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The Road Less Travelled: Examining Alternative Routes to Elementary Teacher Preparation in Mathematics

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Abstract

Background/purpose. The purpose of this qualitative study was to identify strengths and deficits of alternative teacher certification programs, with particular emphasis on approaches to strengthening mathematical content knowledge and pedagogy.

Materials/methods. Six participants included both teacher candidates enrolled in internship in the alternative master's elementary or early childhood program and recent graduates of the programs at a university in the southeast United States. Data were collected through semi-structured interviews conducted via an online focus group to elicit conversation among the participants of their combined perceptions of program-level recommendations to better prepare them to teach elementary mathematics. Using inductive, open coding of the transcribed data, the researchers identified and ultimately agreed upon the emerging themes related to perceptions of preparation program components.

Results. Related to research question one, participants shared meaningful experiences related to the instructor modeling effective mathematics teaching practices that have impacted their own teaching. Related to research question two, five common themes, including recommendations for improvement, were revealed: Need for more preservice mathematics methods instruction and theory into practice; Preparedness for accommodating diverse needs; Analyzing student data to inform practice; Utilizing and securing available resources; and navigating curricular changes/district mandates.

Conclusion. Based on the results of the study, teacher candidates in the elementary and early childhood alternative master's programs are in need additional content, pedagogy, and resources to effectively teach elementary mathematics.

1. Introduction

For more than a decade, academics and education policy experts have raised concerns about a widespread shortage of teachers in the United States (Garcia & Weiss, 2019; Sutcher et al., 2019). The teaching shortage, as defined by Garcia and Weiss (2019), represents the need for teachers in K-12 schools versus the number available for hire. A shortage of over 110,000 teachers was projected by Sutcher et al. (2019) based on data from the U.S. Department of Labor by 2020; however, the COVID-19 pandemic exceeded even that significant estimate. According to Cooper and Martinez Hickey (2022), there was a 4.7% decrease in employment, or 376,000 jobs, in public K–12 schools between February 2020 and December 2021. Educators faced significant challenges in adjusting to novel teaching technologies, implementing COVID-19 health mitigation measures, and managing their personal families' demands alongside their new teaching responsibilities.

According to Garcia and Weiss (2019), the increase in teacher shortage affirmed that the amount of unfilled teaching positions is a result of too few students completing traditional teacher preparation programs. In order to address the national teacher shortage, institutions have created alternative routes to initial certification in addition to traditional teacher education programs (Bowling & Ball, 2018; Sutcher et al., 2019), resulting in approximately 20% of teachers entering the profession through completion of a non-traditional teacher certification program (National Council on Teacher Quality [NCTQ], 2020). While these programs offer a well-intentioned path to certification and to alleviating the teacher deficit, they often lack requirements for teacher candidates to demonstrate strong content knowledge prior to admission (NCTQ, 2020). Furthermore, while elementary teacher preparation programs should provide candidates opportunities to learn and understand the mathematics content that they will teach (Association of Mathematics Teacher Educators [AMTE], 2017), many focus on teaching mathematics rather than the mathematics content itself (Ma, 1999). The purpose of this qualitative study was to identify strengths and deficits of alternative teacher certification programs, with particular emphasis on approaches to strengthening mathematical content knowledge and pedagogy. The study's findings indicate that in order to teach elementary mathematics effectively, teacher candidates in the elementary and early childhood alternative master's programs require more resources, pedagogy, and content.

2. Literature Review

The body of literature that informed this study lies at the intersection of the research on alternative pathways to teacher certification within high-quality programs and preparation to teach elementary mathematics with understanding. In this way, we situate the experiences of current teacher candidates and recent graduates of two alternative master's programs within current ideas of what is necessary to prepare them to implement research-based practices in the elementary mathematics classroom.

2.1. Alternative Teacher Education Preparation Programs

Alternative approaches to certification are generally characterized as expedited and nontraditional paths leading to state teacher certification (Matsko et al., 2022). Conceptually, the goal of these alternative approaches is to fill high-need teaching positions with teachers who did not complete a traditional teacher preparation program. Introduced in the 1980s to diversify and multiply the pool of prospective teachers, alternative certification has taken a variety of forms over the years, from programs that allow non-certified individuals to apprentice under mentor teachers while completing programs to those where early career teachers enter the classroom with limited to no formal preparation and limited mentorship due to the lack of qualified teachers in many schools (Whitford et al., 2017).

