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Utilizing Blended Learning to Mitigate the Challenges Brought by Natural Disasters in South African Schools

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ABSTRACT

This study investigated the potential benefits and challenges associated with the implementation of blended learning as a strategy for curriculum recovery and enhancement of student performance in Grade 12 science and mathematics education. Blended learning, which combines traditional face-to-face teaching methods with online learning, was recognized for its capacity to address educational difficulties. The research employed a theoretical framework integrating the Technology Acceptance Model and Sociocultural Constructivism theory to examine the viewpoints of teachers regarding technology adoption and the impact of personal and social interactions on learning outcomes. A qualitative interpretive case study design was employed, and interviews were carried out with four science and mathematics teachers. The findings revealed that teachers acknowledged the advantages of blended learning, including its potential to overcome barriers to learning and augment student engagement. However, external challenges about technology infrastructure, limitations of online platforms, and the necessity for professional development were identified. Teachers displayed varying levels of internal challenges, including familiarity and confidence in implementing blended learning. The study underscored the importance of continuous support, infrastructure development, and pedagogical training to effectively integrate blended learning into science and mathematics classrooms. Therefore, by addressing these challenges and capitalizing on the benefits of blended learning, the potential for improving curriculum recovery and enhancing student performance in the face of disruptions caused by natural disasters and other educational obstacles was emphasized.

KEYWORDS

Blended learning; curriculum recovery; student performance; intrinsic challenges; extrinsic challenges.

INTRODUCTION

Blended learning, a pedagogical approach that combines traditional face-to-face teaching methods with online learning (Lalima & Dangwal, 2017), has garnered increasing significance due to its positive impact on student learning (Viberg et al., 2020). This approach offers numerous advantages, such as improved pedagogy, increased student engagement, and enhanced teaching and learning flexibility, as Masalela (2009) highlighted. Furthermore, blended learning enables students to actively explore complex concepts, facilitating a deeper understanding of the subject matter (Setiyani et al., 2020). The adoption of a blended learning approach empowers teachers to effectively cover the syllabus while maintaining the quality of education (Gqokonqana et al., 2022; Hamakali & Josua, 2023; Mahaye, 2020). In the context of South African schools affected by natural disasters, blending learning can serve as an effective strategy to address the challenges posed by these events.

The integration of technology into the classroom is a central aspect of blended learning, while simultaneously acknowledging the important role of personal and social interactions inherent in face-to-face education. This integration of technology has been found to enhance the educational experience for both students and teachers. From the student's perspective, the integration of technology in the classroom has numerous benefits, such as promoting the development of critical thinking and problem-solving skills. Students engage with interactive digital tools and resources that require active participation and analytical thinking (Cannon, 2019; Molopo, 2023). Additionally, for teachers, the integration of technology in the classroom offers significant advantages such as providing teachers access to a wide range of learning resources, including online databases, educational software, and multimedia materials, thus expanding the repertoire of teaching materials available (Mlambo et al., 2023). Furthermore, with technology integration, teachers can personalize the learning experience of their students to cater to individual learning styles, preferences, and abilities. In this regard, technology-enabled instruction allows for differentiated instruction, adaptive learning, and the use of analytics to track student progress and tailor instruction accordingly (EI-Sabagh, 2021; Nyika & Motalenyane, 2023).

Consequently, based on these advantages, there is a growing need to emphasize the integration of technology into educational practices. In this regard, the use of blended learning as a teaching approach aims to leverage the benefits of technology to enhance student learning outcomes, promote critical thinking and collaboration, and support teachers in their instructional practices.

Research Problem

Despite significant progress in technology-based learning approaches in certain developed countries, the adoption of these advancements in South Africa has been relatively slow (Oke & Fernandes, 2020). The South African educational system faces multiple challenges, including inadequate infrastructure, overburdened and underqualified teachers, limited learning materials (du Plessis & Mestry, 2019), and overcrowded classrooms (Stols et al., 2015).

