MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2024, 20(1), em2381
ISSN:1305-8223 (online)
OPEN ACCESS Review Article https://doi.org/10.29333/ejmste/13941

Review of research on microteaching in mathematics teacher education: Promises and challenges

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Received 15 June 2023 ▪ Accepted 26 October 2023

Abstract

Microteaching has been viewed as a professional development tool that gives pre-service teachers the chance to strengthen their teaching skills. This paper presents an overview of the research on microteaching in mathematics teacher education, noting its prospects and challenges while also making recommendations for modifications to its application. A thorough analysis of 28 empirical papers on microteaching in mathematics teacher preparation that were published between 2000 and 12 May 2023, was conducted. Findings demonstrate that microteaching is an effective approach for enhancing pre-service teachers' core mathematics teaching skills. It is suggested that microteaching, which begins in a laboratory setting with the development of essential teaching skills, should not end there; it should give trainee teachers an opportunity to learn and practice in a real classroom context. Microteaching activities require more time, more supervisors, and more resources to function at its maximum capacity. Technology has also demonstrated greater promise when it comes to enhancing microteaching's position in facilitating the development of pre-service mathematics teachers' instructional skills.

Keywords: mathematics, microteaching, teacher education

INTRODUCTION

One of the most frequently discussed issues in the study of mathematics teacher education is the development of fundamental teaching skills among prospective teachers. With the growing demand on the development of the 21st century skills among learners of school mathematics, teachers in making ought to be equipped with the relevant knowledge and skills for them to effectively deliver mathematics instruction. The need for a renewed focus on the "future themes of mathematics education research" (Bakker et al., 2021) is further affirmed by the desire to concentrate on training teachers "for the future we want" (UNESCO, 2015). Based on data from a worldwide survey conducted before and during the COVID-19 epidemic by Bakker et al. (2021), teacher professional development is one of the areas for mathematics education research that is highly recommended.

Professional development has been emphasized because it focuses on developing teachers on what and how students should learn (Bakker et al., 2021). According to Kanyongo (2021), mathematics education should no longer be based on antiquated practices that prioritize memory and preparation for exams. However, it suffices to mention that when aspiring teachers are being prepared in ways that they were not exposed to as mathematics students, the complexity and challenges of mathematics teacher education are heightened (Chapman, 2012). This is why mathematics teacher educators and teacher training institutions should put more effort into ensuring that teachers in making are well-versed with fundamental teaching techniques before they are placed in the classroom.

Microteaching is one of the strategies through which core teaching skills are developed among prospective teachers in most teacher training institutions (Alex & Thomas, 2023). It is also worth acknowledging that the value of microteaching in teacher education programs has been emphasized in existing literature. For instance, Bozkurt and Koyunkaya (2022) agree with other researchers (*such as*, Allen & Eve, 1968; Ledger & Fischetti, 2020) that microteaching is an effective method for fostering pre-service teachers' initial experiences and

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Contribution to the literature

- This study lays the foundation for future research by addressing a shortage of review studies on microteaching in mathematics teacher education.
- From a worldwide perspective, this review uncovers the challenges along with opportunities associated with microteaching in mathematics teacher education.
- In view of the identified challenges and opportunities, the study recommends certain changes to the implementation of microteaching to ensure that it achieves its full potential.

giving teacher educators the tools for identifying strong and weak points among their students. Larey et al. (2023) emphasize further that microteaching gives aspiring teachers the chance to teach and reflect on their teaching, which helps them develop useful teaching skills and confidence.

Despite the value of microteaching for teacher development, there do not seem to be many comprehensive reviews in the mathematics teacher education literature that outline the most effective strategies for organizing and carrying out microteaching sessions. Furthermore, not much is known about the challenges and promises of microteaching and their influence on curriculum reform in mathematics teacher education. As a result, this systematic review focuses on the use of microteaching in mathematics teacher education, carefully highlighting the opportunities and obstacles related thereto. The study also discusses how curriculum reform in mathematics teacher education may be influenced by those opportunities and challenges.

In response to the above highlighted concerns, the following research questions were examined:

1. How has microteaching been implemented in the last two decades of research on mathematics teacher education?
2. Over the past two decades, what obstacles and opportunities have been found with regards to the application of microteaching in mathematics teacher education?
3. What adjustments to the microteaching implementation are required in light of the uncovered opportunities and challenges?

LITERATURE REVIEW

Origin & Development of Microteaching in Teacher Education

The origin of microteaching could be traced from 1963 at Stanford University under the leadership of an eminent scholar and lifelong reformist, Professor Dwight W. Allen. Since then, microteaching has undergone some modifications for maximization of its effectiveness. Microteaching has been used as an effective strategy for building teaching skills among prospective teachers in different disciplines including education, medicine, nursing, and anthropology, among others (Larey et al., 2023; Reddy, 2019; Remesh, 2013). According to Cooper and Stroud (1966), as cited by Allen (1967), microteaching was initially established to serve three purposes: first, as a preliminary experience, second, as a research vehicle, and third as an in-service teacher development tool. Traditionally, microteaching is designed for pre-service teachers who are required to teach short lessons of about five to 20 minutes to small groups of peers (who pretend to be learners) in their teaching subject. The lesson is then video recorded after which both the teacher in question alongside his/her peers (learners), and an instructor (lecturer or mentor) are allowed to watch the recording and comment on what they saw happening with regards to the skill(s) being developed. According to Allen (1967), watching the video provided an opportunity for immediate feedback on the teacher's performance by peers (learners), and supervisors.