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As noted by Lindsay et al. (2009), those who complete alternative certification programs contribute to the overall teacher supply by being an essential component of the long-term teacher pipeline. This extensive supply chain includes a variety of sources, including: a) teachers who were retained from the previous year; b) teachers who are in migration, moving from other states; c) recently certified teachers from traditional teacher preparation programs; d) recently certified teachers from alternative teacher preparation programs; and e) teachers who hold a state teaching certification but are not currently employed. The interaction of these various sources of teacher supply with variables affecting teacher demand includes student enrollment, per-student expenditures, and the teacher-to-student ratio. This interaction ultimately determines whether there are labor shortages or surpluses. The conceptual model of the teacher pipeline proves useful in empirically evaluating alternative pathways to certification and addressing teacher shortages.

While many of these programs achieve the same goal—to certify individuals to teach in the P-12 setting that addresses teacher shortages—the approach and quality vary in length of time to completion as well as content addressed (Bowling & Ball, 2018; Matsko et al., 2022). Significant differences exist in the kinds of preparation that are part of these alternate routes, according to Matsko et al. (2022). This includes program components such as the amount of methods coursework required and the extensiveness of field experience in the classroom. Nontraditional preservice teachers, or those who completed an alternative preparation program, have also expressed a lower degree of satisfaction with the quality of their preservice teacher preparation experiences compared to traditional preservice teachers. They have noted a lack of significant learning opportunities during student teaching and a misalignment between coursework and fieldwork (Matsko et al., 2022). In addition, Redding and Smith (2016) noted that teachers who are alternatively certified may also have little pedagogical understanding and limited training and content competency. This, among other factors, could be the cause of high turnover rates, which would be detrimental to the overall teacher supply.

2.2. Preparation to Teach Elementary Mathematics

Building on Shulman's (1986) concept of pedagogical content knowledge, Ball et al. (2008) provided a practice-based theoretical framework of mathematical knowledge for teaching. Mathematical knowledge for teaching is defined as that "needed to perform the recurrent tasks of teaching mathematics to students" (Ball et al., 2008, p. 39). Within this framework are two domains of subject matter knowledge (both common and specialized mathematics content knowledge) and pedagogical content knowledge (knowledge of the relationships between content and the students, teachers, and curriculum). Teachers must both have a deep understanding of the mathematical content and knowledge of the effective teaching strategies within each mathematical domain (Ball et al., 2008).

According to Ma (1999), the mathematics content knowledge needed for teaching can be further defined as a thorough understanding of fundamental mathematics in which a teacher is able to impart to students the conceptual framework and fundamental mathematical attitudes that are present in elementary mathematics. Teachers should know how each mathematics concept relates to prior knowledge as well as to other mathematics concepts throughout the curriculum. This deep, profound, and thorough understanding of mathematics allows teachers to make connections among concepts and procedures, develop flexible thinking and understanding in their students, and gain a fundamental understanding of the entire elementary mathematics curriculum. In the U.S., teachers need opportunities to deepen their content knowledge of mathematics as they hone their craft of teaching mathematics with understanding.

Schmidt et al. (2018) highlighted disparities in mathematical content knowledge among alternatively certified teachers across several states and programs, revealing substantial variations in the type and amount of content-level training. While many programs have less than desirable

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pedagogical training, even fewer dedicate substantial portions of time to specific mathematics content (Schmidt et al., 2018). Furthermore, the majority of graduate elementary teacher preparation programs dedicate less than one credit hour to teaching mathematics content (NCTQ, 2022). Research in the field concludes that preservice mathematics teachers should be provided additional support with mathematical content knowledge during their preparation, specifically by having the opportunity to take more mathematics content knowledge courses for their own content knowledge development (Hine, 2015; Livy et al., 2016; NCTQ, 2022; Schmidt et al., 2018). Specifically, NCTQ (2022) outlines actions needed for teacher preparation programs, including providing teacher candidates with a strong conceptual understanding of mathematics within three content courses as well as field placements with mentor teachers who demonstrate strong mathematical content knowledge.

Within elementary teacher preparation programs, mathematics methods courses support preservice teachers in not only facilitating their mathematics content and pedagogical knowledge, but also increasing their knowledge about the elementary students they will teach—how the students learn and think about mathematics (Althauser, 2018; AMTE, 2017). To adequately prepare beginning mathematics teachers seeking certification in broad grade bands, such as pre-K to sixth-grade, multiple mathematics methods courses are needed to prepare preservice teachers for the "breadth and depth of practices and dispositions needed" (AMTE, 2017, p. 91). In order to promote high-quality mathematics teaching and learning, the National Council for Teachers of Mathematics [NCTM] (2014) provided a list of eight effective, research-based mathematics teaching practices. Within these practices, teachers identify specific learning goals that are situated in learning progressions, using students' prior knowledge to develop a deeper understanding of the mathematics content. In order to improve students' reasoning and problem-solving abilities, teachers also utilize meaningful, authentic, real-world tasks while students engage in productive mathematical discourse with their peers and teacher. Teachers and students pose purposeful, critical-thinking questions. Various representations are also used to make connections among the mathematical concepts through different lenses while building procedural fluency from conceptual understanding, leading to more sophisticated mathematical understanding. These practices provide a framework for enhancing the teaching and learning of mathematics at all levels.

