Bridging Theory and Practice in STEM Teacher Education: Examining the Impact of STEM Teaching Competency Development and Micro-Teaching on Pre-Service Science Teachers' Classroom Readiness in Kenya

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ABSTRACT

Teacher preparation is crucial for improving STEM education quality, particularly in low-resourced settings, where educational disparities hinder learning outcomes. This study sought to understand how STEM pedagogy mastery and micro-teaching influenced the preparedness of pre-service science teachers. The goal was to bridge the gap between theory and practice, particularly in the context of rural and under-resourced settings. This study investigated the impact of STEM pedagogy training and micro-teaching on the classroom readiness of 186 pre-service science teachers at Kibabii University, Kenya. The study aims to bridge educational gaps by evaluating the effectiveness of structured teacher education in equipping student teachers with practical teaching skills. One hundred and eighty-six (186) third-year B.Ed. science students who had completed coursework and school practice participated in the study. The study adopted a mixed-methods approach, and data were collected using structured questionnaires, interviews, and observation checklists, providing a comprehensive view of participants' experiences. The findings revealed that although students appreciated the theoretical grounding in STEM pedagogies, they faced challenges in applying these strategies in real classroom contexts due to resource limitations and rigid instructional practices. Micro-teaching was identified as a vital transitional experience, that boost the student teachers' teaching confidence and facilitated the effective application of the various pedagogical strategies learnt in the coursework. The study emphasizes the importance of aligning teacher education curricula with classroom realities and recommends integrating technology-enhanced resources like simulations. Future reforms should focus on teacher education institutions collaborating with the practicing teachers to provide better mentorship support during school practice and incorporating contemporary pedagogical strategies in the school curriculum to enrich the learning experiences of the pre-service science teachers.

Keywords: STEM pedagogy, micro-teaching, mentorship, school practice.

INTRODUCTION

Globally, significant transformations are reshaping the way STEM subject teachers are prepared. The goal is to better equip future STEM teacher educators with both the practical skills and teaching methods that are necessary for impactful STEM instruction. STEM education has risen in importance, largely because it is seen as crucial for developing competencies such as critical thinking, innovation, creativity and problem-solving in students (Honey et al, 2014; Moore et al., 2017). These competencies are foundational, required to navigate the challenges of a dynamic global landscape, where technological advancements and interdisciplinary collaboration are key to future success (Bybee, 2013).

Nevertheless, effective STEM teaching requires more than just mastery of the subject matter. Teachers must develop the necessary skills to engage learners in their own learning by applying specific, learner centred pedagogies that foster curiosity and inquiry. This includes the ability to create friendly learning environments

that arouse curiosity, encourage exploration and critical thinking, which are key components of an effective STEM education (Liu & Li, 2020). Unfortunately, Teacher Education Programs in many developing countries, Kenya included, often lean too heavily on theoretical frameworks and have insufficient real-world practical experience (UNESCO, 2017). This gap between theory and practice can lead to challenges for newly qualified teachers who struggle to translate instructional strategies learned at university into effective classroom applications when they begin teaching.

This issue is further compounded by insufficient integration of relevant STEM teaching methods that are culturally and contextually appropriate, along with weak connections between university studies and the real-world classroom experiences. Such disconnects hinder the development of teachers who are practitioners and well prepared to address the diverse and dynamic needs of their learners (Darling-Hammond, 2017). That notwithstanding, both theoretical knowledge and practical application are indispensable for effective teaching, particularly in STEM subjects, which require both deep content knowledge and pedagogical expertise.

The rationale for this study stems from the fact that while STEM education continues to be prioritized globally, the gap between theoretical instruction and classroom practices persists, and is wider in rural under-resourced contexts. Research offers limited empirical data on the effectiveness of Teacher Education Programs in preparing science teachers for practical classroom implementation. This study addresses this gap by exploring the impact of integrated pedagogical training on pre-service teacher preparedness.

At Kibabii University, pre-service science teachers undertake targeted STEM pedagogy courses, followed by micro-teaching opportunities and a mandatory school practice in real schools. Micro-teaching provides a simulated classroom context for practicing teaching skills without the risk of being judged. This allows the student teachers to hone their teaching skills in a low-risk environment (Amobi, 2005). On the other hand, school practice involves them in the realities of diverse school environments, complete with real-life context-specific challenges such as large class sizes, limited resources, inadequate teachers etc. Despite this continuum of learning experiences, limited studies have fully explored how effectively this approach develops competent STEM teachers.

It is essential to understand the extent to which pre-service science teachers at Kibabii University transform their STEM pedagogy knowledge and micro-teaching skills into teaching practices in real classrooms. The impact on the effectiveness of their teaching practices, and the ensuant learning outcomes is significant, because research has proved that the application of learned pedagogical strategies directly impacts learner performance (Sata, 2020). This study assessed the connection between mastery of STEM pedagogy, micro-teaching techniques, and their impact on the teaching practices of pre-service science teachers. The relationship between theory and practice is fundamental, as Teacher Education Programs that emphasise practical experience and real-world application have been shown to promote teaching efficacy and learner outcomes (Mishra & Koehler, 2006). The study further seeks to explore barriers to the application of theoretical knowledge in Teacher Education Programs in real classroom teaching. Investigating future teachers' experiences will reveal how they internalize and use the instructional skills they developed through STEM courses and micro-teaching. This underscores the value of linking theory to practice, that has been found to enhance teaching competence, boost teachers' confidence in addressing diverse classroom challenges (Darling-Hammond, 2017).

