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Exploring the influence of the PGCE Life Sciences program on the preparation of pre-service teachers for their TPACK at a South African University.

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A research report submitted in partial fulfilment of the requirement for MEd

School of Education
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2025

DECLARATION

As Vincent Mhlongo (student No. 817832), I declare that this Master's Research Report is fully my own original work. Every single instance in which other people's work was used, it was correctly cited and referenced. It is being submitted to the University of the Witwatersrand in Johannesburg for completion toward a Master of Education degree by coursework and research report. It has never before been submitted to another university for any degree or examination.



Signature of researcher

PROTOCOL NUMBER:**2024ECE030M**

16- March-2025

ETHICAL STATEMENT

The author, whose name appears on the title page of this thesis, has obtained, for the research described in this work, the applicable research ethical approval.

The author declares that he has observed the ethical standard required in terms of the University of the Witwatersrand code of ethics for researchers and the policy guidelines for responsible research.

DEDICATION

I dedicate this Research Report to God, who is my source of Strength through it all. I also dedicate this to my late mom; Lucia Mhlongo who set an example for having a mindset of persistence. Finally, I also dedicate this work to my beautiful family; my lovely wife, Lihle and my amazing son, Vince for their great support and understanding since the beginning of this research journey. Thank You.

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ABSTRACT

Teacher education is vital in equipping and preparing pre-service teachers, with the necessary skills to teach effectively. A key part of this preparation is the development of Technological Pedagogical and Content Knowledge (TPACK). Pre-service science teachers are considered TPACK-prepared if they can successfully link the three core knowledge components - pedagogy, content, and technology - in their instructional designs. However, the PGCE teacher education program is completed in a single year, this is a problem as preservice teachers enrolled at the PGCE program do not necessarily have adequate exposure and sufficient time to be well prepared to link their content knowledge with their pedagogical and technological knowledge so that they effectively integrate technology in their science classroom. Anchored in the TPACK framework (Mishra & Koehler, 2006) and the Synthesis of Qualitative Data (SQD) model (Tondeur et al., 2012), this study explored the influence of the Life Sciences PGCE teacher program on ensuring that its preservice teachers are prepared to teach in terms of their TPACK. The study took a qualitative research approach and the data was collected using semi-structured interviews, lesson observations and document analysis of 5 sampled Life Sciences PGCE preservice teachers and 2 PGCE lecturers at a South African University. Analysis of the qualitative data followed a thematic method, which included selecting and assigning codes and recuring themes. The findings of this study revealed that the PGCE Life Science program has intervened through microteaching, minilesson, and Teaching Experience (TE) and other strategies to ensure the preservice teachers are thoroughly prepared for future teaching practice in terms of their TPACK readiness. Secondly findings indicated that limited time, minimal exposure to digital training during the program, lack of mentorship during TE and infrastructural challenges as some of the difficulties in the program. The study recommends that to better prepare future teachers, PGCE programs must strengthen digital training, promote interactive teaching strategies, and provide structured mentorship during Teaching Experience. The preservice teachers also recommended that the program duration should be extended, the 1-year is not adequate. The study highlighted the need for curriculum reforms that embed subject-specific digital pedagogy and mentorship. Future research should explore longitudinal TPACK growth and scalable support models in teacher education.

KEYWORDS: ***Life Sciences PGCE, Preservice teachers, Science Teacher Education, TPACK***

LIST OF ABBREVIATIONS

Abbreviation	In full
BEd	Bachelor of Education
BSc	Bachelor of Science
CK	Content Knowledge
CTML	Cognitive Theory of Multimedia Learning
ICT	Information & Communication Technology
PCK	Pedagogical Content Knowledge
PGCE	Postgraduate Certificate in Education
PK	Pedagogical Knowledge
PSTs	Preservice Teachers
TE	Teaching Eperience
TEI	Teacher Education Institution
TK	Technological Knowledge
TPACK	Technological Pedagogical and Content Knowledge
TSPCK	Topic-Specific Pedagogical Content Knowledge
SQD	Synthesis of Qualitative Data

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Chapter 1: Introduction to the Study

1.1. Background

Recent decades have been characterized by accelerated technological utilization, and educational landscapes have undergone significant changes as schools progressively adopt a wide variety of technological tools to enhance teaching and learning processes. As the education system continues to evolve in the digital age, there is a growing demand for teachers who can effectively integrate Information and Communication Technologies (ICTs) into their classrooms. Teacher education plays a crucial role in preparing pre-service teachers to effectively teach various subjects, including Life Sciences. One essential aspect of their preparation is the development of Technological Pedagogical and Content Knowledge (TPACK). TPACK refers to the knowledge and skills that teachers need to integrate technology into their pedagogy to enhance student learning (Voogt & McKenney, 2017). The TPACK framework serves as a valuable tool for assessing teachers' competencies in terms of pedagogy, subject content, and technology use in instruction (Lachner et al., 2021). Empowering teachers for effective technology integration do not imply that they must be familiar with the TPACK framework itself, but rather that they must understand how to construct instructional methods that incorporate technological, conceptual, and pedagogical knowledge.

Extensive research has examined how science educators worldwide incorporate technology into their lesson planning. Yeh, Chan, and Hsu (2021) stated that the concept of TPACK encourages teacher educators to go beyond simply teaching how to use technology and instead improve teachers' capacity to incorporate technology into the teaching of specific subject matter. Voogt and McKenney (2017) and Lachner et al. (2021) added that simply knowing how to operate technological tools is insufficient; rather, the focus should be on leveraging these tools to facilitate meaningful and authentic learning experiences. The training of pre-service teachers plays a fundamental role in teacher education, as it establishes the groundwork for their future instructional practices. A key component of this training is the cultivation of TPACK, which involves the effective integration of technology, pedagogy, and subject matter in teaching (Mhakure & Mushaikwa, 2014; Masry & Alzaanin, 2021; Wilson et al., 2019).

Specific strategies and tools that pre-service teachers use to successfully incorporate technology into their pedagogy is essential to developing a better understanding of how teacher education influence Life Sciences pre-service teachers' preparation for TPACK at the Postgraduate Certificate in Education (PGCE) level (Baran et al., 2017). The PGCE program is a one-year qualification designed for graduates seeking to enter the teaching profession. It is structured to provide foundational knowledge in pedagogy and subject content while introducing pre-service teachers to the technological skills required for

effective teaching. Unlike the Bachelor of Education (B.Ed.) degree, which spans several years and allows for gradual skill acquisition, the PGCE's accelerated structure necessitates a more intensive approach to skill-building. In the B.Ed. teacher education program, all first-year pre-service teachers are required to take a computer literacy module, which is designed to equip them with the essential skills, knowledge, and attitudes needed to effectively engage with technology. This module is a compulsory component of the B.Ed. curriculum, ensuring that all students develop a foundational understanding of digital tools. However, the PGCE teacher education program does not offer a similar mandatory course on technology integration.

The emergence of COVID-19 saw a large scale of teacher education institutions shift from their old traditional or face to face teaching and learning approach, towards an asynchronous approach. Since then, most institutions in South Africa have revisited the notion of long distance and online teaching and learning, which have been witnessed in several universities during and after the pandemic. The use of Learning Management systems such as Ulwazi by Wits, Big Blue Button and Microsoft Teams for attending classes. Students are expected to at least have a brief experience or knowledge of using technology to gain access to those online spaces of learning. According to other research, there must be a link between what students learn during their teacher training and their use of use of technology in teaching practice, therefore all preservice teachers need to be adequately exposed to sufficient authentic ICT integration learning experiences in the teacher education programs (Tondeur et al., 2016). Understanding how the PGCE Life Sciences program at a South African university influences the development of pre-service teachers' TPACK is essential for enhancing teacher preparation programs and informing policies within the Department of Education.

Despite the PGCE's importance, its condensed format poses challenges to the comprehensive development of TPACK competencies. This disparity raises critical questions about the program's efficacy in equipping Life Sciences pre-service teachers with the TPACK readiness required to thrive in contemporary classrooms (Mishra & Koehler, 2006). For Life Sciences educators, this preparation is particularly significant given the subject's reliance on visual aids, simulations, and interactive resources to convey complex biological concepts. However, limited research has explored the extent to which teacher education programs—particularly the PGCE—prepare Life Sciences pre-service teachers for TPACK in South African classrooms. Many Life Sciences educators in the country struggle to integrate technology effectively, highlighting the challenges posed by the demands of digital-era teaching (Kavai & Nyamupangedengu, 2021). Given the increasing importance of technology in Life Sciences education, this study seeks to examine the extent to which the PGCE program prepares pre-service teachers for TPACK and supports their readiness for technology-enhanced classroom practices.

1.2. Problem Statement

Science pre-service teachers face the challenge of being adequately prepared to integrate technology into their classrooms (Jita, 2016; Tiba & Condy, 2021; Kavai & Nyamupangedengu, 2021). This highlights the necessity of developing sufficient TPACK competencies, as effective technology integration depends on the ability to align technological tools with pedagogy and content knowledge (Tunjera & Chigona, 2020). The PGCE program in South Africa is extremely important in preparing preservice teachers to become graduate teachers in professional teaching. However, drawing from personal experience as a former PGCE student, the program can be described as an intensive, fast-tracked course, requiring pre-service teachers to master teaching methodologies, including technology integration, within one year or less. The condensed structure of the PGCE program presents challenges, as students are expected to establish connections between their subject matter knowledge, pedagogical strategies, and technological tools to create effective and engaging learning experiences in a limited space of time. During this period, PGCE student teachers do not necessarily get adequate exposure to computer literacy required, nor do they have adequate time to master all the required knowledge components to be well prepared science teachers (Saralar-Aras & Firat, 2021). They are not exposed to different teaching methodologies and learning about the use of ICTs in teaching practice as undergraduate students, which presents challenges in terms of TPACK. This affects their ability to create connections between their content knowledge (CK) with technology (TK or TCK and TPK).

Merisi et al., (2023) and Mkhasibe et al., (2021) argue that there is a problem with the expectations of producing fully prepared qualified teachers within the space of one year in the PGCE program. They highlighted the concerns in teacher education with regards to the teaching practice studies and methods, whereby PGCE students do not have a solid foundation in how to teach (PK) and including the sophisticated need of technology integration in line with their content knowledge. Which is why this study is necessary to be conducted in response to that need and gap.

1.3. The purpose the study

The role of teacher education in preparing Life Sciences pre-service teachers for TPACK at the PGCE level is a critical area of study. Across global teacher education programs, equipping pre-service teachers with effective technology integration strategies is considered essential for their future success as educators (Mhakure & Mushaikwa, 2014; Karaca, 2015; Jimoyiannis, 2010). Investigating how the PGCE prepares them to integrate pedagogy and technology effectively provides valuable insights into the effectiveness of teacher education programs in fostering 21st-century teaching competencies.

This study aimed to explore the influence of the PGCE program on the development of TPACK among Life Sciences pre-service teachers, considering that these individuals already possess subject matter knowledge in science.

The objectives of this study were;

- To determine how pre-service teachers perceive the strategies used in teacher education for TPACK readiness in science classrooms.
- To learn about the interventions utilized in the programs to support the preparedness of pre-service teachers in the life sciences for TPACK.
- To determine the influence of teacher education on the future classroom practices of pre-service Life Sciences teachers.
- To identify challenges that pre-service teachers face with regard to TPACK development in the teacher education programs.

1.4. Research Questions

The study was guided by the research questions and played integral part to reaching or achieving the purpose of this study, which have been expanded from the main research question;

Main Research Question

How do the PGCE teacher education programs support the readiness of Life Sciences pre-service teachers for their TPACK?

Research Sub-Questions

- *What do Life Sciences pre-service teachers perceive to be the effective methods used in the PGCE teacher education for TPACK readiness* in the science classrooms?
- *What interventions are employed in the PGCE teacher education programs to support the readiness of Life Sciences pre-service teachers for TPACK?*
- *How does TPACK readiness in the PGCE teacher education influence the Life Sciences pre-service teacher future classroom practices?*
- *What are the difficulties faced by pre-service teachers in relation to TPACK development during their training?*

1.5. The Rationale of the Study

The Department of Higher Education, Science, and Technology, as well as Teacher Education Institutions (TEIs) offer an opportunity for pre-service teachers to be fully prepared for the 21st century teaching strategies. Tiba and Condy (2021) emphasise that teachers cannot effectively implement technology-based instruction if they have not been adequately trained to do so. The training of pre-service teachers plays a fundamental role in teacher education, as it establishes the groundwork for their future instructional practices.

Pre-service teachers are exposed to various technological tools and resources that can enhance their delivery of life sciences content in the classroom. This experiential learning approach allows them to develop a deep understanding of how to integrate technology in ways that are meaningful to the learning of science for learners (Baran et al., 2017). One notable aspect of the program is its emphasis on hands-on experience and practical teaching opportunities. Understanding how the PGCE Life Sciences program at a South African university influences the development of pre-service teachers' TPACK is essential for enhancing teacher preparation programs and informing policies within the Department of Education. Therefore, TEIs must serve as the starting point for equipping future educators with the knowledge and skills necessary for technology integration in science education. Thus, despite the immense quantity of TPACK research in Teacher Education, it is still necessary to ascertain the influence of teacher education at the PGCE level and the connection between TPACK and technology readiness.

