International Journal of Learning, Teaching and Educational Research
Vol. 21, No. 6, pp. 304-323, June 2022
https://doi.org/10.26803/ijlter.21.6.18
Received Mar 15, 2022; Revised Apr 18, 2022; Accepted May 30, 2022

Pre-Service Teachers' Perspectives towards the Use of GammaTutor in Teaching Physical Sciences in South African Secondary Schools

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Abstract. This paper reports on introducing a techno-blended model for science teaching in South African senior secondary schools. Technological Pedagogical Content Knowledge (TPACK) framework was used as a lens for the interpretation of pre-service science teachers' use of the GammaTutor tool in the classroom for collaboration and creativity. The study employed an interpretivist multi-case design that purposefully sampled ten pre-service science teachers. Data were collected through non-participatory classroom observation and interviews. Data were then analysed qualitatively using deductive approaches with a modified version of TPACK as an analytical framework. The study found that pre-service science teachers were enthusiastic about using the GammaTutor tool because they believed it engaged their learners in the teaching-learning process and facilitated the assessment of tasks. The pre-service teachers felt that the GammaTutor tool enhanced their instruction by expanding their access to teaching-learning resources and personalising instruction. Additionally, the pre-service teachers discussed their concerns, particularly in assisting underperforming learners and effectively utilizing inquiry-based instruction using the GammaTutor tool. Notwithstanding certain apparent drawbacks, the study contributes to our understanding of how the TPACK concept might be employed as a framework for analysis in a particular situation. More crucially, teaching and learning are founded on the thorough integration of technological tools in day-to-day classroom activities.

Keywords: GammaTutor tool, pre-service, science teachers, secondary schools, techno-blended tool, TPACK

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1. Introduction

Learner performance in physical sciences over the years has not been encouraging. Both the National Senior Certificate Examination (NSC) and the international Trends in Mathematics and Science Study (TIMMS) have evidence of the poor learner performance in this subject (Department of Basic Education [DBE], 2018, 2019). Studies by Danso (2020), Mosiane (2019), Ogegbo and Ramnarian (2022) and Ramnarian and Hlatswayo (2018) have identified many factors that may hinder the performance of learners. These factors include teachers' teaching styles (Orhun, 2012), gaps in teachers' content knowledge (Mosiane, 2019; Sondlo & Ramnarain, 2019), learners' learning styles (Danso, 2020), teachers' lack of competency in the use of information and communication technology for teaching and learning, values and attitudes that influence their choice of instructional strategies (Jarosievitz, 2017; Ramnarain & Hlatswayo, 2018) and learners' attitudes towards physical science (Aslan, 2017). However, the teachers' ability to translate their content knowledge into a learning experience for students to learn effectively using technology is crucial (Van Driel & Berry, 2010; Luft et al., 2015). Specifically, the teachers' professionalism (Anderson & Barnett, 2011; Reddy et al., 2012) includes teachers' subject content knowledge, teacher effectiveness, teacher competence through teacher instructional strategies and teachers' proper execution of laboratory activities (Ogegbo & Ramnarain, 2022). Therefore, the teachers' role in teaching and learning is crucial to addressing learners' poor physical sciences performance.

The use of techno-blended methodologies has been extensively reported in science education literature (Fernandes et al., 2020; Walan, 2020) as a powerful tool that articulates and portrays aspects of the implicit, inherent, effective and individualised component of teachers' professional knowledge. According to Bingimlas (2017) and Waghid and Waghid (2018), numerous studies have reported positive outcomes in education using a technological tool for teaching and learning. A cursory review of the literature indicates that technological tools in education motivate learners, improve teachers' skills and promote collaborative and creative teaching (Postholm, 2007; Baidoo et al., 2022; Gershon, 2017). Al-Balushi and Al-Hajri (2014) contend that these assist learners in visualising abstract scientific phenomena and provide them with meaningful contexts which improve their retention and academic achievements.

Chao et al. (2016), Hochberg et al. (2018), Walan (2020) and Zhang et al. (2015) agree that there are numerous studies about the integration of technological tools in science education literature; however, there have been few studies that specifically use science technological tools as a teaching resource to foster creative and collaborative teaching. In addition, few studies have reported on how science teachers, specifically pre-service teachers, used and reflected on the use of innovative software in science teaching in science classrooms when teaching is entirely techno-blended based (Santos & Castro, 2021).

