors in notation, mathematical language, or general language. In these two subdomains, both groups of teachers scored similarly on the MQI, all showing low instances of errors and imprecision. These findings contradict commonly held assumptions in the field, which imply teachers having specific training through their preparation experiences would makes less errors than those who were not specifically training in mathematical teaching.

Another aspect of my literature review discusses the ability of teacher preparation programs, both traditional and alternative, to prepare adequately teachers to teach on their own. One study that discusses the importance of content knowledge in teacher preparation states that "The most serious objection to alternative certification programs is that, given their limited training, their graduates might be much less effective than teachers who were prepared in traditional 4- to 5-year programs" (Schmidt et al., 2020). Though there are many different ways to measure teacher effectiveness, the results of my study indicate that the above statement is not always true and in fact, teachers prepared in alternative certification programs, in this study, were equally or more effective as measured by the Richness of the Mathematics and Errors and Imprecision domains of the MQI.

Similarly, another aspect through which my study fits into the existing literature comes from a perspective offered from the National Research Council (2001). They posit that "teachers may have completed their courses successfully without achieving mathematical proficiency…or they may have learned the mathematics but not know how to use it in their teaching to help students learn. They may have learned mathematics that is not well connected to what they teach or may not know how to connect it." This existing research is important to consider so that we don't assume that teachers who have matriculated through a traditional preparation program are equipped with the MKT and skills needed to effectively teach students mathematics. These statements remind us that we cannot make assumptions about what a novice teacher knows or is able to do based on assumptions about their preparation experiences, as the variance in those experience could be vast. Rather, we must consider the teacher's experiences separately in order to make decisions about the support they need.

A final area of my literature review discussed studies that utilize the MQI to measure teachers' teaching quality (Hill, Kapitula, and Umland, 2011; Hill, Umland, Litke, and Kapitula, 2012; Hill, Blunk, Charalamnous, Lewis, Phelps, Sleep, and Ball, 2008; Hill, Charalambous, Blazar, McGinn, Kraft, Beisiegel, Humez, Likte, and Lynch, 2012; Hill, Charalambous, and Kraft, 2012; Kelcey, McGinn, and Hill, 2014). However, most of these studies examine the quantitative relationship between the MQI and another measure, such as teacher levels of MKT, and most found significant positive associations between levels of MKT and mathematical quality of instruction as measured by the MQI (Hill et al., 2008). These studies, however, did not account for differences in preparation pathway. Since my study did not account for teachers MKT levels, I cannot make connections between these levels and their MQI scores. My findings do raise the question, however, about where teachers learn MKT skills. If the assumption is that teachers learn these skills in their preparation programs, how could the alternatively certified teachers in this study have learned these skills? According to the previous studies linking teacher scores on the MQI to their MKT, one would think that the teachers in my study would have high levels of MKT to match their high scores on the MQI. To account for this phenomenon, the alternatively certified teachers in my study must have learned MKT skills in a setting other than their preparation program, since mathematics specific pedagogy was not part of their preparation experiences. Perhaps they learned these skills from their own experiences as learners, from other colleagues, or from doing their own research and using their own resources.

Revisiting Situated Learning Theory

In this section, I identify how the findings from my study fit into this existing research surrounding Situated Learning Theory, the theoretical framework I used as a lens through which to interpret the results. Several existing studies I discussed in my literature review suggest that programs informed by elements of situated learning theory have been effective when implemented in teacher preparation programs as a method of instruction for preservice teachers (Bell, Maeng and Binns, 2013; Herrington and Oliver, 2000; Koehler, Mishra, and Yahya, 2007; Vannatta, Beyerbach and Walsh, 2001). For example, findings from the study by Herrington and Oliver (2000) suggest that "the use of the situated learning framework provided effective instructional design guidelines…for the acquisition of advanced knowledge." Some of the preparation programs mentioned in the research that have a foundation in situated learning theory aimed to connect learning to the classroom environment, encouraging students to apply their knowledge and understanding to this authentic context (Green, Eady, and Anderson, 2018). Other studies posit that programs founded on key tenets of situated learning theory will be more effective than the traditional decontextualized approach when preparing teachers (Bell, Maeng, and Binns, 2013; Green, Eady, and Anderson, 2018). All these studies discuss the effectiveness of using the tenets of situated learning theory when designing programs to prepare preservice teachers.

I used the components of situated learning theory to gain a deeper understanding of how participant's involvement in their respective teacher preparation program, whether traditional or alternative, possibly had an impact on their preparation experiences as well as their experiences as a novice. I gathered data via interview questions related to the three tenets of situated learning theory: authentic context, social interaction, and constructivist learning approach, and the role that each played in their preparation programs. The findings showed that from their perceptions, all four of my novice teacher participants' preparation experiences took place in an authentic context where the experiences in which they participated were similar to those they would have their own students participate. Each teacher participant, regardless of their preparation pathway, recalled experiences throughout their preparation that took place in an authentic content, included social interaction experiences, and utilized the constructivist learning approach. If the existing research holds true that programs informed by the tenants of situated learning theory are effective in teacher preparation settings, we can assume that, based on their perceptions, all of the teachers in this study had effective preparation experiences when viewed through the lens of situated learning theory.

In this section, I identified areas of the existing literature surrounding pedagogical content knowledge, mathematical knowledge for teaching, the MQI, and situated learning theory that I discussed in chapter two as they apply to teacher certification pathways. I explained the ways in which the findings from my study fit into this existing research as well as discussing the similarities and differences between previous research findings and the findings from my study. In the next section I present implications for practice for teacher educators in traditional and alternative certification preparation programs, as well as those educators who make decisions about teacher induction programs.

Implications

The findings I have presented in this chapter have implications for teacher preparation programs and teacher induction programs for both traditionally and alternatively certified teachers. In this section, I discuss those implications in three sections; those pertaining to traditional teacher preparation programs, those pertaining to alternative preparation programs, and those pertaining to school districts induction programs for novice teachers.

Teacher Education in Traditional Preparation Programs: The findings presented have implications for teacher educators in traditional preparation program settings. First, the most beneficial aspect of traditional preparation programs according to my participants are the clinical experiences. Since that is the case, traditional preparation programs might consider establishing strong partnerships with surrounding districts and consider providing classroom experiences for prospective teachers as much as possible throughout their program. This may require teacher educators in traditional preparation programs to re-structure their programs so that they are more clinically rich. Perhaps, in order to make that possible, some coursework could either be replaced with clinical experiences or could include a clinical component.

These recommendations are consistent with the recommendations presented by the National Council for the Accreditation of Teacher Education's (NCATE) Blue Ribbon Panel Report (BRPR) and The National Association for Professional Development Schools (NAPDS). One of the major categories in which the BRPR's Ten Principles and NAPDS' nine essentials for clinically rich programs align is the first major category which calls for deliberate, planned partnerships and "clear and comprehensive definitions of the commitment and responsibilities of all parties involved with and impacted by teacher education programs" (Van Scoy, 2012). These documents describe the importance of the intentional creation of programs that reinforce partnerships between school districts and teacher education programs. They also recognize that ''teacher preparation programs and districts have to start thinking about teacher preparation as a responsibility they share, working together."

Another aspect for teacher educators in traditional preparation programs to consider is the connection between the courses offered in the mathematics department and those offered through the college of education. Both traditionally certified participants discussed the disconnect between mathematics courses and college of education courses. Though they had different perceptions of the usefulness of courses in both departments, perhaps the coursework could have been more beneficial if there were a connection between the two, so that prospective teachers in the courses received a consistent message or were able to observe best practices throughout all of their coursework. This feedback from the traditionally certified teacher participants could inform the field and could provide potential avenues for improvement for mathematics departments and colleges of educations on the same campuses to collaborate and send a unified message to their students.

Teacher Education in Alternative Preparation Programs: The most evident component revealed from the analysis of the alternatively certified teacher's perceptions is the lack of mathematics specific coursework within their alternative preparation pathway. The alternative teacher participants in this study relied on their colleagues and their own experiences to learn successful techniques for teaching mathematics. Teacher educators in alternative preparation programs might consider adding a content specific component to their preparation pathways to better prepare their prospective teachers. Doing so would help mathematics teachers learn how to apply the general strategies and pedagogy learned in their general preparation courses to the mathematics classroom.

Another aspect of their preparation both alternatively certified participants discussed was the lack of mathematics teacher educators facilitating their coursework. Though they discussed the helpfulness of their trainers, they did not recall having any trainers who had experience teaching mathematics. Therefore, one implication for school district leaders planning and implementing alternative certification courses and experiences is to build capacity in trainers of all subjects and select them carefully to ensure alternative certification program participants learn from those who have experience in the best practices and strategies relevant to mathematics teaching.

In addition, since the traditionally certified teachers stressed the importance of their practicum and internship experiences on their success as effective mathematics teachers, perhaps alternative certification programs could set up similar experiences for their novice teachers. The process would obviously look different, as the alternatively certified teachers are experiencing their preparation simultaneously with teaching, however the experience of working with experienced teachers in the field could be beneficial. Maybe alternatively certified teachers enrolled in alternative preparation programs could have an additional planning period in which they shadow or observe other teachers on campus. These teachers could then have an opportunity to debrief with their mentor or colleagues to maximize the learning from their observations.

A final consideration for educators of alternative teacher certification programs is to establish a partnership with surrounding university preparation program. Rather than seeing each other as competitors, the school district and surrounding university could partner to ensure prospective teachers receive the support their need to become successful mathematics teachers. Perhaps the school district could rely on expertise from the university professors to teach content specific pedagogy to alternatively certified teachers, to account for the missing piece of current alternative certification programs which lack subject specific instruction.

School District Induction Program Considerations: If it is in fact true that "the overwhelming majority of subject matter courses for teachers, and teacher education courses in general, are viewed by teachers, policy makers, and society at large as having little bearing on the day-to-day realities of teaching" (Ball, Thames, and Phelps, 2008) it is imperative that school district induction programs plan experiences for teachers that help fill in the potential gaps that novice teachers have, regardless of the type of teacher preparation program through which they matriculated. When I asked traditionally and alternatively certified teachers about the rationales for their teaching decisions, they named some factors related to in-service teaching, not just factors related to preparation experiences. Because of this, it is useful that I address the considerations that school district induction programs could consider in order to best support novice teachers in their first few years.