Teachers need to be well prepared and motivated to use technology while they are still training at the teacher education level, however when it comes to PGCE students, there is still a need to find out whether one year is sufficient enough to teach the novice teachers methodology while ensuring they also acquire the knowledge and skills to be able to fluently use and integrate technology in their teaching practices. This is the core of this study, to find out to what extent does the teacher education program, the modules and contents taught to PGCE preservice teachers play the role in their TPACK, taking to note that PGCE students do not necessarily have the strong methodology background as those in the Bachelor of Education (B.Ed.). It was therefore important to explore how the Life Sciences PGCE teacher education influences the TPACK readiness of the preservice teachers in a period of one year and the influence it will have according to the preservice teachers' point of view.

1.6. The Significance of the Study

Integrating TPACK into teacher education curriculum provides authentic teaching experiences, structured mentorship, and a well-defined framework to enhance pre-service teachers' readiness for

technology integration in instruction. As teacher education continues to evolve, it is essential to move away from traditional instructional methods and adopt a more technology-driven pedagogical approach (Voogt & McKenney, 2017). To support this transition, teacher education programs must ensure that pre-service teachers develop TPACK as a fundamental competency, equipping them with the skills to effectively integrate technology into subject-specific teaching (Tondeur et al., 2016). By doing so, PGCE programs can contribute to modernizing teaching methodologies, ensuring that new educators are equipped to navigate digital learning environments and meet the demands of 21st-century education.

The significance of this study lies in its ability to assess how well the PGCE Life Sciences program equips pre-service teachers with the necessary skills to navigate technology-enhanced teaching and learning environments. By identifying gaps and areas for improvement, this study can inform policy development and curriculum design to ensure that pre-service teachers are better prepared for the demands of 21st-century classrooms. Examining the influence of the PGCE Life Sciences program on TPACK preparation is particularly significant in the South African context, where the integration of educational technology is still evolving. This study provides critical insights into the strengths and limitations of the PGCE curriculum in preparing teachers to use technology effectively in Life Sciences instruction. By evaluating the program's influence on pre-service teachers' TPACK development, this research contributes to the broader effort of enhancing teacher education in South Africa, ensuring that educators are equipped to meet the challenges of modern, technology-driven classrooms.

Furthermore, investigating the influence of the PGCE Life Sciences program on TPACK can also offer valuable information for curriculum development and instructional strategies. By identifying the specific areas where the program is successful in preparing pre-service teachers to effectively integrate technology into their teaching practices, educational institutions can refine their curriculum and pedagogical approaches to better support future educators. This study will be significant in the context of South Africa's commitment to quality education and its integration of technology in schools and universities. Understanding the influence of the PGCE Life Sciences program on pre-service teacher preparation can contribute to the broader national discourse on enhancing teacher quality and educational practices, ultimately benefiting students and the broader educational system. Exploring the significance of the PGCE Life Sciences program's influence on pre-service teacher preparation for TPACK is crucial for improving the quality of teacher education, informing curriculum development, and contributing to the advancement of education in South Africa.

1.7. Chapter Summary

This chapter explored the crucial role of PGCE programs in preparing pre-service teachers for TPACK as it underscores the importance of integrating TPACK into teacher education. The chapter began with an introduction to the evolving educational landscape, emphasizing the increasing demand for teachers who can effectively integrate technology into subject-specific instruction. In this regard, the development of TPACK was introduced as a critical framework for understanding teacher competence in integrating technology with pedagogy and content.

The background highlighted the structural and curricular distinctions between the (PGCE and Bachelor of Education (B.Ed.) programs in South Africa. It was noted that, unlike the B.Ed., the PGCE does not offer a structured ICT or computer literacy module, posing unique challenges for PGCE students in developing TPACK. The problem statement further identified gaps in the PGCE Life Sciences program in preparing pre-service teachers for effective technology integration, particularly within science disciplines where visualization and digital tools are vital.

The purpose of the study was to explore how the PGCE Life Sciences program influences the development of TPACK among pre-service teachers. The research was guided by one central question and four sub-questions, focusing on pre-service teachers' perceptions, program interventions, readiness for classroom application, and challenges in TPACK development. The rationale was framed within the context of South Africa's broader push towards 21st-century education and the Department of Higher Education's mandate to prepare digitally competent teachers.

This chapter also outlined the significance of the study in contributing to curriculum refinement, institutional policy development, and improved teacher training outcomes. It highlighted the relevance of the study for addressing existing gaps in TPACK preparedness within one-year PGCE programs, especially in the Life Sciences field.

The chapter concluded by affirming the need to investigate how teacher education institutions (TEIs), through the PGCE Life Sciences program, support or constrain the development of TPACK competencies in pre-service teachers. The next Chapter will build upon this foundation by critically reviewing the relevant literature and theoretical frameworks that underpin the study, including the TPACK and SQD model.

Chapter 2: Literature Review

2.1. Introduction

"A literature review has been broadly be described as a more or less systematic way of collecting and synthesizing previous research." (Snyder, 2019. Pg 1). According to Snyder (2019), starting research requires carrying out a literature review to identify relevant themes, research problems, and knowledge gaps. The literature review presented a summary of previous research on how PGCE Life Sciences programs affect pre-service teachers' TPACK at South African universities and other educational institutions around the world. Several studies have examined the effectiveness of PGCE Life Sciences programs in integrating TPACK into the preparation of pre-service teachers. For example, Schmidt et al., 2009 conducted a comparative analysis of pre-service teachers who completed the PGCE Life Sciences program and found that the program significantly enhanced their TPACK skills. Similarly, Jita (2018) explored the effect of the PGCE Life Sciences program on pre-service teacher preparation and concluded that the program effectively improved their TPACK knowledge and instructional practices.

Furthermore, the literature review also delved into the challenges and limitations associated with the integration of TPACK in PGCE Life Sciences programs. Previous research by (Shilenge & Ramaila, 2020) and (Kavai & Nyamupangedengu, 2021) highlighted several barriers, such as limited access to technology and inadequate training for pre-service teachers, which hinder the effective development of TPACK within the Sciences curriculum.

Overall, the literature review provided a comprehensive understanding of how PGCE Life Sciences programs influence the preparation of pre-service teachers for their TPACK at South African universities, as well as identified areas for further research and improvement. To achieve that the following concepts or subtopics will be used in the next sections; *teacher education in South Africa, What is TPACK, the role of TPACK for Life Science teachers, PGCE Life Science program, preparation of Life Sciences preservice teachers for TPACK, TPACK development in preservice teachers, and the conceptual frameworks as well as their alignment with this study.*

2.2. Teacher Education in South Africa

Teacher education in South Africa has undergone considerable reform over the past two decades in response to national development goals and the global movement toward digital and inclusive education. The Department of Higher Education and Training (DHET) implemented the Minimum Requirements for Teacher Education Qualifications (MRTEQ) policy to align teacher preparation with 21st-century

demands, emphasizing ICT integration, inclusive pedagogies, and subject-specific competencies (DHET, 2015). There are three ways of getting a teaching qualification: (i) a four-year Bachelor of Education degree (B.Ed.); (ii) a three-year undergraduate Bachelor degree capped by a one-year Professionally Focused PGCE; and (iii) a technical Diploma capped by a Professionally Focused Advanced Diploma in Teaching, which exits at a level that is marginally lower than graduate status, namely diploma. Only vocational programs are eligible for this third choice. At the degree level, the most promising programs are the PGCE and the B.Ed. degree (Rollnick & Mavhunga, 2017).

Teacher education encompasses the training, research, and professional development of pre-service teachers, integrating teaching skills, pedagogical theory, and professional competencies. This study focuses on the PGCE program as a key teacher education route, examining the interaction between technology, pedagogy, and content (TPACK) rather than just technology integration. In South Africa, technology has the potential to enhance education, but barriers such as insufficient teacher training hinder effective implementation (Ramnarain et al., 2021). To address this, tertiary institutions must strengthen ICT integration in teacher education curricula, ensuring pre-service teachers can effectively combine technological, pedagogical, and content knowledge to improve teaching and learning outcomes.

Yeh et al., (2014) elaborated that teacher education programs should not only focus on the integration of technology but also on the experiences of teachers using technology in the classroom. If this is carefully taken into consideration at PGCE programs, preservice teachers will be exposed to such training experiences which will support and prepare their TPACK development. Which will place them at a better position to be able to effectively incorporate the TPACK into their science teaching practices in their professional teaching.

2.3. What is TPACK?

TPACK refers to the knowledge and skills required by teachers to effectively integrate technology into their teaching practices (Schmidt et al., 2009). Studies have shown that the level of TPACK and readiness of pre-service teachers in various disciplines, except in science, can be high, particularly for Technological Knowledge (TK) (Rafiq et al., 2022). Furthermore, the development of TPACK in teacher education is influenced by the role of pedagogical knowledge, which plays a significant role in enhancing TPACK among pre-service teachers (Valtonen et al., 2020). Table 1 shows the constructs of TPACK as described by (Valtonen et al., 2020).

Recent scholarships have advanced the utility of TPACK in both pre-service and in-service teacher development. For example, Chai, Deng, and Tsai (2023) highlight how TPACK facilitates adaptive

teaching in digitally diverse classrooms. Moreover, the framework has been instrumental in shaping ICT integration modules across teacher education curricula worldwide (Hilton, 2020). TPACK's adaptability to various disciplines and its alignment with 21st-century competencies continue to make it a relevant model for guiding and assessing technology integration in teacher education.

TABLE 1: TPACK constructs. Based on articles by Mishra and Koehler (2006)

TPACK Constructs	Descriptions
CK	...knowledge of the subject matter being taught, including understanding of related ideas, concepts, and procedures. CK includes in-depth understanding of the disciplines' foundations without taking into account how to teach the subject.
PK	...knowledge of instructional strategies, classroom administration and evaluation techniques, and comprehension of how students build knowledge. PK doesn't concentrate on teaching any particular subject; instead, he studies theories in general.
TK	...knowledge of technology, including understanding and taking into account its potential. The term "TK" describes the knowledge required to keep up with the rapid advancement of technology without sacrificing instruction or learning.
PCK	...the ability to adapt subject matter knowledge for instruction and set up circumstances that facilitate the study of particular subjects. PCK is also aware of common misconceptions about particular subjects.
TCK	...knowledge of the ways in which content and technology interact, as well as familiarity with the technologies utilized in various subject areas. Without taking into account teaching the subject matter, TCK is the understanding of how subject matter develops with technology.
TPK	…knowledge and understanding of the pedagogical benefits and limitations of various technologies, as well as how to support specific instructional methods with the right technology. In line with TK, TPK refers to the use of technology in a forward-looking strategy to identify the most effective approaches to enhance learning.
TPACK	...knowledge of using diverse pedagogical approaches and technologies to teach a range of subjects. The knowledge that underpins expert instruction with technology is the understanding that results from combining CK, TK, and PK.

2.3.1 TPACK as an object

Understanding TPACK as an object involves viewing it as a measurable outcome of teacher preparation. Schmidt et al. (2009) created an instrument for assessing pre-service teachers' TPACK self-perceptions, showing that structured exposure to digital pedagogy leads to significant TPACK development. Dewi et al. (2022) highlight how project-based learning and scaffolding strategies enhance TPACK mastery in science contexts.

Mishra and Koehler (2006) and Valtonen et al. (2020) define each construct clearly—from CK to TPACK—emphasizing that true TPACK expertise emerges when teachers synthesize all three domains in real classroom applications.

2.4. The role of TPACK for Life Sciences teachers

PGCE programs at teacher education, have been found to have a positive impact on pre-service teachers' perceptions of TPACK, indicating the potential effectiveness of TPACK-based training programs in enhancing TPACK among pre-service teachers (Diamah et al., 2022), (Saralar-Aras & Firat, 2021). Additionally, the value of high-quality teacher education and field experience for the development of TPACK among pre-service teachers has been emphasized (DeSantis, 2016). It is also important to note that the confidence levels of pre-service teachers in TPACK can vary across different course modes, highlighting the need for tailored approaches in teacher education programs (Rahmadi et al., 2020). Pre-service teachers acknowledged the significance of teaching practice in developing their technological skills and knowledge according to a study done by Admiraal et al. (2017). This therefore makes it evident how teacher education programs affect pre-service teachers' ability to use technology into their lessons. As a result, mentors in schools during student teaching have a crucial role in providing pre-service teachers with the technological teaching skills they require, which tells us that to get the influences of the teacher education on preparing preservice teachers, including Life Sciences, the strategies, instructional designs and usage of technology by lecturers in PGCE classrooms cannot go unnoticed.

The assessment of TPACK among pre-service teachers involves a wide range of approaches, including self-report, lesson plan assessment, and classroom observations, to examine their ability to apply and foster the interplay between content, pedagogy, and technology in their classrooms (Kwangsawad, 2016). However, the overall mean score of the level of TPACK of pre-service science teachers was found to be low in a specific study, indicating the need for targeted interventions in science teacher education programs (Peligro, 2022).

Recent studies emphasized that the lack of technology integration in science teacher preparation has a direct impact on classroom practice. For instance, Tibi and Mafumo (2021) argued that pre-service science teachers who received limited digital training tended to replicate traditional teaching methods, even in tech-equipped environments. Furthermore, research by Zhou et al. (2022) supported the idea that well-structured teacher education programs that focused on subject-specific ICT applications led to more effective science instruction. These insights underscored the importance of embedding TPACK in Life Sciences education programs.

Moreover, the relationship between TPACK self-efficacy belief levels and the usage of Web 2.0 applications of pre-service science teachers has been highlighted, emphasizing the importance of self-efficacy beliefs in the integration of technology in teaching (Wright & Akgunduz, 2018). Additionally, the positive impact of ICT integration on the development of vocational high school teacher, TPACK

has been demonstrated, further underscoring the significance of technology integration in teacher education according (Istiningsih, 2022).