Hence, this study aims to implement a techno-blended tool in the physical science classroom and further investigate how pre-service teachers reflect on their teaching when implementing an innovative technological tool in their physical sciences classrooms during teaching practice.

The following research questions guided the study:

1. How do pre-service science teachers reflect on the use of GammaTutor in the physical sciences classroom during teaching practice?
2. What are the challenges experienced by pre-service teachers when using GammaTutor in the physical sciences classroom during teaching practice?

2. Literature studies

2.1 The use of a technological tool in teaching and learning

There has been considerable debate in education regarding integrating technological tools into daily practice. The necessity of employing technological tools in teaching and learning has been widely publicised (Koopman et al., 2020; Santos & Castro, 2021; Walan, 2020). According to Goldin and Katz (2018), technological tools enable learners to work at an appropriate level for their learning needs and cooperate more efficiently. Goldin and Katz (2018) further assert that learners become empowered in a technological environment because they are isolated from teachers and less fearful of social interaction. This implies that technological tools are helpful in the teaching-learning process because they enable learners to organise information into distinct cognitive structures. As Abboud and Rogalski (2017) mentioned, technological tools directly influence learners' attention, motivation, autonomy, and academic achievement. However, other studies show that using technological tools in education does not continuously improve teaching and learning processes (Cope & Kalantzis, 2009; Pineida, 2011). Nevertheless, technology can positively impact the teaching and learning process if used appropriately. Finger et al. (2013) and Sweeney and Drummond (2012) state that it is necessary to consider teachers' pedagogies, knowledge, and beliefs in instruction when examining the integration of technology in the classroom.

2.2 Preparation of pre-service science teachers for technology-enhanced instruction

Pre-service teachers' preparation for classroom technology use has long been a priority of teacher education institutions in several countries (Agyei & Voogt, 2011; Robinson & Aronica, 2015). In South Africa, the Higher Education White Paper 3 (1997), the National Plan, the National Research and Development Strategy (2002), and the Foresight ICT report (1999) emphasise the importance of information and technologies (ICTs) for education, particularly for teaching and learning. These documents relate the need for ICT-related graduate competencies to economic change in an information economy. However, there is a lack of coordination regarding ICTs in higher education across relevant policy papers, which leaves the door open for critical issues to be disregarded while other relevant issues are prioritised (Czernjewicz et al., 2004).

Despite this, research shows that technology receives scant emphasis in teacher education programmes, either as a tool for secondary education or support for pedagogy in teacher education programmes (Chien et al., 2012). Bekele (2021) states that there has been a rise in technology integration in higher education due to the Covid-19 pandemic. Recent demands indicate that to enhance pre-service teachers' knowledge of technology integration effectively, teacher education programmes must assist them in connecting their knowledge of technology, pedagogy, and content (Sun et al., 2017). Koehler and Mishra (2009) suggest that teachers must be competent in all three domains of knowledge to be able to incorporate technology effectively. However, more significantly, they must integrate technological, pedagogical, and content knowledge to enhance classroom instructions. While pre-service teachers in some South African institutions appear to have adequate technological abilities acquired through their first-year university modules and personal lives, they demonstrate minimal access to computers and occasionally ineffective use of technology in the classroom (Jerrim, 2018). The reason was that their expertise was limited to the operation of technology rather than integrating these technologies into the science classroom instructions. Santos and Castro (2021) argue that there is a critical need for equipping pre-service teachers to be able to integrate technology within a pedagogical context and in accordance with the subject they teach. Moreover, research (Walan, 2020) has demonstrated the value of collaborative teaching techniques to increase classroom instruction by teachers who utilise technological tools to encourage active and collaborative learning.

2.3 The GammaTutor Tool

The GammaTutor device was developed by the Govan Mbeki Mathematics Development Centre (GMMDC) at Nelson Mandela University in Eastern Cape Province, South Africa. It comes pre-installed with customised software that includes the complete TouchTutor® Mathematics and Sciences interactive digital package for learner support (Grades 8-12) (see: https://mbeki-maths-dev.mandela.ac.za). It is introduced as an educational project using the GammaTutor software package that runs on the Gamma Android teaching and learning device, a plug-and-play pocket-sized gadget. It is a complete mathematics and science teaching and learning centre that may be connected to a data projector, television, or screen. The GammaTutor can help teachers, learners, and homeschoolers alike. It contains the entire South African mathematics and science curricula presented in animated PowerPoint presentations, videos, and tutorials. Moreover, it does not require a connection to the Internet. Aimed at non-native English speakers in the country, it provides a wide range of support services for both teachers and learners (Engineering News, 2020). This research is based on pre-service teachers' comments on the GammaTutor training program and how they used the device in the classroom, as well as observations of pre-service teachers' teaching methods during school-based experiences (SBEs).