First and foremost, it is clear from my findings that the variability between and within teacher preparation programs is vast. Knowing this, it is important for school district educators who are charged with planning and facilitating induction programs to plan questions that can help identify teacher strengths and potential gaps in knowledge so their induction practices can best meet the needs of the new teachers in their district.

The data collected from both traditionally and alternatively certified teachers provides evidence to support the importance of collaboration with colleagues, both during preparation and in the field. School district induction programs for novice teachers might consider a component in which teachers are encouraged to collaborate with their colleagues, perhaps in situations such as learning walks or classroom visits where experienced teachers open their classrooms to novice teachers so they can observe and learn from teacher leaders on their school campus.

Currently, in the county in which this study was conducted, all teachers new to the profession or new to the district are strongly encouraged to attend the district sponsored induction program. The program consists of sessions tailored to different aspects of teaching that are not subject specific, such as classroom management, lesson planning, teacher evaluation, and district procedures. In addition, new teachers are asked to attend content area training led by district professionals in their subject area. As the induction program stands currently, courses are not differentiated to meet the needs to teachers who bring various preparation experiences and background knowledge, but rather all teachers receive the same one-size-fits-all information in the sessions. After the courses, which take place before the school year begins, the induction program continues with teachers receiving support from a mentor. Again, teacher’s prior preparation experiences and knowledge about teaching are not taken into consideration, but rather the same one-size-fits-all approached is utilized.

Induction educators within districts need more information about the preparation experiences and backgrounds of their participants in order to meet the needs more efficiently and prepare teachers for teaching on their own by building off of their experiences and attempting to fill in any gaps that prospective teachers may have from preparation. It is imperative for induction program educators to realize the difference between a new teacher who has matriculated through a traditional four-year preparation program, and those who have recently signed up for the alternative certification program and will start teaching, potentially without any prior learning about teaching. Because of the variability between experiences of teachers attending induction programs, it is imperative for induction program planning and facilitating to include the opportunity for novice teachers to describe their prior preparation experiences. Below is a figure including questions that induction program educators could consider asking, with the intention of using the answers to group novice teachers during induction in ways that will best meet their needs. Teacher induction professionals could start by asking novice teachers if they attended a traditional four-year university preparation program for teacher education. Based on their answer, the following questions could follow.

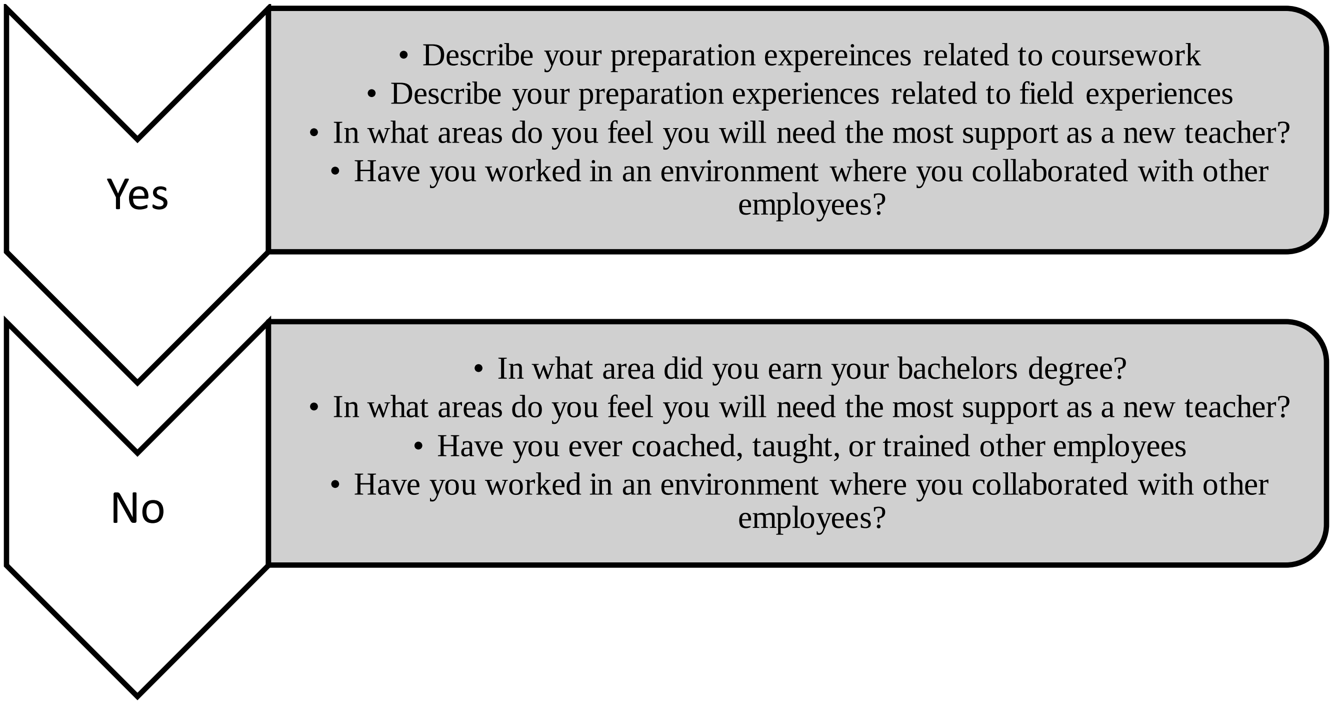


Figure 5. *Possible Questions to Ask Novice Teachers During Induction*

In this section, I presented implications for teacher preparation programs and teacher induction programs for both traditionally and alternatively certified teachers. In the next section I discuss two groups of standards that are important to consult when considering how to use the findings from this study to inform planning teacher preparation and induction programs.

Connection to the Standards

Now that I have presented implications for preservice and inservice teacher preparation, I am now going to consider these implications through the lens of related standards. Two groups of standards are important to discuss in relation to my study and the implications its findings have on the future preparation of teachers. In this section, I discuss each set of standards, their relation to the findings revealed in my study, and their importance in future planning and considerations of teacher preparation programs, both traditional and alternative.

Teacher Induction Program Standards (TIPS). The first set of standards was developed by New Teacher Center and are called the Teach Induction Program Standards (TIPS). New Teacher Center works with state and policy-making agencies, school districts, and other educational institutions to define the elements of high-quality teacher induction programs that support the development of new teachers. Their goal is to define the characteristics of an effective program that will develop new teacher effectiveness and improve teacher retention, all in an effort to increase student achievement. The TIPS are a result of their years of collaboration and program implementation. These standards are separated into three categories; foundational standards, structural standards, and instructional standards. The foundational standards can be viewed at the platform that houses the basis of program design and implementation. The structural standards are the components of the program, practices, and activities in which novice teachers will partake. Lastly, the instructional standards focus on teacher best practices and student achievement (NTC).

For the purposes of discussing implications for teacher induction programs within school districts, I identified the NTC induction standards that connect to novice teacher's preparation experiences. The standards and their description are represented in the table below.

Table 42

Questions to Consider around the New Teacher Induction Standards

Standard	Description	Key Indicator Related to Preparation	Questions to Consider
1.1	Program leader and key decision-makers create a program vision, mission, and program design focused on advancing student learning and accelerating beginning teacher effectiveness within a comprehensive system of development for all educators.	How do we align and provide continuity from teacher preparation to recruitment and initial hire, the first years of teaching, and on through advanced levels of practice?	What about those teachers who are experiencing preparation during their first year of teaching through an alternative route?
1.5	Program leader and key decision-makers ensure that a broad coalition of stakeholders are well-informed and collaborate on and advocate for effective, research-based program implementation that aligns with the institution's vision, mission, and instructional priorities.	Who are the parties in this agreement and what stakeholder groups do they represent (e.g., school leaders, community groups, teacher preparation programs, district leaders, unions/teacher associations, school board members, program alumni, teacher leaders)?	What role do each of these stakeholders play in supporting new teachers and do those roles look different for traditionally and alternatively certified teachers?
2.3	Program leader collaborates and coordinates with organizational leaders to ensure that the program's vision and mission, goals, design, and practices align with teacher preparation, professional learning, leadership development programs, and teacher/school leader evaluation.	How do we work with universities to ensure that their graduates are prepared to succeed in the induction program?	Are the program's visions aligned to all types of preparation, or just those that occur in the traditional University setting?

One major noticing I had when reading these standards is the lack of account for supporting teachers in induction other than those who were prepared in a traditional setting at a university through a college of education. My questions to consider are important for school districts to examine to ensure that all teachers are receiving the support they need through induction. The one-size-fits-all approach to induction program support of new teachers may not be adequate for teachers with varying experiences and knowledge.

AMTE Standards for Preparing Teachers of Mathematics. The Association of Mathematics Teacher Educators (AMTE, 2017) published standards for preparing teachers of mathematics. These standards are guided by five foundational assumptions: (1) ensuring the success of each and every learning requires a deep, integrated focus on equity in every program that prepares teachers of mathematics, (2) teaching mathematics effectively requires career-long learning, (3) learning to teach mathematics requires a central focus on mathematics, (4) multiple stakeholders must be responsible for and invested in preparing teachers of mathematics, and (5) those involved in mathematics teacher preparation must be committed to improving their effectiveness in preparing future teachers of mathematics. The AMTE (2017) standards document also describes what beginning teachers of mathematics should know and be able to do, as well as the dispositions they should develop. These standards can provide direction for teacher educator educators when planning preparation programs of study. The standards are written to address preparation programs that occur in a traditional University setting through a college of education. If the goal is to prepare all math teachers to deliver effective mathematics instruction, it seems obvious that all mathematics teacher's preparation programs should be governed by these standards, regardless of whether the preparation program is traditional or alternative.

The table below outlines each of the assumptions, the connections to those assumptions based on the findings from my study, and wonderings for future preparation.