Moreover, natural disasters further exacerbate these challenges by disrupting the flow of teaching and learning within the classroom context (Onigbinde, 2018). Natural disasters in this study refer to droughts, floods, and storms. Shimada (2022) notes that these natural disasters result in significant socio-economic disruptions and infrastructure damage, posing risks to the safety and operational capacity of educational institutions. In this regard, often leads to the closure of schools and the displacement of students, preventing them from physically attending classes and engaging in face-to-face learning (Buchana et al., 2022).

However, a notable challenge within the South African education system, as identified by Stols et al. (2015), is the lack of technological pedagogical content knowledge among teachers. This limited knowledge inhibits the seamless integration of technology in classrooms, as many teachers may feel hesitant or reluctant to incorporate technology into their teaching practices (Stols et al., 2015). The lack of necessary skills, confidence, and understanding of how to effectively integrate technology into their lessons act as a second-order barrier, which encompasses factors internal to teachers, such as attitudes, beliefs, skills, and knowledge related to technology use (Wniter et al., 2021). These internal barriers prevent teachers from fully embracing and utilizing technology in their classrooms. Additionally, there are first-order barriers that are external to teachers, such as the availability of equipment and resources, which can pose challenges to technology integration (Winter et al., 2021). These external barriers further impede the integration of technology in classrooms. As a result, the potential benefits and opportunities that technology integration can bring to student learning and engagement are not fully realized. Therefore, addressing both the internal and external barriers is essential in supporting teachers to develop the necessary technological pedagogical content knowledge and creating an enabling environment for effective technology integration in South African classrooms.

Nonetheless, South Africa grapples with persistent natural disasters that yield significant impacts. Droughts, arising from prolonged periods of reduced rainfall, instigate water scarcity and setbacks in agriculture (Seleiman et al., 2021). Intense precipitation gives rise to floods, encompassing both rapid-onset flash floods and gradual riverine floods, culminating in property damage and the uprooting of communities (Doocy et al., 2013). Diverse landscapes are susceptible to the proliferation of wildfires, which take a toll on forests and biodiversity (Stavi, 2019). Although infrequent, earthquakes, linked to South Africa's tectonic disposition, retain the capacity to disrupt infrastructure (Brandt, 2014). Within this milieu of challenges, the task of upholding equilibrium across society, economy, and environment acquires complexity. Furthermore, these challenges kindle concerns regarding student absenteeism, thereby compelling the imperative for school closures.

As a consequence, teachers face the loss of valuable teaching time and are compelled to postpone lessons to accommodate the disruptions caused by natural disasters. Furthermore, the compromised quality of teaching arises from the necessity to prioritize specific topics, thereby compromising the comprehensive coverage of the academic year's

requirements (Ramrathan, 2021). This issue is particularly evident in critical subjects such as Life Sciences, Physical Sciences, Mathematics, and Mathematical Literacy (collectively referred to as science and mathematics), where students already encounter challenges and rely heavily on support from their teachers. However, the compromised quality of teaching, as a consequence of disruptions caused by natural disasters, exacerbates knowledge gaps and contributes to inadequate student performance in these subjects.

Rationale

During the COVID-19 pandemic, the global education system experienced a profound transformation, with a shift from traditional face-to-face teaching to online learning, emphasizing the need for digital transformation (Mhlanga & Moloi, 2020). To address the disruptions caused by the pandemic, the Mpumalanga Department of Education in South Africa distributed digital tablets to schools, aiming to facilitate remote learning and ensure continuity in education (Mahaye, 2020). However, despite the well-documented potential of technology to enhance students' comprehension of scientific and mathematical concepts by making them more tangible and accessible (Lee & Kim, 2021, p. 1303), certain second-order barriers impede the effective integration of technology among teachers, specifically in the context of science and mathematics Education.