3. Theoretical Framework

3.1 Technological Pedagogical Content Knowledge (TPACK)

This study is situated within the broad field of the Technological Pedagogical Content Knowledge model of TPACK by Valtonen et al. (2017). This model (TPACK-21) focuses on presenting a validated instrument for measuring pre-service teachers' TPACK based pedagogically on twenty-first-century skills, as Voogt and McKenney (2017) mentioned in their work. TPACK is a theoretical framework for documenting and studying teachers' professional knowledge. According to Koehler et al. (2013), TPACK consists of three components, namely content, pedagogy, and technology, and is the core of effective teaching. The

TPACK framework is based on Shulman's (1986) framework for pedagogical content knowledge (PCK). PCK refers to the body of knowledge required for teaching, which requires a combination of content and pedagogical skills, as described below (Shulman, 1987):

- Content knowledge (CK): This relates to understanding the central theories and concepts of the concepts being taught. In addition, CK demands a comprehension of the nature of the knowledge and the means through which it is acquired in the field (e.g., physical sciences).
- Pedagogical knowledge (PK): This refers to a comprehension of learning processes and the ability to exert control over those processes and direct the learning environment. PK is a generalised form of information concerning cognitive, social, and developmental learning theories.

Technical pedagogical content knowledge (TPACK) adds a technological layer to the pedagogical content knowledge (PCK) framework. TPACK denotes knowledge of ICT applications suitable for use in teaching in terms of pedagogy and content (Koehler et al., 2013). Koehler et al. (2013) describe the following as components of TPACK:

- Technological knowledge (TK): This refers to an understanding of the capabilities and limitations of technology and the abilities necessary to utilise technology effectively. Knowledge of technology also implies an interest in tracking the progression of emerging technology.
- Technological content knowledge (TCK): This relates to an understanding of the relationship between content and technology and how content and technology impact and constrain one another. TCK refers to understanding the technologies utilised within the content field (e.g., physical sciences).
- Technological pedagogical knowledge (TPK): This is an understanding of the nature of teaching and learning using technology in the classroom. It comprises utilising technology and gaining knowledge of the advantages and downsides of various technologies for specific pedagogical practises.

Based on these elements, the TPACK framework describes the seven areas of teacher knowledge that serve as the core of effective teaching (Koehler et al., 2013). According to Dietrich (2018, p. 9), "TPACK refers to the knowledge and competencies at work within the complex teaching profession, examined through the lens of the Technological, Pedagogical and Content Knowledge infrastructure". In other words, TPACK is a theory developed to explain the set of knowledge that teachers need to teach their learners effectively and use technology (McGraw-Hill, 2019).

Hence, in this study, the TPACK framework is used as an analytical tool to explore how pre-service teachers reflect on their teaching in authentic physical science lessons with the GammaTutor tool in senior secondary schools during the school-based experience (SBE).

4. Methodology

This study originated from a research project undertaken by the Mathematics Education and Research Centre (MERC) team in a rural higher education institution (HEI) in the Eastern Cape. This paper reports GammaTutor as an emerging technological tool for teaching and learning physical sciences. The study is situated within the interpretivist paradigm and employs a multi-case qualitative research design (Yin, 2018) to determine the behaviours, interpretations of situations, and viewpoints on specific subjects as well as exploring the use and integration of technology (GammaTutor) tools in physical sciences classroom instruction.

4.1 Sample

Purposeful sampling was used to select ten pre-service teachers majoring in physical sciences and mathematics who have an in-depth knowledge of the GammaTutor tool (Kumar, 2019). The pre-service science teachers were in the undergraduate programme in physical science education at a rural South African HEI. These pre-service teachers entered the four-year Bachelor of Education (BEd) programme to become physical science teachers in secondary schools across South Africa.

4.2 Study instruments

Data were collected using in-depth semi-structured interviews and classroom observation schedules documented with field notes to describe all relevant aspects of the use of GammaTutor in the physical science classroom. This enabled the authors to participate in an engaging discourse with the participants. Eleven open-ended items with probes constituted the interview questions. The questions were developed following a review of related literature and were validated by experts. The open-ended questions allowed the participants to share additional information from their perspectives within the context of the study.

