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Creation of Innovative Teaching Spaces with Gamma Tutor: A Techno-Blended Model for Rural Mathematics Teaching

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Abstract

Innovative techno-blended teaching methodologies are needed for 21st-century classrooms. This paper reports on the introduction of a techno-blended device for mathematics teaching in South African senior secondary classrooms. The research sample included 12 third-year mathematics education student teachers from a rural university. A qualitative case study design was employed. Participants were purposively selected. Data collection methods included non-participatory observation and in-depth individual interviews. The TPACK model and the Mathematical Knowledge for Teaching Framework guided the analysis of the data. The study found that the mathematics student teachers successfully implemented GammaTutor in their classrooms, thus demonstrating their proficiency and aptitude in utilising technology in the learning environment. The GammaTutor device also aided in teaching and learning mathematics by simplifying mathematical ideas for learners. Furthermore, it enabled the development of learner discourse as a crucial component for developing learners' problem-solving skills. Since the mathematics student teachers engaged the learners with a variety of mathematical exercises using the GammaTutor technology, the integration of GammaTutor in the mathematics classroom exhibited learner-centred provisioning. The study proposes a teaching model for creating innovative teaching spaces in rural schools in South Africa.

Keywords: GammaTutor, Information communication technologies, Innovative teaching spaces, Mathematical knowledge for teaching, Techno-blended, Technological equipment, TPACK.

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Contents

Contribution of this paper to the literature
This study investigated the creation of an innovative teaching space with GammaTutor. The goal of the GammaTutor programme is to give teachers unrestricted access to teaching and learning materials for their Grades 8–12 Mathematics and Physical Sciences curricula. It aims to uplift the standard of education in the 4IR era. It is part of technology integration in teaching and learning mathematics.

1. Introduction

The performance in mathematics among senior secondary school learners has been a concern in most developing countries, including South Africa (Mabena, Mokgosi, & Ramapela, 2021). As a result, this has negatively affected the intake of students for science, technology engineering, and mathematics (STEM) related professions. According to Mabena et al. (2021) the evaluation of mathematics teaching and learning interventions points to a lack of motivation and knowledge of mathematics. Incorporating technology into the classroom for teaching and learning is rapidly gaining popularity globally. The use of technology and technological devices are motivating learners to learn mathematics, thus changing the classroom and the responsibilities of teachers and learners. Younger newly qualified teachers are more versatile and adaptable to incorporating technology in mathematics teaching. We argue that training pre-service teachers for technology integration in teaching and learning should be the priority of teacher educators and teacher training institutions.

Alanazy and Alrusaiyes (2021) state that technology integration in the classroom encourages students to be able to apply their knowledge and skills in solving complex mathematical problems. Several studies demonstrate that technology improves students' performance at all levels (Adeniji, Ameen, Dambatta, & Orilonise, 2018; Gachinu, 2014). Therefore, it is important to emphasise the role that technology integration plays in teaching and learning during initial teacher preparation and professional development. Kim, Kim, Lee, Spector, and DeMeester (2013) agree that to appropriately integrate technology in the classroom and improve teaching and learning, teachers must possess the necessary pedagogy and subject-matter expertise. Therefore, learners' achievement depends significantly on the pedagogical content knowledge (PCK) of mathematics teachers. Mishra and Koehler (2006) and Nazari, Nafissi, and Estaji (2020) believe that the PCK is the ability of teachers to implement appropriate pedagogical and content knowledge within the subject context.

One of the hurdles of rural teaching using technology in South Africa is the availability of the Internet to engage online resources. To alleviate this problem, this study engaged the GammaTutor software programme, which is an offline techno-blended model. The GammaTutor software comes pre-installed on the Gamma Universal mini-PC device. The device is easy-to and plug-and-play, which can be used on any available screen, for example a computer, laptop, television screen or data projector. The GammaTutor programme gives teachers instant access to teaching and learning resources for Grade 8-12 Mathematics and Physical Sciences curricula. It is designed to improve the quality of learning in the 4IR era.