The study further assessed to what extent the Teacher Education Programs aligns with real-life classroom practices applied, in accordance with Kenya's Competency-Based Education (CBE) system. The CBE addresses the issue of bridging theoretical constructs with real teaching in classrooms by emphasizing the development of practical skills and competencies that directly impact learning outcomes (Orodho et al., 2013). This alignment between teacher preparation and real classroom practices is critical in ensuring that pre-service teachers are helped to develop the knowledge and skills needed to meet the evolving demands of the dynamic classroom's contexts (Zeichner, 2012). The findings of this study will contribute to ongoing conversations around teacher education, underscoring its fundamental role in fostering effective STEM teaching, particularly in rural contexts where resource constraints and diverse learner needs present unique challenges (Lombo et al., 2020; Stutchbury et al., 2019).

Statement of the Problem

Teacher Education Programs in Kenya, especially for STEM subjects, are often criticised for being overly theoretical, lacking sufficient linkage to practical classroom realities. Additionally, the teachers of STEM subjects have been faulted for being overly theoretical at the expense of practical classroom application teachers. Further, the pre-service science teachers, have been observed to struggle when they apply learned pedagogical strategies in teaching and particularly in under-resourced and rural classroom contexts. This clearly indicates a theory-practice gap, a disconnect that persistently leads to ineffective instructional delivery, poor student engagement, and unsatisfactory performance in STEM subjects. This calls for, highlighting the urgent need for empirically grounded interventions that bridge theory and practice in STEM teacher preparation.

This study sought to investigate how engagement with structured STEM pedagogy courses and participation in micro-teaching sessions jointly contribute to pre-service science teachers' classroom readiness, teaching confidence, pedagogical skill refinement, and effective implementation of STEM instructional methods during teaching practice in real school contexts.

Objectives of the study

1. To evaluate the extent to which mastery of STEM pedagogical knowledge contributes to the classroom readiness of pre-service science teachers at Kibabii University.
2. To examine the influence of micro-teaching experiences on the self-efficacy and practical application of STEM teaching strategies among pre-service science teachers during school practice.

Significance of the Study

This study provides critical insights into how pre-service STEM Teacher Education Program can be restructured to align more closely with the realities in the dynamic classroom context. It brings to light the value of integrating digital resources and tools, structured mentorship, and experiential learning. The findings will inform curriculum reforms and teacher education policies and practices aimed at enhancing STEM teaching effectiveness, especially in rural and under-resourced schools in Kenya.

LITERATURE REVIEW

The Theory-practice Gap in STEM Education

Often, teachers find it difficult to translate abstract pedagogical theories into effective classroom practices, particularly in science-related subjects. This disconnects leads to abstract, disengaging science lessons that cannot promote deep learner engagement and comprehension. Research shows that newly qualified teachers are not able to effectively implement interactive teaching strategies (Abell & van Driel, 2010; Bulat et al., 2020). The inability to apply the theory of teaching in classroom teaching settings not only undermines the quality of teaching but also negatively impacts learning outcomes in standardized national examinations in Kenya. The disconnect between theory and teaching practices is especially a barrier in rural under-resourced schools. In such learning contexts, abstract scientific concepts are not easily accessible to learners. Consequently, students fail to comprehend critical abstract scientific concepts, and this affects their knowledge construction and skills acquisition. Ultimately, they score dismally in standardised national examinations. Recent studies have emphasised that the gap between pre-service teacher education and effective teaching practices is a key factor contributing to the challenge of low learning outcomes in STEM education (Zeichner, 2012; Darling-Hammond, 2017). Despite these recognized challenges, solid empirical evidence detailing how effectively pre-service training programs prepare science teachers to apply their pedagogical knowledge in real classroom contexts is limited. Addressing this gap is crucial for developing Teacher Education Programs that are not only theoretically rigorous but also practically relevant, equipping teachers with the tools they need to bridge the gap between theory and practice.

Theoretical and Conceptual Framework

Effective teacher preparation is anchored on a strong theoretical foundation that informs and shapes classroom instructional practices. Shulman's (1986) concept of Pedagogical Content Knowledge (PCK) emphasises that teachers must not only possess adequate mastery of the subject matter, but also have the capacity to competently translate subject matter knowledge into pedagogically sound and engaging learning experiences for students. Knowing the subject is not enough. The teachers must also understand and discern how to teach it effectively, in ways that can help students access easily and therefore engage with the learning material. This connection between subject knowledge and teaching methods is critical for promoting student understanding and engagement. Over time, research has consistently shown that pedagogically sound content delivery significantly enhances learning outcomes (Darling-Hammond, 2017). Building on this idea, Mishra and Koehler (2006) formulated the Technological Pedagogical Content Knowledge (TPACK) framework. TPACK emphasises the need for teachers to integrate technology into their teaching practices, alongside learner-centered pedagogy and a strong mastery of the subject content. This integrated knowledge base enables teachers to create dynamic, responsive and learner-friendly learning environments. Thus, PCK and TPACK theories emphasise the importance of blending content knowledge, pedagogy, and technology in teacher preparation.

This study conceptualises effective STEM teacher preparation as the intersection of: i.Mastery of STEM pedagogical knowledge ii. Micro-teaching practice iii. Classroom application during school practice iv. Mentorship support. The interaction of these variables is influenced by contextual factors like resource availability, teaching schedules and workload, and classroom diversity. This conceptual framework is particularly crucial for STEM subjects teaching, where the integration of technology has been shown to enhance learning experiences and facilitate deeper conceptual understanding (Voogt et al., 2017). It is thus essential that Teacher Education Programs are enhanced to empower the preservice science teachers to blend theoretical knowledge with real-life practical experience, ensuring they are well-prepared for the dynamic classroom contexts they will face in their future teaching.