Although microteaching has been used frequently in teacher training institutions, Zhang and Lin (2014) report that its exclusive focus on discrete teaching skills has been heavily criticized. Such criticism has led to further investigations on how microteaching can be used to build pre-service teachers' knowledge for teaching. With the recent rise in technology use in higher education globally, there has been a renewed emphasis on blended microteaching model (Bozkurt & Koyunkaya, 2020, 2022; Larey et al., 2023; Ledger & Fischetti, 2020). Conversely, microteaching implementation has been found to be quite effective in building pre-service teachers' technological pedagogical content knowledge (TPCK) (Acikgul, 2020; Agyei & Voogt, 2012; Kafyulilo et al., 2015). This means that while technology makes microteaching implementation incredibly simple, microteaching also helps future teachers acquire their technological skills.

Theoretical Foundations of Microteaching

According to Perlberg (1972), the concept of microteaching is underpinned by programmed learning and computer assisted instructions. The American psychologist B. F. Skinner is credited with developing programmed learning, which is based on the notion that learning is best achieved by small, progressive phases with instant support, or incentives, for the student who is learning. In other words, it is founded on operant

conditioning in which complex tasks are divided into manageable chunks. Along the way, the individual being tested receives feedback on how well he has mastered each step. According to Skinner (1986), programmed instruction is similar to one-on-one tutoring in that it allows the respondent to learn at his own pace, and always corrects mistakes in responses. In a similar manner, microteaching is based on the premise that understanding is improved when a complex skill is broken down into its component parts and mastered gradually before being undertaken as a whole.

Microteaching is a strategy that has been appreciated and applied in most teacher education institutions. Although microteaching has many advantages, it has also its own limitations. Theoretically, microteaching has been found to be greatly influenced by behaviorism, meaning that it places more emphasis on training rather than educating (Seidman, 1969, as cited in Perlberg, 1972). In this sense, microteaching assumes that the role of a teacher or supervisor is to control the students, something that is against the virtues of constructivism that has been emphasized in the 21st century. To address such limitations, Perlberg (1972) advised that microteaching should not end at skill development stage in a laboratory setting but should provide opportunities for trainees to practice those skills.

Microteaching Implementation

In search for better ways to implement the microteaching strategy, different models have been developed over time. While several models may have been developed, this review focuses on five models namely Stanford intern model, minicourse model, expanded microteaching model, microteaching lesson study (MLS) model, and practicum-based microteaching model. It is important to note that this list is not all-inclusive; only those models considered pertinent to the study's objectives are included. Additionally, each of the five models covered here can simply be expanded upon with other models. For instance, any of the models outlined here can readily incorporate the microteaching paradigms (such as experiential learning, learning-centered microteaching, and blended learning microteaching) that have been discussed in Larey et al. (2023, p. 6-7).

Stanford intern model

Stanford intern model was the first microteaching strategy to be implemented by Dwight W. Allen and his colleagues. In this model (Alen, 1967), an intern is given an opportunity to study specific teaching skills, followed by a short presentation of a lesson, usually lasting for five to 10 minutes to a group of four or five pupils. During the presentation, the lesson is video recorded after which the intern is given an opportunity to watch a replay of the lesson. Finally, the intern is given feedback by the supervisor or instructor on his performance regarding a specific skill or set of skills. Based on the feedback given, intern is allowed to replan lesson and presents to another group of four or five pupils. Pictorial representation of the model is depicted in **Figure 1**.

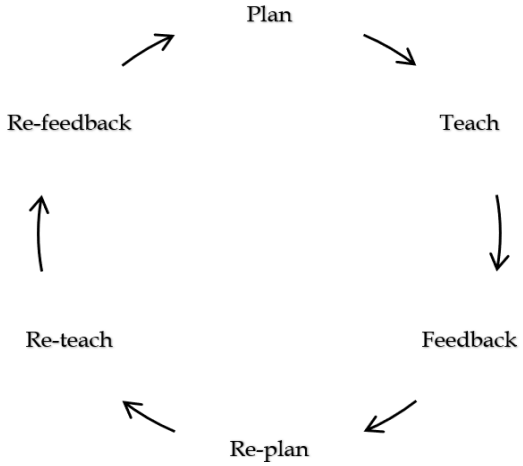

Figure 1. Microteaching cycle (adapted from Alex & Thomas, 2023)

Minicourse model

In the minicourse model (Borg et al., 1969), a full package of in-service training materials is provided to any school, where videotape recording systems are available. Unlike Stanford intern model, where an intern is evaluated by the supervisor, feedback in the minicourse model is provided through comprehensive teacher evaluation of reruns of recorded lessons. This implies that the minicourse model relies heavily on filmed illustrations by model teachers rather than supervisory feedback to provide the trainee with a basis for discriminating the behavior patterns or skills to be learned. Video analysis of self and other trainees' lesson presentations have been found successful in improving individual reflective ability and instructional skills especially when exposure to such an experience is repeated (Nagro, 2020; Nagro et al., 2017).