The GammaTutor was introduced in the student teachers' training programme in a rural university context. The programme aimed to assist students to face challenges with confidence and to teach with passion and enthusiasm to improve learner performance (Boateng, Alex, Adelabu, Sihele, & Momoti, 2022). Therefore, this study investigated the creation of innovative teaching spaces with GammaTutor, a techno-blended model for rural mathematics teaching. This study sought to answer the following research questions:

1) What are the mathematics student teachers' experiences with technology in their practices of the integration of GammaTutor in the classroom?
2) How does the school setting influence the student teachers' perceptions and practices of the integration of GammaTutor in the mathematics classroom?

2. Literature Review

The integration of technology into the education system has been discussed continuously (Costley, 2014). Within the education space there is rapid growth in the use of information communication technologies (ICTs) globally. These researchers have shown that the use of ICT in teaching and learning has a positive impact on learner performance and conceptual understanding (Koch, Heo, & Kush, 2012; Meladi & Awolusi, 2019; Mukuna, 2013; Unal, Yamaç, & Uzun, 2017). Despite, the positive views on technology use in education, the integration of technologies in the South African education system is still a challenge (Meladi & Awolusi, 2019). It has been reported that South African teachers, especially the newly qualified feel underprepared to integrate technologies into their teaching (Chigona & Chigona, 2013). Moreover, Pozas and Letzel (2021) declared that both in-service and pre-service teachers faced challenges in integrating technologies into learning and teaching processes. To exacerbate the situation, the COVID-19 pandemic forced teachers to use technologies (Pozas & Letzel, 2021) despite teachers facing several challenges. One of the major challenges cited by Pozas and Letzel (2021) is the lack of technological skills and resources (Meladi & Awolusi, 2019).

Vrasidas and McIsaac (2001) claimed that:

> "For successful technology integration in schools, teacher education programmes play a crucial role. Teacher preparation on technologies should provide teachers with a solid understanding of the various media, their affordances, and their constraints. Such understandings can only emerge when teachers are actively involved in teaching and learning with technology across the various disciplines".

Hence, it was important in this study to expose pre-service teachers to technologies like the GammaTutor device while they are still studying to become mathematics teachers. As supported by Chigona and Chigona (2013) there is a need to provide training for pre-service teachers with quality and modern technologies that are appropriate to effectively deliver the content to the learners. A study conducted by Meladi and Awolusi (2019) on the influence of ICT integration on teaching and learning in South African schools claimed that the Department of Basic Education (DBE) still faces major challenges that delay the progress of implementing quality education. Amongst their findings, they discovered that there is still a need for the DBE to offer training on ICT integration as a way of empowering teachers with the necessary skills. Meladi and Awolusi (2019) suggest that equipping teachers with ICT integration skills should be part of professional development training for teachers, especially for the newly qualified teachers. Thus, we argue that equipping the mathematics student teachers with skills in using the GammaTutor device could enhance their technological knowledge and enable them to effectively integrate technology when they start their teaching professions. The study mainly focused on the integration of technology in the rural schools of the Eastern Cape Province in South Africa. Thus, the research has confirmed the challenges that rural schools encounter when integrating technologies (Chigona & Chigona, 2013; Howley, Wood, & Hough, 2011). For example, Howley et al. (2011) highlighted that it becomes a challenge in most rural areas to integrate technologies that require an internet connection like video-conferencing, streaming of videos and web-based applications. It is for this reason that this study found GammaTutor, user-friendly as it does not require an internet connection but only the screen that is visible to enable the learners to see the content displayed.

Tondeur et al. (2012) conducted a study based on how teacher education programmes work on preparing teachers to use technology in their (future) classrooms. Their findings revealed that pre-service teachers become motivated to integrate technology into their practices when they observed their colleague's using technology. This means that training mathematics student teachers on GammaTutor might have encouraged them to use the device during their teaching experience. Tondeur et al. (2012) recommended that "technology should be integrated throughout the curriculum to provide pre-service teachers with the experiences needed to apply technology to their specific content areas" (p.9). Therefore, this study finds it important to capacitate mathematics student teachers with the use of technology and technological skills before they complete their teacher training program.