Lastly, it is crucial to explore teachers' perspectives on blended learning as a means to address the challenges arising from natural disasters which result in high absenteeism in the Mpumalanga province (Mahaye, 2020). In this regard, the research question guiding this study is: "*What are the reasons behind the teachers' adoption or non-adoption of blended learning in classrooms affected by natural disasters in the Mpumalanga province, and what are their perceptions of the potential benefits and drawbacks associated with this approach?"* This research question aimed to investigate teachers' perspectives on the use of blended learning as a means to address the challenges arising from natural disasters, which result in high absenteeism. The study sought to understand the factors that influence teachers' decision to adopt or not adopt blended learning in their classrooms and their perceptions of the potential benefits and drawbacks of this approach. Therefore, by gaining insights into teachers' perspectives, the research aims to identify the barriers and facilitators of blended learning implementation in the context of natural disasters. The findings will provide valuable information that can be used to develop effective strategies to promote the adoption of blended learning and address the challenges faced in education due to natural disasters in South Africa.

THEORETICAL FRAMEWORK

The theoretical framework of this study integrates the Technology Acceptance Model and the Sociocultural Constructivism theory to explore technology adoption in blended learning. By combining these theories, we gain insight into the factors influencing teachers' integration of technology in online classrooms, while also recognizing the importance of personal and social

interactions. The Technology Acceptance Model, developed by Davis (1989) and expanded upon by Venkatesh and Davis (2000), highlights the influence of perceived usefulness and ease of use on individuals' attitudes and intentions toward technology. Perceived usefulness as defined by Davis (1989) refers to the belief that technology enhances performance, while perceived ease of use relates to the perception of effortlessness. Therefore, by incorporating this model, we can understand teachers' acceptance and integration of technology, inform evidence-based approaches, and support effective technology integration in science and mathematics Education.

In this study, the Sociocultural Constructivism theory is employed to emphasize the importance of social and cultural factors in the process of learning and knowledge construction. Drawing on the work of Vygotsky (1978) and Säljö (2001), this theory highlights the role of collaboration, communication, and social interactions in shaping students' understanding of concepts and phenomena. Therefore, by incorporating this theory, we recognize the significance of maintaining personal and social interactions, even in online learning environments. This is particularly crucial in the context of blended learning, where a combination of online and face-to-face teaching methods is utilized. Thus, by valuing students' active participation and engagement in social interactions, we emphasize that their presence in the classroom plays a vital role in constructing knowledge and fostering a deeper understanding of science and mathematics Education.

Therefore, the integration of factors that influence teachers' technology integration, such as their attitudes, beliefs, and technological proficiency, along with the consideration of sociocultural factors, including the social context and collaborative learning environments, enriches our understanding of the blended learning implementation process. This theoretical integration strengthens the foundation for analyzing the results and drawing meaningful conclusions, thus facilitating the acquisition of valuable insights into strategies that teachers can employ to effectively implement the blended learning approach in their classrooms. Therefore, by leveraging these insights, teachers can enhance their instructional practices, optimize student engagement, and foster successful outcomes in the context of blended learning.

METHODOLOGY

Research design

The study employed an interpretive case study research design to investigate and interpret the perspectives and experiences of Grade 12 science and mathematics teachers. The specific focus of the study was to understand the potential benefits and drawbacks of using blended learning as a strategy for curriculum recovery and enhancing students' performance. This research design facilitated a comprehensive exploration of the teachers' individual experiences and subjective viewpoints within the context of blended learning in science and mathematics Education.

Data Collection

During the data collection phase, our roles as researchers played a crucial part in purposively selecting four Grade 12 teachers who specialized in diverse science and mathematics subjects from the Libangeni district in Mpumalanga, South Africa. Despite the relatively modest sample size, we meticulously orchestrated the selection process to ensure a balanced gender distribution, comprising two male and two female teachers. Among this cohort, one teacher held recent certification and specialized in Life Sciences, while both Mathematics and Mathematical Literacy instructors brought commendable six-year teaching tenures to the study. Notably, the Physical Sciences teacher, concurrently holding the position of head of the science department, contributed extensive teaching experience spanning over a decade. Notwithstanding the acknowledged constraints of a small sample size, we underscored the advantages it yielded, including profound insights gained through rigorous interactions, judicious resource allocation, and the specialized perspectives contributed by subject matter experts. Through the incorporation of diverse disciplines, the heterogeneous composition of teachers positioned the study to yield a comprehensive understanding of blended learning practices. However, we acknowledged the potential limitations in the generalizability of findings due to the inherent restrictions imposed by a small sample size.