Microteaching lesson study model

This model was first implemented by Fernández (2005) on high school prospective mathematics teachers who worked on collaborative groups of three in lesson planning, lesson delivery, lesson analysis, and revisions. This model combines some features of the traditional microteaching technique (Allen, 1967) and those of the Japanese lesson study (Lewis & Tsuchida, 1998). This model is meant for the development of pre-service teachers' mathematical reasoning skills. Like the Japanese lesson study whose focus is on the learning goals of the study, MLS model's (Fernández, 2005) focus was on the development of students' mathematical reasoning skills.

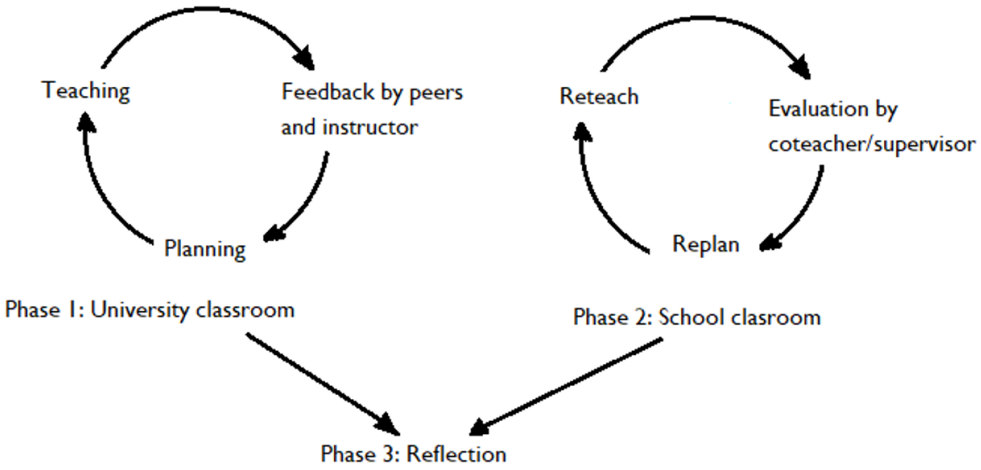

Figure 2. Practicum-based microteaching cycle (adapted from Zhang & Cheng, 2011)

In MLS model, groups of three pre-service teachers are required to make lesson plans of 25 to 30 minutes on selected topics. Each pre-service teacher presents the lesson to a small group of peers while being videotaped. After the presentation, the videotape is watched and the lesson plan is read by the instructor, who then provides initial feedback to the group. After the completion of the first step for the designated number of teacher candidates, new heterogeneous groups (MLS groups) are formed by the instructor for planning and teaching new lessons. Following instructor comments, MLS group members evaluate each other's previously recorded presentations (each on a separate concept). The next step is for each MLS group to conduct research and prepare a lesson plan for a 25- to 30-minute session on a new topic to present to a separate small group of five of their peers. Each of the three teachers are made to watch the recording, and to assess the lesson using a prescribed analysis criteria (*see* Fernández, 2005). The lesson is discussed by peers along with feedback from the instructor, and revisions for the reteaching are made. The analysis and editing procedures are repeated when the second member teaches the lesson to a fresh set of peers a week later. The third participant then teaches a third group of peers in the session. Finally, the lesson is amended once more, and a fresh lesson plan to be distributed to the entire class is created.

Expanded microteaching model

The notion of expanded microteaching was applied in a pre-service mathematics teacher training program (Peker, 2009). The expanded microteaching technique involves more students in a real classroom setting than the conventional microteaching strategy. It also entails a pre-service teacher delivering a lesson to learners in a real classroom at the appropriate grade level (primary, secondary, or senior phase). The trainee teacher is videotaped while teaching the class, and the recording is afterwards seen by the trainee, their peers, and their mentor teacher or supervisor. The focus of the conversation is on the presenter's strong and weak areas in relation to the development of teaching abilities (such as teacher confidence). After pointing out the presentation's flaws, the trainee teacher makes the required adjustments to his or her lesson plan on the same topic and then presents it to a separate class of students who are yet to learn the topic at hand. The first phase's process is done repeatedly until the mentor teacher and supervisor are pleased. Because of its focus on the real classroom environment, expanded microteaching provides an opportunity to pre-service teachers to observe themselves and identify areas, where they need to improve their knowledge of teaching. According to Peker (2009), expanded microteaching can act as a reflective mirror for pre-service teachers. This is because pre-service teachers are given ample time to reflect on how their own instruction compares to that of their peers in a real classroom setting.

Practicum-based microteaching model

The practicum-based microteaching model by Zhang and Cheng (2011), is premised on the notion of "approximation of practice" (Grossman et al., 2009). According to Zhang and Cheng (2011), the practicum-based microteaching model is implemented through a six-step cycle (plan-teach-feedback-reteach-feedback-reflection) across three phases (university classroom, school classroom, and reflection) as depicted in **Figure 2**. Its emphasis on verbal and written feedback from course instructors, peers and supervisors provides opportunities for dialogue from multiple perspectives.

In phase one, feedback is provided to the trainee teacher by peers and the instructor. The feedback evaluation protocol is divided into two sections. The first section, "Compliments", captures the positive aspects of the lesson presented. The second section provides suggestions for improvement, focusing on the skill being developed. The second part of the evaluation protocol is concerned with the subject matter knowledge including the application of the content to other contexts.