2.1. Creating Innovative Teaching Spaces for Mathematics Student Teachers

When used in the classroom, technology enhances learning. Technology-assisted mathematics instruction improves students' conceptual understanding (Almumen, 2021). When utilising technology, learners can perform better and change their perspective of instruction. Technology changes educational procedures, inspires student teachers to study, and exposes them to a variety of strategic learning initiatives by constructing a creative teaching environment for student teachers (Almumen, 2021). Furthermore, there will be collaboration, a desire to learn and intellectual and creative activity in the teaching and learning process (Strutynska, Torbin, Umryk, & Vernydub, 2020; Velichko, Fedorenko, & Kassim, 2018). According to Velychko, Fedorenko, and Kaidan (2021) integrating technology during student-teacher preparation will enable them to develop analogous experiences in the mathematics classroom during their actual teaching. Nevertheless, the use of technology in mathematics classes enables student teachers to collaborate, create and evaluate learning resources as well as to recognise the benefits and potential of technology and instructional approach. Therefore, this allows student teachers to develop ICT-based lesson plans and learn how to effectively use ICT in mathematics teaching (Das, 2019; Dorner & Kumar, 2016). According to Niess (2006) technology is utilised to enhance mathematics education at all levels. Therefore, student teachers will be better equipped to use technology effectively and appropriately in the technologically advanced schools in which they will teach in the future.

2.2. Technological Pedagogical and Content Knowledge in Mathematics Teaching

In this study, TPACK (Technological Pedagogical and Content Knowledge) and Mathematical Knowledge for Teaching (MKfT), pedagogical techniques serve as the foundation. To design effective instruction with technology, the TPACK model developed by Mishra and Koehler (2006) suggests that sound pedagogical knowledge, content knowledge and technology knowledge must be considered. The TPACK model by Mishra and Koehler (2008) expresses two fundamental features of technology integration. According to Thompson and Mishra (2007), the model was created to "emphasise, through the letters, the three kinds of knowledge (Technology, Pedagogy, and Content) and the notion that they form an integrated whole, a 'Total PACKage' as it were, for helping teachers take advantage of technology to improve student learning" (p. 38). TPACK is the foundation of good technology-assisted teaching, and it necessitates an understanding of the representation of technological concepts as well as pedagogical approaches for effectively using technology in content delivery. According to Mishra and Koehler (2006) "thoughtful interweaving of the three primary sources of knowledge: technology, content, and pedagogy" is required to create good content (p. 1039). Furthermore, developing and applying a sophisticated understanding of the complex interactions between technology, material, and pedagogy leads to the development of context-specific techniques and representations (Mishra & Koehler, 2006). A good mathematics teacher should be able to use technology-based tools in the classroom. Therefore, the teacher should understand how to employ appropriate technology-based tools to assist with subject learning. This framework is based on the idea that education is multidimensional and requires a wide range of knowledge categories. The following are the concepts within the TPACK framework that are theorised in this study: CK refers to the understanding of the mathematics ideas taught in the classroom. Knowledge of how to teach concepts for efficient learning is referred to as PK. Knowledge of technology-based tools used in education is referred to as TK. The GammaTutor device, a laptop computer and a projector were among the technology-based tools used in this study. Furthermore, TCK is an understanding of the appropriateness of technology-based instruments for teaching and learning. PCK is knowledge of pedagogy for teaching the subject. In other words, PCK is the knowledge about how to teach mathematics concepts using certain technology-based methods (GammaTutor). The term "pedagogical content knowledge" (PCK) refers to Shulman's (1986) idea of pedagogical content knowledge, which asserts that successful teaching ability is located within the subject context where pedagogical and content knowledge is equally integrated. According to Shulman, teacher knowledge necessary for efficient education emanates from mathematical knowledge (Ball, Thames, & Phelps, 2008). Therefore, theory places a strong focus on teachers' mathematical expertise. To develop and acquire mathematics skills knowledge that will be beneficial and usable for teaching, theory helps to identify what teachers know well. According to Shulman's theory, teachers should have the opportunity to practice applying common mathematical concepts, methods, and principles.Learning to evaluate alternative approaches and opportunities to engage in analytical and rational work can be helpful for teachers in teaching to strengthen mathematical content. These approaches need to make ideas of methods and solutions different from teachers' own. Furthermore, teachers should also consider their work as educators to be mathematically demanding, involving considerable and complex mathematical problem-solving that can provide insight into their mathematical education. The theory opens the way to make professional development for maths instructors more intellectually and technically demanding, while also making it more profoundly useful and practical (Ball & Bass, 2003). The indication is that the quality of mathematics teaching depends on teachers' knowledge of the subject.