As outlined by the AMTE (2017), preservice teachers at both the early childhood and upper elementary levels should learn how to engage students with mathematics using appropriate and effective tools, including manipulatives and technology, to help students use multiple representations of the mathematics concepts leading to deeper conceptual understanding and greater procedural fluency. In order to develop mathematical content knowledge for teaching at the early childhood level, preservice teachers should have multiple opportunities to engage in mathematics content at the pre-K to third-grade level, understand young children's mathematical thinking and solution strategies, develop strong pedagogical content knowledge, and create and use a variety of developmentally-appropriate assessments to extend learning for young learners while building upon their understanding. At the upper elementary level, grades 4-6, preservice teachers need multiple opportunities to develop strong mathematical content knowledge, pedagogical content knowledge, and teaching practices that foster students' mathematical understanding, including conceptual understanding, procedural fluency, mathematical reasoning, and problem solving across all mathematical domains. As these teachers are preparing students for middle school mathematics, the preservice teachers need an understanding of what each standard is building toward and how to help students make mathematical connections across grade levels.

According to Matsko et al. (2022), what seems most absent from research in terms of preservice training in teaching mathematics is attention to resources available to nontraditional path educators and attention to teaching learners from diverse cultural and socioeconomic backgrounds as well as those from a range of special cognitive and linguistic needs. Additionally, a difference in feelings of

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preparedness due to coursework offered and the length of time spent practice-teaching has been noted, as alternatively certified teachers who were offered three or more methods courses felt more prepared to teach mathematics. There is also evidence to support the importance of the timeframe in which practice teaching occurs. Alternatively, certified teachers often complete this while teaching in their own classrooms and with limited access to mentor teachers, while traditionally certified teachers complete this in a classroom with a mentor teacher for the duration of the semester (Kee, 2011). What does seem evident are positive, measurable outcomes from among preservice teachers in alternative programs who had intentional training in paired content knowledge and pedagogical outcomes to advance not only their mathematical content knowledge but their delivery of content and conveyance of knowledge as it pertained to their given grade levels and levels of their students' preparedness to learn the target skills (Norton, 2018).

3. Methodology

3.1. Research Design

To understand how elementary and early childhood educators interpret their experiences throughout a teacher preparation program, a qualitative research design was employed. According to Merriam and Tisdell (2015), qualitative research is inductive and produces richly descriptive data used to understand how people make sense of their world. A convenience sample was used as the potential participants were currently enrolled in or graduated from the alternative master's programs at the research study university. The following research questions guided this qualitative study: 1) What components of their preparation program do elementary and early childhood educators feel were the most beneficial in preparing them for teaching mathematics? 2) What recommendations for program improvement do elementary and early childhood educators suggest regarding their preparation to teach mathematics?

3.2. Participants

Thirty-one current students or program completers at a university in the southeast United States were solicited via email requesting their participation in an online focus group to share experiences in their program; they were recruited to span a variety of levels of program participation or completion for both the elementary and early childhood alternative master's programs. Six participants responded to the email, all female, and included teacher candidates enrolled in their internship semester of their respective program and graduates of the programs teaching in their own classroom. Of the six, four were enrolled in the final internship semester, one was a recent graduate (less than 1 year in the classroom), and one was an early career teacher in her third year of teaching. See Table 1 for an overview of the participants (all participant names are pseudonyms).

Table 1. Overview of each participant

Participant	Program	Program status	Ethnicity
Alex	Early Childhood	Internship	African American
Mackenzie	Early Childhood	Internship	Caucasian
Casey	Elementary	Internship	Caucasian
Sydney	Elementary	Internship	African American
Josie	Elementary	Recent graduate	Caucasian
Jasmine	Elementary	Early career	African American

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3.3. Program Context

The elementary and early childhood alternative master's programs are 42-credit hour programs that lead to initial teacher licensure with a Class A teaching certificate. Within each program, blended coursework includes fully online courses as well as on-campus courses. The teacher candidates complete one on-campus mathematics methods course –taught by one of the researchers– focused on developing effective, engaging pedagogical content knowledge for pre-K through sixth-grade mathematics. Throughout the 16-week methods course, effective teaching practices (NCTM, 2014) are consistently modeled to prepare the preservice teachers to implement these practices in their future classrooms. Working in small groups, the teacher candidates employ multiple representations and strategies to engage with mathematics tasks that promote their own reasoning and problem-solving abilities, recording these representations and strategies in their mathematics journal. The use of appropriate concrete and virtual manipulatives is integral to solving these cognitively demanding tasks. The teacher candidates also engage in productive mathematics discourse as they work collaboratively to unpack the content standards they will teach in order to deepen their own understanding of the pre-K to sixth-grade mathematics content. Using the content and pedagogical content knowledge gleaned from the experiences in the methods course, teacher candidates plan instruction that engages all learners in using multiple representations, concrete manipulatives, and a variety of strategies to solve high-level tasks, promoting students' mathematical reasoning and conceptual understanding of the content.