A twelve-section observation guide (schedule) was created from the model of TPACK (Valtonen et al., 2017) to collect data. The observation schedule was prepared using the TPACK construct.

4.3 Data collection procedures

Ten pre-service physical science teachers on SBEs (teaching practice) participated in the study. Each participant was observed twice during the study for five weeks during SBE. A pre-observation interview was held before the actual classroom observations, and the participants were instructed on constructing a lesson plan and teaching in the classroom. The purpose of the pre-observation interview was to orient the pre-service teachers and determine their degree of comprehension regarding integrating technology (GammaTutor) in the classroom. Classroom interactions, pre-service teacher activities, and learner behaviours, including using technology (GammaTutor) in the classroom, were documented as field notes.

Semi-structured interviews were also conducted with the participants after the classroom observation. The one-on-one interviews lasted approximately 45 minutes. Intermingling, questioning, probing, listening, writing and audio recording data were used to engage participants (Kivunja & Kuyini, 2017).

Data triangulation was performed using two data sources to establish a complete understanding of the phenomena. All instruments for data collection were piloted. This helped clarify the research concept and improved the observation schedules and techniques. The use of semi-structured approaches improved the validity of the content, as participants were unrestricted in their discussion of concerns and constraints. Validity was ensured by gathering data from ten pre-service teachers in ten different schools and using the same tool. All transcribed interview data were returned to participants for member checking.

The study was authorised by the Walter Sisulu University Human Research Ethics Committee (Ethical Clearance Number: FEDSRECC001-06-21). As a result, all participants signed a written informed consent form, which included permission to capture audio data during the research procedure. To establish the participants' trust, issues of anonymity and confidentiality were addressed.

4.4 Data analysis

All transcripts were captured and coded manually. The transcribed interviews and classroom observation data were deductively analysed. The data were read and reread to understand the data and establish a coding scheme in an Excel spreadsheet. To track general classroom interactions, engagement, and interventions, the coding scheme was established using a priori codes (Johnson & Christensen, 2019). The components and codes for TPACK are listed in Table 1:

Table 1: TPACK components and codes

TPACK components	Codes
TPACK	Pre-service science teacher's knowledge of GammaTutor
PK	How the pre-service teacher handles the lesson
TCK	Overall classroom interactions/engagement and intervention
TK	Challenges of using GammaTutor
TPK	The description of how student teachers mediate learning with GammaTutor

5. Results

5.1 Pre-service teachers' use of GammaTutor in the physical science classrooms

The demographic characteristics of the pre-service science teachers (PSSTs) are presented below (n=10):

Table 2: Demographic characteristics of pre-service science teachers

Subjects	Gender	Age	Grades Taught	No of Learners in Class
PSST 1	male	22	10	20
PSST 2	female	22	11	50
PSST 3	male	21	10/11	41
PSST 4	male	31	10/11	50
PSST 5	male	22	10	41
PSST 6	male	27	10	54
PSST 7	female	21	10/11	44
PSST 8	female	22	10	65
PSST 9	female	24	10	59
PSST 10	female	22	10/11	46

Table 2 reveals that, of the 10 pre-service physical sciences teachers who participated in the study, 50% were males and 50% were females. All these pre-service teachers taught Physical Sciences with the GammaTutor tool.

It was observed that the pre-service science teachers used the GammaTutor tool daily in their classrooms. In addition, participants gave clear instructions during lessons and promoted interaction with learners in the classroom. One pre-service teacher narrated as follows:

> *"I was trained to teach Physical Sciences with a special tool known as the GammaTutor device and I use it every day in my physical sciences classroom instructions. This tool enhances my interaction with my students and engages them actively in the lesson"* (PSST 2).

The pre-service physical science teachers received training on GammaTutor tool integration in their classroom instructions before they embarked on the SBE. As a result, these pre-service science teachers were motivated to use the tool in their respective classrooms for assessment purposes. This finding is in line with the finding of a study conducted by Pima (2019), namely that teachers in high schools are ready to use ICT in teaching and learning.