Table 43
AMTE Assumptions, Teacher Experiences, and Wonderings

5 AMTE Assumptions	Experiences of Traditionally Certified Teachers in my Study	Experiences of Alternatively Certified Teachers in my Study	Wonderings
Ensuring the success of each and every learner requires a deep, integrated focus on equity in every program that prepares teachers of mathematics.	Recall learning about equity and diverse learners in prep program	Recall learning about equity and diverse learners in prep program	It appears that both types of preparation programs my participants experiences addressed this assumption.
Teaching mathematics effectively requires career-long learning	Recall professional development and learning from other colleagues within novice years	Recall professional development and learning from other colleagues within novice years	Are these learning experiences sought out by teachers or provided?
Learning to teach mathematics requires a central focus on mathematics	Preparation programs included math methods courses and math content courses	Preparation programs did not contain any math specific learning experiences	Both groups of teachers learned to teach with quality (MQI) but alt. cert teachers' programs did not have a central focus on mathematics.
Multiple stakeholders must be responsible for an invested in preparing teachers of mathematics.	Preparation experiences included work with professors, cooperating teachers, students, parents, school personnel	Preparation experiences included work with school district trainers, site-based colleagues, and peers	It appears that both types of preparation program participant experiences addressed this assumption.
Those involved in mathematics teacher preparation must be committed to improving their effectiveness in preparing future teachers of mathematics.	Preparation experiences included learning from math professors and college of education professors.	Lack of instructors with mathematics teaching experience in preparation coursework	How important is it for preparation experience facilitators to have successful mathematics teaching experience?

AMTE posits that the assumptions underlie the standards and "reflect the emerging consensus of those involved in mathematics teacher preparation in response to the needs of both their teacher candidates and the students those candidates will teach" (AMTE, 2017). It is clear from the findings of my study that the AMTE assumptions are not met by the preparation pathways and experiences through which my alternatively certified participants matriculated. Two potential lines of thinking come to mind when considering these standards in relation to my study; (1) It is imperative that teacher educators who prepare mathematics teachers in alternative preparation programs are aware of these standards and adjust the coursework and experiences within their program to reflect the assumptions and standards, or (2) the AMTE standards could be amended, or another version published, to account for teachers prepared through an alternative certification program.

Future Research

In the previous section, I discussed the implications for teacher education in traditional and alternative preparation programs, as well as implications for educators of teacher induction programs for novice teachers. I also discussed two important groups of standards that impact mathematics teacher preparation and induction. In this section, I make recommendations for future research in the area of teacher preparation pathway and its potential effect on the quality of a teacher's instruction.

It is clear from my findings that many factors contribute to the quality of a mathematics teacher's instruction. Teacher perceptions about the effectiveness of their preparation and the reasoning behind their teaching decisions is valuable information for the future of teacher education and preparation. In order to add to the growing body of research about the potential ways in which teacher's preparation pathway has an impact on the quality of their mathematics instruction, I make several recommendations for future research.

First, future research could include qualitative studies that use interviews to probe teachers to think about why they make the teaching decisions they do, and what factors influence those decisions. School administrators and mentors who conduct teacher evaluations could add a component during the post conference where they ask teachers to describe their rationales for teaching decisions. This data could then be collected and shared with teacher educators who make decisions about preparation program coursework and experiences, who could then use it to modify their programs accordingly. Research in this area could inform teacher preparation programs by giving insight into the most important factors influencing teaching decisions, and programs could account for those factors during preparation experiences.

Another important area to consider for future research is the evaluation of teacher preparation program effectiveness. Currently, it is difficult to evaluate the effectiveness of a teacher preparation program due to the complexities of teaching as a profession. The American Psychologicial Association has identified three methods to assess teacher education program effectiveness. These methods are: (1) value-added assessments of student achievement, (2) standardized observation protocols, and (3) surveys of teacher performance. The association claims that "these methodologies can be used by institutions to demonstrate that the teacher candidates who complete their programs are well prepared to support student learning" (APA paper). Though these methods may capture a portion of the effectiveness of a program, they do not include any aspects of teacher perceptions of their program or the effects of those perceptions on their teaching decisions. A final recommendation for future research includes improving the method used to evaluate teacher preparation programs in a way that considers the many factors that influence preparation program effectiveness. Evaluation of preparation programs involving an approach that considers using qualitative and quantitative data including teacher insight, could help create a better system for program evaluation while considering these factors.

Conclusion

Perhaps good teaching is so complex that there isn't a clearly discernable link to preparation experiences. For this reason, it is important to systematically examine the whole story of each mathematics teacher, including their pathway, induction, support, and continual professional development. It is not about which preparation pathway is better, but rather understanding what experiences teachers encounter in their pathway as well as understanding the variability within programs. When teacher preparation educators can understand the entire system, we can work together as a field to ensure mathematics teachers are fully prepared to teach mathematics effectively. We must think beyond preparation and think forward about the support our novice teachers will get. It is important to recognize that the work of preparing mathematics teachers does not stop after preparation, and that induction programs and inservice math teacher educators know what gaps to look for and what questions to ask. If we know, on an individual basis, what teachers need, we can provide opportunities for them to do gain that knowledge. My study exemplifies that how a teacher teaches is complicated, includes many factors, and is much more involved than just the experiences they encountered through their preparation pathway. To best prepare future teachers of mathematics, we must consider all these factors and treat each teacher as an individual with unique experiences, skills, and knowledge.

References

Abell, S., Boone, W., Arbaugh, F., Lannin, J., Beilfuss, M., Volkmann, M., and White, S. (2006). Recruiting future science and mathematics teachers into alternative certification programs: Strategies tried and lessons learned. *Journal of Science Teacher Education*, *17*(3), 165-183.

Adelman, N. E. (1986). An Exploratory Study of Teacher Alternative Certification and Retraining Programs.

Amrein-Beardsley, A. (2008). Methodological concerns about the Education Value-Added Assessment System (EVAAS). Educational Researcher, 37, 65–75. doi:10.3102/0013189X08316420

Amrein-Beardsley, A. (2014). Rethinking value-added models in education: Critical perspectives on tests and assessment-based accountability. New York, NY: Routledge.

Appling, S. E., Naumann, P. L., and Berk, R. A. (2001). Using a faculty evaluation triad to achieve evidence-based teaching. *Nursing and Health Care Perspectives*, *22*(5), 247-247.

Association of Mathematics Teacher Educators (2017). *Standards for Preparing Teachers of Mathematics*. Retrieved from amte.net/standards.

Ball, D. L., Thames, M. H., and Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59*(5), 389–407.

Bell, R. L., Maeng, J. L., and Binns, I. C. (2013). Learning in context: Technology integration in a teacher preparation program informed by situated learning theory. Journal of Research in Science Teaching, 50(3), 348–379, http://dx.doi.org/10.1002/tea.21075.

Berk, R. A. (2005). Survey of 12 strategies to measure teaching effectiveness. *International journal of teaching and learning in higher education*, *17*(1), 48-62.

Berliner, D. C. (1987). Simple views of effective teaching and a simple theory of classroom instruction. *Talks to teachers*, 93-110.

Berliner, D. C. (2005). The near impossibility of testing for teacher quality. *Journal of teacher education*, *56*(3), 205-213.

Bill and Melinda Gates Foundation. (2013). Ensuring fair and reliable measures of effective teaching: Culminating findings from the met project. Seattle, WA: Bill and Melinda Gates Foundation. Retrieved from http://www.metproject.org/downloads/MET_Ensuring_Fair_and_Reliable_Measures_Practitioner_Brief.pdf

Blazar, D., Braslow, D., Charalambous, C. Y., and Hill, H. C. (2017). Attending to general and mathematics-specific dimensions of teaching: Exploring factors across two observation instruments. *Educational Assessment*, *22*(2), 71-94.

Bonner, E. P., Ruiz, E. C., and Travis, B. (2013). Investigating Content Knowledge of Traditionally vs. Alternatively Prepared Pre-Service Secondary Mathematics Teachers. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, *1*.

Boone, W., Abell, S., Volkmann, M., Arbaugh, F., Lannin, J., Adelman, N. E., Policy, S. A. (2009). Evaluating selected perceptions of science and mathematics teachers in an alternative certification program. *International Journal of Science and Mathematics Education*, *9*(3), 551-569. doi:10.1007/s10763-010-9205-8

Boyd, D., Grossman, P., Hammerness, K., Lankford, H., Loeb, S., Ronfeldt, M., and Wyckoff, J. (2010). Recruiting effective math teachers: How do math immersion teachers compare?: Evidence from new york city. *NBER Working Papers*, 1.

Brantlinger, A., and Smith, B. (2013). Alternative Teacher Certification and the New Professionalism: The Pre-Service Preparation of Mathematics Teachers in the New York City Teaching Fellows Program. *Teachers College Record*, *115*(7), n7.

Calderhead, J. (1981). Stimulated recall: A method for research on teaching. *British journal of educational psychology*, *51*(2), 211-217.

Charalambous, C. Y., and Hill, H. C. (2012). Teacher knowledge, curriculum materials, and quality of instruction: Unpacking a complex relationship. Journal of Curriculum Studies, 44(4), 443–466. https://doi.org/10.1080/00220272.2011.650215.

Charmaz, K. (2006). *A pratical guide through qualitative analysis*. Sage.

Chesley, G. M., and Jordan, J. (2012). What's missing from teacher prep. *Educational Leadership*, *69*(8), 41-45.

Cohen, D., and Crabtree, B. (2006). Qualitative research guidelines project.

Cohen, D. K., Raudenbush, S. W., and Ball, D. L. (2003). Resources, instruction, and research. *Educational evaluation and policy analysis*, *25*(2), 119-142.

Common Core State Standards Initiative. (2010). Common *Core State Standards for Mathematics.* www.corestandards.org

Cox, A. (2005). What are communities of practice? A comparative review of four seminal works. *Journal of information science*, *31*(6), 527-540.

Creswell, J. W. (2011). Controversies in mixed methods research. *The Sage Handbook of Qualitative Research, 4*, 269-284. Retrieved from: http://www.sagepub.com.

Creswell, J. W., and Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Sage publications.

Creswell, J. W., and Poth, C. N. (2017). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications

Darling-Hammond, L. (1990). Teaching and knowledge: Policy issues posed by alternate certification for teachers. *Peabody Journal of education*, *67*(3), 123-154.

Darling-Hammond, L. (2000). How teacher education matters. *Journal of Teacher Education,* (3)

Darling-Hammond, L. (2009). Educational opportunity and alternative certification: New evidence and new questions. *Policy Brief, 1.*

Darling-Hammond, L., Barnett Berry, a., and Amy Thoreson, a. (2001). Does teacher certification matter? evaluating the evidence. *Educational Evaluation and Policy Analysis,* (1), 57.