For the early childhood program, field experiences are completed in both pre-K and K-3 classrooms, whereas for the elementary program they are completed in both K-3 and K-4 to K-6 classrooms. The elementary mathematics methods course includes field experience totaling a minimum of 10 hours in which students observe and reflect upon the teaching practices of their mentor teacher. The teacher candidates are also required to plan, implement, and reflect upon a minimum of four mathematics lessons. Prior to the internship semester, teacher candidates also complete a practicum course that includes a minimum of 250 hours in the elementary or early childhood classroom in which they plan, implement, and reflect upon a minimum of one lesson in each content area, including mathematics. During internship, teacher candidates are immersed in their field placement planning, implementing, and reflecting upon a minimum of ten lessons for each content area, including mathematics. Teacher candidates may complete the program in their own classroom while teaching under an emergency certificate; however, they must still have field experiences at both grade bands according to their program requirements for state certification.

3.4. Data Collection and Analysis

Data were collected through semi-structured interviews conducted in online focus groups via Zoom. To accommodate their schedules, the participants were able to join one of two scheduled Zoom meetings in late fall or early spring of the same academic year. The interview protocol was designed primarily to gain insight into the participants' perceived strengths and deficits of the alternative teacher certification programs, with particular emphasis on approaches to strengthening mathematical content knowledge and pedagogy. Using open-ended questions and follow-up questions, the semi-structured protocol elicited conversation among the participants that painted a picture of their combined perceptions of program-level recommendations that would better prepare them to teach elementary mathematics. Sample questions included: What aspects of your university coursework helped you be an effective mathematics teacher? What resources or support do you feel are necessary to effectively teach mathematics lessons in the elementary classroom? What could have better prepared you to understand the mathematics content well enough to teach mathematics conceptually?

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Interview data were transcribed and separated into sentence fragments, the unit of analysis, and entered onto a spreadsheet where each sentence fragment could be coded. Initially, the two researchers simultaneously coded one of the transcripts in order to create a shared understanding of the codes, after which the researchers independently coded the second transcript. Codes were compared, and the researchers reached a consensus on the codes for each sentence fragment—the unit of coding. The researchers used open, inductive coding in tandem to identify and ultimately reach a consensus on all of the emerging themes concerning perceptions of program components for preparation, including both positive aspects and suggestions for enhancement.

4. Results

While data analysis trended toward feedback for program improvement, there were some comments that reinforced positive aspects of the existing singular mathematics methods course. The comments relevant to the first research question were directly related to the instructor consistently modeling effective mathematics teaching practices throughout the methods course. While several aspects of the teaching practices were discussed amid suggestions for program improvement, the limited overall comments did not justify a separate table. However, it seems worthy of mention that the positive aspects of the program may be carried over to the improved methods courses, including justification of additional methods courses.

Participants shared meaningful experiences related to the instructor modeling effective mathematics teaching practices that impacted their own teaching. As mentioned by Sydney, "You're facilitating. That's something (the instructor) has always pushed about, yes, you're the teacher. But sometimes they have to teach themselves." Mackenzie also shared on a personal level that knowing how to teach the standards was helpful as it "better prepares the teacher to go into any content," also sharing that she "needed every strategy (the instructor) showed us." Casey focused on the positive experience of posing and responding to critical-thinking questions as they "practiced" what was being taught when they would respond to questions such as "why," and "why do you think that," giving the participants an opportunity to experience how effective questioning can help students develop a more meaningful understanding of the mathematics content. The experiences that the participants had as the instructor modeled these effective mathematics teaching practices were positively reflected, with Alex stating that "it makes all the difference in the world, when I go to teach; that's how I'm teaching because I experienced it in your classroom."

Participants also reflected on engaging in challenging tasks and problem solving to develop their own conceptual understanding of the mathematics content. Mackenzie provided an encouraging aspect of the course related to her experience with problem solving and investigating mathematical concepts as the instructor facilitated by reflecting, "So, continue doing that, because now I'm sitting here remembering we definitely investigated." As the students engaged in mathematical problem solving each class meeting, both Josie and Jasmine described the positive impact of journaling on their own teaching and learning. Josie noted "I love those journals, I pulled them out when I was doing fractions and stuff for this year and I was like, what did we do again?" Jasmine also expressed how using the mathematics journals to engage in high-level tasks helped her explore the "conceptual piece" of the content areas across the mathematics curriculum.