2.5. Preparation of Life Sciences preservice teachers for TPACK

The preparation of pre-service teachers for the TPACK is crucial for effective integration of technology in teaching of science subjects. Several studies have examined the effectiveness of the PGCE programs in preparing pre-service teachers for TPACK. The PGCE Life Sciences program in South Africa is designed to provide graduates with pedagogical training and school-based experience in teaching biology at the secondary level. However, its accelerated nature poses challenges for the comprehensive development of TPACK competencies (Merisi et al., 2023). Unlike four-year B.Ed. programs, PGCE curricula often lack dedicated ICT integration modules, relying instead on incidental exposure during teaching practice, as this was also highlighted under the problem statement for this study.

Scholars have critiqued this approach. Makgato and Mudau (2020) argue that pre-service teachers in PGCE programs are frequently underprepared for technology-rich classrooms due to insufficient time, lack of modelling by lecturers, and limited access to school-based digital resources. On the other hand, where technology integration is scaffolded through workshops, mentoring, and feedback cycles, students report higher confidence and competence in TPACK (Diamah et al., 2022; Mhlanga, 2023).

In a study by Mishra and Koehler (2009), they proposed a framework that emphasizes the importance of TPACK in teacher education. They highlighted the need for teacher preparation programs to integrate TPACK into their curricula to effectively equip pre-service teachers with the necessary knowledge and skills for technology integration. Tondeur, Pareja Roblin, van Braak, Fisser, and Voogt (2013) conducted a case study to investigate how TEIs support the development of TPACK. They discovered that TEIs were difficult to integrate TPACK into the curriculum. Although everyone agreed that linking TPACK to topic domains was beneficial, it also resulted in less emphasis on ICT in the teacher education curriculum. This proved that there are still difficulties and challenges within the teacher education as much as TPACK is concerned, and the PGCE is not exempted from those challenges, hence it is through this study that we can find out those challenges according to the experiences of the preservice teachers and the lecturers in this program.

In order provide pre-service teachers the opportunity to (a) comprehend the educational reasons for utilizing ICT and (b) experience how ICT can enhance teaching and learning across many topic domains, Tondeur et al. (2012) came to the conclusion that ICT should be integrated into the entire curriculum. They examined how preservice teachers are prepared to use and integrate technology into their curricula for effective pedagogical practice. Teacher education programs must seek to better integrate technology

throughout the program and across subjects. To meet these requirements, rather than focusing solely on how to utilize technology, student instructors must learn how technology may be used to support creative ways of teaching and learning. Thus, the need for carrying this research study.

2.6. TPACK Development in preservice teachers

Several studies have explored the development of TPACK among pre-service teachers in general (Valtonen et al. (2020), (Ilahude et al., 2023), with others also focusing on both in-service and preservice teacher. This can tell us that development of TPACK among teachers is not only achieved during teacher training, but rather it is a lifelong learning endeavour. Inasmuch one cannot say they have fully grasped and mastered all the components of TPACK (Ramnarain et al., 2021), as long as teaching evolves, teachers will also need to acquire the necessary knowledge and skills to make sure they are aligned with emerging changes in the profession of teaching. Their teaching methods and strategies (Pedagogy), and their subject matter knowledge (Content) as well as their knowledge and use of specific new era technologies (Technology), will need to keep developing to meet the standard of education at that time. Thus, the development of TPACK among science teachers is one critical aspect of the system. This section will then attempt to review studies on how the TPACK of preservice teachers can be achieved and why it is important.

Valtonen et al., 2018 provided fresh perspectives on pre-service teachers' appraisal of their challenging and confident TPACK areas, highlighting the pivotal role of pedagogical knowledge in TPACK development. Additionally, (Dewi et al., 2022) introduced a project-based scaffolding TPACK model to enhance the learning design ability and TPACK of pre-service science teachers, emphasizing the influence of confidence in technology on TPACK ability. These studies underscore the significance of pedagogical knowledge and confidence in technology as key factors in TPACK development. TPACK is characterized as a developing form of knowledge created by the synthesis of teachers' technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). It is as well as intersecting knowledge, pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK) that are developed by the interconnection of TK, PK, and CK (Mishra & Koehler, 2006).

Hence, TPACK is characterized as a developing form of knowledge created by the synthesis of teachers' technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). It is as well as intersecting knowledge, pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK) that are developed by the interconnection of TK, PK, and CK (Mishra & Koehler, 2006).

2.7. PGCE Life Sciences program

The influence of the PGCE program's structure and content on pre-service teachers' TPACK development was investigated by Archambault et al., 2009. According to their findings, pre-service teachers' preparedness for incorporating technology into their teaching practice can be enhanced by a well-designed PGCE curriculum that effectively integrates TPACK. Another study that examined the influence of PGCE program on pre-service teachers' TPACK was carried out by Angeli and Valanides (2009). Their findings emphasized the significance of providing opportunities for pre-service teachers to develop TPACK through authentic experiences and mentorship. This highlights the importance of practical experiences and guidance in the PGCE program to enhance pre-service teachers' preparation for TPACK. There is still need for more motivation and study that will delve more on PGCE science education.

2.8. Conceptual framework

Conceptual framework is the lens in which researchers use to have directions of their study, lens in which new research can be assessed with. The TPACK instruments by (Schmidt et al., 2009) which was adapted from the TPACK framework (Mishra & Koehler, 2006) and some aspects of the Synthesis of Qualitative Data (SQD) model (Tondeur et al,. 2012) have been complementarily used as conceptual frameworks to guide this study. While the TPACK framework conceptualized the kind of knowledge teachers need for effective technology integration, the SQD model offered the practical guidelines for fostering such competencies in the teacher education programs, which in this case the Life Sciences PGCE program.

The concurrent use of both frameworks was intentional and necessary in this study. This was because the TPACK framework outlined "*what*" preservice teachers were expected to know (technological, pedagogical, and content knowledge and their intersections), while at the same time the SQD model outlined "*how*" teacher education programs can support the development of these knowledge domains. Thus, the use of both frameworks was significant because that offered a coherent framework that aligned with the research objectives for this study.

2.8.1. TPACK framework

Effective teaching, according to Shulman (1986), is based on pedagogy and content knowledge, but Mishra and Koehler (2006) expanded on this understanding to include technology. According to Koehler and Mishra (2008), a teacher must possess the following three knowledge bases in order to successfully integrate technology into their lessons: content knowledge (CK), pedagogical knowledge (PK), and

technological knowledge (TK). The intersections of technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK), and context—which have been shown in *figure 1* of the TPACK framework—are also significant. Teachers' abilities are constrained by what they can accomplish in their own surroundings, which makes context essential.

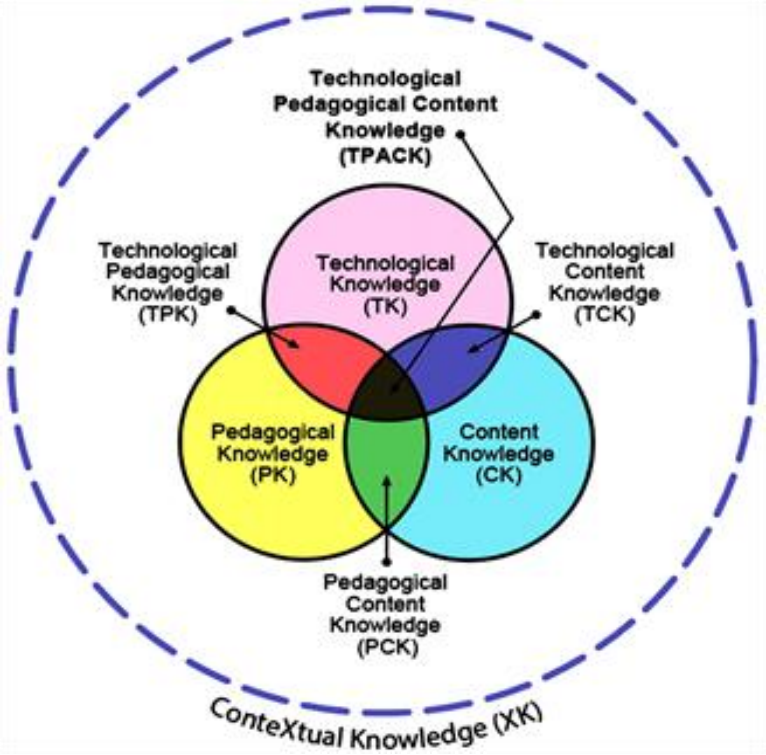


Figure 1: TPACK Framework by (Koehler & Mishra, 2006)

The framework shown above in figure 1, was introduced by (Mishra & Koehler, 2006), (Koehler & Mishra, 2009), TPACK emphasizes the dynamic interplay between technology, pedagogy, and content knowledge. TPACK is the most accepted framework in defining how technology can be integrated into teaching (Tiba & Condy, 2021). This framework has been applied to various educational contexts, including science teacher education, where it has been used to understand and develop teachers' pedagogical content knowledge (Uluçinar Sağir & Küçükaydın, 2015). Teacher education is regarded at the most if not the only channel for preparing and nurturing preservice teacher to be effective practitioners of teaching tomorrow. As the world has been rapidly moving towards the 4th IR, mostly everything being digitalized, the education has also taken a step forward to ensure that learners are exposed to the use of ICTs in their learning environments. This then means, that teachers of science have had to become students of the ICTs, they need to be fluent users of technology. But according to (von Kotzebue, 2023), it is not just about using the technology, instead having the strategies to be able to select appropriate tool for specific topic.

i) CK, PK & PCK

Shulman (1986) defined PK as teachers' knowledge of teaching methods, while CK is teachers' knowledge of the subjects they teach. Conversely, PCK, or the ability to teach a certain subject, is what is needed to be qualified for the teaching profession (Shulman, 1986).

ii) TK, TCK & TPK

Technology knowledge (TK) includes hardware, software, and peripheral usage. Because technology is constantly evolving, TK becomes old rapidly if people don't stay up to date with current developments. Once more, TCK is an understanding of how technology and content influence and constrain one another, while TPK is an understanding of how teaching and learning change when particular technologies are used (Koehler & Mishra, 2006). Although, various research has indicated that TPK is challenging for most teachers (Baran et al., 2017) and (Voogt & McKenney, 2017).

iii) TPACK

TK, CK, and PK are the three knowledge domains that intersect to form TPACK. Understanding TPACK extends beyond any one TK, CK, or PK category. Expertise that is distinct from and superior to that of disciplinary experts (such as mathematicians), technology experts (such as ICT specialists), and pedagogical experts (such as seasoned teachers) can be found in a teacher who is able to navigate these interactions. The TPACK framework has been updated to encompass 21st century skills, reflecting its adaptability to evolving educational needs (Valtonen et al., 2017). Studies have also evaluated the effectiveness of TPACK-based training programs in enhancing pre-service teachers' perceptions of TPACK, highlighting its practical implications in teacher education (Diamah et al., 2022).

Understanding of this framework and its significance to teaching and learning of science concepts was very crucial for this study. Therefore, preservice teachers in the science discipline must not only focus on their content knowledge (CK) or their technological knowledge (PK), instead they need to be able to make the connections between their pedagogical knowledge (PK) as well as their content knowledge in order to be able to integrate technology into their teaching effectively. This is where the problem was explored, if the preservice teachers of Life Sciences in the PGCE program were adequately prepared for making the connections between their existing subject matter knowledge with pedagogies and technology, so that they are TPACK ready for teaching in science classrooms.

2.8.2. The SQD Model

Tondeur et al. (2012) did an in-depth analysis of research evaluating the integration of technology into educational settings and developed a model for pre-service teacher training (Synthesis of Qualitative

Evidence Model). There is now a model for teaching aspiring in-service teachers in technology integration. Using teacher educators as role models, reflecting on the role of technology in education, learning how to use technology by design, working with peers, scaffolding authentic technology experiences, and giving ongoing feedback are some of the strategies Tondeur et al. (2012) examined in their study and developed an overall synthesis of qualitative evidence (SQD)-model.

A useful tool for evaluating preservice teachers' perspectives of the assistance they received from their teacher education programs in terms of using educational technology in their future classrooms was the SQD scale (figure 2), which was created based on this model (Tondeur et al., 2016). Tondeur et al. (2012) modelled the training that pre-service teachers should get and carried out a qualitative analysis of research evaluating the integration of technology into the educational context. To meet this demand, Tondeur et al. (2016) developed a measuring tool based on the SQD model. According to Tondeur et al. (2016), it was the first tool used to assess the preparation preservice teachers received for integrating technology into the classroom.