This means Teacher Education Programs must be intentional in adopting an integrated knowledge base to be able to prepare teachers who are not only knowledgeable in their subjects, but also skilled in designing and implementing instruction that promotes conceptual understanding and increased learner engagement (Mishra & Koehler, 2006). Additionally, Teacher Education Programs must reflect the obstacles and complexities of today's classrooms in a bid to remain relevant, responsive, and effective in preparing future teachers. Contemporary classrooms are characterized by learner diversity, technological integration, curriculum reforms, and shifts in pedagogical expectations. These calls for pre-service teachers to be equipped with adaptive expertise and reflective capabilities (Darling-Hammond, 2017; Zeichner, 2012). This means that effective teacher preparation must be beyond theoretical instruction and include experiential opportunities that simulate the complex realities of the classroom contexts such as inclusive education, differentiated instruction, digital literacy, and classroom management in resource-constrained environments (Cochran-Smith et al., 2016).

In contexts such as Kenya, where rural and under-resourced schools are common, teacher education must also address context-specific challenges, including large classrooms sizes, limited teaching materials, and socio-cultural dynamics that influence learning (Orodho, Waweru, Ndichu, & Nthinguri, 2013). This approach to teacher education ensures that pre-service teachers are not just knowledgeable about STEM teaching and friendly learning environments, but are also resilient and pedagogically responsive to the dynamic demands of the teaching profession. Thus, grounding teacher preparation in the lived realities of school settings enhances the practical relevance and effectiveness of the Teacher Education Programs.

Micro-teaching, globally adopted in Teacher Education Programs, is a vital pedagogical tool for bridging the gap between the theory of teaching and learning, and real classroom practice. It provides pre-service teachers with a structured, low-risk setting in which to develop and hone their teaching skills through brief, focused instructional sessions (Amobi, 2005). Within this framework, pre-service teachers have a low-risk opportunity to experiment with teaching, learning, and assessment strategies, receive timely and targeted feedback from peers and supervisors, and collaboratively reflect on their instructional decisions (Fernandez, 2010). This iterative process promotes self-awareness, pedagogical confidence, and reinforces the development of

professional competencies aligned with effective classroom instruction (Kpanja, 2001). Further, micro-teaching promotes a collaborative learning culture in which participants benefit from shared insights and mentorship. This is a cyclical nature of practice, reflection, and improvement that underpins quality teacher preparation. This process not only improves teaching effectiveness but also fosters a professional community where teachers learn from their peers' experiences (Zhou et al., 2020). Thus, micro-teaching is integral in bridging the gap between theory and practice in teacher education. Micro-teaching supports pre-service teachers to hone their instructional practices before beginning to teach in real-world classrooms.

METHODOLOGY

This study adopted a mixed-methods approach to delve into how STEM pedagogies and micro-teaching impact pre-service science teachers at Kibabii University. The mixed-methods approach is known to provide deep insights and a broad understanding of phenomena by integrating both numerical data and descriptive accounts. The quantitative data and descriptive accounts are known to capture the complexity of educational settings (Polius, 2018; Creswell & Plano Clark, 2018) hence, the dual approach ensured the findings were not only statistically significant but also contextually relevant and captured nuances that purely quantitative or qualitative approaches would not have provided (Johnson & Onwuegbuzie, 2020). The study therefore provides a balanced outlook on preservice science students experiences and an understanding of how the pre-service science Teacher Education Program is implemented. More importantly, the study explored how theory connects to practice, which is pivotal in teacher preparation research. Connecting the theory of teaching and its application in real classrooms is critical for the development of teachers who are practitioners (Polius, 2018). Understanding teacher education's complexities hinges on this connection because the theory-practice gap reflects the issues, challenges and barriers that teachers experience in their quest to apply pedagogical theories in diverse, dynamic teaching environments (Lombo et al., 2020).

The study participants were a hundred and eighty-six (186) third-year Bachelor of Education (science) students at Kibabii University, all of whom had completed STEM pedagogy courses, micro-teaching, and a 14-week teaching practicum. Purposive sampling of participants was applied, focusing on those with exposure to all three stages of training to ensure the relevance and representativeness of the collected data. This approach aligns with best practices in educational research, which emphasise the importance of purposeful selection to gather data that are directly pertinent to the research question (Hidayat et al., 2019). Questionnaires, interview schedules, and observation checklists were used to collect data about the student teachers' experiences and the STEM pedagogies they applied. This aligns with the recommendations in educational research methodologies that stress the need to use multiple data sources to make the validity and reliability of findings solid and comprehensive (Bryman, 2019; Creswell & Plano Clark, 2017).

FINDINGS

Triangulated Analysis

The findings were multifaceted and aligned with the aim of the study. Quantitative data were triangulated with interview excerpts and observational notes. These provided a solid and comprehensive analysis, which enhanced the credibility, reliability, and validity of the study. Methodological triangulation is crucial for validity and reliability in educational research because it enables the researcher to cross-check findings from multiple sources hence the interpretation of complex phenomena is accurate and rigorous (Tashakkori & Teddlie, 2020). This approach aligns with best practices that advocate for mixed methods, particularly in the field of teacher education, where both quantitative and qualitative data provided a comprehensive understanding of educational practices (Creswell & Plano Clark, 2017).

The integration of multiple data sources enabled a clear understanding of the study because the intricacies and contextual specificities of teacher education environments were captured comprehensively. This approach also illuminated participant perceptions which were found to be directly aligned with and advanced the objective of the study (Flick, 2018). Thus, a triangulated analysis within the context of pre-service science teacher education at Kibabii University significantly enhances the validity and depth of the findings because the study captured a holistic view of the teaching and learning experiences during school practice in real schools.

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The methodological triangulation of data enabled the cross-verification of emerging patterns and accounts for the complexities inherent in the Teacher Education Programs. Specifically, the realities of school practice were captured and this allowed the researcher to account for biases and inconsistencies in individual data sources (Bryman, 2019). Consequently, the discussion of findings was comprehensive and objective, offering credible insights into the effectiveness of pedagogical training, the application of STEM instructional strategies, and the real-world challenges faced by pre-service science teachers in diverse classroom settings.