In phase two, there is a transition from the controlled (laboratory) system at the university to the real

classroom environment at school. Unlike the traditional microteaching model(s) in which replaying and reteaching occurs in the same context (laboratory environment), this model requires that what the trainee learned in phase one is transferred to the real classroom environment. Similar to the expanded microteaching model (Peker, 2009), the practicum-based microteaching provides an opportunity to the trainee teacher to experience the real classroom environment while learning how to teach. At this stage, the mentor teacher and/or supervisor would evaluate trainee teacher using the same feedback protocol that was used in phase one.

Finally, phase three involves the compilation of a reflection report by the trainee teacher based on the feedback provided by the mentor teacher, supervisor, and the peers. The pre-service teacher is supposed to report on what was observed and learned with regards to lesson planning, lesson presentation and feedback from peers, mentors, and supervisors. The practicum-based microteaching model has been acknowledged as being effective in the sense that the feedback provided to trainee teachers from multiple sources is a great source of reflection and inspiration for pre-service teachers' future undertakings (Phan, 2022). In all, the practicum-based microteaching model integrates theory and practice thereby providing trainee teachers with opportunities to develop core teaching skills.

Despite its effectiveness in developing pre-service teachers' knowledge for teaching, and its emphasis on connecting theory to practice, the practicum-based microteaching model, too has some limitations. Based on the survey and interviews administered by Zhang and Cheng (2011) at the end of the intervention, respondents expressed some concern about time constraints and mismatch in microteaching and teaching practice schedules. The peers' knowledge and maturity levels in the university class may also have presented some artificial classroom context.

METHODOLOGY

Article Selection Procedure

This paper is a desk review in which empirical studies that speak to microteaching in mathematics teacher training were reviewed. As per the tradition, every systematic review employs specific criteria for selecting suitable articles for review. Studies published in journals or conference proceedings within a given field are usually selected from databases like Google Scholar, Education Resources Information Center, ProQuest, Scopus, and Web of Science among others (Celik et al., 2022; Heitink et al., 2016; Ukobizaba et al., 2021). For this review, we selected articles that have been published on microteaching in mathematics teacher education from the year 2000 until 12 May 2023. We searched Google Scholar and ProQuest databases using key words such as microteaching, microteaching in teacher education, and microteaching in mathematics teacher education. With these keywords, 180 articles were downloaded from the two mentioned databases.

We filtered articles based on the database in which their respective journals are indexed because we were aware that both Google Scholar and ProQuest databases may have held some papers published by journals that are not recognized by the South African Department of Higher Education and Training (DHET). As such, the only articles that qualified for evaluation were those that appeared in journals indexed by DHET, Directory of Open Access Journals (DOAJ), SciELO, Scopus, and Web of Science. Other articles were excluded because they were not relevant to the research focus. That is, the term "microteaching" was only mentioned in the text without being the focus. The analysis also disregarded articles that addressed microteaching but were not focusing on mathematics teacher education. The other group of articles that are not included are those that were duplicated, or rather downloaded more than once.

Consistent with the recommended procedures for conducting systematic reviews (Hallinger, 2013; Page et al., 2021), we undertook the steps depicted in **Figure 3** to obtain a total of 28 reviewed empirical studies. **Appendix A** provides further information about the serial number, author(s), year of publication, research focus, and major conclusions for each of the reviewed publications.

Data Analysis Approaches Used

Three analysis approaches were employed during data gathering and analysis: document analysis (Kitchenham, 2004), content analysis (Krippendorff, 1989), and thematic analysis (Braun & Clarke, 2006, 2012). The goal of the document analysis technique was to identify relevant publications in relation to microteaching research in mathematics teacher education. This approach was crucial in filtering 28 articles from the 180 articles that were acquired from the two databases (**Figure 3**).

After locating appropriate data, each article was reviewed, annotated, and arranged in line with the key themes and issues that were crucial for addressing the specified research questions. Braun and Clarke (2006) recommended thematic analysis method was used at this point. This included getting acquainted with the data, doing some preliminary coding, finding and reviewing themes, and matching themes to the stated research questions. Through content and thematic analysis, the meanings and linkages of important components were established. The data for research question 1 and research question 2 are presented and discussed in the next section, while answers to the third research question are provided the last section.