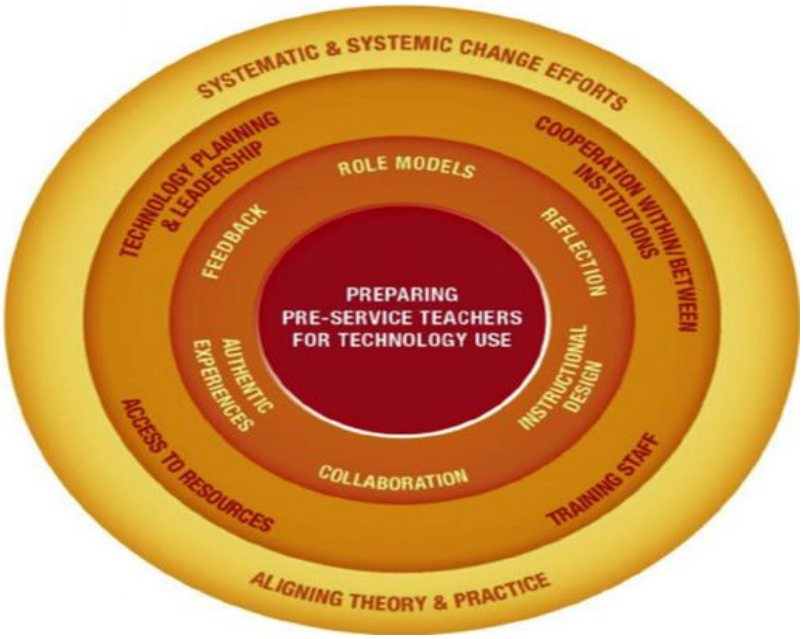


Figure 2: SQD Model to prepare preservice teachers to teach with technology (Tondeur et al., 2012).

2.8.3. Application of the TPACK and SQD Model

The application of TPACK in pre-service teacher education has been a subject of interest. (Baran & Uygun, 2016) proposed an integrated TPACK-design-based learning approach to foster understanding of TPACK in teacher education contexts, addressing critical gaps in the literature. Moreover, Setiawan et al. (2018) explored teacher educator's experiences in modelling TPACK to create English language

multimedia, highlighting the practical implementation of TPACK in technology courses. These studies emphasize the importance of innovative approaches to integrate TPACK into teacher education programs. The framework was used in this study to check the preservice teacher's understanding of the Life Sciences pedagogy, content knowledge as well as how well they teach with technology. Which then addressed the gap and/or the question, how does the PGCE teacher education influence the development of the preservice teachers TPACK and the framework which guided this study for answering this question.

As stated earlier in this section, the two frameworks were used to guide my study because they were both important in finding out how prepared the preservice teachers in PGCE Life Sciences program were for TPACK readiness. TPACK was used to check how the preservice teachers intersected the three components of the TPACK and the other, SQD model checked how these components were integrated in their use of technology during their teacher training as well as during their teaching experience (TE) weeks. The SQD model was adapted and it served the purpose of this study according to the scope, only the second and the third levels of the model were used in this study, because I felt they were applicable to this study.

In the PGCE program, students were required to do their minilessons during their teaching experience period, those minilessons were peer assessed (collaboration), in which they received feedback from both their peers and their teaching experiences mentors (Role Model). Because after their minilessons, the students were expected to reflect (Reflection) on their lessons, on how they have integrated technology with regards to their pedagogy and content knowledge. So, the effective use of information and communication technology (ICT) in the classroom by preservice teachers was developed through the synthesis of qualitative evidence (SQD) strategies. In contrast, TPACK established what constitutes an effective ICT integration teacher's knowledge.

2.9 Chapter Summary

This chapter looked at the different retrospective studies which has been conducted in research relevant to the keywords of my study which are influence of PGCE Life Sciences, Teacher education, TPACK preparation. Lastly the chapter outlined the 2 conceptual frameworks which have been found important for guiding this study, the TPACK framework and the SQD model.

The review has focused on studies that have examined the influence of the PGCE Life Sciences program on the development of TPACK among pre-service teachers in the South African context. Although, other

studies from international level were also included to compare and find the research gap. This chapter also explored any challenges or successes that have been documented in the literature regarding the implementation of the program and its influence on teacher preparedness.

Furthermore, the literature review also identified any gaps in the existing research and proposed areas for further exploration, which supported the need for this study. By synthesizing the findings from a range of scholarly sources, this literature review has provided a comprehensive understanding of the ways in which PGCE can influence the preparedness of these aspiring future teachers for TPACK at other countries, except in the context of South Africa, which we were looking to find by carrying this study.

Chapter 3: Methodology

3.1. Introduction

The study's overall methodology used to explore the influence of the PGCE Life Sciences program on preservice teachers' preparation for TPACK is covered in this chapter. It covered issues like the research paradigm and approach aspect used in this study, the worldview assumption. The research design, sample techniques, data collection instruments employed and motivation for selecting those instruments were all discussed in this chapter. In order to address the research questions and expand upon the constructivism paradigm, the study employed a case study research design and a qualitative approach as the methodology. The study's ethical considerations, credibility, and validity were also covered.

3.2 Research Design

A research design is the plan for collecting and evaluating data that will allow the researcher to respond to the addressed question. Tegan (2021) explains a research design as a means to establishes the decision-making processes, conceptual structure of investigation, and analytical methods used to address the study's central research problem. The design of an inquiry affects every aspect of the research, from the choice of data collection methods to the minute details of collecting the data. This study employed a case study as its research design. A case study, as defined by Delmas & Giles (2023) and Creswell (2009), is a qualitative investigation that looks at a phenomenon in its actual context. Because case study research encompasses an extensive investigation of a phenomenon, a variety of data collection techniques are used. The case for this study included focusing on a PGCE Life Sciences program at a South African university, selected for its relevance in examining the preparation of pre-service teachers for TPACK within a time-constrained, one-year teacher education structure. This case was significant as it offered a context-specific lens through which to explore how effectively the program supports the development of integrated technological, pedagogical, and content knowledge required for 21st-century science teaching. By focusing on this particular program, the study generated nuanced insights into the opportunities, constraints, and pedagogical strategies that shape TPACK readiness in pre-service Life Sciences teachers. This design was chosen because of its exploratory nature and its feasibility to address the research questions for this study, which is; *How do the PGCE teacher education program support the readiness of Life Sciences pre-service teachers for their TPACK?* This design allowed the use of observations and in-depth semi-structured interviews to find the experiences of the targeted population.

3.3 Research Approach

This study took a qualitative research approach to address the problem of this study. Qualitative research gathers participants' experiences, perceptions, and behaviour. It answers the how's and whys instead of how many or how much. (Busetto et al., 2020) defined qualitative research as the study of phenomena' nature, encompassing aspects such as their features, various forms, contexts in which they occur, and perspectives from which they can be viewed, but not their range, frequency, or place in an objectively established cause and effect. Instead of collecting numerical data points or intervening or introducing treatments just like in quantitative research, qualitative research helps generate hypothenar to further investigate and understand quantitative data Moser and Korstjens (2017). This description gave meaning to the approach that was taken in this study, as it was to explore the perceptions and the experiences of preservice teachers on the phenomenon of TPACK. This qualitative method approach also provided a holistic view of pre-service teachers' proficiency levels and perspectives on integrating technology into their teaching practice while also aligning their pedagogy and content knowledge (Yulisman et al., 2019) and (Jita, 2016).

The three central types of qualitative study objectives are exploratory, descriptive and comparative methods. For this study, an exploratory approach of qualitative research was used. According to Tegan (2021), exploratory research is a methodology approach that investigates research questions that have not previously been studied in depth. Exploratory research can help you narrow down your topic and formulate a clear hypothesis and problem statement. It is carried out to gain a better understanding of the current problem (Olajide & Lawal, 2020; Elman, Gerring, & Mahoney, 2020). The great advantage of exploratory research is that it is flexible and adaptable to change. When conducting exploratory research, the researcher must be willing to change their direction as a result of new data that appear and new insights that occur to them (Lelissa, 2018). This design was chosen because of its exploratory nature and its feasibility to address the research questions for this study. According to Saunders, Lewis and Thornhill (2016) an exploratory research design is a valuable means of finding out 'what is happening; to seek new insights; to ask questions and to assess phenomena in a new light. The topic focused on a more thorough understanding of how PGCE teacher education influenced pre-service teachers' preparedness for TPACK was attained.

3.4 Research Paradigm

Research paradigms can be described as different ways of viewing the world and form an integral part of the foundation of research. They are based on a set of assumptions about reality, the nature of knowledge, and what is worthwhile to learn (Junjie & Yingxin, 2022). An interpretivism paradigm was

also employed in this qualitative approach and address the main research question. This is because my goal as a researcher was to gather thorough data that would address the research questions. Interpretivism is the primary paradigm of reality knowing that have historically been presented as diametrically opposed points of view. According to the interpretative paradigm, which is the basis of qualitative research, the study of an individual's subjective experiences and the significance they place on particular events are the primary objectives of the research, with no consideration given to the researcher's subjective opinions about the situation under study. In this study the interpretivism paradigm was used to better determine how prepared PGCE Life Sciences preservice teachers are to use technology into their classroom instruction.

3.5 Population and Sampling of Participants

Population is the group of people or entities that the study will be focusing on and sample is the targeted individuals which may be representations of whole or larger quantity of people, the particular group or individuals that are targeted to participate in the study. Sampling refers to the process of selecting a subset of individuals, units, or cases from a larger population for the purpose of conducting research. According to Creswell and Creswell (2018), sampling involves identifying a group of participants that best represents the characteristics of the population being studied, allowing the researcher to make inferences and gain insights about the whole. A group may include individuals, pairs or organizations. This group is the primary focus of the research, and the findings can be used or applied to them. Populations assist in defining the parameters of the study, provide the reader with context and surrounding details, and allow the researcher to concentrate on particular regions within a predefined range.

The population for this study included preservice teachers enrolled at a South African University, a Teacher Education Institution (TIE) in the Gauteng province. This is because this study was conducted in South Africa and the title of this research includes that contextual aspect. For selecting participants who could respond to the research topic, a technique known as purposive sampling technique has been used in this study. A purposive sample technique is employed, according to (Bertram & Christiansen, 2020), when the researcher specifically wants to include a particular group in the study, which was exactly the need to answer the research question of this study and reaching the goal of this research report.

To gather relevant data for this study, a purposive sampling strategy was employed. The sampling method involved selecting participants based on specific characteristics that are pertinent to the research

questions. By using purposive sampling, ensured that the selected participants have direct experience with the PGCE Life Sciences program and were able to provide valuable insights into its influence on the development of their TPACK. Through purposive sampling, in-depth perspectives and experiences were gathered, which contributed in getting the complete grasp on the influence of the PGCE Life Sciences program on the TPACK preparation of pre-service teachers. This was on the assumption that the researcher wanted to discover, understand, and gain insight and hence selected a sample from which the most could be learned, which in this case, the participants were preservice teachers doing PGCE with Life Science majors as well as their respective lecturers, and were able to give insights into the integration of technology in teaching when this study was conducted.

The selected population were initially all the PGCE students with Life Sciences as a major, a teaching subject for the 2024 academic year. There was a total of 36 PGCE students meeting this sampling criteria and all the 36 of them were invited to participate in the study. However, only 5 students responded to the invitation and showed interest. A targeted sample of five (5) Life Sciences pre-service teachers for the Senior or FET phases at PGCE level were included in the study, see table 3 for summary of their educational background. as well as two (2) Life Sciences lecturers teaching at the PGCE level, this was because of the intended purpose of this study; to explore the influence of PGCE program on Life Sciences preservice teachers for preparing their TPACK. All participants were in a position to have used technology (teaching resource) in the classroom and held a specialization in senior or FET phase pre-service teachers of the Life Sciences methodology from a South African university, that was for easy accessibility and because of the scope of the study which allowed convenience and easy logistics during data collection.

3.5.1 Demographic information of participants

This study included preservice teachers (***n=5***) and lecturers (***n=2***) who were in the Life Sciences PGCE program at a South African university. As part of this study, the interview instrument was also used to gather the information on the demography of the participants. Question 2, of the lecturers' profile, from the semi-structured interviews asked about the teaching experience of the lecturers in the Life Sciences PGCE program. Table 2, below shows the information of the lecturers who were interviewed for their perceptions on how the program supports the preservice teachers for their TPACK. For ethical purposes, the gender of the 2 participated lecturers was not stated throughout this report.

TABLE 2: PGCE Lecturers demographic information

#	***Participant ID***	***Title***	***Module lecturing***	***No. of years teaching with technology***
1.	Lecturer 1	Dr	Life Sciences & Natural Sciences	10
2.	Lecturer 2	Dr	Life Sciences, Chemistry and Physical Sciences	10

The total number of the PGCE students that enrolled in Life Sciences for the year was 36. From which, 25 were females and 11 were males. However, as indicated in the previous sections out of the 36 invited students that were enrolled in PGCE Life Sciences, only 5 students were part of this study, since they showed interest and consent. Again, on the interview questions 2, 3 and 4 were asked to the preservice teachers to gather their demographics information, as shown below on Table 3.

The preservice teachers identified above; their content tests scripts were collected for content analysis from their respective lecturers. As indicated by the lecturer, the acceptable mark for content test was 80. This was on the assumption that PGCE students have strong content background. As, per their respective educational background, their undergraduate qualification. The table below summarises the educational background as well as their experience in teaching practice prior to enrolling for PGCE.

TABLE 3: Preservice teachers' demographic information (pseudonym names, gender and age)

Participant Pseudonym names	***Gender***	***Age range***
Nandi	Female	20-30
Tsholo	Female	20-30
Mbali	Female	20-30
Sino	Female	20-30
Thabo	Male	30-40

TABLE 4: Preservice teachers' educational background.

Participant Name	***Gender***	***Education background & majors***	***Years of teaching experience prior PGCE***
Nandi	Female	BSc in Human Physiology and Genetics	0
Tsholo	Female	BSc, Physical and Mineral sciences.	2 months
Mbali	Female	BSc, Biological Sciences	1,5 years
Sino	Female	BSc, Human Physiology and Biochemistry	0
Thabo	Gender	BSc Physiology & Zoology	6 months

3.6 Data Collection

Data collection is the most important stage of the research. Choosing the correct data collection tool ensure that one gets the answers to the research questions outlined in the study. The data for this study were collected using the instruments; Observations of minilessons, semi-structured interviews and content analysis also known as document study.