Participant Experiences during STEM Pedagogy Coursework

The STEM Pedagogy courses received positive feedback, specifically regarding the theoretical underpinnings of learner-centered teaching practices that are central in current educational paradigms. (Baker et al., 2021). Learner-centred teaching practices emphasize active engagement, promoting a deeper connection with content, which aligns with current educational transformations (Harmer, 2020).

Most participants indicated that the STEM pedagogical courses were instrumental in enhancing critical thinking and problem-solving abilities among learners. Indeed, about 84% of participants reported the STEM pedagogy courses deepened their grasp of active STEM teaching strategies. This finding is consistent with research that emphasie on the value of active learning for improved learner outcomes, particularly in promoting skills acquisition such as creativity, collaboration and communication, and critical thinking (Johnson, 2019; Moise et al., 2020). These results mean that active learning strategies contribute significantly to preparing students for real-world challenges (Harris & Jones, 2021).

Nevertheless, 62% of the B.Ed. (science) students revealed that there were more challenges in the implementation of STEM pedagogies in under-resourced schools. This agrees with the findings of Johnson, 2019 who opined that the lack of resources, both infrastructure and teaching tools, is a major barrier in the implementation of modern STEM pedagogical strategies. In the absence of appropriate resources, application of effective pedagogical methods will not impact learning outcomes. These findings show that the gap between teacher preparation and real-world classroom settings must be addressed (Shen et al., 2020), and imply the need for stronger alignment between theoretical content and practical application in diverse contexts.

The pie chart below illustrates how pre-service science teachers regarded their preparedness after the STEM pedagogy courses.

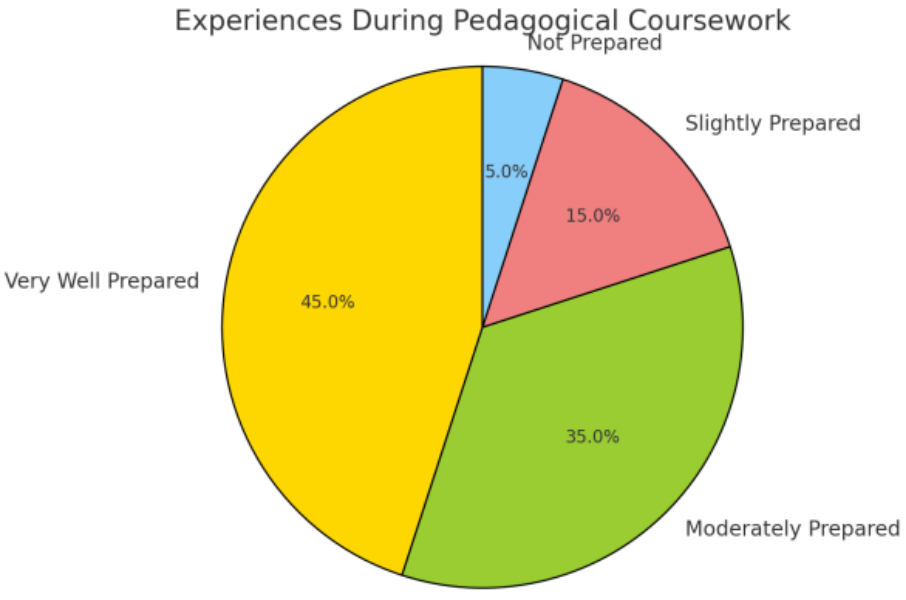

Figure 1: Experiences During Pedagogical Coursework - Preparedness Level of Participants

Interviews conducted with the participants showed that pre-service science teachers preferred whole-class and practical activities they had experienced in their coursework. Such preferences align with research evidence indicating that experiential learning is one of the most effective strategies for teacher development. Experiential learning allows teachers to directly apply theoretical concepts in realistic teaching contexts (Liu & Hu, 2020). This calls for a review of curricula to adequately prepare upcoming teachers for the realities across dynamic classroom contexts. Indeed, Teacher Education Programs must reflect the barriers and complexities found real-life teaching and learning contexts in order to remain relevant, responsive, and effective in preparing future teachers (Roberts & Liu, 2018).

Effectiveness of Micro-teaching

In the current study, micro-teaching was reported as the most impactful component of the preservice Teacher education program. Over 90% of students stated that micro-teaching built their confidence and helped them refine lesson planning and questioning techniques. Findings from the observation data indicated improved clarity in instructional delivery and classroom control during micro-lessons. However, the participants pointed out on the limited subject-specific feedback due to time constraints. This implies that micro-teaching significantly boosts confidence and should be maintained with improved subject-specific feedback. Research is consistent on the value of the micro-teaching component of the Teacher Education Program on the aspect of the development of key teaching skills (Wajahat et al., 2020; Abell et al., 2010, pp. 1105-1149). Pre-service teachers practice to improve their pedagogical skills and promote their teaching confidence (Baker et al., 2019). This approach fosters a deeper understanding of teaching strategies and facilitates the development of pedagogical skills for effective learner engagement (Khalid & Khan, 2019). The feedback given during micro-teaching is cyclical and with real-time implementation. Studies have proved that the iterative nature of micro-teaching is critical for reinforcing teaching strategies and improving classroom management skills (Smith & Strong, 2020). Moreover, it allows pre-service teachers to hone their teaching practices and the immediate assessment and feedback is essential for enhancing both the competence and confidence in teaching practices (Johnson & Williams, 2021).

The bar chart below shows how pre-service science teachers rated the effectiveness of micro-teaching in building their confidence.