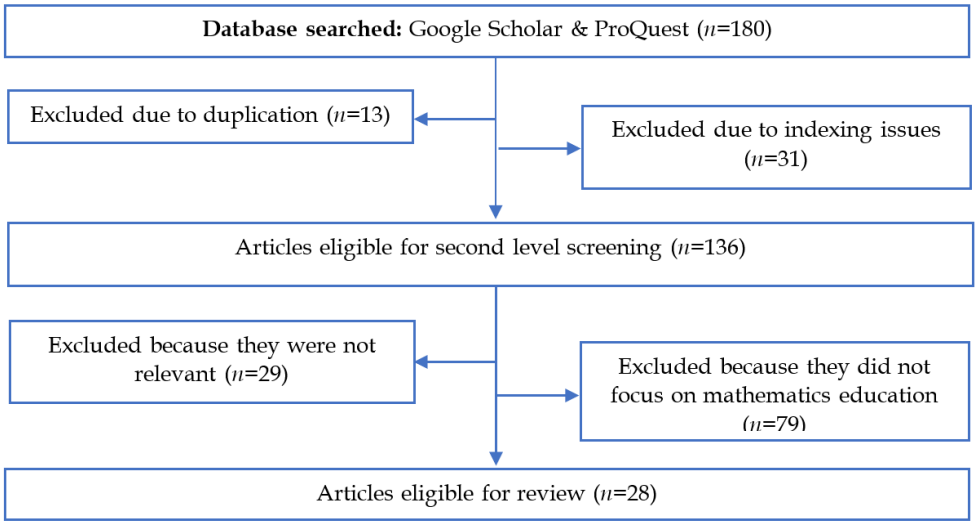

Figure 3. Article selection process (Adapted from Page et al., 2021)

RESULTS & DISCUSSION

Demographic Patterns of Reviewed Articles

Based on the prescribed article inclusion/exclusion criteria, empirical research from 13 countries were reviewed. Out of the 28 studies examined, 11 were conducted in Turkey, five were from the USA, and two were from Greece. The findings also revealed that each of the other nine countries–Australia, Canada, China, Ghana, Indonesia, Kenya, Kuwait, South Korea, Taiwan, and Tanzania–had only one paper reviewed from there. This indicates that only three out of the research that were assessed were done in an African setting.

The findings also show that the bulk of the examined research were carried out in Turkey, then the USA. Our analysis reveals that only seven (25.0%) of the examined papers were published between 2000 and 2013, and that 21 (75.0%) of the works reviewed were published during the last 10 years. This highlights the growth of microteaching research in the field of mathematics teacher education. A new book edited by Okeke et al. (2023), "Managing the microteaching process: A practical guide to teaching practice preparation" is a convincing example of how valuable microteaching is–even in the context of Africa.

Regarding the methodological approaches used, the findings indicate that 22 (78.6%) of the studies under examination used qualitative methods for data gathering and analysis. Only four (14.3%) of the research applied quantitative techniques, and two (7.1%) blended qualitative and quantitative methods. One potential explanation for this is that the majority of microteaching sessions employ video recordings, whose analysis is particularly successful when qualitative methodologies are applied. Additionally, qualitative analysis of video annotations helps and extend both self-reflection and peer assessment (Walshe & Driver, 2019).

Microteaching Implementation in Mathematics Teacher Education

The application of microteaching has evolved since its inception in the early 1960s. While microteaching has numerous benefits, it also has its own drawbacks. These possibilities and difficulties have sparked more insightful experiments that have given rise to various implementation approaches to microteaching. Stanford intern model, minicourse model, expanded microteaching model, MLS model, and practicum-based microteaching model are the five models that this review focuses on. It is also important to note that this list is not exhaustive and that only models deemed relevant to the goals of this review were included. **Table 1** shows how frequently each of these five models was used in the reviewed publications.

It is most likely that just one study included all the microteaching strategies because of the substantial overlaps between them. In this regard, a thorough analysis of the use of microteaching in each study was carried out, and the most prevalent model(s) for each article were determined as indicated in **Table 1**. This does not imply that every article falling under a certain model had microteaching implemented strictly in accordance with that model's requirements. It simply means that a sizable chunk of that particular model was applied in the study. Results shown in **Table 1** show that over the past 20 years, Stanford model has dominated research on microteaching in mathematics teacher education. Stanford model, which is regarded as the de facto method of microteaching, was used in more than 53% (n=15) of reviewed publications. One explanation for this is that Stanford model is straightforward to implement since, unlike other models, it does not call for exposing pre-service teachers to the actual classroom environment. Second, the other models were built on Stanford model, which was their starting point.

Table 1. Microteaching implementation techniques from reviewed studies

Article number	Stanford intern microteaching	Minicourse microteaching	MLS	Expanded microteaching	Practicum-based microteaching
1	✓		✓		
2	✓	✓	✓		
3	✓				
4	✓	✓			
5	✓	✓			
6				✓	✓
7					✓
8		✓			
9	✓				✓
10			✓		
11			✓		
12			✓		
13	✓		✓		
14	✓				
15	✓				
16	✓				
17	✓	✓			
18	✓				
19			✓		
20	✓				
21				✓	
22	✓	✓			
23				✓	✓
24			✓		
25	✓				
26					
27		✓			✓
28		✓			
Count	15	8	8	3	5
Percentage (%)	53.6	28.6	28.6	10.7	17.9

Minicourse model (n=8; 28.6%) and MLS model (n=8; 28.6%) appear to have been used by a significant number of the examined papers. Since MLS model (Fernandez, 2005) was created especially for mathematics pre-service teachers, it may have been applied significantly. Minicourse model (Borg et al., 1969) has also been around for a while, much like Stanford model. Practicum-based microteaching model (n=5 or 17.9%) and extended microteaching model (n=3, 10.7%) had the lowest implementation rates. Although not widely used, practicum-based microteaching model has been quite effective in the sense that feedback given to trainee teachers from a variety of sources is an excellent avenue for reflection and inspiration among pre-service teachers (Phan, 2022; Zhang & Cheng, 2011). It has also received praise for its emphasis on bringing microteaching into the classroom setting.