Semi-structured interviews (Schedule)

According to According to (D. L. Morgan, 2014), an interview is a methodical way of speaking and listening to people with the goal of gathering information from them during the exchange. He also argues that, during an interview, the subject becomes engaged and shares their opinions, perceptions, and interpretations of the topic at hand. In a semi-structured interview, the interviewer is free to ask any questions they deem relevant and suitable, without adhering to a predetermined order. They can also prompt and go deeper into the scenario at hand to allow the interviewee to elaborate further on any points if needed, this was promptly adhered to and applied during the interview data collection process.

Semi-structured interviews were employed because they provided a way to go deeper into and explore participants' answers by follow up questions. The PGCE Life Sciences students, which are referred to as the preservice teachers in this study, were asked questions about their experiences in terms of TPACK readiness to find out their perceptions, their application of the interactions of all the knowledge components of TPACK in science teaching. Moreover, the teacher educators (lecturers) were also interviewed in this study for their perception in terms of support given to the PSTs in the program for TPACK readiness *(See appendix B).*

The participants were interviewed by myself as the researcher, through online setting at a time that was convenient to them. The interview questions were designed in categories to probe and assess their confidence levels and competency in integrating technology into their teaching practice *(See appendix G).* The instruments were based on the seven domains of the Technological Pedagogical Content Knowledge framework proposed by Mishra and Koehler. Creswell (2018) states that a using qualitative approach to collect data offers to the chance to gather information about participants' attitudes, behaviours, beliefs, and practices.

Semi-structured interviews were conducted online (via Microsoft Teams) only, with a subset of pre-service teachers at PGCE level to gather more in-depth information about their experiences and perceptions regarding technology integration in the Life Sciences classroom. Participants were given the freedom to express their own opinions without hindrance when answering questions during interviews based on TPACK, which was used to collect the data. In addition, participants were also interviewed to collect qualitative data based on TPACK. The semi-structured interviews with pre-service teachers provided a rich qualitative data on their experiences and perceptions of technology integration in the Life Sciences classroom. Thus, allowing for a deeper exploration of the challenges they faced, the strategies they employed, and the resources they relied on when integrating technology into their pedagogical practices (Ramnarain et al., 2021). So, using this instrument enabled me to get the opinions and perspectives of the lecturers and the preservice teachers on TPACK preparedness of the PGCE students.

Minilessons observations (Observation schedule)

With these techniques, first-hand data was collected by direct observation of events, behaviours, interactions, processes, during their minilessons activities in order to gain a conceptual understanding. This instrument was employed, so in situations where the semi-structured interview was unable to provide sufficient information for various reasons, such as participants' lack of awareness, inability to discuss a certain topic or question, or where they voiced preference not to discuss it. According to (Kabir, 2016), generally, observation extends beyond only seeing and hearing as a method of data collection, observation helps the researcher grasp what is occurring in the immediate vicinity. This method requires listening intently, articulating the events intelligibly, engaging with the research environment, and obtaining high-quality recordings. (Taherdoost, 2021).

In this particular study, observation of minilessons were chosen to see how lecturers as role model supported and motivated the TPACK development of the Life Sciences preservice teachers, and how they applied what they were trained in the program to real teaching contexts. During the minilesson I

observed and recorded on the observation schedule (See Appendix C), everything that was taking place during the teaching and learning, to see how content, pedagogy and technology are integrated into the teaching practice in terms of TPACK. Any other information which was counted be relevant and contributed to the study, was also written down on my journal. Observation of minilessons of the 5 consented participants was carried out to pre-service teachers enrolled in the PGCE program for Life Sciences, which was extremely helpful for this study because it entailed getting direct information, and produced highly accurate and reliable data for analysis. In the observation, the experiences, reflections and feedback for the participants was analysed by looking at all the aspects of TPACK and SQD model.

Content analysis (scripts)

As briefly described above, content analysis according to (Seers, 2012), is the extensive study of written material. The data collected through the content analysis were the scripts of the targeted sample, the PGCE Life Sciences preservice teachers. This was done for the purpose of checking for their content knowledge (CK) which also played a part to their TPACK development. And the PGCE Life Sciences novice teachers were expected to be having a strong subject matter knowledge, which is the content acquired from their BSc or their undergraduate qualification.

By conducting a document analysis, it made it possible and easy to obtain data that would otherwise have needed a great deal of time and effort to collect (Morgan, 2022). The test scripts then helped to determine the preservice teachers' CK aspects of their TPACK by looking at their marks and how they have scored (See Table 6).

3.7. Data Analysis

Data analysis refers to the systematic process of examining, organizing, coding, and interpreting collected data in order to identify patterns, themes, or insights that answer the research questions (Moser & Korstjens, 2017). The qualitative data that was gathered from the interviews and minilesson observation during this study, was analysed through thematic analysis technique. The thematic analysis involved reading through a set of data such as transcripts for more in-depth and looking for patterns in the meaning of the data in order to identify themes. The qualitative data analysis involved an iterative and inductive process where meaning was derived through the careful examination of textual, visual, or audio data (Braun & Clarke, 2006). Qualitative data from observations, semi-structured interviews and content analysis were thematically analysed to identify recurring themes related to pre-service teachers' perceptions of TPACK and its integration into their education. Additionally, data from TPACK

instruments and technology usage was analysed using SQD model methods to measure the levels of TPACK and the influence of in teacher education on the readiness of preservice teachers for TPACK. The Technology Pedagogy Content Knowledge levels of pre-service teachers was also analysed through activities and assessed using previous conceptual frameworks to determine their proficiency in integrating technology into pedagogical practices. Furthermore, the beliefs of pre-service teachers about learning science through inquiry and their performances were also analysed to understand their readiness for TPACK integration. Overall, the data collection procedure and analysis has provided valuable insights into the influence of teacher education on the preparation of Life Sciences pre-service teachers for TPACK at the PGCE level.

The analysis of the data collected using qualitative method focused on emerging themes which were triangulated from the three sources of data collection. When trying to determine how the lecturers considered the PGCE program prepared the students for their TPACK, the qualitative data was first gathered through semi-structured interviews, from lecturers' point of view. Transcription was the initial phase of analysing the interview data. Each audio-recorded interview was carefully transcribed into its own transcript by myself. Secondly, in order to become acquainted with the data, every transcript was examined repeatedly. Thirdly, the data was openly coded based on the order in which the participants were asked questions. For instance, when the participants were asked *"In your own opinion, what is the role of the PGCE teacher education in preparing pre service teachers for TPACK?"*. According to their responses, one responded **Lecturer 2**: *"What they have is the content, but they do not have the teaching methodology for Life Science."* And another response from **Lecturer 1**: *"…actually the PGCE programme itself is to upskill former BSc graduates to become teachers."*

These responses showed that the PGCE program does have a role in the preparing the newcomer teachers in terms of TPACK, and as it was highlighted in the literature chapter (Page 10), that TPACK is not only a single component, rather the interaction and combination of all the knowledge components (M. Koehler & Mishra, 2009). This is then up to the PGCE program. BSc graduates, come to the program with content, to be upskilled with the necessary teaching methodology for the subject.

After that, under each question, the coded data was presented in a table that highlighted common aspects. The codes that were related to the research questions and unifying were grouped into themes, and some codes that were directly related to the research questions were also categorized as themes, which are discussed in chapter 4. Data analysis relied upon finding common themes and reaching the conclusion as well as the recommendations and suggestions for future research which was discussed on the upcoming chapters of this paper. Triangulation can be defined as the use of multiple methods or data sources in qualitative research with the aim of developing a comprehensive understanding of the

phenomenon being studied or investigated. The reason triangulation was used in the analysis was because this increased the validity and ensured the quality of the study.

3.8. Validation of data collection instruments

Validation of data collection instrument involved the process of putting together evidence to support the validity and reliability of particular instrument chosen for a study. Validity is the degree to which an instrument measures what it is intended to measure. And reliability is the extent to which an instrument can be consistent and repeatable in such a manner that it will produce the same results. Properly examination of the data collection instrument validity and reliability ensures authentic findings (Taherdoost, 2021). According to (Creswell & Creswell, 2018), validity can be achieved by triangulation, which involves combining of multiple findings from various instruments, such as surveys, interviews, and observations to create a coherent argument for the themes. In this study validity was preserved by using not only one instrument, but three data collection instruments; observation, semi-structured interview and document study, which ensured that the data collected was rich in personal insights, more direct, ensured emerging themes and also avoided biases respectively. Then the data collected from these sources was triangulated for precise conclusion.

3.9 Ethical Considerations

Ethical consideration in research refers to the principles and protocols that guide researchers in conducting their studies with integrity, respect, and responsibility toward participants (Lellisa,2018). As stated by Babbie (2020), ethical research must prioritize informed consent, voluntary participation, confidentiality, and the right to withdraw at any point. Adhering to ethical standards ensures that participants are protected from harm and that the research process upholds trust and academic credibility. The permission to conduct this study was requested from the Wits School of Education, through the Research Ethics Committee, the University Registrar as well as the Head of School. Through the University Registrar, Head of School, and Research Ethics Committee, approval to conduct this study was granted (see Appendix F) from the University of the Witwatersrand School of Education.

Before any data collection tools were employed, a formal email was sent to all the PGCE student teachers who had enrolled in Life Sciences inviting them to take part in the study. I told each participant that their livelihood would not be harmed and that the research was being done strictly for academic purposes. I gave them my assurance that their personal data would be kept confidential and anonymous, and that they could stop taking part in the study at any time. Consent was obtained from research participants by having them sign a consent form that was formally emailed to them.

As promised, only consenting participants' minilessons were observed, and only the accepted interviewees were interviewed online using the Microsoft Teams app to make sure they could do it whenever it was most convenient for them. The Research Ethics Committee-approved open-ended questions were asked to interviewees. In order to facilitate transcription and the evaluation of data analysis, each participant was asked to have the interview recorded. Throughout the study, participants' names were kept anonymous, any written responses were kept confidential, and whatever information they submitted was kept private. The opinions of the participants were represented in the research report using pseudonyms. The names of the lecturers were not stated; instead, Lecturers 1 and 2 were cited as their representatives. The findings collected using the three research tools are presented in the following chapter. Starting with the lecturers' interview responses, then the preservice content test before presenting their interview responses and lastly the preservice teachers minilesson observations on TPACK.

3.10 Chapter Summary

This chapter looked at the methodology this study will employ to achieve the purpose of the study. The chapter explained the research approach, research design as well as the research paradigm. It also described the population and sampling techniques as well as the data collection procedures for the study. Data collection for this study was in three forms, observations, interviews, then followed by the content analysis of written tests materials of targeted groups in the program. This has provided quality data as the preservice teachers were interviewed and observed at the end of the third block, to identify their position in regards to their TPACK levels as well as their experiences. The participants were interviewed to see how far they were with their TPACK development subsequently after they have undergone teacher education programs in the PGCE overall. A 5 scale SQD model that has been modified from retrospective studies was also used to collect qualitative data for the minilessons observations, to find out the preservice teachers' preparedness to use technology in their science classroom based on their exposure to the PGCE program by aligning all the knowledge components. This collection was also supported by the SQD subscales (authentic experiences; collaboration; instructional design; feedback; reflection; and role model) which have been adapted from the study by (Tondeur et al., 2016)- to determine how the lecturers also played the role in this process, specifically addressed the authentic experiences, feedback, reflections and role model for TPACK preparation of the preservice teachers.

Chapter 4: Results Presentation and Data Analysis

4.1. Introduction

This chapter presented and interpreted the findings of the study based on data collected from pre-service Life Sciences teachers and their lecturers in a PGCE program. It focused on how the PGCE program influenced the development of TPACK and aligned the findings with the guiding conceptual frameworks: TPACK and the Synthesis of Qualitative Data (SQD) model. These frameworks provided the analytical lens through which the data is interpreted, allowing for a deeper understanding of how institutional design (SQD) and knowledge integration (TPACK) contribute to or hinder the readiness of pre-service teachers.

This study's purpose was to explore the influence of PGCE Life Sciences teacher education on the preparation of pre-service teachers for TPACK at a South African University, because they are already supposedly equipped with adequate science subject matter knowledge due to their strong undergraduate background. To explore the influence of the PGCE Life Sciences program on supporting the TPACK of the preservice teachers, the main research question was addressed; *How do the PGCE teacher education programs support the readiness of Life Sciences pre-service teachers for their TPACK?* This research question guided the study throughout by further stretching to other 4 sub-questions which will be used to present the findings in this study. This study has adopted a qualitative approach, and three qualitative instruments were used to collect the data- semi-structured interviews, content analysis & minilesson observations.

As argued on literature, the PGCE program is supposed to upskill the preservice teachers content knowledge, through equipping with the necessary pedagogical skills, attitudes and knowledge for them to become proficient teachers in the profession. This, then does not leave the technological knowledge and skills. In order to determine the preparedness of the preservice teachers for their TPACK by the program, I decided to firstly interview the teacher educators- lecturers, to get their perceptions on how they think the preservice teachers are being prepared in the training program by them first, for TPACK. Then, after this, the preservice teachers' content knowledge test marks of the participants were collected to see if they all obtain the 80% pass mark, which was said to be the acceptable score for teachers who must be the master of the content they teach (Shulman, 1986).