Our engagement persisted through the selection process, informed by prior interaction with teachers in a professional development workshop. This workshop had a specific emphasis on implementing blended learning strategies, aiming to furnish essential support to science and mathematics educators. This endeavor was a response to challenges spanning a triennial duration, encompassing difficulties in adequately addressing the prescribed curriculum and observing suboptimal student performance during the National Grade 12 Examinations. These challenges were accentuated by factors such as student absenteeism due to natural catastrophes and the disruptive influence of the COVID-19 pandemic.

During the data analysis phase, we employed semi-structured interviews as the primary method to apprehend teachers' viewpoints and encounters with blended learning. These interviews facilitated a thorough exploration, yielding qualitative insights. Our concentration on teachers' voices and an approach centered on participants aimed to capture valuable insights into their cognitions and challenges. While alternate methodologies could heighten rigor, the suitability of semi-structured interviews for this study was grounded in their alignment with teachers' perspectives. Face-to-face interviews were conducted during designated lunch intervals, and the employment of audio recordings ensured the precision and dependability of participant responses. To substantiate the validity of instruments, a pilot group meticulously honed the interview schedule, enhancing its efficacy in capturing pertinent data.

Data Analysis

Concerning data analysis, the collected data underwent a descriptive analysis approach. This process encompassed transcription, organization, and analysis to ascertain prevalent themes

and distinctive aspects associated with teachers' adoption of blended practices. Employing a close-reading technique, we iteratively scrutinized transcripts and audio recordings to cultivate a more profound understanding of participants' language, perspectives, and experiences. To bolster data accuracy, member checking was executed, allowing participants to validate audio recordings and contribute feedback, consequently bolstering the credibility of the collected information. Ethical considerations were vigilantly attended to, involving the acquisition of ethical clearance from the University of South Africa's College of Education and unwavering adherence to the requisite ethical guidelines and protocols.

RESULTS

The primary objective of this study was to assess the potential advantages and disadvantages associated with the integration of blended learning by Grade 12 science and mathematics teachers. This integration was explored as a strategic approach to facilitate curriculum recovery. The findings suggest that blended learning shows promise for curriculum recovery in these subjects. However, certain challenges related to both intrinsic and extrinsic factors are the reason why implementation is difficult and needs to be addressed to fully capitalize on the benefits of blended learning. The study identified four key themes: *Familiarity and Implementation, Potential Benefits, Challenges and Concerns, and the Role of Technology*. These themes contribute to a comprehensive understanding of teachers' perspectives on blended learning.

Theme 1: Familiarity and Implementation

Firstly, the teachers were asked: *How familiar are you with blended learning as a strategy for curriculum recovery in science and mathematics education? Can you provide examples of how you have implemented blended learning in your teaching practice?*

These statements from the Life Science teacher and the Physical Science teacher shed light on their beliefs and approaches to blended learning. The findings suggest that both teachers are aware of the advantages that blended learning can offer in overcoming challenges and enhancing student learning. However, there are hesitations and concerns about implementing blended learning in their teaching practice.