It was observed that the pre-service teachers used the GammaTutor tool to facilitate their instructions, ensuring that their learners understood the concepts taught in the classrooms. Thus, the GammaTutor is mainly used for content delivery and assessment. This supports the reasons for using a technological tool given by Lim and Hang (2003), who found that science teachers use technological tools for curriculum and assessment, as learning resources, for teachers' development, and as physical and technological infrastructure. In

South African classrooms, the pre-service teachers also used the GammaTutor tool for assessment purposes. One pre-service teacher commented as follows:

> *"Using the GammaTutor for assessment motivates learners to set their own goals and evaluate their work. One thing that is so fascinating about the assessment resources is that every question given has procedures to solve the question. In addition, there are so many different forms of assessments that you can give your learners. For example, there are higher-order questions and low order questions."* (PSST 1).

This means learners were exposed to a variety of assessment strategies which presented them with different kinds of information to build their confidence in the challenging concepts.

The outcome in the TPACK model is required for pre-service teachers to operate the GammaTutor tool with confidence to engage learners collaboratively (Santo & Castro, 2021). Evidence from the classroom observations established that the participants were technologically competent (TK). They never struggled with controlling the projectors and the whiteboards they used to project their lessons during the teaching and learning of physical sciences to promote collaboration and creativity. According to Ghavifekr and Rosdy (2015), one of the most critical variables in technology-based teaching and learning effectiveness is teachers' being well-equipped with ICT tools and facilities. They frequently augmented the technology (GammaTutor) tool with additional resources and practical exercises to aid in acquiring a particular content (TCK).

A mix of presentations, individual and group work, group discussions, and practical questions were part of the classroom instructions. The authors observed that the participants engaged their learners in various tasks to increase learner retention and achievement in the subject. As a result, learners were offered the opportunity to work with tasks of varying difficulty. They appeared to be inspired to seek out answers about the content relating to the tasks, thereby accelerating learners' learning in physical science.

5.2 Pre-service teachers' perspectives on their reflections on the use of GammaTutor in the physical science classroom

5.2.1 Perspective on technological knowledge

Several sub-themes arose from this perspective, including attitudes toward technology and the time it takes to learn and prepare lessons. All pre-service teachers said they possessed a high degree of technological understanding and were enthusiastic about their classroom instructions, including the use of the GammaTutor tool. Hence, they had no difficulty navigating the GammaTutor's technical capabilities. Two pre-service teachers narrated as follows:

> *"I am familiar with and proficient in the use of this interactive technology. I have no difficulty operating this equipment"* (PSST7).

> *"I received training on how to utilise the GammaTutor tool in my classroom instructions, and I must say that teaching with this technology is much more fun. It alleviates the stress associated with*

lesson preparations and notes written on the chalkboard during the teaching-learning process." (PSST5).

A few participants mentioned initial technological difficulties; however, these were solved within a few minutes of the start of the first lessons. This sentiment is shared by one pre-service teacher who said:

> *"I initially encountered some technical difficulties, possibly because I could not return to the main application after opening it and navigating through the other lessons"* (PSST2).

The participants knew that navigating the resources and searching for other items to augment the planned lesson take time. One pre-service teacher had this to say:

> *"While it takes time to navigate the GammaTutor tool, it is still helpful to have all resources handy, and while preparations with additional resources take time, I save a lot of my time when I have all those resources I will be using in my classroom for my lesson"* (PSST10).

When asked whether the use of the GammaTutor tool necessitates more preparation by participants prior to entering the classroom, one pre-service teacher shared this sentiment:

> *"Indeed. I needed more preparation before entering the classroom. Sometimes, I practise the entire lesson in my room…just you know. to be sure of myself…hahaha…if I would be able to deliver my lesson. I even practise solving all the learner practice activities to ensure that I do not miss anything"* (PSST3).

5.2.2 Perspectives toward technological pedagogical knowledge

When data were triangulated, two sub-themes arose, namely available time and the social milieu of the classroom. The pre-service teachers asserted a high level of technical and pedagogical knowledge and were critical of their use in classroom instruction. It was observed that all learners were active and involved in the teaching-learning process since using the GammaTutor tool supported a particular pedagogical principle. However, evidence from the classroom observations shows that little time was available to the pre-service teachers to assist each learner in the classroom. One participant corroborated this:

> *"The GammaTutor assisted me a lot in my instructions. Indeed, most of my learners love this teaching method, especially when simulation videos assist them in understanding a particular concept which often seems too abstract to grasp"* (PSST10).

When the participants discussed the consequences of the social milieu in the classroom, one pre-service teacher had this to say:

> *"Most often, I put learners into mix-ability groups so that they could interact with each other as they share ideas and thoughts. However, I do not do much group works. Still, I was considering the possibility of making learners work alone sometimes. I fear that if I let my learners work alone, there will be fewer social interactions"* (PSST2).