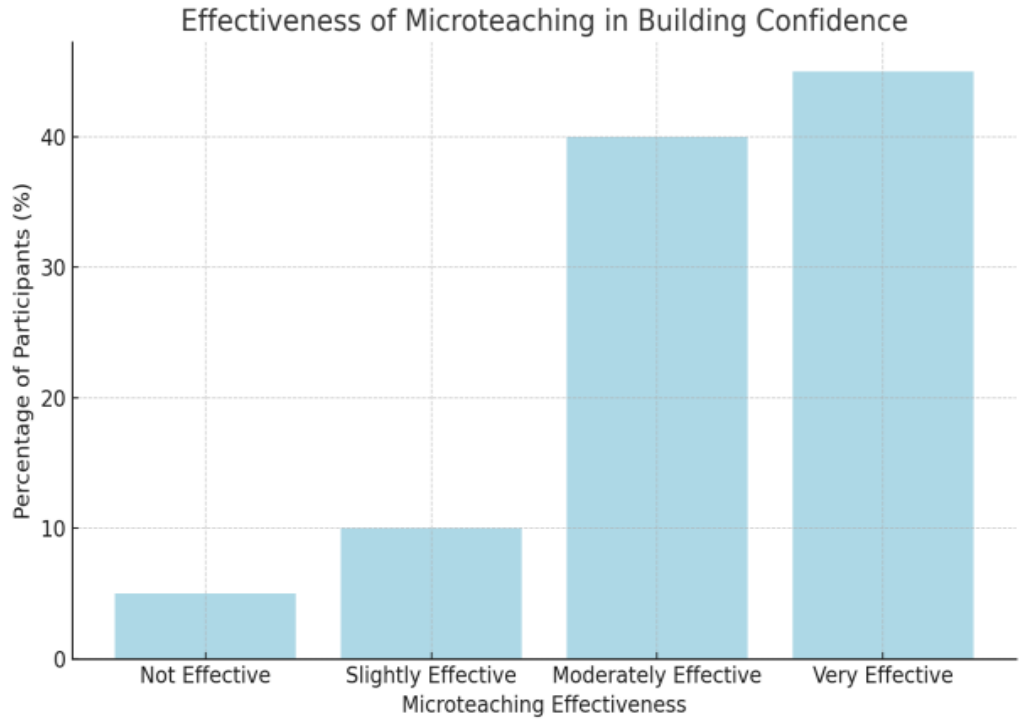

Figure 2: Effectiveness of micro-teaching in Building Confidence

The study findings indicate that micro-teaching enhances teachers' instructional abilities and this, according to research evidence promotes their professional growth (Moise et al., 2021). The cyclic nature of micro-teaching with the inherent practice-reflection alignment positions micro-teaching as a key preparatory tool in Teacher Education Programs. The reflective practice is a crucial aspect of teacher development because boosts the impact and support of teacher professional growth in diverse learning settings, and, allows preservice teachers to critically analyze and hone their instructional strategies (Roberts & Liu, 2018). As educational practices continue to evolve, micro-teaching remains central in preparing future teachers to meet the dynamic needs of teaching and learning contexts (Williams & Huang, 2020).

School Practice Experiences

The participants faced classroom hurdles during the 14-week period. The large classes, high workload, limited resources like lab equipment and technological infrastructure, and rigid teaching schedules were notable barriers. These challenges are often cited in research as key factors that hinder the effective implementation of innovative teaching strategies, particularly in under-resourced educational settings (Gao & Zhang, 2018). Notably, 75% of the student teachers managed to use interactive teaching strategies such as group work, student demonstrations and peer teaching which are known to engage learners.

The line graph below illustrates the percentage of pre-service science teachers who encountered various challenges during their school practice.

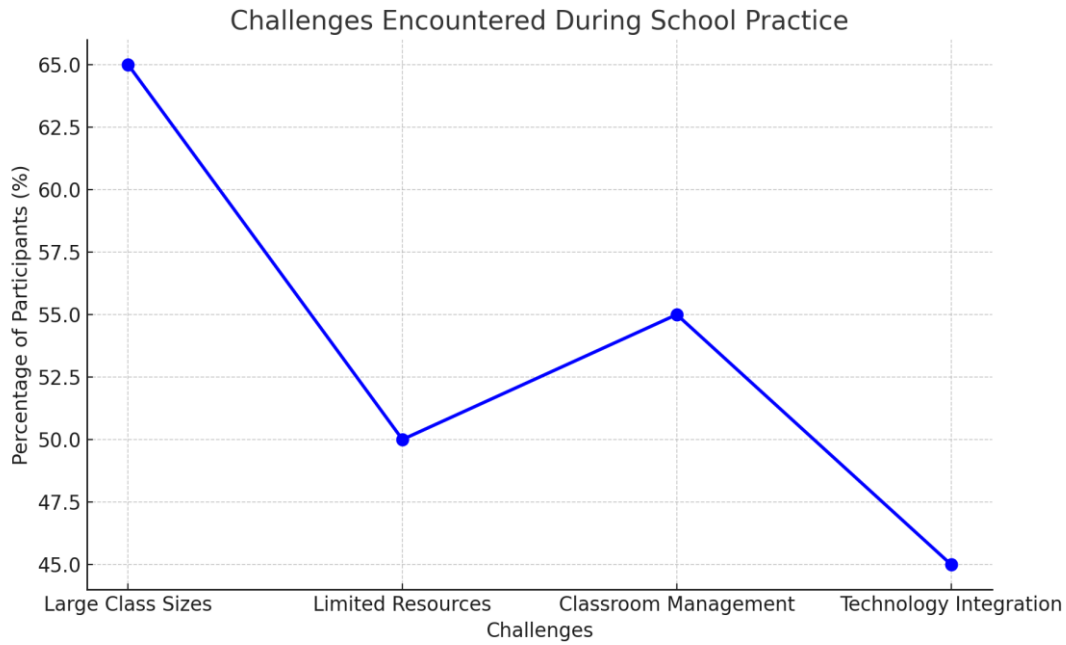

Figure 3: Challenges Encountered During School Practice

However, interviews conducted revealed that mentorship from the host teachers was unreliable and did not boost a teacher's pedagogical skills for curriculum delivery. Thus, despite challenges, a significant number managed to use interactive methods like group work and peer teaching, which are generally known to help students engage better and improve learner comprehension of scientific concepts and processes (Lombo et al., 2018). The use of group work and peer teaching aligns with findings of studies suggest that when interactive teaching strategies are used, even in resource-constrained environments, it can enhance learner engagement and promote deeper understanding (Shen et al., 2020).