Life Science teacher*: "As a new Life Science teacher, I believe in using technology to overcome challenges such as bad weather, power outages, or water shortages, which can cause students to miss school and fall behind. To address this issue, I have implemented blended learning in my teaching approach. Blended learning involves combining in-person instruction with online resources and tools. By utilizing platforms like WhatsApp or Google, I can share recorded video lessons, online assignments, and interactive learning materials with my students. This allows them to access and engage with the materials even when they are unable to attend physical classes. With blended learning, my students can continue learning and make progress in their studies regardless of the obstacles they face."*

Physical Science teacher*: "Even though I have knowledge about blended learning and understand its benefits for both myself as a teacher and my students, I have been hesitant to use it in my teaching. Instead, I tend to rely on my familiar and safe traditional teaching methods. The main reason behind my hesitation is a fear that I may not be able to implement blended learning correctly or effectively. However, I also recognize that embracing new teaching methods can provide valuable opportunities for my personal growth and improvement. Therefore, I understand that to overcome my fear, I need to gradually adapt blended learning in my lessons. Therefore, by taking small steps and making adjustments over time, I know I can build my confidence and successfully integrate blended learning into my classroom."*

The results underscore the variety of attitudes and experiences among teachers concerning blended learning. The Life Science teacher proficiently incorporated blended learning to surmount challenges and amplify student learning. These findings may indicate that the teacher's recent teaching practice possibly acquainted them with implementation strategies during their training. Conversely, the Physical Science teacher manifests reservations and apprehensions regarding the adoption of this approach. The expressed reservations by the Physical Sciences teacher regarding the integration of this methodology could potentially suggest that teachers with substantial teaching experience may be inclined towards a deeper adherence to their established techniques.

Nevertheless, these findings underscore the necessity of continual assistance and opportunities for professional development for teachers to foster their confidence and competencies in integrating blended learning within their instructional methodologies. Relying solely on a solitary blended learning workshop may prove insufficient in addressing all apprehensions and supplying essential guidance. Instead, an ongoing support structure is recommended, entailing facilitators visiting schools and classrooms to assist teachers in gradually assimilating blended learning in alignment with accessible resources. This method ensures personalized guidance for teachers and the capacity to tackle any predicaments encountered during the incorporation phase. Hence, by delivering continuous guidance, teachers can fully harness the advantages of blended learning, thereby crafting immersive and effective learning experiences for their students.

Theme 2: Potential Benefits

Secondly, the teachers were asked: *What do you believe are the potential benefits of blended learning in the context of curriculum recovery for science and mathematics education at the Grade 12 level? How do you think it can enhance students' understanding and engagement with the subject matter?*

The results indicate that blended learning, utilizing resources such as Siyavula and Microsoft Forms, can significantly benefit Mathematical Literacy students. Siyavula is an educational initiative based in South Africa that provides open educational resources and digital learning materials for mathematics and science. Its offerings encompass free content

such as textbooks, simulations, videos, and practice exercises, tailored to subjects like mathematics and science. Siyavula's primary objective is to enhance both the accessibility and quality of education.

Mathematical Literacy teacher: "*Blended learning is very beneficial for my students. I make use of a valuable resource called Siyavula, which is an online platform for science and mathematics. Siyavula offers a special feature called 'student practice' that allows me to provide my students with additional study materials when they are unable to attend school. Through this feature, my students can work on Mathematical Literacy questions at their own pace from home. In case they encounter any difficulties, Siyavula provides step-by-step instructions to assist them. One of the best things about Siyavula is that it is free, ensuring that all students can access and benefit from it. In addition to Siyavula, I also utilize Microsoft Forms to create quizzes, which enables me to monitor my students' progress even when they are learning remotely. This helps me gauge their understanding of the material and identify areas where they may need further explanations or support. Therefore, by incorporating blended learning and utilizing these resources, I can effectively enhance my students' Mathematical Literacy, even in situations where they cannot physically be in the classroom."*

These results highlight the benefits of blended learning and the use of online resources such as Siyavula and Microsoft Forms in enhancing students' Mathematical Literacy. The availability of Siyavula's 'student practice' feature allows students to engage with additional study materials at their own pace, even when they cannot attend school. The step-by-step instructions provided by Siyavula offer support and guidance when students encounter difficulties. The fact that Siyavula is a free resource ensures equal access for all students, regardless of their financial circumstances. Additionally, the use of Microsoft Forms allows the teacher to assess students' progress and identify areas where further explanations or support may be needed, even in remote learning situations. These results suggest that by incorporating blended learning and utilizing these resources, the teacher can effectively enhance students' Mathematical Literacy, even when physical classroom attendance is not possible.