3. Methodology

For this study, the Mathematics Education and Research Centre (MERC) team conducted a research project in a rural Higher Education Institution (HEI) in the Eastern Cape. In this paper, GammaTutor is described as a new technological instrument for mathematics teaching and learning.To answer the research questions on the creation of innovative teaching spaces with GammaTutor, a techno-blended model for rural mathematics teaching, this study adopted a qualitative research method. A qualitative research method is a descriptive approach to the student teachers' experience of incorporating technology based (GammaTutor) tools into their teaching during school-based experience (SBE) commonly known as teaching practice.

3.1. Data Collection Instrument

The researcher used a semi-structured interview schedule to collect data. After six weeks' of teaching practice, the student teachers underwent 'observation' throughout their sessions and were then individually interviewed. The instrument for the interviews was developed by researchers at the Mathematics Education and Research Centre, Walter Sisulu University and its reliability was determined.

3.2. Study Sample

Twelve student teachers whose major subject is mathematics were selected to participate in the study. The inclusion criteria were that they had to have experience in using GammaTutor and were chosen using purposeful sampling (Shaheen, Gupta, & Kumar, 2016). The participants were enrolled in rural South African HEIs for a four-year under-graduate mathematics education program. On completion of the degree programme, they will be allowed to teach mathematics in a secondary school in South Africa.

3.3. Data Collection Procedure

The 12 participants were invited to attend an individual interview. The interview was scheduled according to the time and availability of each student. Interviews took place at a venue that was convenient for the participant. The interview schedule was used as a guide during the data collection process. Each student was asked a question and probing questions followed whenever there was a need for further explanation. All data were audio-recorded with the permission of the participant. These recording were later transcribed to ensure that the data was correctly captured.

3.4. Data Analysis

The interviews were audio-recorded, transcribed, organised, and coded. The data were analysed descriptively, aligned with relevant literature and the theoretical framework. All transcripts were carefully recorded and coded. Data from the transcript interviews were analysed. To develop a fundamental knowledge of the data and create a coding scheme in an excel spreadsheet, we read and reread the data. After several readings, the researchers identified relevant themes.

3.5 Ethical Considerations

All ethical conditions were met, and the student teachers consented to participate in the study (Ethical Clearance Number: FEDSRECC001-06-21). Data were analysed inductively using the TPACK and MKfT frameworks as lenses.

4. Result

The demographic characteristics of the mathematics student teachers are shown in Table 1:

Table 1. Demographic characteristics of mathematics student teachers.

Demographics Characteristics (N = 12)			
		N	**%**
Gender			
	Males	8	67
	Females	4	33
Age			
	21	4	7
	22	5	73
	23	2	13
	24	1	7
Level of studies			
	B. Ed	12	100
Major in Natural Sciences	-		
First major for SBE teaching practice	Mathematics	12	100
Location of Teaching Practice high school			
	Urban	1	8
	Sub-urban	1	8
	Rural	10	84

The transcript interview coding approach was created using a priori codes to track common classroom interactions, engagement and interventions (Johnson & Christensen, 2019). Table 2 below is a list of the parts and codes for TPACK.

Table 2. TPACK parts and codes.

TPACK components	Codes
TPACK	Mathematics student teacher's knowledge of GammaTutor.
PK	How the student teachers handle the mathematics lesson.
TCK	Overall classroom interactions and engagement as well as intervention.
TK	Challenges of using GammaTutor in mathematics class.
TPK	The description of how student teachers mediate mathematics learning with GammaTutor.

4.1. Mathematics Student Teachers' Experiences with the GammaTutor tool

This section describes the findings of the experiences of mathematics student teachers with the integration of the GammaTutor tool in their mathematics classroom instructions during school-based teaching experience (known as teaching practice in South Africa). For reporting purposes, the participants were coded as MST1, MST2, to MST12. Their responses are described in no particular order. The interview results are presented as follows.