The findings from interviews conducted revealed that mentorship was inconsistent, and support was not sufficient to improve the pre-service science teachers' instructional skills. This inconsistency underscores a critical gap in the mentorship structure, which is crucial for the development of newly qualified teachers. This implies that mentorship systems require strengthening and training must include strategies for navigating real

classroom constraints. Empirical evidence underscores the critical role of structured mentorship in fostering pre-service teachers' professional growth and teaching confidence. Without consistent and supportive mentoring frameworks, student teachers often struggle to develop the self-efficacy and pedagogical competence necessary for effective teaching (Liu et al., 2019; Zhang, 2018). The findings of this study resonate with existing literature that highlights the transformative potential of mentorship in shaping reflective practice, nurturing instructional decision-making, and facilitating the development of contextually responsive teaching strategies (McAllister, 2019). High quality mentorship has been shown to significantly contribute to pre-service teachers' capacity to create meaningful learning experiences and to successfully transition from theory to practice (Smith & Hammerness, 2019). These insights point to the urgent need for Teacher Education Programs to institutionalize solid mentorship structures that are intentional, systematic, and context-sensitive. Such programs have potential to enhance pre-service teachers' confidence and improve the overall quality of teaching and learning in the classrooms (Zhang & Li, 2020).

Benefits and Limitations of Training

Teacher educators consider the curriculum as a key tool for student teachers to build essential knowledge and teaching competency, which are critical for their professional growth. In the current study the Kibabii University student teachers acknowledge that the pedagogy coursework at university has helped them gain teaching knowledge and develop classroom skills. Notably, majority of participants found the training beneficial, with 80% viewing it positively, while 20% pointed limitations in the program. Additionally, 58%, had concerns that the training was not always relevant to the real issues they encountered most schools and in particular the rural schools. This mismatch implies that the curriculum should be reviewed to ensure relevance to rural contexts, enhance hands-on and mentorship components. These are areas that Teacher Education Programs need to improve so that pre-service science teacher education is made more practical.

The bar chart below compares the perceived benefits and limitations of the Teacher Education program.

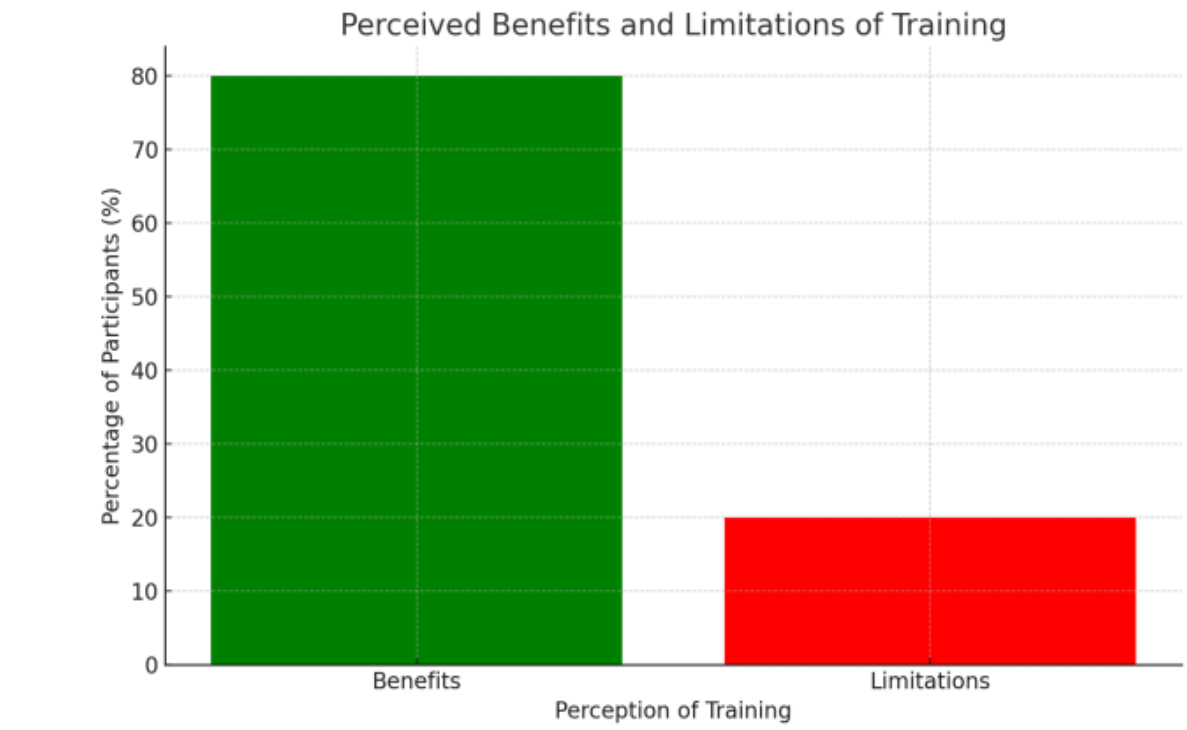

Figure 4: Perceived Benefits and Limitations of Training

The fact that a considerable number of student teachers (58%), were unsure of the training's applicability to the situations they face, especially in rural areas, confirms a disconnect between what they learn at university and their school practices. This difference indicates a gap in the current Teacher Education Program, where the