Theme 3: Challenges and Concerns

Thirdly, the teachers were asked: *Could you discuss some of the potential drawbacks or challenges associated with implementing blended learning for curriculum recovery in science and mathematics education? Have you encountered any specific obstacles or concerns when using blended learning strategies*?

The results indicate that each teacher faces specific challenges in implementing blended learning in their respective subjects.

Mathematics teacher*: "Implementing blended learning in my classroom has presented several challenges. One significant issue I face is the impact of power outages on network connectivity. As a Mathematics teacher, I heavily rely on online software like Matlab to solve mathematical problems. Regrettably, in the event of a power outage, the software fails to*

function properly, and the instructional videos I utilize consistently experience buffering issues. This situation poses challenges for my students in their learning journey and can lead to frustration for both my students and myself. Additionally, this results in the unfortunate wastage of valuable teaching time that could have been utilized more effectively."

Life Science teacher: "*I have faced a challenge in implementing blended learning due to the limitations of WhatsApp, the platform I use to share resources with my students. WhatsApp has restrictions on the size of videos that can be sent, making it difficult for me to share crucial videos that would visually explain abstract and complex scientific concepts to my students. This limitation can be frustrating as teaching and learning Life Science without visual aids can be challenging. To overcome this challenge, I need to explore alternative platforms or solutions that facilitate the seamless sharing of videos, which would greatly improve the effectiveness of blended learning in my classroom."*

Physical Science teacher*: "The main challenge with blended learning is the lack of internet access in our schools. Without Wi-Fi available, students are required to use their data to access online study materials. This poses a problem, as some students have expressed concerns about the cost of using their data consistently. It is important to address this challenge to fully harness the benefits of blended learning. Finding solutions to provide affordable or free internet access for students within the school environment will be crucial for the successful implementation of blended learning."*

The results of the study underscore the specific challenges encountered by teachers during the implementation of blended learning in their classrooms. The mathematics teacher highlights the adverse effects of power outages on network connectivity, resulting in compromised functionality of online software and instructional videos, thereby impeding student learning and causing inefficiencies in teaching time utilization. The Life Science teacher identifies limitations associated with the WhatsApp platform, specifically about constraints on sharing visual resources due to size limitations, thereby impeding the effective elucidation of intricate and abstract scientific concepts. These limitations pose significant obstacles in teaching and learning processes that rely on visual aids. The Physical Science teacher draws attention to the absence of internet access in educational institutions, necessitating students to utilize their data for online learning, consequently raising concerns about affordability for certain students. These challenges underscore the imperative of addressing infrastructure and platform limitations to fully capitalize on the advantages of blended learning. The teachers propose potential solutions such as exploring alternative platforms that facilitate seamless sharing of videos, devising strategies to provide cost-effective or cost-free internet access within schools, and establishing contingency plans to mitigate disruptions caused by power outages, thereby ensuring uninterrupted online learning experiences.

Theme 4: The Role of Technology

Fourthly, the teachers were asked: *How do you perceive the role of technology in blended learning for Grade 12 mathematics and science education? Do you think it can effectively support curriculum recovery and address learning gaps in these subjects? If so, how? If not, what limitations or reservations do you have?*

The results indicate that the integration of technology in teaching has had a tremendous impact on the teacher's experience in rural school contexts.