Darling-Hammond, L., Chung, R., and Frelow, F. (2002). Variation in teacher preparation: How well do different pathways prepare teachers to teach?. *Journal of teacher education*, *53*(4), 286-302.

Drever, E. (1995). *Using Semi-Structured Interviews in Small-Scale Research. A Teacher's Guide*.

Edwards, R., Hyde, R., O'Connor, M., and Oldham, J. (2015). The importance of subject knowledge for mathematics teaching: An analysis of feedback from Subject Knowledge Enhancement Courses.

Evans, B. R. (2010). Secondary mathematics teacher differences: Teacher quality and preparation in a new york city alternative certification program. *Mathematics Educator, 20*(2), 24.

Evans, B. R. (2010). Determining quality teachers: Mathematical content knowledge, perceptions of teaching self-efficacy, and attitudes toward mathematics among a Teach for America cohort. *Journal of the National Association for Alternative Certification, 5*(2), 23-35.

Evans, B. R. (2011). Content knowledge, attitudes, and self-efficacy in the mathematics new york city teaching fellows (NYCTF) program. *School Science and Mathematics, 111*(5), 225-235.

Feuer, M. J., Floden, R. E., Chudowsky, N., and Ahn, J. (2013). *Evaluation of Teacher Preparation Programs: Purposes, Methods, and Policy Options*. National Academy of Education. 500 Fifth Street NW Suite 339, Washington, DC 20001.

Foote, M. Q., Brantlinger, A., Haydar, H. N., Smith, B., and Gonzalez, L. (2011). Are we supporting teacher success: Insights from an alternative route mathematics teacher certification program for urban public schools. *Education and Urban Society, 43*(3), 396.

Gardner, D. P. (1983). A nation at risk.

Glaser, B.G. (2000). The future of grounded theory. *Grounded Theory Review*, 1, 1 – 18.

Glaser, B.G (2014). No preconceptions: The grounded theory dictum. Mill Valley, CA: Sociology Press.

Goldhaber, D. D., and Brewer, D. J. (2000). Does teacher certification matter? High school teacher certification status and student achievement. *Educational Evaluation and Policy Analysis,* (2), 129.

Green, C., Eady, M. J., and Andersen, P. J. (2018). Preparing quality teachers: Bridging the gap between tertiary experiences and classroom realities.

Guarino, C. M., Lucrecia Santibaez, A., and Daley, G. A. (2006). Teacher recruitment and retention: A review of the recent empirical literature. *Review of Educational Research*, (2), 173.

Harris, D. N., and Sass, T. R. (2011). Teacher training, teacher quality and student achievement. *Journal of public economics*, *95*(7), 798-812.

Hawk, P., and Schmidt, M. W. (1989). Teacher preparation: A comparison of traditional and alternative programs. Journal of Teacher Education, 40 (5), 53–58.

Herrington, J., and Oliver, R. (2000). An instructional design framework for authentic learning environments. Educational Technology Research and Development, 48(3), 23–48.

Hill, H. C., and Ball, D. L. (2004). Learning mathematics for teaching: Results from California's mathematics professional development institutes. *Journal for research in mathematics education*, 330-351.

Hill, H. C., Blunk, M. L., Charalambous, C. Y., Lewis, J. M., Phelps, G. C., Sleep, L., and Ball, D. L. (2008). Mathematical knowledge for teaching and the mathematical quality of instruction: An exploratory study. *Cognition and Instruction*, *26*(4), 430-511.

Hill, H. C., Charalambous, C. Y., Blazar, D., McGinn, D., Kraft, M. A., Beisiegel, M., Humez, A., Litke, E., and Lynch, K. (2012). Validating arguments for observational instruments: Attending to multiple sources of variation. *Educational Assessment*, *17*(2-3), 88-106.

Hill, H. C., Charalambous, C. Y., and Kraft, M. A. (2012). When rater reliability is not enough: Teacher observation systems and a case for the generalizability study. *Educational Researcher*, *41*(2), 56-64.

Hill, H. C., Kapitula, L., and Umland, K. (2011). A validity argument approach to evaluating teacher value-added scores. *American Educational Research Journal*, *48*(3), 794-831.

Hill, H. C., Umland, K., Litke, E., and Kapitula, L. R. (2012). Teacher quality and quality teaching: Examining the relationship of a teacher assessment to practice. *American Journal of Education*, *118*(4), 489-519.

Humphrey, D. C., and Wechsler, M. E. (2007). Insights into alternative certification: Initial findings from a national study. *Teachers College Record*, *109*(3), 483-530.

Humphrey, D. C., Wechsler, M. E., and Hough, H. J. (2008). Characteristics of effective alternative teacher certification programs. *Teachers College Record*, *110*(1), 1-63.

Ilmer, S., Elliott, S., and Snyder, J. (2005). Analysis of urban teachers' 1st year experiences in an alternative certification program. *Action in Teacher Education*, *27*(1), 3-14.

Joyce, B. R., Weil, M., and Calhoun, E. (1986). *Models of teaching* (Vol. 499). Englewood Cliffs, NJ: Prentice-Hall.

Kane, T. J., and Staiger, D. O. (2012). Gathering Feedback for Teaching: Combining High-Quality Observations with Student Surveys and Achievement Gains. Policy and Practice Brief. MET Project. *Bill and Melinda Gates Foundation*.

Kelcey, B., McGinn, D., and Hill, H. (2014). Approximate measurement invariance in cross-classified rater-mediated assessments. *Frontiers in Psychology*, *5*, 1469.

Kirby, S. N., Darling-Hammond, L., and Hudson, L. (1989). Nontraditional recruits to mathematics and science teaching. *Educational Evaluation and Policy Analysis*, *11*, 301-323. doi:10.3102/01623737011003301

Koehler, M. J., Mishra, P., and Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers and Education*, *49*(3), 740-762.

Kupermintz, H. (2003). Teacher effects and teacher effectiveness: A validity investigation of the Tennessee Value-Added Assessment System. Educational Evaluation and Policy Analysis, 25, 287–298

Lave, J. (2009). The practice of learning. *Contemporary theories of learning*, 200-208.

Lave, J., and Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge, UK: Cambridge University Press

Leech, N. L., and Onwuegbuzie, A. J. (2007). An array of qualitative data analysis tools: a call for data analysis triangulation. *School psychology quarterly*, *22*(4), 557.

Leonard, D. (2002). Learning theories: A to Z. Westport, CT: Greenwood Press

Loewenberg Ball, D., Thames, M. H., and Phelps, G. (2008). Content knowledge for teaching: What makes it special?. *Journal of teacher education*, *59*(5), 389-407.

Ludlow, C. (2013). Alternative certification pathways: Filling a gap? *Education and Urban Society*, *45*(4), 440.

Matlock, K. L., Goering, C. Z., Endacott, J., Collet, V. S., Denny, G. S., Jennings-Davis, J., and Wright, G. P. (2016). Teachers' views of the Common Core State Standards and its implementation. *Educational Review*, *68*(3), 291-305.

McCaffrey, D. F., Lockwood, J. R., Koretz, D., Louis, T. A., and Hamilton, L. (2004a). Let's see more empirical studies on valueadded modeling of teacher effects: A reply to Raudenbush, Rubin, Stuart and Zanutto, and Reckase. Journal of Educational and Behavioral Statistics, 29(1), 139–143.

McDiarmid, G. W., and Wilson, S. M. (1991). An exploration of the subject matter and knowledge of alternative route teachers: Can we assure they know their subject? Journal of Teacher Education, 42(2), 93-103.

Merriam, S. B. (2009*). Qualitative research: A guide to design and implementation: Revised and expanded from qualitative research and case study applications in education*. San Francisco, CA: Jossey-Bass.

Miles, M., Huberman, A. M., and Saldana, J. (2014). Qualitative Data Analysis: a methods sourcebook (3rd ed.). Thousand Oakes, California: Sage

Moffett, E. T. and Davis, B. L. 2. (2014). The road to teacher certification: Does it matter how you get there? *National Teacher Education Journal*, *7*(4), 17-26.

Monk, D. H. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. *Economics of education review*, *13*(2), 125-145.

Morse, J. M. (2003). Principles of mixed methods and multimethod research design. *Handbook of mixed methods in social and behavioral research*, *1*, 189-208.

Muijs, D., and Reynolds, D. (2017). *Effective teaching: Evidence and practice*. Sage.

National Research Council. (2001). *Adding it up: Helping children learn mathematics.* J. Kilpatrick, J. Swafford, and B. Findell (Eds.). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, D.C.: National Academy Press.

New Teacher Center TIPS Standards (https://info.newteachercenter.org/l/576393/2018-08-14/3476ddg)

Orgill, M. (2007). Situated cognition. In G. M. Bodner and M. Orgill (Eds.), Theoretical frameworks for research in chemistry/science education (pp. 187–203). Upper Saddle River, NJ: Prentice Hall.

Paige, R. (2002). Meeting the highly qualified teachers challenge: The secretary's annual report on teacher quality. *US Department of Education.*

Parrish, J. A. (2008). *Comparison of a middle and secondary MAT teacher preparation program: Examining candidate satisfaction with alternative certification and regular certification preparation*. University of Louisville.

Patton, M. Q. (2015). *Qualitative research and evaluation methods: integrating theory and practice*. SAGE Publications, Inc.

Qu, Y., and Becker, B. J. (2003). Does Traditional Teacher Certification Imply Quality? A Meta-Analysis. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Schell, J. W., and Black, R. S. (1997). Situated learning: An inductive case study of a collaborative learning experience. Journal of Industrial Teacher Education, 34(4), 5–28.

Schmidt, W. H., Cogan, L., and Houang, R. (2011). The role of opportunity to learn in teacher preparation: An international context. *Journal of Teacher Education*, *62*(2), 138-153.

Schmidt, W. H. (2012). At the precipice: The story of mathematics education in the United States. *Peabody Journal of Education*, *87*(1), 133-156.

Schmidt, W. H., Burroughs, N. A., Houang, R. T., and Cogan, L. S. (2020). The Role of Content Knowledge in Mathematics Teacher Preparation: A Study of Traditional and Alternative Teacher Preparation in Texas. *Journal of Teacher Education*, *71*(2), 233-246.

Scribner, J. P., and Akiba, M. (2010). Exploring the relationship between prior career experience and instructional quality among mathematics and science teachers in alternative teacher certification programs. *Educational Policy*, *24*(4), 602.