theoretical knowledge does not adequately prepare teachers for the challenges they will face in the field. The result is limited self-efficacy, lack of teaching confidence, and inability to effectively engage with learners in diverse classroom contexts especially among newly qualified teachers (Darling-Hammond, 2017). Evidently, graduate teachers are not adequately equipped for the realities in the dynamic classroom contexts, particularly in under-resourced settings where infrastructure and support systems are lacking. Teacher Education programs must therefore be reviewed for relevance to a more holistic model by integrating innovative practical training, with supported real-world applications (Ingersoll & Strong, 2011 and Agyei, 2014). The participants in the study indicated that practical experience they are exposed to, and mentorship provided during school practice is inadequate and restricted. This scenario likely leads to a disproportionate impact on newly qualified teachers, particularly in rural under-resourced schools. Research has shown that teachers in such contexts face challenges of insufficient resources and professional isolation, which further hinders their development (Barrera & Saavedra, 2019).

According to McDonald et al. (2016), increasing the duration of Teacher Education Programs and integrating simulations of classroom scenarios into the pedagogy coursework has the potential to link what is learned at university to actual teaching in schools. This would significantly enhance the practical relevance of the curriculum, and better prepare teachers for the complex classroom contexts and thereby address the disconnect between theory and practice.

DISCUSSION OF FINDINGS

Triangulated Analysis and its Contribution to Study Validity

The use of triangulated analysis in this study contributed to the rigor and credibility of the findings. By integrating data from structured questionnaires, classroom observation checklists, and reflective interviews with pre-service science teachers and their school-based supervisors, it was possible to draw on diverse perspectives and data sources. This approach provides deep insights into the pedagogical content knowledge, micro-teaching, and STEM instructional strategies during the school practice session. Triangulation enhances research validity and reduces bias because evidence across methods and sources is corroborated (Denzin, 1978; Patton, 2002). This approach is comprehensive and adds to the credibility of the study because the findings are supported by multiple sources.

In this study, the triangulated findings offered a substantiated basis for interpreting the impact of teacher preparation at Kibabii University and formulating actionable recommendations for enhancing science teacher education in comparable low-resource contexts. This holistic approach aligns with recent trends in educational research, which advocate for mixed-methods and triangulation to capture the complexities that influence teaching and learning (Tashakkori & Teddlie, 2020). Further, triangulation in educational research allows for accurate depiction of how pre-service teachers apply their pedagogical knowledge to real-world classroom contexts, which has implications for teacher education curricula review with regard to the needs of contemporary classrooms.

Micro-teaching: A Critical Component of Teacher Preparation

The findings of this study affirm the need for Teacher Education Programs to align closely with the realities and complexities of contemporary classrooms. Pre-service science teachers at Kibabii University reported that they encountered diverse instructional challenges while on school practice, which included large class sizes, limited teaching and learning resources, and the need to adapt pedagogical approaches to meet varied learner needs. These experiences call for urgent grounding of the Teacher Education Program in authentic school contexts that reflect the complex dynamic nature of contemporary teaching contexts. As Darling-Hammond (2017) observes, contemporary classrooms are increasingly diverse, technologically evolving, and shaped by shifting learner needs, all of which require that teachers develop adaptive expertise and reflective practice.

Effective teacher education must therefore transcend theoretical instruction and integrate experiential learning which is known to expose student teachers to real-world teaching demands (Zeichner, 2012). This is particularly important for preparing Kibabii University student teachers to engage in inclusive education,

differentiated instruction, and responsive classroom management, including within rural under-resourced settings that are common in Kenya. Cochran-Smith et al. (2016) highlight that the Teacher Education Programs should be able to cultivate pedagogical resilience and contextually responsive practices so that newly qualified teachers are capable of adapting to diverse classroom challenges. This approach supports the development of teachers who are confident and flexible, prepared to address the complexities of classroom dynamics and are therefore practitioners. In the Kenyan context, Orodho, Waweru, Ndichu, and Nthinguri (2013) point out that the teacher education should address local challenges such as curriculum overload, infrastructural constraints, teacher efficacy and socio-cultural diversity. Integrating these realities into Teacher Education programs would ensure that pre-service teachers are not only theoretically sound but also practically prepared to navigate the complex dynamic classroom contexts.

Thus, Teacher Education Programs that reflect contextual challenges are one that will produce competent, innovative, and resilient science teachers who are capable of promoting meaningful learning outcomes. This finding suggests that pre-service science teachers at Kibabii University are gaining valuable teaching skills, but the teacher education curriculum should be reviewed to refine the alignment between theory and practice so that the theoretical knowledge of teaching is translated into real-world classroom settings.

STEM Teaching and Technological Integration

The findings of the current study concur with the study conducted by Kirui and Koech (2023), which revealed that digital tools are increasingly adopted in Kenyan universities. It is however, concerning that STEM teaching pedagogies and simulations not mandatory in Teacher Education Programs in Kenya as would be expected resulting in a gap between the availability of technology and its effective use in classrooms. Mwai and Gitonga (2022) note that the presence of technology is insufficient if that technology cannot be integrated into teaching methodologies to empower teachers to use digital tools in their instruction. This disconnect likely contributes to the under-utilization of digital resources in during the pre-service science teacher's coursework, which could limit the development of Kibabii University pre-service science teachers' digital competencies. Kinnunen et al. (2016) posits that improving STEM pedagogies can help align digital skills with the actual teaching methods applied by student teachers, particularly in rural low-resourced schools. By integration technology into pedagogy, teachers enhance their instructional practices and also make the learning material more engaging and accessible to students. In addition, the findings suggest that while pre-service science teachers at Kibabii University are being exposed to basic STEM pedagogies, there is room for improvement in integrating more advanced technological tools and interactive simulations into their training. This gap highlights the need for Teacher Education Programs to integrate technology-enhanced teaching and learning strategies. Integrating simulations and digital platforms into the pre-service science teacher preparation can facilitate STEM teaching skills development in ways that are both effective and engaging, particularly in rural under-resourced contexts.