Life Science teacher*: "As a teacher in a rural school in Mpumalanga, I have witnessed firsthand the tremendous impact of technology on my teaching. Technology has allowed us to enhance our lessons by incorporating videos of experiments and simulations that vividly explain scientific concepts. In the past, we faced limitations due to the lack of resources for conducting experiments or lab work. However, with the help of virtual experiences, our students can now grasp scientific principles through engaging visuals and interactive learning. While hands-on experiments may be limited, students can actively participate in group discussions and collaborative simulations, even from the comfort of their homes. This enables them to work together and learn as a team, despite any physical constraints we may face."*

The results highlight the significant positive impact of technology on teaching in a rural school in Mpumalanga. The use of technology, such as videos of experiments and simulations, has greatly enhanced the quality of lessons by providing vivid explanations of scientific concepts. It has overcome the limitations previously faced due to the lack of resources for conducting hands-on experiments or lab work. The virtual experiences have allowed students to understand scientific principles through engaging visuals and interactive learning. Although physical constraints may restrict hands-on experiments, technology has provided opportunities for students to actively participate in group discussions and collaborative simulations, even from their homes. This suggests that technology can bridge the gap and create an inclusive learning environment where students can work together and learn as a team, regardless of physical limitations. These findings indicate the importance of integrating technology into teaching practices, particularly in rural schools, to enhance students' learning experiences and promote collaborative learning.

DISCUSSION

The findings of this study provide substantial empirical evidence that bolsters the practical implementation of blended learning as a potent strategy for curriculum recovery and elevating students' academic performance. This alignment with the outcomes of Annamalai (2019) reinforces the successful execution of blended learning by a Life Science teacher through a WhatsApp group. This instructional approach involved sharing recorded video lessons, assigning tasks, and extending student support, particularly when adverse weather conditions posed challenges. This consonance with Annamalai's findings gains additional validity from the research conducted by Ohanu et al. (2022), which highlights that the use of platforms like

WhatsApp for blended learning significantly shapes teachers' perceptions of platform usability, perceived utility, and overall attitudes towards blended learning integration.

In a comparative context, Kilinc et al. (2016) embarked on a study that delved into the realm of technological integration in education. Their exploration centered around the assimilation of digital tools, including online platforms, into teachers' instructional methods. While nuances in platforms and contexts may introduce variations, both studies underscore the pivotal role of technology in shaping educators' attitudes and practices, emphasizing its potential to amplify engagement and foster superior learning outcomes. This shared thread of insight contributes to a more comprehensive comprehension of the transformative potential inherent in technology integration within educational contexts.

These findings resonate harmoniously with the foundations of the Technology Acceptance Model, asserting that the adoption and integration of technology are influenced by perceived benefits and ease of use. However, it is imperative to acknowledge that, unlike Batista-Toledo and Gavilan's (2022) findings, the Physical Science teacher in our study did not have the opportunity to implement blended learning during the extended COVID-19 lockdown. Nevertheless, this educator acknowledges and underscores the importance of considering and embracing the potential integration of technology in their pedagogical practices. These combined observations underscore the dynamic evolution of educational technology and its profound impact on pedagogical paradigms.

Furthermore, the resonance between our study and the insights of Hennessy et al. (2022) serves to underscore the pivotal importance of continuous support and professional development for teachers endeavouring to adeptly incorporate blended learning into their instructional methods. Our study, mirroring the work of Hennessy et al. (2022), recognizes the demands placed on teachers during blended learning implementation, necessitating the acquisition of novel competencies, adaptation to technological advancements, and adeptly navigating the intricacies that arise from blending online and face-to-face instructional modes. This coherence accentuates the shared challenges and adaptations that educators must undergo when integrating technology into their pedagogical practices.

Significantly, our study underscores that effective blended learning hinges on an ongoing and sustained support system, as opposed to the limited impact of isolated training sessions or workshops. This sentiment echoes Ohlin's (2019) research, which centered on teachers' continuing professional development and their perceptions of self-understanding within the realm of digital tools. Analogous to our findings, Ohlin (2019) emphasizes the critical nature of continuous support. Specifically, Ohlin underlines the imperative for teachers to engage in continuous learning opportunities to enhance their digital competencies and instructional methodologies.