Effectiveness of Microteaching in Mathematics Teacher Education

Similar to reviews undertaken in other fields (Chen, 2023; Reddy, 2019), this study found that using microteaching in the preparation of mathematics teachers is associated with a number of advantages.

First, this review has established that microteaching is an effective strategy for building up TPCK skills among mathematics trainee teachers (Acikgul, 2020; Agyei & Voogt, 2012; Kafyulilo et al., 2015). Similarly, the adoption of microteaching for improving mathematics instructional skills among future teachers has proven to be effective with the help of various digital technologies (Bozkurt & Yigit Koyunkaya, 2020, 2022; Buttler & Scheurer, 2023; Larey et al., 2023; Ledger & Fischet, 2019).

As a result, both technology and microteaching can be effective tools for helping pre-service teachers strengthen their fundamental mathematical teaching abilities. Other studies also show that pre-service teachers who participated in microteaching activities were more likely to be job-ready, particularly in three crucial areas such as, lesson preparation, lesson implementation, and lesson evaluation (Altammar & Aljassar, 2021; Murtafiah & Lukitasari, 2016; Unver et al., 2020).

Second, microteaching has been found to be a significant enhancer of trainee teachers' self-efficacy beliefs about the teaching of mathematics. Microteaching also improves trainee teachers' self-confidence regarding lesson delivery. Altammar and Aljassar (2021) concur with Bilen (2015) that microteaching sessions enables teacher candidates to acquire core teaching skills that eventually leads to an increase in their self-confidence. As a result, their anxiety levels towards lesson delivery tend to reduce (Peker, 2009).

Third, MLS has been perceived worthwhile in building up trainee teachers pedagogical and subject matter knowledge. Findings show that MLS, not only bridges the gap between theory and practice but also fosters a sense of collaboration among aspiring teachers (Fernández, 2005, 2010; Fernández & Robinson, 2006). Collaboration is one of the 21st century skills that is critical to the teaching and learning of mathematics. Some scholars (*such as*, Goos, 2004; Mueller et al., 2014; Mukuka et al., 2019, 2023) have confirmed that collaboration in mathematics classes orchestrates discussion that leads to improved conceptual understanding and mathematical reasoning skills.

Fourth, the findings indicate that microteaching is a useful technique for identifying the unique needs of each trainee teacher and ensuring that concerns are addressed before actual teaching takes place. This is supported by the findings of the study by Ozcan and Gercek (2019), which showed that engaging in microteaching enabled prospective teachers to gain more control over the classroom, and their students became more motivated and interested in the lesson.

Fifth, our review has shown that giving pre-service teachers the chance to see recorded lessons of their peers improves their oral and written communication skills as they offer comments. Pre-service teachers get an opportunity to reflect on and evaluate their own performance by watching their own lessons.

According to a study by Lin (2005), pre-service teachers who participated in journal writing, and watched and discussed video instances that had been enhanced by the developers displayed deeper reflections. Other studies by Roller (2016) and Yilmaz and Yetkin-Ozdemir, (2021) support the same conclusions, emphasizing that using video in the implementation of microteaching is an effective way for enhancing teachers' noticing abilities.

Challenges Associated With Microteaching Implementation

Microteaching also has limitations despite having advantages like those mentioned in the previous section. First, our analysis has shown that a lack of resources could make microteaching unproductive. For instance, a study done in Turkey by Sen (2009) found that it was difficult to use microteaching to its fullest potential due to the artificial nature of the learning environment and the lack of cameras to record the sessions.

Second, insufficient time allocated, and a lack of supervisors were also mentioned as barriers to effective implementation of microteaching (Basturk & Tastepe, 2015; Koech & Mwei, 2019). These barriers are not specific to mathematics as other studies from other fields have cited comparable drawbacks. For example, Reddy (2019) pointed out that the time constraints associated with microteaching may raise administrative issues while planning, which may lead to delays in the process.

Third, the findings indicate that certain pre-service teachers exhibit significant levels of anxiety brought on by fear of being reprimanded and being caught on camera. This causes some trainees to lose concentration on the work they are supposed to do. According to Bilen (2015), some pre-service teachers were unable to fully utilize the advantages of microteaching in developing their fundamental teaching abilities because they lacked time management skills and were uncomfortable with video recordings. Another study by Basturk and Tastepe (2015) found that pre-service teachers' development of core teaching skills in mathematics was negatively impacted by anxiety, poor time management, inability to control peer excitement, a lack of content knowledge, and fear of criticism from peers and supervisors.

Fourth, it has been shown by this review that the standard microteaching approach is used in a laboratory setting that is artificially controlled, which may not consider the distractions and student misbehavior that may be present in a real classroom setting (Menon et al., 2023; Sen, 2009). Because of this, some scholars (Peker, 2009; Perlberg, 1972; Zhang & Cheng, 2011) have suggested extending microteaching to the actual classroom setting to give aspiring teachers a richer learning environment as they hone their teaching techniques. Alternatively, Cheng (2017) shows that pre-service teachers can develop their teaching skills before having chance to teach in a real classroom by involving expert secondary mathematics teachers in microteaching activities that take place in university setup.