Shaw, M. (2008). The impact of alternative teacher certification programs on teacher shortages. *International Journal of Learning*, *15*(3), 89-97.

Shen, J. (1997). Has the alternative certification policy materialized its promise? A comparison between traditionally and alternatively certified teachers in public schools. *Educational Evaluation and Policy Analysis, 19*(3), 276-283.

Shen, J. (1999). Alternative certification: Math and science teachers. *Educational Horizons, 78*(1), 44-48.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher*, *15*(2), 4-14.

Stake, R. E. (2013). *Multiple case study analysis*. Guilford Press.

Stein, D. (1998). *Situated learning in adult education* (pp. 195-202). ERIC Clearinghouse on Adult, Career, and Vocational Education, Center on Education and Training for Employment, College of Education, the Ohio State University.

Strauss, A., and Corbin, J. (1990). *Basics of qualitative research*. Sage publications.

Strauss, A., and Corbin, J. (1998). Basic of qualitative research: Techniques and procedures for developing grounded theory (2nd ed.). Thousand Oaks, CA: Sage.

Strong, M. (2011). *The Highly Qualified Teacher: What Is Teacher Quality and How Do We Measure It?*. Teachers College Press. 1234 Amsterdam Avenue, New York, NY 10027.

Tai, R. H., Liu, C. Q., and Fan, X. (2006). Alternative certification and retention of secondary math and science teachers: A study based on "SASS/TFS". *Journal of the National Association for Alternative Certification, 1*(2), 19-26.

Tashakkori, A., and Creswell, J. W. (2007). *Editorial: The new era of mixed methods*. United States: Sage Publications.

Tatto, M. T., Ingvarson, L., Schwille, J., Peck, R., Senk, S. L., and Rowley, G. (2008). *Teacher Education and Development Study in Mathematics (TEDS-M): Policy, Practice, and Readiness to Teach Primary and Secondary Mathematics. Conceptual Framework*. International Association for the Evaluation of Educational Achievement. Herengracht 487, Amsterdam, 1017 BT, The Netherlands.

Tellis, W. M. (1997). Application of a case study methodology. *The qualitative report*, *3*(3), 1-19.

Thomas, K. R., Friedman-Nimz, R., and Mahlios, M. C. (2005). Where are they coming from? beyond the demographics of individuals seeking an alternative route to mathematics and science teacher licensure. *Action in Teacher Education, 27*(1), 15-25.

Vannatta, R., Beyerbach, B., and Walsh, C. (2001). From teaching technology to using technology to enhance student learning: Preservice teachers' changing perceptions of technology infusion. *Journal of Technology and Teacher Education*, *9*(1), 105-127.

Van Scoy, I. J. (2012). NCATE's Blue Ribbon Panel Report and NAPDS: Working Together. *School-University Partnerships, 5*(1), 7-12.

Walsh, K., and Jacobs, S. (2007). Alternative Certification Isn't Alternative. *Thomas B. Fordham Institute*.

Wayman, J. C., Foster, A. M., Mantle-Bromley, C., and Wilson, C. (2003). A comparison of the professional concerns of traditionally prepared and alternatively licensed new teachers. *High School Journal*, (3), 35.

Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems thinker*, *9*(5), 2-3.

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge university press.

Wenger, E., McDermott, R. A., and Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Harvard Business Press.

Whitehurst, G. J. (2002). Scientifically based research on teacher quality: Research on teacher preparation and professional development. In *White House Conference on Preparing Tomorrow's Teacher*.

Whitford, D. K., Zhang, D., and Katsiyannis, A. (2018). Traditional vs. alternative teacher preparation programs: A meta-analysis. *Journal of Child and Family Studies*, *27*(3), 671-685.

Yin, R. K. (1994). Case study research: Design and methods (2nd ed.). *Thousand Oaks, CA: Sage*.

Zeichner, K. M., and Schulte, A. K. (2001). What we know and don't know from peer-reviewed research about alternative teacher certification programs. *Journal of Teacher Education*, *52*(4), 266-282.

Zientek, L. R. (2006). Do teachers differ by certification route? novice teachers' sense of self-efficacy, commitment to teaching, and preparedness to teach. *School Science and Mathematics*, (8), 326.

Zientek, L. R., Adelman, N. E., Bogart, J., Michie, J., United States Dept of Education Planning and Evaluation Service State and Local, Grants Division, and Policy, S. A. (1986).

Preparing high-quality teachers: Views from the classroom. *American Educational Research Journal, 44*(4), 959.

Zientek, L. R., Kadhi, T., and Capraro, R. M. (2005). Alternative certification program analysis. *Academic Exchange Quarterly,* (3), 121.

Appendix A: IRB Approval Letter

EXEMPT DETERMINATION

February 13, 2020

Gail Stewart
2611 bayshore blvd
205
Tampa, FL 33629

Dear Ms. Gail Stewart:

On 2/12/2020, the IRB reviewed and approved the following protocol:

Application Type:	Initial Study
IRB ID:	STUDY000005
Review Type:	Exempt 2
Title:	Teacher Certification Pathway and Mathematical Quality of Instruction
Funding:	None
Protocol:	Gail Stewart

The IRB determined that this protocol meets the criteria for exemption from IRB review.

In conducting this protocol, you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Please note, as per USF policy, once the exempt determination is made, the application is closed in BullsIRB. This does not limit your ability to conduct the research. Any proposed or anticipated change to the study design that was previously declared exempt from IRB oversight must be submitted to the IRB as a new study prior to initiation of the change. However, administrative changes, including changes in research personnel, do not warrant a modification or new application.

Ongoing IRB review and approval by this organization is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit a new request to the IRB for a determination.

Sincerely,

Jennifer Walker
IRB Research Compliance Administrator

A PREEMINENT RESEARCH UNIVERSITY

Institutional Review Boards / Research Integrity & Compliance
FWA No. 00001669
University of South Florida / 3702 Spectrum Blvd., Suite 165 / Tampa, FL 33612 / 813-974-5638

Page 1 of 1

Appendix B: Hillsborough County Approval Letter

School Board
Tamara P. Shamburger, Chair
Melissa Snively, Vice Chair
Steve P. Cona III
Lynn Gray
Stacy A. Hahn
Karen Perez
Cindy Stuart

Hillsborough County
PUBLIC SCHOOLS
Preparing Students for Life

Superintendent of Schools
Jeff Eakins

Deputy Superintendent, Instruction
Van Ayres

Deputy Superintendent, Operations
Chris Farkas

Chief of Schools, Administration
Harrison Peters

General Manager
Office of Strategy Management
Joe Cochran

March 15, 2019

Ms. Gail Stewart
2819 52nd Lane N.
St. Petersburg, FL 33710

Dear Ms. Stewart:

The Hillsborough County Public School district has agreed to participate in your research proposal, *Teacher Certification Pathway and Mathematical Quality of Instruction*. A copy of this letter **MUST** be available to all participants to assure them your research has been approved by the district. **Your approval number is RR1819-135. You must refer to this number in all correspondence.** Approval is given for your research under the following conditions:

1) Participation is to be on a voluntary basis. That is, participation is **NOT MANDATORY** and you must advise **ALL PARTICIPANTS** that they are not obligated to participate in your study.
2) If the principal agrees the school will participate, it is up to you to find out what rules the school has for allowing people on campus and you must abide by the school's check-in policy. You will **NOT BE ALLOWED** on any school campus without first following the school's rules for entering campus grounds.
3) Confidentiality must be assured for all. That is, **ALL DATA MUST BE AGGREGATED SUCH THAT THE PARTICIPANTS CANNOT BE IDENTIFIED**. Participants include the district, principals, administrators, teachers, support personnel, students and parents.
4) Any student data **MUST** be **DESTROYED** when the project has been completed
5) Since you are an employee of the Hillsborough County Public Schools, all work related to this research **must be done outside your normal working hours** unless your administrator believes the research is a function of your position.
6) If this work is **not part of your job, you can not use the school mail or email system** to send or receive any documents.
7) Research approval does not constitute the use of the district's equipment, software, email, or district mail service. In addition, requests that result in extra work by the district such as data analysis, programming or assisting with electronic surveys, may have a cost borne by the researcher.
8) This approval **WILL EXPIRE ON 12/31/2019**. You will have to contact us at that time if you feel your research approval should be extended.
9) A copy of your research findings must be submitted to this department and for our files.

Raymond O. Shelton School Administrative Center • 901 East Kennedy Boulevard • Tampa, Florida 33602
School District Main Office: 813-272-4000 • P.O. Box 3408 • Tampa, Florida 33601 • website: www.sdhc.k12.fl.us
Office of Strategy Management

Appendix C: Hillsborough County Approval Letter (Extension)

School Board
Melissa Snively, Chair
Steve P. Cona III, Vice Chair
Lynn Gray
Stacy A. Hahn
Karen Perez
Tamara P. Shamburger
Cindy Stuart

Hillsborough County
PUBLIC SCHOOLS
Preparing Students for Life

Superintendent of Schools
Jeff Eakins

Deputy Superintendent, Instruction
Van Ayres

Deputy Superintendent, Operations
Chris Farkas

Chief of Schools, Administration
Harrison Peters

General Manager
Office of Strategy Management
Joe Cochran

December 13, 2019

Ms. Gail Stewart
2819 52nd Lane N.
St. Petersburg, FL 33710

Dear Ms. Stewart:

Your request for an extension in your research project, *Teacher Certification Pathway and Mathematical Quality of Instruction*, **(RR1819-135)**, has been **approved**. This approval has been extended to **6/30/2020**.

Remember, **all conditions** of the original letter dated **3/15/2019** still apply. Feel free to contact me if you have any questions.

Sincerely,

Julie McLeod, Manager
Strategic Data and Evaluation
Office of Strategy Management

JM/sk

Raymond O. Shelton School Administrative Center • 901 East Kennedy Boulevard • Tampa, Florida 33602
School District Main Office: 813-272-4000 • P.O. Box 3408 • Tampa, Florida 33601 • website: www.sdhc.k12.fl.us
Office of Strategy Management

Appendix D: Participant Consent Form

UNIVERSITY OF SOUTH FLORIDA

Informed Consent to Participate in Research Involving Minimal Risk

Information to Consider Before Taking Part in this Research Study

Title: Teacher Certification Pathway and Mathematical Quality of Instruction

Pro # _00040237___________________

Overview: You are being asked to take part in a research study. The information in this document should help you to decide if you would like to participate. The sections in this Overview provide the basic information about the study. More detailed information is provided in the remainder of the document.