4.1.1. Mathematics Student Teachers' Integration of GammaTutor Tool in the Mathematics Classroom

The interview data revealed that most participant's experiences with GammaTutor integration in mathematics classrooms were very positive and appreciative. They found significant benefits in using the GammaTutor in their lessons. 10 of the 12 participants stated that they used the GammaTutor tool to assist them in organising their lesson plans to effectively expose and teach content to learners. This demonstrates that the participants were competent and skilled in the use of the GammaTutor tool as a device for their teaching and learning. According to the TPACK model, this is evidence of implementing technological knowledge (TK) to enhance teaching and learning for the 21st-century. According to the field notes, participants focused on utilising the tool to facilitate conversation and engage their learners fully in their classroom instructions. One mathematics student teacher remarked:

> *It simplified my approach to the material when I included the GammaTutor technology in my classroom teachings. It enhances the engagement of lessons and keeps learners captivated by the tool. Additionally, my preparations were always precise. There are no problems or complications associated with copying notes on the whiteboard* (MST6).

Another mathematics student teacher stated:

> *GammaTutor is the finest tool for teaching and learning mathematics since it includes all necessary resources for learning mathematics, such as textbooks, lesson presentations, previous question papers and memoranda, and calculators. Indeed, I no longer need to bring textbooks to class because I have everything, I need on that tool to aid in the acquisition of mathematics subject* (MST2).

The above responses indicate that the interaction between the student teachers and learners was extremely engaging, as the participants emphasised the need for an active and critical approach to learning. All the participants who utilised the GammaTutor tool in their instruction agreed on the importance and value of the tool. It significantly assisted in teaching mathematics curriculum content and enhancing student's knowledge and understanding of mathematics concepts. Therefore, the researchers agree that the use of the GammaTutor tool provided the students with hands-on experience, assisting them to implement common mathematics concepts, procedures, and principles in the classroom.

When participants were asked about the detrimental features of GammaTutor tool to their ability to acquire mathematics content, a few expressed certain opinions. One participant expressed the following sentiments:

> *Pity though, my learners were not able to access fully all resources like they do when surfing the Internet and that was disadvantageous* (MST8).

On the question of how beneficial the GammaTutor tool is for learning mathematics, most participants agreed that GammaTutor simplified content by allowing them to develop learners' mathematics discourse which is an integral part of mathematics learning in problem-solving skills. Furthermore, they said that they managed their classes effectively and employed a variety of teaching styles and classroom management techniques. Moreover, they felt more confident in responding to learners' questions because the GammaTutor tool supported classroom instruction. This indicates that mathematics student teachers possessed substantial pedagogical knowledge (PK) to direct learners' conversations and assist them to resolve challenges using the GammaTutor tool. Thus, the participants used the GammaTutor tool to enhance their classroom practices by allowing them to prepare their teaching and learning to appropriately address learners' needs. Furthermore, participants believed that using the GammaTutor tool enabled them to conduct assessments differently as a result of using the tool. They also agreed that incorporating the GammaTutor tool in their teaching improved the student teachers' mathematics knowledge and learners' mathematical reasoning as well as problem-solving abilities.

According to two participants:

> *Developing learners' mathematics discourse is a critical part of mathematics teaching and learning with the GammaTutor tool. Indeed, teaching has become so easy for me because my learners may study independently in my absence and complete exercises with solutions, which implies that learners can grade themselves after completing each task* (MST9).
>
> *All mathematics information is organized, and data sheets and other relevant data sheets are included. This simplifies things for me as a teacher and gives me the confidence to communicate crucial ideas to my learners* (MST11).

There were instances wherein participants displayed an in-depth understanding of GammaTutor integration in the mathematics classroom for teaching, utilising appropriate pedagogies, methodologies, and pedagogies (Technology Pedagogy and Content Knowledge TPACK). This was evident during classroom observations. The participants displayed an understanding of TPACK by incorporating it into their classroom practices. They demonstrated, to some extent, how to use the GammaTutor tool to teach mathematics and to foster critical thinking in their learners. Also, how to facilitate instructions that support learners in sharing ideas.