Initial open coding of the transcribed data resulted in many categories that addressed the second research question, which fell under the area of program improvement. The categories were then further refined and grouped – based on the analytical and theoretical ideas gleaned from the literature – resulting in five emergent themes: 1) Need for more preservice mathematics methods instruction and theory into practice; 2) Preparedness for accommodating diverse needs; 3) Analyzing student data to inform practice; 4) Utilizing and securing available resources; and, 5) Navigating curricular changes/district mandates. Table 2 presents the final coding framework organized by theme.

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Table 2. Final vs. initial coding framework

Final coding framework	Initial coding framework
Need for more preservice mathematics methods instruction and putting theory into practice	• Need for additional mathematics methods courses • Need for varied grade-level teaching experiences • Need for more math content/vocabulary • Need for additional seminars
Preparedness for accommodating diverse needs	• Meeting students' diverse academic learning needs • Meeting the needs of diverse learners
Analyzing student data to inform practice	• Collecting and analyzing student data • Providing student feedback
Utilizing and securing available resources	• Individual student resources • Teaching centers/small group • Teaching with manipulatives • Learning available technologies
Navigating curricular changes/District mandates	• Knowledge of curriculum changes • How to navigate curriculum changes • Teaching strategies with a new curriculum

4.1. Need for More Preservice Mathematics Methods Instruction and Putting Theory into Practice

The participants noted a desire for more than one mathematics methods course in that there would be more opportunities to "break down" standards at all grade levels, with one participant having stated:

> For me, the teaching math aspect, it probably should be an A and B course. It might need to be broken down a little smaller, you know. Especially in elementary education. One year you may teach fifth grade, the next year you may have kindergarten. So, it's not a great idea to keep it all as one course because the standards are so different. [Mackenzie]

One participant, related to the cost of an additional course, described the benefit to the students as "they probably won't want to pay for a second class, but they will come back and thank you later." As the methods courses have embedded field experience, a need for varied grade-level teaching experiences was shared by the participants by remarking, "We need to spend a semester in a K-3, or even a challenging K-2 class, and then a K-3 to K-6 class, because then we could learn from teachers who know what it's like." This was specifically related to the need for additional teaching experiences in a mathematics classroom at different grade levels.

Besides additional coursework and more varied teaching experiences at all levels, a need for developing more mathematics content and vocabulary within the program was discussed. As shared by Josie, a recent graduate, "It shouldn't feel like you're hitting a brick wall because you've never heard of these concepts before and never seen these symbols before or never heard this terminology before." Also related to having the opportunity to develop a deeper understanding of the

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mathematics content and vocabulary, a desire for additional content-specific seminars, and not necessarily an additional course, was expressed by Alex, "I don't know if we need another math class completely, but maybe seminars on the most frequently confused terminology or most commonly used terminology that kind of passes across to all the grade levels."

4.2. Preparedness for Accommodating Diverse Needs

All of the participants mentioned the need for more pedagogy related to meeting students' diverse academic learning needs. Specifically, participants desired more specific practice with linking back to fill gaps in order to catch students up to grade-level skills. Jasmine expressed appreciation for attending to needs surrounding filling academic gaps but also remarked, "there were gaps and issues prior to the pandemic that were never addressed." Sydney also expressed a lack of understanding of "how to go back to the last standard, fill the gap, and get them back on grade level." Participants also felt underprepared to assist students who are above grade level and desire an extra challenge with Casey remarking, "So, I wish that I could have had more experience on providing a little more rigor for kids that are on level and above." Alex explained, "It's facilitating all the needs of all the different students on all the different levels and meeting them where they are, and I don't know if that's a tool that we have."

In addition to meeting students' diverse academic, some of the participants specifically requested more training surrounding linguistically diverse students in order to provide "strategies set for needs at each linguistic fluency level," particularly as it aligns with teaching mathematical content. Others also expressed concerns over supporting students outside the classroom, particularly those who come from low socioeconomic situations or for those students who are underhoused. This all echoed the need for more specific tools to meet the needs of students with identified and nonspecified special needs, for as Sydney observed, teachers feel that:

> [They] don't get as much support as needed to make sure they are successful while also helping all the other students in the class who are struggling to connect the dots between skills they know and those they are kind of fuzzy about. [Sydney]

4.3. Analyzing Student Data to Inform Practice

Participants expressed a need for more learning experiences in collecting and analyzing student data to guide instruction and reengagement activities. They reported feeling unprepared, knowing the amount of data that they are expected to collect. Jasmine responded, "If I had any suggestions, it would be just to learn how to collect data. That's something they don't teach us in school, the amount of data that I need to collect is so important." Participants noted their own gap in being able to identify "what the problem is" related to student misunderstandings and misconceptions. Casey described her lack of confidence in providing meaningful student feedback with, "I feel like that would have been really helpful for us to see more examples of student feedback and how to address it." Sydney also related, "We understand about procedural fluency and everything else that comes with it as far as the teacher's side, but I think we need to put more emphasis on understanding through the lens of students."