Thirdly, the 5 selected preservice teachers, were interviewed to find out according to their point of view, how they think the program prepare them for TPACK, to determine if there is complement between their perceptions and those of the lecturers. The final data was collected thorough observations, of the

preservice teachers minilessons. This was then to see if what both the lecturers as well as the students themselves claimed was actualized in their minilessons, which was where they were teaching different Life Sciences topics. I will now begin with presenting the results of the study in the next sections. Starting with the lecturers' interview responses, followed by the content test mark analysis, then moving to the preservice teachers interview responses, and then lastly, I will present the results from the minilessons observation schedule. The interview responses from both lecturers and the preservice teachers will then be further followed by an inductive analysis approach, this was because I wanted to find their perceptions on the influence of the program for TPACK, thus the coded data from this instrument was further grouped according to the identified themes and categories during the qualitative coding.

4.2. Results

4.2.1. Lecturers' interview responses

The interviews were conducted to determine the preparation of preservice teachers with regards to their TPACK, by the PGCE program. The responses to the interview questions were provided by the 2 interviewed participants. The analysis of the interview data followed a thematic analysis, as stated in the methodology. Themes from the coded interviews were identified and grouped into categories to make sense of the data in addressing the research questions of this study. Both lecturers confidently believed that the PGCE teacher program, sufficiently prepared the preservice teachers. The lecturers highlighted several key interventions within the PGCE program aimed at fostering TPACK competencies. Their perspectives focused on structured ***microteaching and minilessons, and teaching experience (TE)*** as some of the key intervention components (see table 5).

According to lecturers, TPACK scaffolding also played a significant part in supporting and encouraging the readiness of the preservice teachers for TPACK, as one of the interventions by the PGCE program. This was done by introducing TPACK principles gradually, with structured guidance to help students transition from theory to practice. The exposure to real-context teaching and importance of the teaching experience (TE) was also noted and through which the lecturers ensure that, the preservice teachers are prepared for such experience in advance through the micro teaching and minilessons activities. For example, both lecturers validated this assumption- *"TE is where students get to really test their ability to integrate technology into their lessons."* And *"...we prepare them through micro-lessons so that they are confident during their Teaching Experience (TE)."*

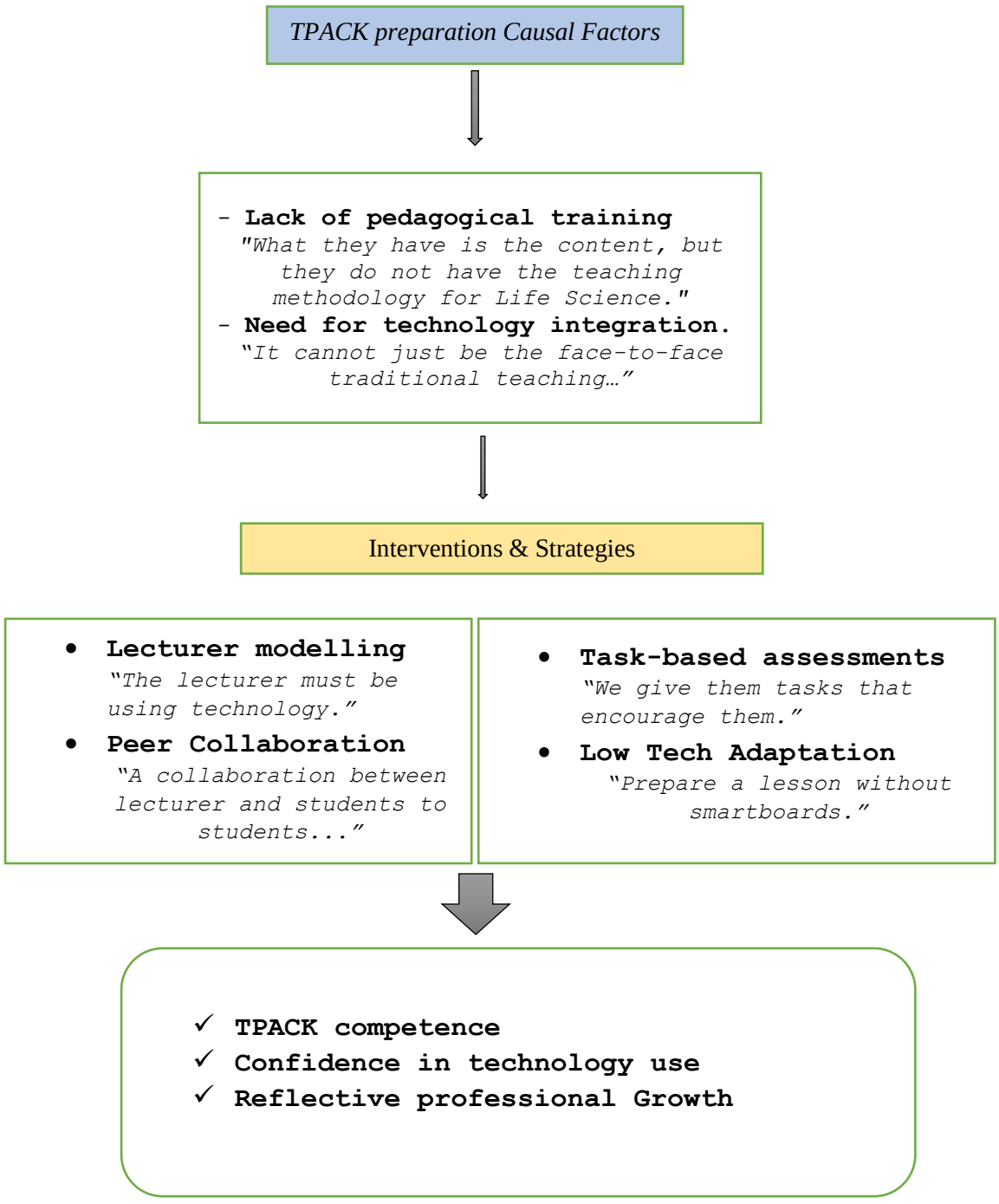
TABLE 5: Summary of Themes and Features for Research Question 1 and 2 (Lecturer Interviews)

Theme	Feature	Represents	Number of Cases	Participant	Counts	Evidence Quotes
Interventions in PGCE	Microteaching & Minilessons	Structured learning practice	3	Lecturer 1	4	*"Minilessons allow students to experiment with integrating technology in a controlled setting."*
	Teaching Experience (TE)	Hands-on teaching exposure	3	Lecturer 2	3	*"The teaching experience ensures they get real exposure to classroom technology applications."*
Effective Methods in PGCE	Reflection & Self-Assessment	Continuous improvement	2	Lecturer 1	3	*"Reflecting on TPACK usage after teaching helps them refine their methods and troubleshoot issues."*
	Use of Simulations & Virtual Labs	Enhancing conceptual learning	3	Lecturer 1, Lecturer 2	5	*"Simulations offer an effective way to teach abstract concepts without requiring physical resources."*
	Student-Centered Approaches	Engaging learners interactively	2	Lecturer 2	3	*"We encourage student-centered teaching strategies to ensure active participation in lessons."*

According to the lecturers' point of view, there are few driving factors for the need of TPACK preparation for the preservice teachers in the PGCE program. Some of those factors included the lack of pedagogical training from the incoming PGCE student into the program. **Lecturer 2** argued that *"what they have is the content,,,,"*, claiming that the students come with strong content knowledge and less on their pedagogical knowledge. While **lecturer 1** also indicated this, "*... then you know these teachers have been prepared for all these components, rather than just being people that can be able to share their knowledge in terms of content."* Another driving factor was the complexity of Life Sciences concepts. This is because of the nature of Life Science being an abstract subject. As seen in the response by **lecturer 2:** *"Life Sciences is dealing with cells,,, some of the things are micro, that the students cannot see. But if you're using TPACK, then you include some application."* And then again, there is diverse technological backgrounds, as another driving factor why it is necessary for preparing the preservice teachers for TPACK. Which was emphasized in both

lecturers' responses, alluding to the fact that preservice teachers have diverse backgrounds or experiences in their interaction with technology. **Lecturer 2:** *"...some students come from technologically advanced backgrounds, but others are left behind."*

The primary focus of the PGCE Life Sciences program is to equip pre-service teachers with the necessary **Technological, Pedagogical, and Content Knowledge (TPACK)** for effective teaching in modern classrooms. The concept mapping below summarises the insights and experiences of the lecturers on the significance of the PGCE program for TPACK readiness of preservice teachers.



The lecturers believed that they have sufficiently prepared the preservice teachers for TPACK competence; *"By the time they finish their PGCE, they are ready to become teachers"*- **Lecturer 2.** While the point made by **Lecturer 1,** *"They have a reflection session…",* shows how the lecturers are paying attention to their role as one of the subscales of the SQD model, in ensuring meaningful reflections.

4.2.2. Results from Content Analysis of Preservice teachers' tests

As discussed in chapter 3 (section 3.4, page 25) of this report, one of the instruments used to collect data was the content/ text analysis, whereby the purpose was to find out the how the preservice teacher performed on the Life Sciences test. The study did not only look the lecturers' perspectives to explore the purpose of the study, but it also involved getting data from the concerned subject, the preservice teachers. Content analysis of the preservice teacher's tests was also used to determine their content knowledge levels. I had mentioned already in the methodology sections, that preservice teachers are expected to and must have a strong content knowledge, and be masters of the subject, Life Sciences.

In this research, the test marks of the 5 preservice teachers were collected and analysed. Before presenting these results, it was crucial to briefly analyse the educational background of the preservice teachers, the undergrad qualification they hold, their areas of specialization or discipline (see table 4). Using the demographic data, we can analyse how participant backgrounds, prior experience, and content knowledge test scores relate to their TPACK readiness and perceptions. The demographic information of the preservice teachers revealed that, they all did the same undergrad degree. Participants were all ***BSc graduates*** with varying specializations (Physiology, Biochemistry, Zoology, Physics, etc.). Three of them (***Tsholo, Mbali, and Thabo***) had prior teaching experience before the PGCE. Nandi and Sino had no prior teaching experience**,** meaning their exposure to pedagogical practices started with the PGCE**.** Although they had varying majors, it was interesting to determine that they all did the Bachelor of Science degree, which means they must have had the same content experience, probably on their first year of the BSc study.

TABLE 6: Preservice teachers and their educational background with content test scores.

Participant Pseudonym	Gender	Age range	Qualification & specialisations	Content (CK) Test score
Nandi	Female	20-30	BSc Physiology, Genetics & Psychology	87
Tsholo	Female	20-30	BSc Physics & Mineral	83,33
Mbali	Female	20-30	BSc Biological Science	86
Sino	Female	20-30	BSc Human Physiology & Biochemistry	89,67
Thabo	Male	30-40	BSc Physiology & Zoology	83,67

Index:

< 80	80 - 84	85- 95	> 95
Not acceptable	Basic	Proficient	Sophisticated

From the data above, all participants had above the acceptable score, 80, which was the pass mark or standard set by the PGCE Life Sciences program. The preservice teachers then confirmed that having science qualification prior to joining PGCE means high or proficient subject matter knowledge, which is the content knowledge (CK) component of the TPACK. Sino had one of the highest CK test scores (89.67%), with specialisations of Human Physiology and Biochemistry. Both Tsholo and Thabo also had good CK (83.33% and 83.67%) respectively. A strong CK score was also shown for Nandi (87%). The content test scores does show some degree of strong and proficiency in terms of the content knowledge of the preservice teachers. Which was the reason why this analysis was done, to determine their CK component as qualifying PGCE students. This may translate to good mastery of the subject during teaching practice when effectively integrated with the other TPACK knowledge components, and this will be further analysed in comparison with their TPACK level which will be determined in the minilesson observation results section of this chapter later on.

4.2.3. Results from the Preservice teachers Interviews

Pursuant within this paper, preservice teachers' TPACK preparation was also established by asking them questions during interviews to gain insight into how they perceive TPACK constructs. The purpose of the study's interviews was to find out how participants perceived the PGCE program in relation to their preparedness for TPACK. The thematic approach stated in chapter 3, section 3.5, and page 20 was followed to evaluate the interview data.