Regarding the benefits of using the GammaTutor tool, participants merely criticised the tool for using several sources of information that confused the learners. According to one mathematics student teacher:

> *Using several sources can occasionally confuse learners…* (MST12).

Furthermore, participants were questioned about their positive experiences integrating GammaTutor into their mathematics classroom practices. They mentioned that the GammaTutor tool simplified teaching by sustaining and retaining learners' attention in the classroom, by organising content more effectively for their learners understanding and comprehension skills. Evidence from the observations indicated that mathematics student teachers have a high level of content knowledge (CK) in the subject they teach and are conversant with the subject's content as they organise lessons to meet the needs of their learners. The participants expressed the sentiments outlined below.

> *I ensure that I organise my lessons in such a manner that I am always utilizing differentiated instructions and varying the ways I present my lesson to learners. I practice the topic for each day before going to the classroom, ensuring that I am conversant with the content for the day. I also present many types of question papers that are quite beneficial since they demonstrate various styles of question sets for formal tasks and memorandums demonstrate various approaches to answering questions* (MST1).

> *GammaTutor is the optimal tool for classroom application. It was quite beneficial to me. It has excellent content and simplifies the instructional process. There is a lot of information that is useful and can be used in the future or the next upcoming generation as we are living in the 21st century* (MST5).

GammaTutor tool integration facilitates teaching and learning and ensures that learners receive information effectively. This was also evident from the classroom observations during SBE. The responders pointed to the fact that the GammaTutor tool provided them with in-depth knowledge throughout their lesson preparation and teaching practices in the classroom.

4.2. Mathematics Student Teachers' Readiness to Use the GammaTutor Tool in Future

Participants enthusiastically expressed their overall favourable impression of using the GammaTutor tool in their mathematics classrooms. They agreed that it improved their teaching practices and helped them to deliver the subject matter to their learners with ease and confidence. They also claimed that the GammaTutor tool helped them in guiding their learners through content-related problem-solving on the topics they taught. Participants were optimistic that they were ready to use the tool in the future. This implies that they have strong mathematical knowledge and pedagogical content knowledge (PCK) of the subject they teach. This knowledge provides them with an opportunity to guide their learners in reflective thinking in mathematics to improve upon their performances in the subject. One mathematics student teacher recounted her experience in the following manner:

> *To me, GammaTutor is the best tool for teaching and learning no time for erasing the board we just page and in fact, seeing learners participating so well in the lesson means a lot to me, which means I am using great content. My instructions are enriched with resources to facilitate learner understanding. My learners can respond very well, and they listen very well as I deliver my lesson. I guide them to also reflect on their thinking when solving problems in Analytical geometry (*MST9).

During the SBE observations, there were episodes of PCK and mathematical knowledge that were observed and documented. It was discovered that most mathematics student teachers could guide their learners in organising their learning and incorporating problem solving mathematics in their teaching. Participants' responses suggest that they were currently using the GammaTutor tool and intend to continue doing so in the future.

4.3. Influence of School Settings on Mathematics Student Teachers' Use of GammaTutor Tool

The school environment appears to be critical in determining whether mathematics student teachers use and continue to use the GammaTutor tool in their classrooms. Numerous variables such as insufficient power point, computer monitor, smart white board were mentioned by mathematics student teachers as influencing and shaping their use of the GammaTutor tool in the mathematics classroom.

4.3.1. Access to Technological Equipment

When data were triangulated, it was found that participants integrated their content knowledge with the GammaTutor tool to revolutionise their mathematics classroom practices. The technological content knowledge (TCK) of participants was found to be very strong, as they regularly integrated the GammaTutor tool into their teaching. They were knowledgeable about how to use the tool to illustrate difficult concepts and how to use it to help their learners better understand the subject's content. It was also evident that the school environment in general encouraged them to incorporate the tool into their lessons.