4.4. Utilizing and Securing Available Resources

Resources, including how to use them and where to obtain them, were also a prominent point for discussion. This spans the range from individual and small group student resources, physical manipulatives to educational software, apps, and hardware. Participants described a need for student "resources to help them practice in a way that actually is going to help them not just keep him busy." Coupled with a desire for additional resources to support individual students were resources and training on how to meaningfully facilitate small groups. Mackenzie noted, "I feel really

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equipped to do the upfront teaching, but then, as far as like when I'm pulling a small group, like what everyone else is doing, I guess the independent practice, like resources for that."

Resources related to mathematics manipulatives and technology to assist with the teaching of mathematics were also mentioned. The study's participants expressed a need for not only access to mathematics manipulatives, but also to training on how to use them effectively and appropriately. They also expressed a need for resources in the form of "strategies that will help these kids' prior skills that we know they don't know…even down to mastering manipulatives." As Sydney, an elementary intern, described, "a lot of these kids don't use manipulatives at all so it's so foreign." She also identified a personal weakness of being able to identify "which instructional apps are more beneficial" related to the mathematics content standard she is teaching. Josie also admitted, "I'm trying to learn these new technologies. All this other stuff. And the biggest thing for me was being able to tie it all together and speak the children's language." While they have access to innovative technologies, the participants claimed being inadequately trained on how to use them.

4.5. Navigating Curricular Changes/District Mandates

The emergent theme that surprised the researchers was teacher preparedness for curricular changes; for while not every change can be predicted, the participants indicated that having more foresight about periodic curricular and standards changes would be beneficial. As Jasmine reflected, "It should be implemented, or at least mentioned, that you're probably gonna go through a curriculum change. Maybe every year. Maybe every 2 years. Maybe every 3 years. You need to have those basic strategies." Related to knowledge of mathematics curriculum changes is how to navigate curriculum changes once the transition is in place. Several participants mentioned that the county had adopted a new mathematics curriculum, and "not only are the kids struggling, the teachers are struggling." The need for teaching strategies for navigating and implementing this new mathematics curriculum was also an area of need for the participants, as shared by Josie: "We need to better prepare teaching strategies, especially with the new curriculum. We're flying an airplane and building it at the same time." Casey also expressed concern about not being prepared to effectively implement new mathematics curriculum and appropriate teaching strategies:

> I knew they give you a curriculum, but actually being given a curriculum to try to put your own spin on it, and then immediate changes made by the district, on top of new state standards, wow staying true to that was another big thing. [Casey]

At the time of the current study, both school districts in which the participants were teaching had recently implemented a new curriculum. The two inservice teachers received brief training during the summer on the new curriculum. Unfortunately, the four participants completing their internship semester did not receive any training and had to rely on their mentor teacher to assist them in navigating and implementing the new curriculum to fidelity.

Casey's description is reflective of the struggle teachers faced with both implementing a new curriculum that was not written specifically for their students and making instruction "their own" while meeting the needs of their students at the same time.

5. Discussion

The study's first research question explored what elementary and early childhood educators felt were the most beneficial components of their preparation program in preparing them for teaching mathematics. While there were fewer comments related to this query, the feedback gained was affirming in proceeding with existing aspects of the program that promote the modeling of the NCTM's (2014) effective mathematics teaching practices. Participants noted that the experiences the students had while the instructor modeled these effective teaching strategies for mathematics were beneficial, in order to prepare preservice teachers to implement these practices when teaching any mathematical content. Related to the NCTM (2014) practice of asking and responding to higher-

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order, purposeful questions, participants noted the positive experiences related to purposeful questioning that they would feel more confident in implementing this practice in their classroom that would give the students an opportunity to experience how effective questioning can help students develop a more meaningful understanding of the mathematics content.

Within these alternative teacher preparation programs, the teaching of mathematics in the methods course also included elements of coursework and teaching methods for fluency of mathematics concepts, depth of knowledge, and content-specific pedagogy related to the different mathematical domains promoted by the AMTE (2017). The participants also discussed how they developed their own conceptual understanding of the mathematics content by engaging with tasks that enhanced their own mathematical reasoning and problem-solving abilities. However, as noted in the literature, vast differences exist in the overall preparation of alternatively certified teachers (Matsko et al., 2022; Redding & Smith, 2016) and in the amount of mathematics content-level training and the development of mathematical content knowledge for teaching among alternatively certified teachers across several states and programs (Schmidt et al., 2018). Thus, the positive aspects noted by the participants should remain and be enhanced going forward into improved existing methods courses as well as newly proposed mathematics methods courses.