The analysis of the responses given by the preservice teachers generated the themes that will be discussed below to reveal the role and interventions of the PGCE Life Sciences program in supporting and developing the TPACK of the preservice teachers.

i) Strengths of the PGCE Program in TPACK Preparation

The PGCE program plays a central role in providing structured TPACK training and digital lesson planning as the PGCE Life Sciences program emphasizes technology integration, requiring pre-service teachers to design lesson plans with digital tools, according to **Nandi** and **Tsholo**. *"Almost every week, we had to prepare a digital lesson using technology."* (Nandi) *"We were given assignments to create lesson plans integrating videos, simulations, and other tech tools."* (Tsholo). Another identified strength of the program as mentioned by **Thabo** and **Tsholo**, was the Teaching Experience (TE) which they believed to have acted as a key learning opportunity for the preservice teachers during the program. This is because the Teaching Experience (TE) allows pre-service teachers to test TPACK application in real classrooms. *"During TE, I was able to teach with technology in a real-life classroom setting. That really helped me."* (Thabo) *"I was well-prepared to use simulations when teaching grade 11 and grade 8."* (Tsholo). The strength of the program in TPACK preparation also included encouraging reflection and continuous improvement. Structured reflection on lesson planning and TPACK application enhances professional growth. *"Reflecting after lessons helped me see what worked and what didn't."* (Sino) *"During microteaching, we reflected on how technology influenced learning, and I realized what I needed to improve."* (Nandi). Another emerging theme for the strength of the program for TPACK readiness was collaborative learning and peer support in TPACK development, according to Sino and Nandi. Peer discussions allowed pre-service teachers to exchange digital teaching strategies. *"When we discuss with our peers, we get different perspectives on using technology in teaching."* (Sino) *"Group projects helped me learn about tech tools I didn't know before."* (Nandi)

ii) Challenges in TPACK Development

Question 7 of category B, preservice teachers were asked, *what **challenges** do you still encounter in applying your TPACK knowledge and skills in actual classroom settings?* The responses were analysed and they revealed that preservice teacher still encountered some challenges in terms of their TPACK in actual classroom settings. Some of these challenges are discussed below and presented in the summary table (Table 6). The first challenge, was limited hands-on technology training in PGCE. As perceived by both **Mbali** and **Nandi**, pre-service teachers feel they lack practical exposure to using technology in

classrooms, which was also aligned with the responses from the preservice teachers whether they perceived the 1-year study period adequate time to complete all the necessary skills for PGCE students. Preservice teachers felt that the duration of the PGCE program is inadequate. *"We don't get enough opportunities to practice using technology before teaching."* (Mbali) *"We were told about technology tools, but we were not trained on how to use them effectively."* (Nandi) Expressed by 4 of the 5 preservice teachers (Nandi, Sino, Mbali and Thabo) was the perception that the PGCE program does not provide adequate time.

"No, I don't think it has adequate time. I I believe that the programme is quite packed, it has a lot of work and some topics feel rushed"- **Sino.** Which was also supported by **Nandi**, *"No, no, no, no, 'cause. We're doing what B.Ed. students are doing in four years in just a year. So I it's really, it's really not enough."*

Then there were confidence gaps in using technology for teaching, also perceived to be a challenge in the development of preservice teachers' TPACK. Some pre-service teachers struggle to balance technology with pedagogical demands as declared by **Sino** and **Thabo**. *"Sometimes, I find it difficult to balance the use of technology with teaching demands."* (Sino) *"At the moment, I don't think I can confidently say I can teach lessons that combine content, pedagogy, and technology effectively."* (Thabo)

There were other challenges with minimal lecturer support during TE. Preservice teachers may be needing more than just TE as an assessment tool, but as a guidance tool or support. Again, **Nandi** and **Thabo** expressed in their responses that lack of frequent lecturer guidance during TE makes it harder to implement TPACK. This finding aligned directly with SQD's emphasis on modelling and authentic experience. When modelling is absent, TK and its intersections with PK and CK (i.e., TPK, TCK, and TPACK) do not develop effectively. As such, the analysis highlighted the need for consistent and deliberate demonstrations of technology-enhanced pedagogy by teacher educators.

"Lecturers only visit once during TE, and by then, we've already faced most challenges alone." (Thabo) *"There should be more lecturer support during TE, not just one visit."* (Nandi)

Limited Technology Access in Schools

Nandi and **Mbali** also indicated that many pre-service teachers struggle to implement TPACK due to a lack of resources in their TE schools, there is limited technology access in Schools. *"We need more resources because many schools don't have the technology we are trained to use."*

(Mbali)

"I struggled during TE because the school had no smartboards or projectors." (Nandi)

Last challenge explored was challenges in Selecting the Right Technology for Teaching a few of the pre-service teachers encounter difficulty to align digital tools with lesson objectives. *"It's difficult balancing digital teaching methods with traditional teaching methods."* (Mbali) *"Sometimes, technology takes too much time, so I end up just using a textbook."* (Sino). From a TPACK perspective, the failure to integrate ICT in Life Sciences classrooms due to external constraints suggests that even when pre-service teachers possessed theoretical TK, the absence of authentic practice undermined its application. The findings thus highlighted the interdependency of TPACK's internal knowledge domains and SQD's structural and pedagogical supports.

iii) Effective Teaching Strategies for TPACK Readiness

Preservice teachers were also asked the question, *what methods used in the programme do you perceive to be the most effective when it comes to preparing your TPACK for future practise?* So, after analysis, the responses were categorised and grouped into themes that addressed the question, because the purpose of the question was not only to name the methods, but rather to identify to what extent did those methods effectively prepare them for comprehensive TPACK preparedness. Minilessons/ microteaching as TPACK training tools came first as the most effective method in the PGCE program according to the preservice teachers. Pre-service teachers value structured microteaching as a way to test their TPACK skills.

"Minilessons helped us see how far we are in terms of readiness for real classroom teaching." (Mbali)

"The PGCE required us to integrate technology into microteaching, which made us think deeply about its impact." (Nandi)

And another method recorded by **Thabo** and **Mbali**, was using technology for visualizing abstract science concepts. This is because Life Sciences is believed to be an abstract subject, so according to the preservice teachers, Simulations, animations, and virtual labs help learners grasp difficult Life Sciences topics.

"Instead of just talking, I can use a simulation to show how DNA codes for proteins." (Thabo)

"Technology helps learners visualize microscopic processes they can't see in real life." (Mbali)

Lastly, the program introduced TPACK as a method of Student-Centered Learning with Technology to the PGCE students. Interactive learning approaches such as gamification and flipped classrooms engage learners.

"I use Cahoots and interactive quizzes to make lessons more engaging." (Sino)
"Giving students videos before class allows them to come prepared for discussions." (Nandi)

TABLE 7: Summary of the categories of codes for preservice teacher's interview and connections.

Category	Subcategories (Derived from Initial Codes)	Relationships & Connections
PGCE Interventions for TPACK Readiness	- CTML and TSPCK frameworks - Teaching Experience (TE) - Digital lesson planning	**PGCE provides structured exposure** to technology integration, but practical implementation remains limited.
Perceived Effective Methods for TPACK Development	- Microteaching and mock lessons - Lesson planning with technology - Use of digital tools - Peer discussions	Teachers learn best through hands-on experience and peer collaboration, reinforcing TPACK components.
Challenges in TPACK Development	- Time constraints in PGCE - Lack of hands-on training - Infrastructure issues - Struggles with technology selection	TPACK, in theory is emphasized, but real-world constraints hinder its effective implementation.
TPACK Influence on Future Teaching Practices	- Increased confidence in tech integration - Adapting to diverse learning styles - Enhancing engagement - Potential implementation barriers	Pre-service teachers see the value of TPACK, but express concern about practical challenges in applying it.

These findings suggested that the Participants identified lesson planning workshops, micro-teaching, and peer feedback as helpful strategies for developing teaching skills. These strategies directly align with the SQD model's emphasis on *instructional design* and *collaboration*. The PGCE program's use of simulated teaching scenarios was seen as useful in fostering pedagogical strategies (PK) and linking them with subject content (CK), yet most students reported minimal use of technological tools, indicating a weakness in technological knowledge (TK) integration.

TABLE 8: Themes and their features related to the research questions

Research Question	Theme	Description	Example Quote
RQ1: Interventions	Structured TPACK Training Through Microteaching/Minilessons	Hands-on practice sessions enable integration of technology, pedagogy, and content.	*"Minilessons helped us see how far we are in terms of readiness for real classroom teaching"* (**Mbali**)
	Teaching Experience (TE)	Real classroom teaching experience enhances TPACK application.	*"The practical teaching experience during TE helped me test what I learned about TPACK"* (**Thabo**)
	Limited Hands-On Technology Training	Theoretical discussions dominate; practical digital tool training is insufficient.	"*The PGCE did not teach me anything about how to use technology"* (**Sino**)
RQ2: Effective Methods	Use of Technology for Visualizing Concepts	Digital tools help illustrate complex scientific concepts effectively.	"*I can use virtual labs for experiments that may not be possible in a normal classroom"* (Mbali)
	Active Learning Strategies	Interactive methods and gamification improve learner engagement.	*"I create pre-video questions to keep them engaged"* (Thabo)
	Role of Reflection	Reflective practices help refine TPACK integration over time.	"*Reflecting after using technology in class helps me improve my TPACK skills"* (Sino)
RQ3: Difficulties	Limited Time for TPACK Development	The duration of the program restricts full competency development.	"*I don't think one year is enough to develop all the necessary teaching skills"* (Mbali)
	Unequal Exposure to Technology	Variability in technological familiarity hinders uniform development.	"*I don't know enough about technology*" (Sino)
	Balancing Pedagogy and Technology	Struggle to integrate technology meaningfully with pedagogical methods.	"*Sometimes, I find it difficult to balance the use of technology with teaching demands*" (Sino)
RQ4: Future Impact	Increased Confidence and Adaptability	TPACK training builds confidence and adaptability in diverse school settings.	"*By the end of PGCE, I felt confident in using technology*" (Mbali)
	Commitment to Lifelong Learning	Pre-service teachers are motivated to continue developing their digital skills.	"*Even after PGCE, I want to keep up with new technology trends"* (Mbali)

Findings also suggested that the PGCE program provides structured learning opportunities that facilitate the integration of pedagogy (PK), content (CK), and technology (TK). Microteaching, reflective practices, and peer learning were identified as valuable components as summarised on the table (Table 8). The thematic analysis highlighted that the PGCE Life Sciences program systematically supports TPACK development through structured training, modelling, and assessment. However, disparities in technological competence, school resources, and student attitudes present challenges. The program addresses these issues through task-based learning, scaffolding, and reflective practices, ensuring that pre-service teachers are well-prepared for technology-integrated teaching.

4.2.4. Results from the minilesson observation

After getting the perceptions of both the lecturers and the preservice teachers, I then decided to observe the lessons of the students during their minilessons presentations. The analysis of the minilesson observation took a deductive approach, this was because the codes were derived from the TPACK components (M. Koehler & Mishra, 2009). Table 9 below shows the summarized information about the preservice teachers' teaching experiences, technology exposure, minilesson topic and technology tools used.

TABLE 9: Minilesson observation of Pre-Service Teachers

Participant	Teaching Experience	Technology Exposure	Mini-Lesson Topic	Technology Used
Nandi	No prior experience	Basic ICT training, PowerPoint, simulations	Reproduction (Grade 12)	PowerPoint slides
Tsholo	University assistant (limited)	Microsoft Office, simulations	Meiosis (Grade 10)	Projector, laptop
Thabo	6 months voluntary teaching	Whiteboards, projectors	Cellular Respiration (Grade 11)	PowerPoint, projector, laptop
Sino	No prior experience	Limited exposure to ed-tech tools	Cell Division (Grade 10)	PowerPoint slides
Mbali	No prior experience	Basic PowerPoint usage	Reproduction (Grade 12)	PowerPoint slides

The mini-lesson observations were scored using the TPACK framework, with categories evaluating Pedagogical Knowledge (PK), Technological Knowledge (TK), Content Knowledge (CK), and the integration of these components (TPACK). Each of the participants that were observed gave consent for the lesson to be recorded for the purpose of this study. Subsequently, the preservice teachers' lesson observations were recorded on the minilesson observation schedules using the scores 1 to 4, whereby 1 represented poor and 4 excellent for each event in the respective components of TPACK (see Table 10). Table 10, was inserted for a better understanding of how the preservice teachers were scored and the

criteria used during the minilesson observation. Refer to Appendix C for the complete minilesson observation scores which was recorded in the schedules. All the preservice teachers had to choose any topic of their preference in which they were going to teach it integrating all the TPACK components. It was observed also that the lecturers employed peer assessment during the minilessons, whereby the students marked each other's rubrics, and the lecturers themselves played the role by ensuring reflections and providing feedback at the end of each minilesson, allowing the preservice teachers an opportunity to reflect on their minilesson presentations.