5.2.3 Perspective on technological content knowledge

The authors observed this perspective in the classrooms and during the interviews. The GammaTutor tool was beneficial for both participants' instruction and learner comprehension of the physical science content given by pre-service teachers during the study. The GammaTutor tool's planned exercise was sufficient to engage learners in inquiry-based problem-solving activities as described in the Curriculum and Assessment Policies Statement (CAPS) guidelines for physical sciences. Two pre-service science teachers contended as follows:

> *"GammaTutor is my everything. To be precise, all the information on the GammaTutor tool is very detailed and covers the content of the CAPS curriculum. All the practice activities are aligned with the examination guidelines and the content"* (PSST2).
>
> *"The GammaTutor's study material is quite fully packed…My learners are always engaged in the projected activities, making my work as a teacher quite easy. This assists me in reflecting on my lesson and knowing how individual learners are progressing"* (PSST1).

5.2.4 Perspectives toward pedagogical knowledge

The authors observed pre-service teachers as they taught lessons, incorporated instructional strategies, and managed their classrooms. Evidence from the lesson observations indicates that participants possess a high level of expertise in guiding learners' discussion in classroom activities. Most of the participants observed showed an in-depth knowledge of using differentiated instruction in their classroom. Additionally, it was observed that pre-service teachers assisted learners in developing their problem-solving aptitudes and motivated them regarding steps to take in approaching a problem in physical sciences. This indicates that pre-service teachers have a firm grasp of fostering learners' problem-solving abilities through their classroom instruction, which is widely recognised as a crucial component of pre-service teachers' pedagogical knowledge development.

To capture learners' interest in the teaching-learning process, the pre-service teachers varied their teaching strategies and activities, making their lessons more learner-centred as they managed their classrooms.

5.2.5 Perspectives toward technological pedagogical content knowledge

The sub-themes under this perspective are pre-service teachers' preparation prior to lessons, learners' comprehension, and learners' assessment. This point of view was also emphasised in the interviews. Concerning the pre-service teachers' preparation for teaching before going to deliver each lesson, two pre-service teachers reported as follows:

> *"My lesson plans are often completed prior to the actual lessons with my learners. I make certain that I have all the materials necessary for the lesson. I prepare additional notes as my lesson summary which I provide [sic] the learners during the lesson. I practise my lesson notes with the*

GammaTutor tool and go over all the activities before going to my class" (PSST8).

"I devote much of my time to planning well before my lesson. I ensure that everything needed during my lesson is included in the preparation book ahead of my lesson" (PSST6).

In response to the issue of whether GammaTutor improves learners' comprehension of content, pre-service teachers stated that the tool increased learners' creativity in the teaching-learning process, connected learners' conceptions to the topic, and helped them rejuvenate their attitude. One pre-service teacher narrated as follows:

"I begin my lesson by recapping the previous lesson, creating links between learners' previous knowledge and real-world experiences, and inviting them to share their views during the teaching-learning process and how it relates to the content" (PSST 3).

The authors observed that learners often responded admirably throughout the teaching-learning process and their responses were quite creative.

Regarding whether GammaTutor supports the assessment of learner knowledge, pre-service teachers expressed optimism about how the integration of the GammaTutor tool supported the assessment of learner knowledge of the content. One pre-service teacher had this to say:

"Assessments are so much easier to manage now that I am not required to sit down and create questions for learners to practice with. Each concept I teach in the classroom has its own set of prepared activities that encourage learners' creativity and teamwork. Additionally, learners receive feedback much more quickly. Just a flip into the next slide…and there we are... solutions to all the activities" (PSST2).

The authors' views were shared by some participants. Indeed, the integration of GammaTutor in classroom instruction was unquestionably beneficial to both the pre-service teachers and the learners at large.

5.3 Challenges experienced by pre-service teachers when using GammaTutor in the physical sciences classroom

This research question sought to ascertain the difficulties faced by pre-service physical science teachers when implementing the GammaTutor tool in physical sciences classrooms. The pre-service teachers acknowledged that they initially encountered difficulties with the tool, while the challenges stem from school-level and classroom-level challenges.