The second research question illuminated recommendations for program improvement regarding elementary and early childhood teacher candidates' preparation to teach mathematics. The study's findings affirmed that there is a desire and need for a more in-depth knowledge and understanding of mathematics vocabulary and content. As there is currently no required mathematics content coursework within both alternative master's programs, the development of this mathematical content knowledge needs to be embedded in the mathematics methods courses, preparing preservice teachers with the content knowledge needed for effective mathematics instruction (Schmidt et al., 2018). As posited by Ball et al. (2008), if teachers do not have deep, subject-matter understanding, they will be less likely to have the knowledge required to effectively teach their students and help them gain a deep understanding of the content. Teachers need to possess the mathematical knowledge required for analyzing student work and making sense of students' mathematical understanding (AMTE, 2017; Ball et al., 2008). Having a singular elementary mathematics methods course has posed challenges to ensuring deep mathematical and pedagogical content knowledge spanning grade levels pre-K to sixth grade that have been imparted to preservice teachers.

Regarding readiness to adequately meet students' diverse needs, all of the participants stressed the need for additional pedagogy that would better prepare them to address the varied learning needs, both in terms of pre-K to sixth-grade students' content competencies and cognitive abilities. With less than 10% of students on grade level and with pressure from administrators to "bridge the gaps," many early career teachers feel similarly to Alex—that there are numerous issues at play (Linek et al., 2012). Since it relates to teaching mathematical content, some participants also expressed the necessity of training regarding linguistically diverse students. Others voiced concerns about helping students outside of the classroom, especially those from low-income backgrounds or those who live in substandard housing. The resources available to educators on nontraditional paths, as well as the importance of teaching students from a variety of special cognitive and linguistic needs and cultural and socioeconomic backgrounds, are, in Kee's (2011) opinion, the most conspicuously lacking from research on preservice training in mathematics education.

In terms of analyzing student data to guide practice, the current study's participants identified a weakness in their own ability to pinpoint the "problem" pertaining to misconceptions and misunderstandings among students. In order to inform instruction and reengagement initiatives, participants also indicated a need for additional learning opportunities involving the collection and analysis of student data. One key element of teacher response to practice that has received limited

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attention in alternative teacher preparation programs is analysis of student data to inform future instruction and remediation efforts, and even less emphasis has been placed on student feedback about delivery of instruction, comprehension, and assessment measures. According to Datnow and Hubbard (2015), teachers without adequate training are less confident in their ability to use data to drive instruction and meet the needs of each of their students. As we are now asking teachers to "use more complex forms of data and to implement new instructional strategies to respond to students' needs" (Datnow & Hubbard, 2015, p. 20), it is important that preservice teachers are trained and feel prepared to meet this expectation at the state, district, and national levels.

Resources, including how to use them and where to find them, was a major topic of conversation amongst the study's participants; along with having access to math manipulatives, and indicated the need for instruction on their proper and efficient use. Remillard and Heck (2014) defined instructional materials as resources that guide or complement instruction. These resources include textbooks, mathematical tasks, pacing guides, educational software, and tools for teaching mathematics – both concrete and virtual manipulatives. Therefore, equipping preservice teachers with resources as well as being open to changing technologies and resources prior to entering their own classroom can give them a foundation for success (AMTE, 2017).

The participants' critical desire for greater foresight regarding recurring changes to curricula and content standards gave rise to the theme of teacher preparedness for curricular changes. Also reflected in their comments were challenges that they as teachers confront in adopting a new curriculum that was not created especially for their students and in making instruction "their own" while still meeting the unique needs of their students. Giving teachers adequate time to visualize and plan for curriculum changes, including professional learning opportunities, provides them with the confidence and capacity to implement new curricula whilst meeting the diverse needs of their individual community, school, and students (Jenkins, 2020).

6. Conclusion

Although program improvement was the main focus of the data analysis, some comments emphasized the advantages of the current mathematics methods course. The outpouring of support for modeling best practices affirmed that methods courses need to attain the components that challenge preservice teachers to construct meaning in active and actionable ways that they can in turn model for their students. Additionally, participants confirmed the idea held by the researchers that preservice teachers developing their own conceptual understanding of mathematics content are imperative in their later confidence in teaching strategies to their students; however, it is currently limited to only one semester of methods coursework. With additional mathematics methods courses, preservice teachers would have more opportunities to develop advanced content and pedagogical content knowledge and more experiences with effective implementation of the mathematics teaching practices (AMTE, 2017; Ball et al., 2008) that exist in the current, singular methods course.