CONCLUSION

The findings from this study suggest that Teacher Education Program should provide consistent practical experience and strong mentorship to address the unique challenges of rural and under-resourced schools are critical to developing effective science teachers. However, it is crucial to note that without intentional and seamless integration of technology into teacher education, effectively preparing teachers for an increasingly digital world will remain a challenge. If technology is not incorporated systematically into teacher training, pre-service science teachers may struggle to realize their full teaching potential. This highlights the urgent need to strategically embed digital resources and STEM pedagogies into Teacher Education Programs to ensure that future educators are well-equipped for modern classrooms (Hardman et al., 2020).

Despite the theoretical foundation provided in the pedagogy coursework, the participants exhibited inconsistencies in their classroom practices. For instance, integration of STEM pedagogies alongside digital resources were minimal. This means they encountered difficulties in adopting STEM digital tools in their classroom instruction, and highlights that a gap exists in the effective integration of digital tools into the classroom (Adarkwah et al., 2021). This study sought to understand how STEM pedagogy mastery and micro-teaching influenced the preparedness of pre-service science teachers. A key goal was to bridge the gap between

theory and practice, particularly regarding the use of digital tools. Based on the findings, the preservice science Teacher Education Program at Kibabii University provided a solid theoretical base, many participants struggled to apply what they learned in university to actual classroom practices, primarily due to real-world constraints. This challenge is not specific to this study and is commonly observed in Teacher Education Programs around the world. This calls for robust support frameworks to empower pre-service science teachers to effectively connect their theoretical knowledge with classroom practice. Notably, micro-teaching emerged as a valuable tool for enhancing student teachers' confidence in the practical application of STEM pedagogy and simulations. It acted as a bridge between theory and practice, and offered the pre-service science teachers an opportunity to experience hands-on teaching in a controlled, low-risk environment. Despite this, the inadequate integration of the diverse classroom realities in Teacher Education Programs, coupled with insufficient mentor support, highlights the need for Teacher Education Program to be more adaptive and responsive to the challenges of the contemporary classrooms, particularly under-resourced schools in rural areas.

RECOMMENDATIONS

The findings of this study suggest several key areas for enhancing teacher preparation at Kibabii University. Teacher Education Programs should prioritize the integration of STEM pedagogies and digital tools, and ensure that pre-service science teachers are not only exposed to the digital resources but also taught how to effectively apply them in their classroom practice. Clearly, there is need to embed the integration of digital tools and interactive STEM simulations into the preservice science teacher education curriculum. This will ensure that pre-service science teachers are adequately helped to develop the pedagogical skills necessary for incorporating technology into classroom practices. This means increase opportunities for hands-on technology-based learning including simulation of classroom contexts and online resources to bridge the gap between theoretical learning and practical teaching (Kinnunen et al., 2016). Training in these areas should be hands-on and aligned with the realities and need in the complex dynamic contemporary classroom contexts, especially in resource-constrained environments.

Teacher Education programs need to embed stronger mentorship support during the school practice component. This study has shown that pre-service science teachers would benefit from consistent and structured mentorship, particularly in the integration of STEM pedagogies and application of digital resources in teaching. This means that universities should collaborate with school-based mentors to align the pedagogy coursework at university with the classroom realities, to support preservice science teachers' transition from theory to practice.

Teacher Education Programs must put into consideration the specific needs of rural and under-resourced schools, where infrastructure and resources are limiting. Incorporating practical strategies for managing large class sizes, utilizing low-cost teaching materials, and adapting STEM pedagogy to rural and under-resourced school contexts will better equip the pre-service science teachers for the challenges in these kinds of settings. Emphasis should be on reflective practices, helping teachers critically analyse their teaching methods and adapt to the diverse needs of their students.

While micro-teaching is an effective tool for building confidence and providing a controlled environment for teaching practice, Teacher Education Programs should include increased opportunities for real-world teaching experiences. This includes providing more immersive and sustained exposure to diverse classroom settings under the guidance of experienced mentors. These will allow the pre-service science teachers to develop adaptive teaching strategies that can be applied across a range of contexts, particularly in rural and under-resourced schools.

Teacher Education Programs should develop and implement a framework for the integration of digital technologies into the STEM Pedagogy coursework. This would involve access to digital resources and empowering the pre-service science teachers how to seamlessly incorporate digital resources including tools such as simulations into their teaching strategies so that they enhance student engagement and learning outcomes.

FUTURE RESEARCH

Future research should focus on examining how STEM digital tools and resources are integrated into teaching strategies and the impact this integration has on both pre-service and practicing teachers, particularly in rural, under-resourced schools. Focus should be on access to the digital resources and tools, learner engagement in settings with limited resources, and the influence of the digital tools and resources on curriculum delivery and learning outcomes (Purdue, 2022; Parker et al., 2022).

Additionally, an examination into how digital tools such as simulations (e.g., PhET, LabXchange) can be integrated into STEM teaching in under-resourced rural schools should be conducted. Investigating how these tools can be incorporated into Teacher Education Programs could provide insight into how to better prepare newly preservice student teachers for the digital demands of the contemporary classrooms. Focus should be on the development of curriculum models that emphasise the use of digital resources to create engaging and dynamic learning environments, fostering student-centered teaching and learning. This line of research could contribute significantly to the development of effective, technology-enhanced school practices that better support the learning needs of students in the digital age (Ndlovu, 2022; Dzinoreva et al., 2022).

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