All 12 participants indicated that the classroom environment prompted them to do so. They cited the availability of technology tools as a critical factor in their choice to incorporate the GammaTutor tool into their classroom instruction. Additionally, our classroom observations revealed that the school culture in general was a supportive factor in their decision to integrate the GammaTutor technology. Two participants mentioned:

> *Although my school is rural, the school atmosphere has a good effect on how I use technology in the classroom. This is because all of the school's classrooms are equipped*

> *with cutting-edge digital technology, which I require to incorporate the GammaTutor application* (MST 5).
>
> *Well, my school's science laboratory is equipped with all the necessary technical tools. All I need to do is to make an arrangement with other teachers to use the laboratory for my mathematics lessons using the GammaTutor tool* (MST1).

On the other hand, a few participants claimed that their schools lacked adequate technological resources. Therefore, they borrowed projectors and computer monitors from other schools to integrate the GammaTutor tool. Two participants expressed their sentiments:

> *My school is in a rural area, I believe the largest problem I had occurred during the second week when the projector became damaged and ceased to function; I was forced to return to using chalk* (MST4).
>
> *Lack of material at the school (projector); it was difficult to locate it because there was only one and many teachers were also using it, resulting in the gadget being used just a few times each week (2 or 1 times per week)* (MST2).

Another participant alluded to the fact that the school timetable had been scheduled in such a way that before you set up the projector and the GammaTutor tool, about 30mins is already gone. He narrated:

> *This technology takes a long time to be integrated into the lesson as it didn't fit well in a school subject period (1 hour), especially the videos (MST1).*

The above responses also indicate the lack of resources such as dedicated teaching venues to support technology-integrated teaching.

4.4. Learners' Interest in Mathematics Lessons That Incorporate the GammaTutor Tool

All 12 participants indicated that they were familiar with how to integrate the GammaTutor tool into their classroom instructions. They were confident to promote critical and reflective thinking in their learners (technological pedagogical knowledge, TPK) and aroused their learners' interest and curiosity about the lesson. As a result, they all indicated that their learners were extremely engaged in the teaching-learning process when the GammaTutor tool was integrated into their lessons. The following quotations illustrate this point:

> *My learners were captivated by this tool since it included question papers and memorandums that allowed them to double-check their calculations. Yes, they understood very well. One of them even stated, "We like this new technology because it is better than the board because when information is in this Gamma, it is easier to see than when it is on a chalkboard, which is sometimes faint." They also understood the content very well with Gamma because there are also videos to reinforce everything, I teach them* (MST4).
>
> *Many schools are in remote rural locations because it is difficult to use technology and the learners who live there are not exposed to technology, which creates an issue. They were overjoyed that the device was used; you could almost hear them say that it was simple since we could go back and forth, as opposed to the whiteboard, where information would be swiped if there was no room left* (MST6).
>
> *They were so interested whenever I used this tool in the classroom. They paid attention when it comes to teaching using a GammaTutor tool. They want to learn through lessons presented as PowerPoint presentations, videos, and images all the time. They feel more comfortable when I use such technology … they concentrate more on the lesson and become more active* (MST8).

4.5. GammaTutor Integration Experience with Other Teachers in The School

On the question of incidences where other teachers in the school watched the student teachers when they taught with GammaTutor in their mathematics classroom, the participants indicated that particularly mathematics teachers appeared to be fascinated by the tool. They expressed their wish that they had the tool for their classroom so that they could also use it in their lessons. According to the participants, since few teachers used such technological tools in these schools, they wanted to use GammaTutor to teach their learners. Two mathematics student teachers recall their experiences with these other teachers:

> *Yes, there were comments like why the GammaTutor tool has only Mathematics, Physical Sciences and Life sciences. To them, it was like the tool prioritizes those subjects more, and other subjects are not important. Many teachers liked my class because of this GammaTutor, even my mentor wanted to buy it. I told him it was not for sale, then liked the information in it sometimes we prepared for lessons together because he wanted the information in that GammaTutor* (MST9).
>
> *Yes. They were interested in it. I even taught them how to use GammaTutor they considered a GammaTutor as the best tool. The mathematics teacher was so interested in this device in such a way that he needed it. My mentor was so impressed to the point whereby he wanted me to share the contents, unfortunately, it wasn't sharable* (MST10).