The findings in this study indicate that teacher candidates enrolled in alternative master's programs in elementary and early childhood education require more resources, pedagogy, and content and more time spent on implementation and training in data analysis in order to teach elementary mathematics to students in an effective manner (AMTE, 2017). This, along with other previously mentioned limited aspects of programs, speaks to the need for additional methods courses focused on content-specific pedagogy. According to Ball et al. (2008), teachers are less likely to have the knowledge necessary to effectively help their students develop a thorough understanding of mathematics if they lack a deep understanding of the mathematical content. Given that neither of the alternative master's programs at the university of study currently requires any pre-K to sixth-grade mathematics content coursework, development of this mathematical content knowledge must instead be embedded within the single mathematics methods courses.

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Concerns were also raised by the participants about assisting students outside of the classroom, particularly those from low-income families or those who reside in subpar housing. According to Kee (2011), teachers who choose nontraditional career paths have fewer resources at their disposal when it comes to instructing students with a range of unique cognitive and language needs, as well as cultural and socioeconomic backgrounds. Additional pedagogical resources, especially including the use of and access to mathematics manipulatives, as well as training on how to use them effectively, would better equip teachers for successful mathematics instruction. Thus, giving preservice teachers access to these resources and encouraging them to be flexible with emerging technologies before they start teaching can set them up for success (Linek et al., 2012).

Insufficiently trained teachers lack confidence in their ability to use data to inform instruction and tailor it to each student's needs (Datnow & Hubbard, 2015). We currently expect teachers to respond to students' needs by utilizing new instructional strategies and more complex forms of data; thus, all teachers need to feel prepared and adequately trained to meet the demands of the state, district, and federal levels of education. Preservice teachers also lack sufficient training on planning for and implementing new curricula while still making the curricula meaningful and relatable to their students. Giving all teachers enough time to envision and prepare for curriculum changes—including professional development opportunities—affords them the self-assurance and ability to operationalize the new curriculum while satisfying the various needs of their students, school, and community.

Limitations of the current study include the low number of participants providing feedback. While there may be any number of reasons for this low response rate, those who participated remarked on the abundance of emails and district-mandated professional development that has increased in the past several years, which may account for the unwillingness of many to participate in voluntary engagements. The study is further limited to two graduate programs at a single university, making the results less generalizable to all alternative teacher preparation programs.

7. Suggestions

Several implications for practice have been identified based on the study's findings. Many key issues have been brought to the attention of the stakeholders involved in elementary mathematics education, faculty in elementary teacher preparation programs, and district leaders, with regard to the effective preparation of elementary mathematics teachers in the pre-K to sixth-grade classroom. Recommendations for elementary alternative teacher preparation programs, as well as for district-level programs, which could enhance the intentional preparation and support of alternatively certified teachers, are presented.

One challenge is to determine how teacher educators can design programs that offer sufficient preparation so that novice, alternatively certified teachers will feel well prepared to teach mathematics at any grade level from pre-K to sixth grade. For elementary and early childhood preservice teachers pursuing alternative certification, more support with mathematical content knowledge should be given during their training in teacher preparation programs. This support could take the form of more opportunities for expanding mathematical content knowledge to further their own content knowledge development. Furthermore, preservice teachers should be trained in the use of appropriate and efficient tools, such as technology and manipulatives, to help students engage with mathematics. This will enable preservice teachers to apply multiple representations of mathematical concepts, which will deepen their own conceptual understanding and increase their procedural fluency that will ultimately impact their future students' mathematical proficiency. Additional mathematics methods courses will help preservice teachers enhance their understanding of mathematics content and pedagogy and will also increase their knowledge about how elementary students learn and think about mathematics.

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As these alternatively certified teachers enter the classroom, it is vital that district-level support is relevant, timely, and consistent. As many of these programs aim to certify teachers to teach in P-12 settings, the methods and quality differ in terms of the amount of time required to complete the program as well as the course content included. There is evidence-based research to support the importance of the timeframe in which practice teaching occurs. Alternatively, certified teachers often complete this while teaching in their own classrooms–sometimes as an apprentice under a mentor teacher and at other times with limited access to mentor teachers–whereas traditionally certified teachers complete this in a classroom with a mentor teacher for the duration of the program. This supports the need for teacher preparation programs to partner with school districts to intentionally place preservice teachers and early career teachers with strong mathematics mentor teachers and assist them with providing these alternatively certified teachers with additional professional development opportunities related to teaching mathematics to all learners and supporting students at all cognitive levels. Additionally, findings from this study may lead to more robust collaborations with stakeholders at the district and state levels to jointly modify curricula to produce alternatively certified teachers who are better prepared to teach elementary mathematics.

Declarations

Author Contributions. Both authors have equally contributed to, read, and approved the published on the final version of the article.
Ethical Approval: IRB approval was granted through the researchers' university Institutional Review Board under protocol number 1751211-1.
Data Availability Statement: Data for the study are protected under IRB protocol 1751211-1 and are securely stored on the key researcher's drive.
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