The application of the Technology Acceptance Model in our study to analyze teachers' perceptions concerning platform usability, perceived utility, and overall attitudes toward adopting blended learning strategies finds resonance in Ohlin's research, shedding light on the

factors that shape teachers' incorporation of technology in online classrooms. While our study particularly emphasizes the role of continuous support and professional development in the context of blended learning integration, Ohlin (2019) explores the broader theme of self-understanding within the multifaceted roles of educators. This comprehensive exploration encapsulates factors such as creativity, critical thinking, communication, and collaboration.
Hence, the connection between our study's findings and the insights gleaned from Ohlin (2019) imparts a more profound understanding of the intricate landscape of teacher professional development and technology integration. Both studies align in emphasize the necessity of sustained support, customized assistance, and ongoing learning opportunities. Such efforts empower teachers to integrate technology seamlessly and effectively into their instructional practices, thereby fostering heightened engagement and enriched learning outcomes.

The present study's findings harmonize with earlier research conducted by Padayachee et al. (2011) and Thurm and Barzel (2021), underlining the benefits of integrating technology into mathematics education to enhance students' comprehension. These studies corroborate the efficacy of Siyavula, an educational platform spotlighted by the Mathematical Literacy teacher, in enhancing students' mathematical literacy through its learning experiences and practice components. Additionally, the endorsement of tools like Microsoft Forms, as advocated by Dolighan and Owen (2021), emerges as a secure platform for conducting quizzes, enabling teachers to assess students' comprehension and offer targeted assistance, even in remote learning scenarios, thereby minimizing teaching time loss.

However, as highlighted by van Rensburg and Oguttu (2022), the implementation of blended learning in South African classrooms encounters various barriers. A significant hindrance is poor internet connectivity, exacerbated by ongoing power outages in the country. The mathematics teacher in our study underscores the extrinsic challenges tied to network connectivity, emphasizing its adverse impact on student's academic success in an online learning environment. Likewise, the Physical Science teacher voices concerns about the lack of internet access in schools, necessitating students to rely on their data for online learning. This constraint has been shown to negatively affect students' attitudes towards online learning, as indicated by Basar et al. (2021). Hence, the findings underscore the pivotal influence of network connectivity and internet access on the efficacious implementation of blended learning in South African classrooms.

Nevertheless, notwithstanding the challenges encountered, earlier studies (Kalonde, 2017; Kormos & Wisdom, 2021) consistently underline the potential of technology to afford rural students opportunities, experiences, and resources that enrich their learning capabilities and enable them to perform at par with their urban and suburban peers. The positive experience shared by the Life Science teacher in our study underscores the role of technology, including virtual experiences, videos, and simulations, in compensating for limited resources in rural schools and supporting effective teaching practices. Moreover, students' ability to

engage in remote interaction and collaboration, as highlighted by Schindler et al. (2017), underscores technology's potential to facilitate meaningful learning experiences. This discovery aligns with the principles of the Sociocultural Constructivism theory, which accentuates collaborative learning and the co-construction of knowledge through social interactions.

CONCLUSION

In conclusion, the findings of this study provide empirical evidence supporting the practical implementation of blended learning as an effective strategy for curriculum recovery in science and mathematics education. The results are consistent with previous research and align with theories such as the Technology Acceptance Model and Sociocultural Constructivism. The positive experiences shared by teachers who have utilized blended learning platforms, such as WhatsApp and Siyavula, as well as tools like Microsoft Forms, demonstrate the effectiveness of these approaches in enhancing student comprehension and providing targeted support. However, extrinsic challenges related to poor internet connectivity and limited access in South African classrooms hinder the widespread adoption of blended learning. Nonetheless, technology has the potential to bridge the educational divide between rural and urban/suburban schools, offering equitable learning opportunities for all students. Future research should delve deeper into the factors that contribute to the successful implementation of blended learning and explore its impact on student outcomes in science and mathematics education. The implications of this study underscore the importance of effectively integrating technology, addressing infrastructure challenges, and promoting equitable access to enhance the implementation of blended learning in science and mathematics education.

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