Finally, even though using technology and microteaching has helped pre-service teachers improve their fundamental teaching skills, doing so might be difficult due to time management issues and technical issues. The adoption of technology-based microteaching is fraught with obstacles, according to certain studies (Yenmez et al., 2017; Lee, 2017; Setyawati & Indiati, 2018; Zalavra & Makri, 2022). These difficulties include handling technology correctly, reduced involvement, time constraints, and a lack of resources.

Study Limitations & Future Directions

Notwithstanding all the strengths associated with this paper, the authors are cognizant of the limitations associated with this study.

First, majority of the reviewed articles addressed the preparation of mathematics teachers for secondary schools. While authors had no control over this, it suggests that future research should also focus on how microteaching is carried out in the context of foundational phase teacher training. Second, only publications found in particular databases were considered. Although this has been justified on the basis of accreditation by South Africa's DHET, it suggests that the data presented in this study may not be all-inclusive. Third, not all papers from subscription-based publications might have been included since the authors' institution of affiliation had restricted access to the content. Despite these shortcomings, it's important to remember that this study is timely in that it has shown several implementation strategies for microteaching as well as its obstacles and prospects. The study has also highlighted how the uncovered challenges and opportunities may influence the curriculum reform for mathematics teacher training.

CONCLUSIONS & RECOMMENDATIONS

According to this review, microteaching is a useful approach for developing mathematics core teaching skills among pre-service teachers. Microteaching is a powerful professional development tool that can be used in a variety of fields in addition to mathematics teacher education. It has been established that the conventional microteaching technique has more potential when used to actual classroom settings since it allows aspiring teachers a chance to connect with practicing teachers, their peers, and supervisors. This means that microteaching, which starts in a laboratory setting with fundamental teaching techniques should not end there; it should give the prospective teacher a chance to study and practice in a real classroom setting. Considering this, we suggest introducing significant elements of practicum-based microteaching and lesson study into the process of developing pedagogical and content expertise in aspiring teachers of mathematics. This will combat the artificiality of the laboratory setting used to implement the conventional microteaching technique.

For microteaching activities to reach their full potential, more time, more supervisors, and more resources must be dedicated to them. When it comes to the improvement of microteaching's standing in the development of teaching capabilities among pre-service mathematics teachers, technology has shown more potential. To this effect, we concur with the existing literature's assertions that curriculum reform efforts at all levels of education should prioritize technology integration in mathematics teaching and learning. Priority should be given to the need for curriculum reform and access to digital tools that are essential for implementing microteaching. This may be attributed to the requirement that mathematics teacher educators and student teachers study technology and use it to assist pupils in better understanding mathematical concepts. Building digital skills at the individual and organizational levels will therefore promote innovation and agility across key delivery areas, such as the provision of high-quality and adaptive teaching for students, as well as establishing the necessary competences that teacher educators and student teachers need to perform at their best in the modern, technologically advanced world.

Author contributions: All authors have sufficiently contributed to the study and agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that, as this study is a systematic review, it did not require ethical approval. However, we have ensured that all utilized data sources are appropriately recognized and cited in accordance with academic standards.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A

Table A1. Reviewed articles

S/N	Author(s)	Research focus	Country	Major findings
1	Acikgul (2020)	Microteaching-supported games & pre-service teachers' TPACK self-efficacy perception levels	Turkey	TPCK self-efficacy perception ratings of pre-service teachers are indeed raised by microteaching techniques.
2	Agyei and Foogt (2012)	Development of pre-service teachers' TPACK through collaborative design	Ghana	Microteaching was found to be an essential strategy for development of trainee teachers' TPACK in their respective design teams.
3	Altammar and Aljassar (2021)	Microteaching in mathematics classrooms & promotion of responsiveness using 21st century skills	Kuwait	Prospective teachers who used microteaching had higher levels of work preparedness, particularly in three crucial areas of lesson planning, implementation, & evaluation. Teachers became more confident & prepared.
4	Yenmez et al. (2017)	Changes in pre-service teachers' TPCK from their microteaching practices	Turkey	Pre-service teachers' TPCK improved in that they were able to use the technological tools to attain what they had specified in their instructional plans.
5	Basturk and Tastepe (2015)	Elementary pre-service teachers' difficulties in teaching mathematics with microteaching method	Turkey	Anxiety, lack of materials, & lack of time management skills. Failure to control excitement among peers, limited content knowledge, & fear of criticism from peers & jury teams were observed.
6	Bilen (2015)	Effect of microteaching on teacher candidates' beliefs regarding mathematics teaching	Turkey	Through microteaching sessions, teacher candidates acquired core teaching skills that eventually increased their self-confidence.
7	Bozkurt and Koyunkaya (2020)	From microteaching to classroom teaching: An examination of prospective mathematics teachers' technology-based tasks	Turkey	By more effectively utilizing their planned technology operations, future teachers of mathematics raised levels of mathematical complexity of their assignments.
8	Bozkurt and Koyunkaya (2022)	Prospective mathematics teachers' planning & teaching technology-based tasks in context of a practicum course	Turkey	Using technology-specific frameworks improved how prospective teachers designed & taught technology-based tasks.
9	Butler and Scheurer (2023)	Pre-service teachers' perspectives on microteaching within Zoom's breakout rooms	Canada	Microteaching activities within breakout rooms facilitated an environment, where pre-service teachers engaged and conversed with peers while developing teaching skills.
10	Cheng (2017)	Impact of microteaching guided by expert secondary mathematics teachers on pre-service teachers' teaching practice	China	Pre-service teachers can learn how to be precise in their classroom instruction by participating in microteaching sessions led by experienced secondary mathematics teachers.
11	Fernández (2005)	Learning through MLS in teacher preparation	USA	Along with offering a comprehensive teaching experience, MLS enabled pre-service teachers to improve their subject matter knowledge & understanding of reform-oriented teaching through peer collaboration & instructor feedback.
12	Fernández (2010)	Investigating how & what prospective teachers learn through MLS	USA	Thoughtful conversation, preparation, practice, & guidance from an expert are key components of active learning. MLS provided pre-service teachers with chance to test, analyze, reconsider, & change.
13	Fernández and Robinson (2006)	Prospective teachers' perspectives on MLS	USA	Findings revealed that pre-service teachers perceived MLS to be a worthwhile learning experience as it enhanced collaboration, & reflection skills.