5.3.1 Challenges at the school level

Some of the challenges experienced at the school level included limited access to projectors and computer monitors. One school had only one data projector placed in the laboratory. This laboratory is used as a classroom under the same arrangement. As a result, pre-service teachers needed to negotiate with other teachers before using the data projector. One pre-service teacher complained:

"Even though I now possess this GammaTutor tool, I must still negotiate with other teachers to teach using this technology. This is

because my school only has one data projector placed in the laboratory. Also, the laboratory serves as a classroom. I am continually negotiating with other teachers to relocate their classes to my classroom so that I can bring my learners to the laboratory for my lesson" (PSST 8).

Similarly, pre-service teachers' reflections highlighted that some pre-service teachers had to borrow data projectors or computer monitors from another school to enable them to use the GammaTutor tool in their classroom pedagogies.

Support constraints were another challenge that surfaced from the field notes and interviews. The pre-service teachers commented that during the early stages of the commencement of SBE, they needed technical support simply to use the GammaTutor tool, which might have been avoided had educational institutions provided technology and information technology experts. One pre-service teacher expressed regret:

"Occasionally, I wanted to flip back to the previous slide in the classroom, or I needed to close the screen and proceed to the slide…" labelled activities... However, navigating to other activities becomes difficult, and this alone waste my time since... occasionally, I grab my phone from the staffroom and call a peer from another school to assist me in navigating to the content I desire" (PSST 2).

Another challenge identified in the field notes was an intermittent electrical power supply. The pre-service teachers expressed regret that they sometimes prepared thoroughly for their lessons only to discover that there was no electricity available, forcing them to revert to traditional teaching methods. The following is the comment expressed by one pre-service teacher:

"… Due to power interruptions, I was unable to utilise my GammaTutor tool for three consecutive periods. When I organised my lesson on Tuesday, I was able to acquire all the additional resources I needed. I entered the classroom for my lesson and immediately noticed that the electricity had gone out...I was very disappointed" (PSST 10).

5.3.2 Challenges at the classroom level

The challenges included time and large class sizes at the classroom level. Similar constraints were also reflected in the field notes derived from observations. It was revealed that pre-service teachers were not time conscious in ensuring that their lessons were completed within a given period. One pre-service teacher lamented:

"I actually do not have enough time in the day for me to complete my lesson… My lesson is not well-planned. There is always the possibility that my lesson will extend into the following period. Teachers are constantly at the entrance of my classroom, waiting for me to leave so they can conduct their own lessons" (PSST 7).

Another pre-service teacher, on the other hand, believed that the activities undertaken by the learners were time-consuming. He recounted:

"It takes time to prepare assessment activities and worksheets for learners to complete in class. I'll need to schedule additional time for the learners to finish these activities" (PSST 9).

This means that pre-service science teachers required additional time to create handouts, print assessment activities, mark learners' exercises and provide feedback to learners.

A further challenge encountered by pre-service teachers was the huge class sizes in most practising schools. Pre-service teachers claimed that too many learners in their classrooms made it impossible for them to provide equal opportunity to all learners, perform learner activities, and provide timely feedback on learners' assessments. In other words, they were unable to provide feedback on some assessments since it took an excessive amount of time to complete the marking before they could provide feedback to the learners.

One pre-service teacher had this to say:

"It's quite tough for me to provide timely feedback and comments on my learners' assessments. My time is completely consumed by marking of learner's activities which often take more than the one hour allocated to me" (PSST 3).

The outcome of this study indicates that large class sizes have a detrimental influence on the effectiveness of physical science instruction. This is consistent with Commeyras's (2000) study which revealed that successful teaching appears impractical for teachers with large class sizes.

6. Discussion

This research study aimed to determine how pre-service physical science teachers use technology in the classroom. The observation and semi-structured interview showed that the pre-service teachers had a good level of technological knowledge, and they were excited about using the GammaTutor technological tool in the classroom lessons. The results also demonstrated that pre-service teachers had a high degree of technical and pedagogical understanding and were critical users of the technological tool (Gamm Tutor) in the classroom. In addition, the GammaTutor tool's information is extensive and covers the entire CAPS curriculum. Therefore, the GammaTutor tool was found to be helpful for both participant instruction and learner comprehension of the science topics presented by pre-service teachers (Engineering News, 2020). These results encourage and develop the pre-service teachers' TPACK to integrate technology such as GammaTutor in their classroom.