Study Staff: This study is being led by Gail Stewart who is a doctoral candidate at the University B. This person is called the Principal Investigator. She is being guided in this research by Dr. Sarah van Ingen. Other approved research staff may act on behalf of the Principal Investigator.

Study Details: This study is being conducted at the College of Education at the University B and Sunshine High School. The purpose of the study is to find out if there is a relation between the type of certification that a teacher has and the quality of their mathematics instruction, according to the Mathematical Quality of Instruction instrument (MQI). Participants will be video-taped teaching math lessons (2-3) and will participate in one interview before the videotaping and one interview after the videotaping.

Participants: You are being asked to take part because you are either a traditionally or alternatively certified novice high school mathematics teacher.

Voluntary Participation: Your participation is voluntary. You do not have to participate and may stop your participation at any time. There will be no penalties or loss of benefits or opportunities if you do not participate or decide to stop once you start. Your decision to participate or not to participate will not affect your job status, employment record, employee evaluations, or advancement opportunities.

Benefits, Compensation, and Risk: We do not know if you will receive any benefit from your participation. You will not be compensated for your participation. This research is considered minimal risk. Minimal risk means that study risks are the same as the risks you face in daily life.

Confidentiality: Even if we publish the findings from this study, we will keep your study information private and confidential. Anyone with the authority to look at your records must keep them confidential.

Why are you being asked to take part?

We are asking you to take part in this study because you are either a traditionally or alternatively certified novice high school mathematics teacher.

Study Procedures:

For the study, I or a research assistant will set up a video camera in your classroom and ask you to wear a microphone during the lessons that we tape. We will record two lessons for each participant and will conduct one interview before the video-taped lessons and one follow up interview after the taping. The interviews will last approximately 45 minutes and will take place in a location that is convenient for you. I will work with you to find times for taping and interviewing that work within your schedule.

If you take part in this study, you will be asked to:

- Meet with me and answer some questions about your teacher preparation program and experiences.
- Allow me or a research assistant to use the video recording equipment to record you teaching two mathematics lessons to your class.
- Meet with me after I have watched the video-recorded lessons and answer some questions regarding the lesson. The questions that I will ask will depend on the specific lesson that you teach but an example is "Why did you choose to use those specific manipulatives during your lesson?" Questions will be related to the video-taped lesson as well as to your experiences within your teacher preparation program.
- Per your consent, I will audio record the interviews on a recording device. I will have access to the recording and possibly my supervising faculty member, Dr. Sarah van Ingen. I will transcribe the interviews and use a pseudonym for your name and the school name. The tapes and transcripts will be maintained on a password protected computer for five years after the final report is submitted to the IRB. After that time, they will be deleted.

Total Number of Participants

About 4 individuals will take part in this study at UNIVERSITY B/Sunshine High School.

Alternatives / Voluntary Participation / Withdrawal

You do not have to participate in this research study.

You should only take part in this study if you want to volunteer. You should not feel that there is any pressure to take part in the study. You are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study. The decision to participate or not to participate will not affect your job status.

Benefits

There are no direct benefits to subjects participating in this study. One indirect benefit to subjects participating in this study is the potential for you to gain some insights into your own teaching. In addition, results from the study could help benefit the future preparation of teachers alternatively and traditionally certified.

Risks or Discomfort

This research is considered to be minimal risk. That means that the risks associated with this study are the same as what you face every day. There are no known additional risks to those who take part in this study.

Compensation

You will receive no payment or other compensation for taking part in this study.

Costs

It will not cost you anything to take part in the study.

Privacy and Confidentiality

We will do our best to keep your records private and confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Certain people may need to see your study records. These individuals include:

- The research team, including the Principal Investigator, study coordinator, research nurses, and all other research staff.
- Certain government and university people who need to know more about the study, and individuals who provide oversight to ensure that we are doing the study in the right way.
- Any agency of the federal, state, or local government that regulates this research.
- The UNIVERSITY B Institutional Review Board (IRB) and related staff who have oversight responsibilities for this study, including staff in UNIVERSITY B Research Integrity and Compliance.

We may publish what we learn from this study. If we do, we will not include your name. We will not publish anything that would let people know who you are.

Data collected for this research will be stored at the College of Education, located at the University B in the United States.

You can get the answers to your questions, concerns, or complaints.

If you have any questions, concerns or complaints about this study, call Gail Stewart at (352)275-4125. If you have questions about your rights, complaints, or issues as a person taking part in this study, call the UNIVERSITY B IRB at (813) 974-5638 or contact by email at RSCH-IRB@University B.edu.

Consent to Take Part in Research

I freely give my consent to take part in this study**.** I understand that by signing this form I am agreeing to take part in research. I have received a copy of this form to take with me.

____ ________

Signature of Person Taking Part in Study Date

____

Printed Name of Person Taking Part in Study

Statement of Person Obtaining Informed Consent and Research Authorization

I have carefully explained to the person taking part in the study what he or she can expect from their participation. I confirm that this research participant speaks the language that was used to explain this research and is receiving an informed consent form in their primary language. This research participant has provided legally effective informed consent.

____ ________

Signature of Person Obtaining Informed Consent Date

____

Printed Name of Person Obtaining Informed Consent

Appendix E: MQI Scoring Rubric Tool

Richness of the Mathematics					
	Not Present	Low	Mid	High	Notes
Linking Between Representations					
Explanations					
Mathematical Sense Making					
Multiple Procedures or Solution Methods					
Patterns and Generalizations					
Mathematical Language					

Errors and Imprecision					
	Not Present	Low	Mid	High	Notes
Mathematical Content Errors					
Imprecision in Language or Notation					
Lack of Clarity in Presentation of Mathematical Content					

Appendix F: Probes for Interview Question

General Questions related to Preparation Pathway:

- Describe the teacher preparation program and experiences in which you participated, including a timeline from start to finish.

- Are there any aspects of your teacher preparation experience that stand out to you as particularly helpful? Not helpful?

- Now that you have been teaching, are there any aspects of teaching that you think were missing from your preparation program?

- What factors influenced your decision to participate in the teacher preparation program that you chose (traditional or alternative)

Possible Questions Related to Situated Learning Theory (related to the three tenets):

Tenet	Possible Questions
Authentic Context	• Describe the extent to which your preparation program experiences did or did not take place in an authentic context? • Approximately what portion of your preparation experiences took place in a school setting with students? • In what ways were your preparation experiences similar or not similar to the experiences that you provide for your students? • In what ways did the instructors in your preparation program create experiences similar to those that you might encounter when you were teaching?
Social Interaction	• What role did social interaction with other prospective teachers play in your preparation program and experiences? • To what extent were you provided opportunities to interact with peers in your preparation program? • Did you preparation program include any experiences or opportunities what required you to interact socially with others in your program?
Constructivist Learning Approach	• Please describe any experiences within your preparation program in which you constructed your own learning of a topic or idea. • To what extent do you think that new information was linked to prior information in your preparation program or experiences? • Describe any experiences within your preparation program where you were asked to reflect upon specific learning or experiences in which you participated.

General Questions related to the MQI:

- (For domains on which they scored high) You were really strong with _______, how did you learn to do that?

- (For domains on which they scored low) I noticed you did not ______. Have you had a chance to practice that in any of your past experiences or preparation experiences?

Richness of the Mathematics

		Possible Interview Questions
Meaning of Facts and Procedures	**Linking Between Representations**	This code refers to the explicit linking and connections between different representations of a mathematical idea or procedure presented by the teacher and the students.
		• How did you decided to use the specific representation(s) that you did while teaching the lesson? • What made you choose those representations instead of other possible representations?
	Explanations	This code refers to mathematical explanations that focus on why a procedure works or doesn't work, why a procedure is appropriate or note appropriate, and why and answer is true or not true.
		• Is the way that you explained a certain procedure(s) consistent with the way that you learned it? • How did you decide which explanation to use and why do you think that is the most appropriate explanation? • Did you make connections to other mathematics in your explanation? Why or why not.
	Mathematical Sense Making	This code refers to the extent to which the teacher or students attend to the meaning of numbers, the relationship between numbers, the relationships between contexts and the numbers or operations that represent them, connections between mathematical ideas or representations, give meaning to mathematical ideas, use modeling and answers to determine sense-making
		• To what extent did you use estimation when discussing the answers to specific problems? • Why did you use the specific figure or model that you did to describe a certain topic?
Key Mathematical Practices	**Multiple Procedures or Solution Methods**	This code refers to the extent to which different mathematical approaches to solving a problem are taken and discussion is had about how to solve a word problem using two different strategies.
		• How did you decide to use those methods of explanation versus other possible methods? • Are there other possible methods that could have been used in your explanation? • How did you determine that more than one approach was needed when solving that specific problem?

	Patterns and Generalizations	This code intends to capture instruction during which the class first examines instances or examples, then uses this information to develop or work on a mathematical generalization in order to notice, extend or generalize a mathematical pattern.
		• How did you determine what definition you would give for a specific term? • How did you decide to use that particular case ore example to make a generalization or pattern?
	Mathematical Language	This code refers to the teacher and students' ability to use mathematical language and also whether or not the teacher supports students' mathematical language use.
		• What strategies to you use to encourage students to use mathematical language?
Overall Richness of the Mathematics		

Errors and Imprecision

	Possible Interview Questions
Mathematical Content Errors	This code captures events in the segment that are mathematically incorrect, including but not limited to solving problems incorrectly, defining terms incorrectly, forgetting a key condition in a definition, or equation two non-identical mathematical terms.
	• At what point did you realize the mathematical error? What steps did you take to correct it? • How did you come up with the answer that led to the error?
Imprecision in Language or Notation	This code refers to the extent to which problematic mathematical language or notation are used. Examples include errors in notation which includes mathematical symbols, errors in mathematical language and general language including definitions, and appropriate use of terms and in distinguishing everyday meanings from their mathematical meanings.
	• Can you elaborate more about when you said _____ ? What did you mean? • Are there any other terms you could have used that may have been more precise? • It the language or notation that you used consistent with how you learned?
Lack of Clarity in Presentation of Mathematical Content	This code intends to capture instances where a teacher's utterances cannot be understood such as when a mathematical point is muddled, confusing, or distorted. Other examples include when a teacher's launch of a task or activity is unclear or problematic, and when a teacher neglects to clearly solve problems or explain content.
	• What rationale do you have for teaching _________ the way that you did? • How did you decide to use that example to introduce the concept? • Have you seen that concept introduced the same way before?
Overall Errors and Imprecision	

Appendix G: Copyright Permissions

This email gives permission from the author to use Figure 1 (Multiple Measures of Teaching Effectiveness).