Table A1 (Continued). Reviewed articles

S/N	Author(s)	Research focus	Country	Major findings
14	Kafyulilo et al. (2015)	Information & communications technologies use in science & mathematics teacher education in Tanzania	Tanzania	Pre-service teachers had chance to explore technology integration in a setting similar to a real classroom. Pre-service teachers gained knowledge of strategies for addressing technology integration issues in actual classroom situations & gained confidence in their ability to move around & between technology, pedagogy, & content.
15	Koech and Mwei (2019)	Secondary school mathematics teachers' perceptions of effect of media practical & microteaching on teaching practice	Kenya	Although microteaching aids in practice of various teaching techniques that student teachers learn, majority of teacher respondents stated that they were unable to put all of techniques they had learned into practice during their teaching practice because majority were only evaluated once
17	Ledger and Fischetti (2019)	Micro-teaching 2.0: Technology as classroom	Australia	Microteaching 2.0 has proven to be a successful diagnostic tool for determining unique needs of pre-service teachers & a tool for preparing for in-real-world placements.
18	Lee (2017)	Convergent & divergent thinking in task modification: A case of Korean prospective mathematics teachers' exploration	South Korea	Because they lacked skills to link areas of images, equations, & inequalities, learners' variability was not tied to meaningful construction of mathematics in micro-teaching.
19	Lin (2005)	Research-based video-cases on pre-service teachers conceptualizing their understanding of contemporary mathematics teaching	Taiwan	Video recordings enhanced pre-service teachers' ability to develop instructional representation & to recognize a problematic scenario from many angles.
20	Menon et al. (2023)	Pre-service secondary teachers' understanding & enactment of standards-based practices during microteaching	USA	Goal of microteaching was to close gap between theory & practice by providing a supportive & low-risk setting.
21	Murtafiah and Lukitasari (2019)	Pedagogical content knowledge of mathematics pre-service teacher through lesson study application in microteaching	Indonesia	There was an increase in mathematics pre-service teachers learning practice in terms of lesson planning, content knowledge, pedagogical knowledge, ability to use learning media, & appropriateness of assessment techniques.
22	Ozcan and Gercek (2019)	Multidimensional analysis of microteaching applications in teacher education via video graph	Turkey	In second microteaching application, prospective teachers' control over classroom improved, while students' motivation & interest in lesson rose thanks to reinforcement & efficient communication.
23	Peker (2009)	Use of expanded microteaching for reducing pre-service teachers' teaching anxiety about mathematics	Turkey	Pre-service mathematics teachers' levels of teaching anxiety were lowered by increased microteaching in teaching practicum course.
24	Roller (2015)	Secondary mathematics prospective teachers' noticing when viewing video of their own teaching in microteaching setting	USA	One way for improving teachers' noticing abilities is to use video in microteaching implementation.
25	Sen (2009)	Views & suggestions of prospective teachers on effectiveness of peer/microteaching in practice	Turkey	Pre-service teachers' self-confidence improved & first-time teaching anxiety reduced.

Table A1 (Continued). Reviewed articles

S/N	Author(s)	Research focus	Country	Major findings
25	Sen (2009)	Views & suggestions of prospective teachers on effectiveness of peer/microteaching in practice	Turkey	Pre-service teachers' self-confidence improved & first-time teaching anxiety reduced.
26	Setyawati and Indiati (2018)	Misconception of integers in microteaching activities	Greece	While technical difficulties in handling technologies, time limitation and inadequate resources were experienced, it was observed that microteaching improves teaching competencies for e-learning.
16	Unver et al. (2020)	Pre-service mathematics teachers' PCK through microteaching	Turkey	Pre-service teachers became knowledgeable different instructional strategies in respect of their microteaching topic. But their knowledge of learners was relatively poor.
27	Yilmaz and Yetkin-Ozdemir (2019)	Pre-service middle school mathematics teachers' discussion skills in context of MLS	Turkey	Microteaching enabled pre-service teachers to begin anticipating student thinking. They also successfully sequence student thoughts & connecting important points related to big ideas.
28	Zalavra and Makri (2022)	Technology-enhanced microteaching practice in teacher education: Challenges & implications	Greece	Microteaching is an effective strategy for cultivating teaching competencies for e-learning.