This finding aligns with Martin's (2018) conclusion that endless possibilities for technology integration in teacher preparation programmes could improve, hence increasing the chances of successful technology integration in teacher education settings. Therefore, Thompson and Mishra (2007) posited that in order to be a superior teacher, every teacher should have a strong command of technology knowledge, pedagogical knowledge, content knowledge, technological pedagogical knowledge, technological content knowledge, pedagogical content knowledge, and technological pedagogical content knowledge. According to Joo et al. (2018), TPACK indirectly influenced teachers' intentions to use technology since high-TPACK teachers spent more time dealing with learners' unexpected behaviour than performing an anticipated role in a technology-integrated class. Furthermore, for teachers to integrate continuous technology teaching, teacher educators must look into strategies to support and model the use of technology in the classroom for pre-service teachers. This will aid teacher educators in assisting our country's teachers in moving beyond familiarity with and utilisation of technology into full integration of technology into classrooms so that 21st-century learners can benefit from the full impact of current technologies (Smith & Greene, 2013).

The findings also indicated that pre-service teachers encountered difficulties in using technology (GammaTutor) in the physical sciences classroom. The survey showed that projectors, whiteboards (or smart boards), and computer displays are in short supply. There is inadequate technical assistance and peer support, poor electricity supply, and large class sizes. Furthermore, according to Joshi (2017), technical factors are one of the elements that affect ICT (GammaTutor) integration in teaching and learning. The researcher went on to say that constructivist teaching and learning beliefs have a considerable beneficial impact on class computer use.

In contrast, traditional views have a detrimental impact on integrated classroom computer use. In their study, Smith and Greene (2013) found that pre-service teachers did not have access to the appropriate ICT tools. Dalal et al. (2017) learnt that teachers are concerned about Internet access issues, insufficient technology resources such as laptops and projectors, and weak network signals. However, teachers' ICT skill development has a favourable impact on ICT tools (GammaTutor) integration in teaching and learning (Joshi, 2017). According to Thompson and Mishra (2007), teachers' experience, pedagogical and technological knowledge, pedagogical beliefs, access to resources, institutional support, institutional culture, curriculum and assessment requirements, perceived abilities, motivation, and behaviours of students, preservice education programme, practicum, and professional development of teachers all influence how useful the ICT tool (GammaTutor) is when used in teaching.

7. Conclusion

The TPACK of pre-service teachers in physical science has been influenced by the inclusion of GammaTutor in their teaching. The findings demonstrated that pre-service teachers' use of the GammaTutor device in the classroom was associated with learners' content comprehension (TPACK). This indicated that the pre-service teachers could successfully implement the teaching strategies and manage the classroom (PK). Incorporating GammaTutor also signifies interactive technology and engagement to help learners understand physical science concepts (TCK). Furthermore, the integration of the GammaTutor tool in science teaching (TK) mediates learning and supports specific pedagogy for a specific situation in the science classroom (TPK). Pre-service teachers can obtain fresh insights into planning and organising, pedagogical strategies, content delivery, content knowledge, and classroom management by incorporating GammaTutor into physical science classes. Moreover, pre-service teachers were inspired to learn more about using various applications and new teaching strategies in technology-integrated classes because of their use of GammaTutor.

Therefore, this study recommends that incorporating technology into classroom practices will allow pre-service teachers to address the learners' needs effectively, increase learners learning, better prepare learners for future studies in science-related fields and further prepare learners for digital society in their future practices.

8. Implications of the study

The findings have implications for both student teachers and teacher educators in HEIs. Both should be able to integrate technology into their classroom teaching. In-depth research should be carried out with a more significant number of student teachers since teaching and learning science with technology is rapidly gaining attention.

9. Limitation of the study

The findings from this study are not generalisable owing to the limited number of physical science student teachers who participated in this study. The study was conducted in a rural province, which might have contributed to some of the difficulties the pre-service teachers encountered while using technology (GammaTutor) in the physical sciences classroom.

Acknowledgement

GammaTutor™ is an innovative, recently introduced mobile presentation system for education. It consists of a mini-PC device called Gamma and accompanying mathematics and science software developed by the Govan Mbeki Mathematics Development Centre (GMMDC), Nelson Mandela University, Eastern Cape, South Africa. The research team in the Mathematics Education and Research Centre gratefully acknowledges the innovative GammaTutor device developed by the GMMDC. More research is being carried out and it is also acknowledged that the collaborative partners are publishing articles based on the device. In addition, the generous funding from the Walter Sisulu University is gratefully acknowledged for the purchase of the GammaTutor devices.

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