Bill & Melinda Gates Foundation

Media <Media@gatesfoundation.org>
Wed 10/14/2020 3:44 PM
To: Stewart, Gail

Hi Gail,

Yes, you are welcome to use that figure, and copyright to Bill & Melinda Gates Foundation.

Thank you,

Media Relations Team
Bill & Melinda Gates Foundation
www.gatesfoundation.org

Name: Gail Stewart
Email: gailstewart@usf.edu
Phone: (727) 285-4549
Street: 2819 52nd Lane N
City: St. Petersburg
State: Florida
Postal/Zip Code: 33710
Country: United States
Message: I am requesting copyright permission to use a figure (Figure 1 - Multiple Measures of Teaching) from the following article in my dissertation, please.

Kane, T. J., & Staiger, D. O. (2012). Gathering Feedback for Teaching: Combining High-Quality Observations with Student Surveys and Achievement Gains. Policy and Practice Brief. MET Project. Bill & Melinda Gates Foundation.

My dissertation will be made openly available in USF's institutional repository.

This email gives permission from the author to use Figure 2 (The Mathematical Knowledge for Teaching Framework).

Copyright Clearance Center | RightsLink®

Home | Help | Email Support | Sign in | Create Account

SAGE

Content Knowledge for Teaching

Author: Deborah Loewenberg Ball, Mark Hoover Thames, Geoffrey Phelps

Publication: Journal of Teacher Education

Publisher: SAGE Publications

Date: 11/01/2008

Copyright © 2008, © SAGE Publications

Gratis Reuse

Permission is granted at no cost for use of content in a Master's Thesis and/or Doctoral Dissertation, subject to the following limitations. You may use a single excerpt or up to 3 figures tables. If you use more than those limits, or intend to distribute or sell your Master's Thesis/Doctoral Dissertation to the general public through print or website publication, please return to the previous page and select 'Republish in a Book/Journal' or 'Post on intranet/password-protected website' to complete your request.

BACK | CLOSE WINDOW

This email gives permission from the author to use Figure 3 (Tenets of Situated Learning Theory).

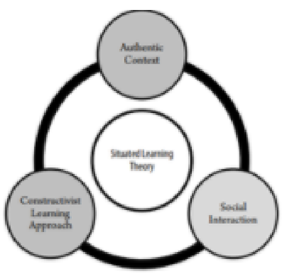
Wed 9/23/2020 12:43 PM

To: cab968@uowmail.edu.au; meady@uow.edu.au; petera@uow.edu.au

Hello!

I am writing to ask you for copyright permission to please use the figure below from your article ("Preparing quality teachers: Bridging the gap between tertiary experiences and classroom realities") in my dissertation, where I used situated learning theory as my framework. I am a doctoral candidate at the University of South Florida. Thank you so much!

Gail Stewart



Corinne Green <corinneg@uow.edu.au>

Thu 9/24/2020 1:30 AM

To: Stewart, Gail; Corinne Green <cab968@uowmail.edu.au>; Michelle Eady <meady@uow.edu.au>; Peter Andersen <petera@uow.edu.au>

Hello Gail,

Thanks for your email!

We are happy for you to use this image in your dissertation, as long as you include the citation for our paper alongside it.

Out of curiosity, what is your research about? I'm interested to hear more 😊

Kind regards,

Corinne Green

This email gives permission from the author to use Figure 4 (MQI Dimensions and Interactions).

SAGE

Resources, Instruction, and Research

Author: David K. Cohen, Stephen W. Raudenbush, Deborah Loewenberg Ball
Publication: EDUCATIONAL EVALUATION AND POLICY ANALYSIS
Publisher: SAGE Publications
Date: 06/01/2003

Gratis Reuse

Permission is granted at no cost for use of content in a Master's Thesis and/or Doctoral Dissertation, subject to the following limitations. You may use a single excerpt or up to 3 figures tables. If you use more than those limits, or intend to distribute or sell your Master's Thesis/Doctoral Dissertation to the general public through print or website publication, please return to the previous page and select 'Republish in a Book/Journal' or 'Post on intranet/password-protected website' to complete your request.

BACK

CLOSE WINDOW

Appendix H: Mathematical Quality of Instruction Rubric

Linking Between Representations

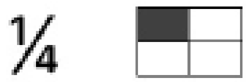
This code refers to teachers' and students' explicit linking and connections between different representations of a mathematical idea or procedure. To count, these links must occur across different representational "families" e.g., a linear graph and a table both capturing a linear relationship. So, two different representations that are both in the symbolic family (e.g., 1/4 and 0.25) are not candidates for being linked.

For Linking Between Representations to be scored above a Not Present:

- At least one representation must be visually present
- The explicit linking between the two representations must be communicated out loud

For Linking Between Representations to be scored Mid or High, two conditions must be satisfied:

- Both representations must be visually present
- The correspondence between the representations must be explicitly pointed out in a way that focuses on meaning (e.g., pointing to the numerator in 1/4, then commenting that you can see that one in the figure, pointing to the four in the denominator, pointing to the four partitions in the whole. "You can see the 1 in the 1/4 corresponds to the upper left-hand box, which is shaded, showing one piece out of four total pieces…")



For geometry, we do not count shapes as a representation that can be linked—we consider those to be the "thing itself." However, links can be scored in geometry if the manipulation of geometric objects is linked to a computation, e.g., showing that two 45-degree angles can be combined to get a 90 degree angle and linking that to the symbolic representation 45 + 45 =90.

Note: If links are made but underlying representation/idea is incorrect, do NOT count as linking between representations.

Not Present	Low	Mid	High
No linking occurs. Representations may be present, but no connections are actively made.	Links are present in a pro forma way; For example, the teacher may show the above figure and state that one quarter is one part out of four. These links will not be very explicit or detailed; both representations need not be present.	Links and connections have the features noted under High, but they occur as an isolated instance in the segment.	Links and connections are present with extended, careful work characterized by one of the following features: • Explicitness about how two or more representations are *related* (e.g., pointing to specific areas of correspondence) OR • Detail and elaboration about the relationship between two mathematical representations (e.g., noting meta-features; providing information about under what conditions the relationship occurs; discussing implications of relationship) These links will be a characterizing feature of the segment, in that they may in fact be the focus of instruction. They need not take up the majority or even a significant portion of the segment; however, they will offer significant insight into the mathematical material.

Back to Table of Contents

Explanations

Mathematical explanations focus on why, e.g.:

- Why a procedure works (or doesn't work)
- Why a solution method is appropriate (or inappropriate)
- Why an answer is true (or not true)
- In geometry: justification using a definition, why an object is symmetrical, why a second figure is a transformation of the first
- In data analysis: why you would choose a specific graph to represent a set of data, why median is different than mode or mean of a dataset, etc.

Do NOT count *"how"* e.g., simply providing descriptions of steps (first I did x, then I did y) or definitions unless meaning is also attached.

Note: Do NOT count incorrect or incomplete explanations as explanations.

Not Present	Low	Mid	High
No mathematical explanations are offered by the teacher or students or the "explanations" provided are simply descriptions of steps of a procedure.	A mathematical explanation occurs as an isolated instance in the segment.	Two or more brief mathematical explanations occur in the segment OR an explanation is more than briefly present but not the focus of instruction.	One or more mathematical explanation(s) is a focus of instruction in the segment. The explanation(s) need not be most or even a majority of the segment; what distinguishes a High is the fact that the explanation(s) are a major feature of the teacher-student work (e.g., working for 2-3 minutes to elucidate the simplifying example above).

Scoring Help - Explanations

Examples of explanations:

- Explaining the reason for steps in simplifying fractions (dividing by 2/2 is same as dividing by 1; anything divided by 1 is still itself)
- Explaining why particular steps in a complex problem are justified or work to achieve the solution
- Classifying triangles as polygons because they are closed and made up of line segments that do not cross
- Explaining why a formula can be used to find an outcome (why *l* x *w* works to find area)

Note that when scoring, you can count the build-up to an explanation as part of the explanation. Ask yourself: Was the point of the instruction to provide the explanation, even if it only emerged at the end? If so, you may score that clip as a High.

To help understand the difference between the Explanations code and the Mathematical Sense-Making code, see the Scoring Help for Sense Making.

Mathematical Sense-Making			
This code captures the extent to which the teacher or students attend to one or more of the following: • The meaning of numbers • Understanding relationships between numbers • The relationships between contexts and the numbers or operations that represent them • Connections between mathematical ideas or between ideas and representations • Giving meaning to mathematical ideas • Whether the modeling of and answers to problems make sense Examples include: • Focusing on value of quantities (e.g., "7/8 is close to 1") • The meaning of quantities (e.g., "the six represents the number of groups") • Discussing reasonableness of an expression, solution method, or answer • Using estimation or number sense • Giving meaning to procedures (e.g., "1/4 x 2/3 means taking 1/4 *of* 2/3 *of* a whole") • Giving meaning to expressions or equations For word problems, score for activities like explaining why an operation is called for by a problem, why certain numbers are used in the operation, reasonableness of answer, reasonableness of solution method, etc. In geometry, include making sense of definitions (what counts as a polygon, what does not count as a polygon), formulas, by elaborating them, applying them, finding counter-examples, etc. rather than just stating/executing them. Do not count "Give me examples of a circle" – instead, count cases where the definition or formula has meaning made around it. If sense-making is partially correct and partially incorrect, only score the portion that is correct (e.g., would be a High, but vague for parts, thus receives a Mid).			
Not Present	**Low**	**Mid**	**High**
Not present or incorrect.	Teacher and/or students focus briefly on meaning. For instance, a student may remark that 7/8 is "almost 1" or attends to reasonableness of the solution method.	Teacher and/or students focus on meaning more than briefly (e.g., several instances within the segment or one somewhat long instance), but this work is not sustained or substantial.	Teacher and/or students focus on meaning in sustained way during segment. Need not be the entire segment, but must be substantial.