4.6. Inadequate Technical Support

All 12 participants expressed frustration with their teaching practice schools because these schools showed a lack of support when utilising the GammaTutor tool. Two participants shared the following sentiments:

> *'I received training at the university but that was all. In the practicing school where I integrated the GammaTutor tool, I struggled initially but some of my colleagues and*

some teachers assisted me with technical support when I experienced any technical glitches (MST1).

'there is a lack of technical equipment such as projectors and monitors in this school. I had to borrow from other schools. Besides, the teachers in this school do not have any expertise when it comes to technology. For that reason, I did not receive any technical support from this school (MST9)

As observed during the SBE observation, few mathematics student teachers demonstrated little knowledge of how to use the GammaTutor tool, but they were all trained on how to incorporate the tool into their classroom lessons.

5. Discussion

In this study, a technologically hybrid paradigm for teaching mathematics in rural areas called GammaTutor was used to create a novel learning environment. The goal of the study is to help pre-service teachers use the GammaTutor tool with confidence in their teaching practices to improve student performance. The results of this study revealed that the participants integrated GammaTutor into their classroom which demonstrated their competence and skills in using the technological device. The results also revealed that the GammaTutor device benefitted the teaching and learning of mathematics. This tool aided in simplifying mathematical concepts for the learners. It allowed them to develop learners' discourse which is an integral part of mathematics learning in problem-solving skills. The integration of GammaTutor in mathematics classrooms demonstrated learner-centred provisioning since the mathematics student teachers engaged the learners with different exercises. In this regard, the mathematics student teachers were able to demonstrate all aspects of TPACK in their mathematics classrooms.

This aspect of the results agrees with Chigona and Chigona (2013) and Makgati and Awolusi (2019) where the researchers suggested that pre-service teachers should integrate technology in the classroom. This will ensure quality and effective delivery of mathematics to learners. This finding also concurs with Mercado and Ibarra (2019) who found that there will be higher and better performance of the pre-service teachers with TPACK, when integrating technology in the mathematics classroom. The results also revealed the readiness of the student teachers to use the GammaTutor tool in their classrooms. Another benefit was that learners were interested in mathematics lessons when student teachers used the GammaTutor tool in their lessons. Using technology as a learning tool by pre-service teachers, according to Tondeur, Pareja Roblin, van Braak, Voogt, and Prestridge (2017) is the exercise of knowledge and abilities. In this regard, pre-service teachers have more positive approaches toward technology use, and they have been able to provide opportunities for learner-centred technology use.

According to McCulloch, Hollebrands, Lee, Harrison, and Mutlu (2018) teachers employed technology that is well-aligned with their educational goals, such as improving mathematical understanding, practicing skills and assessment. The researchers further mentioned that when it comes to technology integration in the classroom, different decisions have to be made for each lesson. When employing a specific tool for a lesson, the technology would also allow for collaboration, exploration, assessment, and communication.

6. Conclusions and Recommendations

The findings of this study demonstrated that participants were able to incorporate GammaTutor into their mathematics teaching and learning. Although some of the participants had technical difficulties when incorporating the GammaTutor into their lessons, this is a common problem when integrating technology into learning in the Eastern Cape due to the lack of ICT infrastructure. GammaTutor is a technology tool that improves mathematics and physical science teaching and learning. As a result, the teacher educator encouraged the student teachers to implement it in their classrooms. Consequently, the student teachers (participants) gained more knowledge and competence, and they were confident in using the technological tool. GammaTutor enhanced learning mathematics and encouraged a learner-centred approach which motivated the rural school learners to become interested in mathematics.

Furthermore, by incorporating technology into mathematics teaching, student teachers (participants) were able to gain a better knowledge of TPACK and its effectiveness. According to the findings, HEIs should incorporate technology into teacher education programs, with a focus on using technology to teach mathematics. Teacher educators in HEIs should encourage student teachers to include technology in their teaching practices, build competence, and be productive with it so that they can use it in the future. Since few student teachers who use GammaTutor in mathematics teaching were included in the study, it is recommended that student teachers should be involved in further research, as well as learners, to demonstrate how GammaTutor enhances learner's learning and improves their mathematical performance.

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