Multiple Procedures or Solution Methods

Multiple procedures or solution methods occur or are discussed in the segment:

- Multiple solution methods for a single problem (including shortcuts)
- Multiple procedures for a given problem type

Defined as, e.g.:

- Taking different mathematical approaches to solving a problem (e.g., comparing fractions by finding a common denominator AND comparing fractions by finding a common numerator)
- Solving or discussing how to solve a word problem using two different strategies.

If the initial strategy or strategies occurred in a prior segment, score Multiple Procedures in the subsequent segment (i.e., no need to go back and adjust your score in the initial segment).

Note: Do NOT count incorrect procedures or solution methods.

Not Present	Low	Mid	High
No evidence of multiple procedures or solution methods for single problem or a given problem type.	Teacher or student briefly mentions a second procedure or method, but the method is not discussed at length or enacted ("we also showed yesterday that you can do it XYZ").	Multiple procedures or solution methods occur or are discussed in the segment (e.g., solving division problems in two ways), but does not include the special features listed in High, or feature these only momentarily (e.g., "this method is easier than the other" without explicit discussion of why).	Multiple procedures or solution methods occur or are discussed in the segment, and include special features: • Explicit comparison of multiple procedures or solution methods for efficiency, appropriateness, ease of use, or other advantages and disadvantages • Explicit discussion of features of a problem that cues the selection of a particular procedure • Explicit connections between multiple procedures or solution methods (e.g., how one is like or unlike the other)

Scoring Help - Multiple Procedures and Solution Methods

You will need to use some judgment when deciding whether to count two methods as distinct from one another. We consider methods distinct when they feature two different mathematical paths to the solution. For instance, in the case of comparing fractions, we would NOT consider it distinct if student A compares 3/5 and 7/10 by finding a common denominator of 10, and student B finds a common denominator of 50. However, we would consider finding common numerators and finding common denominators to be distinct methods.

Patterns and Generalizations			
This code is meant to capture instruction during which the class *first* examines instances or examples, *then* uses this information to develop or work on a mathematical generalization; to notice, extend or generalize a mathematical pattern; to derive a mathematical property; or to build and test definitions. Examples of this activity include: • Examining particular cases and then noticing and extending a pattern (e.g., looking at the sum of the angles in 3, 4, 5, and 6-sided regular polygons and extending the pattern or generalizing to an n-sided regular polygon) • Saying whether mathematical procedures work in all cases • "Building up" a mathematical definition or deriving a mathematical property (e.g., defining "polygons" after considering different examples and non-examples of polygons) Notes: • Patterns, generalizations and definitions must be based on *at least two examples* (either explicitly worked on or referred to) • Do NOT count incorrect generalizations, incorrect pattern noticing, or incorrect definition building • Do NOT count when teachers and/or students *state* generalizations, patterns, or definitions without first developing them from examples			
Not Present	**Low**	**Mid**	**High**
No generalizations are developed or worked on; no patterns are noticed or extended; no definitions are built or tested.	There is brief work on developing a generalization or building a definition, but this work is undeveloped and/or is not the primary focus of the segment. OR Teachers and/or students engage in pattern-noticing and/or extending. This is done in a pro forma way (e.g. red, blue, blue, red, blue, blue, ??, blue blue)	There is work on developing a generalization, extending a pattern or building a definition, but the work is not finalized. For instance, a pattern may be noticed, extended, or reasoned about but not codified ("it looks like when we increase the coefficient, the line might get steeper"). OR Teachers and/or students develop a generalization, extend a pattern, or build a definition, but the work is not complete, clear or detailed.	The pattern or generalization is codified, AND the work is complete, clear and detailed. For instance, the teacher and/or students may carefully develop a generalization from examples in detail; or summarize and codify a pattern by describing how the pattern is generated.

Mathematical Language			
This code captures how fluently the teacher (and students) use mathematical language and whether the teacher supports students' use of mathematical language. Examples: • Fluent use of technical language • Explicitness about mathematical terminology • Encouraging students to use mathematical terms			
Not Present	**Low**	**Mid**	**High**
Score here when NO mathematical terms are used. Teacher uses non-mathematical terms to describe mathematical ideas and procedures AND/OR teacher talk is characterized by sloppy/incorrect use of mathematical terms.	Low density of mathematical language. Not necessarily an indication that teacher is not "fluent" in mathematics, but simply a segment where few mathematical terms are used, or the same term is used over and over without features of High. Also score as Low when segment has middling density, but sloppy use.	Teacher uses mathematical language as a vehicle for conveying content, with middling density. However, the segment has few or none of the special features listed under High. Also score as Mid when segment has both features of High but includes some linguistic sloppiness or low density.	Teacher uses mathematical language correctly and *fluently*. Can be achieved in two ways: 1. Density of mathematical language is high during periods of teacher talk. 2. Moderate density, but also explicitness about terminology, reminding students of meaning, pressing students for accurate use of terms, encouraging student use of mathematical language. Instances of students using sophisticated mathematical vocabulary can also count toward a High.

Back to Table of Contents

Mathematical Content Errors			
The code is intended to capture events in the segment that are mathematically incorrect. For example: • Solving problems incorrectly • Defining terms incorrectly • Forgetting a key condition in a definition • Equating two non-identical mathematical terms Mathematical errors that are made by students and endorsed by the teacher (e.g., leaving it on the board, saying it is correct, adopting an incorrect definition of fractions) should be counted here. Also score here if the teacher evaluates a correct solution method as incorrect. Do not count • Intentional errors (teacher following a wrong student idea or doing a procedure incorrectly to make a point) • Errors that are corrected within the segment			
Not Present	**Low**	**Mid**	**High**
None.	A brief content error. Does not obscure the mathematics of the segment.	Content errors occur in part(s) of the segment. OR Error(s) obscure the mathematics, but for only part of the segment.	Content errors occur in most or all of the segment. OR The errors obscure the mathematics of the segment.

Examples - Mathematical Content Errors			
Not Present	**Low**	**Mid**	**High**
	When solving a multi-step problem, the teacher makes a calculation error in the last step, which results in an incorrect answer. Other similar problems are solved correctly.	The teacher's discussion of the solution to a problem is incorrect. This discussion is more than brief, but correct mathematics also occurs more than briefly during the segment.	The teacher uses an inappropriate metaphor for most of the segment (e.g., in a graph comparing distance and time, the teacher refers to the upward slope as runner going up the hill, flat slope as runner running straight).

Back to Table of Contents

Imprecision in Language or Notation

This code is intended to capture problematic uses of mathematical language or notation. For example:

- Errors in notation (mathematical symbols)
- Errors in mathematical language
- Errors in general language

Definitions

- ***Notation*** includes conventional mathematical symbols (such as +, -, =) or symbols for fractions and decimals, square roots, angle notation, functions, probabilities, exponents, etc. Errors in notation might include inaccurate use of the equals sign, parentheses, or division symbol. By "conventional notation," we do not mean use of numerals or mathematical terms.
- ***Mathematical language*** includes technical mathematical terms, such as "angle," "equation," "perimeter," and "capacity." If the teacher uses these terms incorrectly, record as an error. When the focus is on a particular term or definition, also score errors in spelling or grammar.
- Teachers often use "***general language***" to convey mathematical concepts (i.e., explaining mathematical ideas or procedures in non-technical terms). General language also includes analogies, metaphors, and stories. Appropriate use of terms includes care in distinguishing everyday meanings different from their mathematical meanings. If the teacher is unclear in his/her general talk about mathematical ideas, terms, concepts, or procedures, record as an error.

Not Present	Low	Mid	High
None.	Brief instance of imprecision. Does not obscure the mathematics of the segment.	Imprecision occurs in part(s) of the segment. OR Imprecision obscures the mathematics, but for only part of the segment.	Imprecision occurs in most or all of the segment. OR Imprecision obscures the mathematics of the segment.

Lack of Clarity in Presentation of Mathematical Content

This code is intended to capture when a teacher's utterances cannot be understood. For example:

- Mathematical point is muddled, confusing, or distorted
- Language or major errors make it difficult to discern the point
- Teacher neglects to clearly solve the problem or explain content

Teacher's launch of a task/activity lacks clarity (the "launch" is the teacher's effort to get the mathematical tasks/activities into play). If the launch is problematic, score for the launch plus amount of time students are confused/off-task/engaging in non-productive explorations

Not Present	Low	Mid	High
None.	Brief lack of clarity. Does not obscure the mathematics of the segment.	Lack of clarity occurs in part(s) of the segment. OR Lack of clarity obscures the mathematics, but for only part of the segment.	Lack of clarity occurs in most or all of the segment. OR Lack of clarity obscures the mathematics of the segment.

Scoring Help - Lack of Clarity

Definition: You have to ask: "What, mathematically, was the teacher trying to say?"

Examples:

- Discussion of why 7 + -3 = 4 heads toward "-4 is too small to be the answer"
  - This is not wrong, but the mathematical point is not clear.
- Teacher endorses conflicting definitions for same concept
  - "The area is a number of square units needed to cover the figure, and we've talked before about the box like a gift that somebody gives you. The box itself and everything inside the box is the area, but the wrapping paper around it would be like surface area and we talked about that and we talked about the perimeter is walking around the fence around an area."
- Talking through a division problem and alternating back and forth between "making 3 groups" and "making groups of 3."
- Garbling a task launch, e.g., by asking initially "How much TV is watched in the US?" when students really must draw a graph to show "How many TVs in US vs. Europe vs. rest of the world?"

Examples -

Not Present	Low	Mid	High
	The launch of task is unclear, but the teacher clarifies quickly. A sentence or phrase is unclear, but the main mathematical point is not affected.	To introduce inverse operations, teacher explains that multiplication and division are "best friends" and "if you know something about one, you know something about the other." Examples later in the segment make the point clearer.	Teacher states that the lesson is going to be on surface area and volume. When students are asked to describe a cardboard box using math terms, the teacher endorses correct and incorrect student suggestions. The teacher then tries to define volume by asking whether a twelve foot TV would fit into the box. Surface area is mentioned numerous times but never defined. It is unclear if the teacher is using surface area as a synonym for volume or whether the term is simply never defined.

Back to Table of Contents