TABLE 10: Minilesson observation schedule scoring for Nandi

TPACK OBSERVATION CHECKLIST		Poor	Good	Very Good	Excellent	**Score**
Pedagogical Knowledge (PK)						
1.	Teacher knows essential pedagogical approaches for the lesson preparation & presentation	1	2	3	4	**3**
2.	Teacher displays understanding of different learning styles of learners	1	2	3	4	**3**
3.	Teacher structures the lesson to promote learning	1	2	3	4	**2**
Technological Knowledge (TK)						
1.	Teacher has essential technology tools for the lesson	1	2	3	4	**3**
2.	Teacher utilizes technology to support teaching strategies	1	2	3	4	**4**
3.	Teacher uses technology tools without any problems	1	2	3	4	**4**
Content Knowledge (CK)						
1.	Teacher exhibits a good mastery of subject matter knowledge	1	2	3	4	**4**
2.	Teacher provides a variety of reference for the learners to gain relevant content taught	1	2	3	4	**3**
3.	Teacher presents relevant and accurate facts in relation to the topic	1	2	3	4	**3**
Technological Content Knowledge (TCK)						
1.	Teacher uses technology to show complex ideas that would otherwise be difficult to learn	1	2	3	4	**3**
2.	Teacher uses technology to allow learners to observe things that would otherwise be difficult for the naked eye	1	2	3	4	**4**
3.	All teaching aids are attractive & support the lesson theme	1	2	3	4	**3**
Technological Pedagogical Knowledge (TPK)						
1.	The teacher introduces technology-based tasks that enable learners to engage in the learning process	1	2	3	4	**3**
2.	Teacher uses technology to interact and collaborate with learners in different activities					**2**
TPACK OBSERVATION CHECKLIST		Poor	Good	Very Good	Excellent	**Score**
3.	Teacher adapts the use of technology to promote problem-based learning approaches in teaching & learning activities.	1	2	3	4	**3**
Technological Pedagogical and Content Knowledge (TPACK)						
1.	Teacher teaches a lesson that appropriately combines subject content, technologies and teaching and learning approaches	1	2	3	4	**2**
2.	Teacher uses technology to promote learners learning of the topic being taught	1	2	3	4	**3**
3.	Teacher is well prepared and able to manipulate technology to present relevant lesson content	1	2	3	4	**2**
4.	Teacher uses technology to promote learners' collaborations and engage learners during the lesson	1	2	3	4	**3**
	Total score:					**57**

TABLE 11: All the preservice teachers Mini-Lesson Observation Scores (Out of 70)

Participant	PK Score	TK Score	CK Score	TCK Score	TPK Score	TPACK Score	Total Score
Nandi	8/12	10/12	11/12	8/12	7/12	10/16	**57/70**
Tsholo	8/12	9/12	12/12	8/12	7/12	9/16	**57/70**
Thabo	12/12	10/12	12/12	9/12	9/12	11/16	**69/70**
Sino	10/12	9/12	11/12	8/12	7/12	9/16	**57/70**
Mbali	10/12	9/12	12/12	8/12	7/12	10/16	**63/70**

Key Findings summarized from the minilesson observations

According to the collected data summarised on Table 11**, Thabo** scored the highest (69/70)**,** thus demonstrating strong pedagogical, technological, and content integration**.** While **Nandi**, **Tsholo**, and **Sino** all scored 57/70**,** indicating limitations in either technology use or integration strategies**.** However, **Mbali** (63/70) showed strong content and pedagogical knowledge but had minor technology gaps**.**

Theme 1: Strong Content Knowledge, but Limited Technology Integration Skills (TABLE 12)

Evidence from Observations	Supporting Data
Pre-service teachers showed strong content mastery in lesson delivery.	*"Teacher exhibits a good mastery of subject matter knowledge."* (Observation - Thabo) 【50】 *"Teacher presents relevant and accurate facts in relation to the topic."* (Observation - Sino) 【49】
Some struggled with technology integration beyond basic PowerPoint slides**.**	*"Technology was mainly used to present slides rather than for active learning."* (Observation - Nandi) 【48】 *"Lesson was structured well, but technology was underutilized."* (Observation - Tsholo) 【51】

Pre-service teachers understand content well**,** but there are gaps that showed they need better training in using technology interactively rather than just for presentations in a science classroom. Many pre-service teachers expressed concerns about their readiness to implement ICTs in actual Life Sciences classrooms. Despite their confidence in subject matter and general teaching techniques, they lacked confidence in selecting appropriate digital tools aligned with curriculum goals. This reflects a gap in developing *technological content knowledge (TCK)* and *technological pedagogical knowledge (TPK)* both essential for full TPACK competence.

Theme 2: Variability in Pedagogical Approaches and Learner Engagement (TABLE 13)

Evidence from Observations	Supporting Data
Some lessons were teacher-centered, relying on direct instruction rather than learner engagement.	*"Teacher-led lecture approach rather than interactive engagement."* (Observation - Mbali) 【47】
Others used technology to encourage learner interaction.	*"The questioning and teaching skills were acceptable and satisfactory for the use of technology."* (Observation - Tsholo) 【51】
Thabo demonstrated the most effective learner-centered approach.	*"Good tool for the topic, and strategy showing excellent linking between technology, content, and pedagogy."* (Observation - Thabo) 【50】

The learner-centred approach improves engagement, but not all pre-service teachers applied it effectively during the lesson. Training should focus on balancing pedagogy with technology use to make lessons more interactive.

Theme 3: Some Teachers Lack Confidence in Using Advanced Technological Tools (TABLE 14)

Evidence from Observations	Supporting Data
Some teachers hesitated in using digital tools fully.	*"Teacher used technology well but was hesitant in handling digital tools."* (Observation - Tsholo) 【51】
Limited variety of technological tools used across lessons.	*"Most students used PowerPoint slides with minimal interactive elements."* (Observation - Sino) 【49】
Some overcame challenges by adapting technology creatively.	*"Teacher was well-prepared and able to manipulate technology effectively."* (Observation - Thabo) 【50】

The challenges observed was that some pre-service teachers need more hands-on training to build confidence in using interactive technology tools. More exposure to simulations, gamification, and digital lab activities would enhance engagement and confidence.

TABLE 15: Summarised preservice teachers minilesson observations analysis

TPACK Component	Nandi	Tsholo	Mbali	Sino	Thabo
Pedagogical Knowledge (PK)	**Moderate** – Structured lesson but lacked engagement. *"There was evident interaction between the teacher and those she is teaching."*	**Weak** – Limited adaptation to learning styles. *"Teacher displays understanding of different learning styles" (Score: 2).*	**Strong** – Well-structured lesson, effective classroom management. *"Teacher structures the lesson to promote learning." (Score: 4)*	**Moderate** – Structured lesson, but limited interactive strategies. *"Teacher structures the lesson to promote learning." (Score: 4)*	**Strong** – Adapted lesson to learning styles and classroom needs. *"Teacher knows essential pedagogical approaches." (Score: 4)*
Technological Knowledge (TK)	**Moderate** – Used PowerPoint but lacked broader tech expertise. *"Teacher utilizes technology to support teaching strategies." (Score: 4)*	**Weak** – Used projector and laptop, but struggled with integration. *"Some limitation in technology knowledge."*	**Strong** – Used PowerPoint effectively but could expand to interactive tools. *"Teacher uses technology tools without any problems." (Score: 3)*	**Weak** – Basic use of PowerPoint but lacked engagement. *"Teacher uses technology tools without any problems." (Score: 3)*	**Good** – Confident with technology but relied on presentation tools. *"Teacher has essential technology tools for the lesson." (Score: 4)*
Content Knowledge (CK)	**Strong** – Good subject mastery, but limited application. *"Teacher exhibits a good mastery of subject matter knowledge." (Score: 4)*	**Strong** – Demonstrated accurate facts and references. *"Teacher presents relevant and accurate facts in relation to the topic." (Score: 4)*	**Very Strong** – Confident in subject knowledge and reference use. *"Teacher exhibits a good mastery of subject matter knowledge." (Score: 4)*	**Very Strong** – Highest CK score but weak TPACK application. *"Teacher provides a variety of references." (Score: 3)*	**Very Strong** – Well-prepared content delivery. *"Teacher presents relevant and accurate facts." (Score: 4)*

Technological Content Knowledge (TCK)	**Limited** – Used PowerPoint but no advanced digital tools. *"Teacher uses technology to show complex ideas." (Score: 3)*	**Limited** – Used projector but lacked interactive tools. *"Technology knowledge limitations observed."*	**Good** – Used technology to clarify complex ideas but no simulations. *"Teacher uses technology to show complex ideas that would otherwise be difficult to learn." (Score: 3)*	**Limited** – PowerPoint used but lacked visualization of concepts. *"Teaching approaches supported technology tool, but limitations observed."*	**Moderate** – Used PowerPoint and projector effectively but no additional tools. *"Teacher uses technology to allow learners to observe things otherwise difficult." (Score: 3)*
Technological Pedagogical Knowledge (TPK)	**Limited** – Technology used for presenting, not interaction. *"Teacher introduces technology-based tasks that enable learners to engage in the learning process." (Score: 3)*	**Weak** – Some interactive tasks but lacked depth. *"Teacher uses technology to interact and collaborate with learners." (Score: 3)*	**Good** – Engaged learners but lacked variety in tools. *"Teacher introduces technology-based tasks that enable learners to engage." (Score: 2)*	**Weak** – No strong student-technology interaction. *"Teacher uses technology to interact with learners but limited."*	**Good** – Used problem-based learning approaches effectively. *"Teacher adapts the use of technology to promote problem-based learning." (Score: 3)*
Technological Pedagogical and Content Knowledge (TPACK)	**Limited** – Some integration but struggled with execution. *"Teacher teaches a lesson that appropriately combines subject content, technologies and teaching approaches." (Score: 2)*	**Limited** – Some integration but lacked effectiveness. *"Teacher uses technology to promote learners' learning of the topic." (Score: 3)*	**Very Strong** – Best combination of content, pedagogy, and technology. *"Teacher is well prepared and able to manipulate technology to present relevant lesson content." (Score: 3)*	**Weak** – Struggled to integrate content, pedagogy, and technology. *"Teacher teaches a lesson that appropriately combines subject content, technologies and pedagogy." (Score: 3)*	**Good** – Strong execution but limited variety in tools. *"Teacher uses technology to promote learners' collaborations." (Score: 4)*

4.3. Triangulation of the data (interviews, content test analysis and minilesson observation)

To ensure validity and reliability of findings, data from semi-structured interviews, content test analysis, and mini-lesson observations were triangulated. This allowed cross-verification of insights into pre-service teachers' TPACK readiness. There was an alignment between Semi-Structured Interviews and Mini-Lesson Observations. Interviews revealed that pre-service teachers felt confident in content knowledge but expressed concerns about limited hands-on exposure to digital tools. Mini-lesson observations confirmed this, as technology was mostly used passively rather than for interactive engagement. Content Test Analysis and teaching practice performance were also compared and contrasted, and it was established that pre-service teachers scored well in content tests, demonstrating strong CK. However, high CK scores did not always translate to effective TPACK application in lessons, for instance, **Sino** had the highest CK score but the lowest mini-lesson performance. The results also showed the link between prior teaching experience and technology integration such that both interviews from preservice teachers and lecturers (Table 16) and minilesson observations showed that pre-service teachers with prior teaching experience had better TPACK performance (see Table 20). Those with no teaching experience struggled to integrate technology effectively, reinforcing the need for structured hands-on digital training.

TABLE 16: The perspectives from both preservice teachers and lecturers

Theme	Pre-Service Teachers' Perspectives	Lecturers' Perspectives
1. PGCE Interventions for TPACK Readiness	- Strong theoretical focus on TPACK and CTML - TE (Teaching Experience) provides real-world application but lacks lecturer involvement - Limited practical exposure to tech tools	- Lecturers model technology use in their teaching - Assessment tasks require students to integrate TPACK - Mini-lessons prepare students for TE
2. Effective Methods for TPACK Development	- Microteaching and lesson planning help internalize TPACK - Simulations and gamification engage students - Peer discussions enhance collaborative learning	- Mini-lessons allow for practical application - Gamification, digital TSPCK, and interactive videos are effective - Student-centered learning is emphasized
3. Challenges in TPACK Development	- Time constraints in the one-year PGCE - Unequal access to technology among students - Lack of hands-on training on software and tools	- Students come from diverse technology backgrounds, leading to different skill levels - Some schools lack electricity, projectors, or access to technology - Some students lack motivation for teaching

4. Influence on Future Teaching Practices	- Confidence in using technology for student engagement - Adapting lessons for different learning styles - Some worry about limited resources in schools	- Lecturers prepare students for tech-limited classrooms - Student-centered, interactive teaching is emphasized - Continuous professional development is needed

TABLE 17: Content Knowledge (CK) vs. TPACK Readiness (Minilesson Scores & Perceptions)

Participant	CK Test Score (%)	Minilesson Score (TPACK Readiness)	Observation
Nandi	**87%**	**73%**	Strong CK but lower TPACK readiness
Tsholo	**83.33%**	**78%**	Balanced CK and TPACK skills
Mbali	**86%**	**90%**	High CK and highest TPACK readiness
Sino	**89.67%**	**55%**	High CK but lowest TPACK readiness
Thabo	**83.67%**	**85%**	Balanced CK and TPACK skills

High CK Doesn't Guarantee High TPACK Readiness

The Content Knowledge (CK) test scores and minilesson scores (TPACK readiness) as shown in Table 17, provided insight into how well participants transitioned from subject mastery to teaching practice using technology. **Sino** had one of the highest CK test scores (89.67%), yet she had the lowest TPACK readiness (55%)**.** This suggested that a strong content knowledge (CK) alone does not translate to effective TPACK skills, especially without prior teaching experience.

Prior Teaching Experience Improves TPACK Scores

Mbali (90%) and **Thabo** (85%) had prior teaching experience, and they had higher TPACK scores than those with no experience. **Nandi** and **Sino,** who had no teaching experience, had lower TPACK scores (73% and 55%)**,** despite good CK scores. This indicates that experience in a teaching environment helps bridge the gap between CK and TPACK application**.**

Balanced CK and TPACK Readiness

Tsholo and **Thabo** had strong CK (83.33% and 83.67%) and relatively high TPACK readiness (78% and 85%)**,** showing that a balance of CK, teaching experience, and exposure to technology helps in TPACK development. It was impressive to see that **Mbali** stood out as the most TPACK-Ready preservice teacher**,** *w*ith 86% in CK and 90% in TPACK, **Mbali** demonstrated that a strong balance of CK, teaching experience, and adaptability to TPACK concepts can lead to high teaching readiness in terms of TPACK**.**

TABLE 18: Perceptions vs. Actual TPACK Readiness

Participant	Self-Perceived TPACK Confidence (Based on Interviews)	Actual TPACK Score (Minilessons)	Mismatch?
Nandi	Feels comfortable with CK but struggles with tech integration	**73%**	Matches perception
Tsholo	Confident in using videos and simulations	**78%**	Matches perception
Mbali	Very comfortable with tech-based teaching	**90%**	Matches perception
Sino	Acknowledges difficulty in using technology effectively	**55%**	Matches perception
Thabo	Feels confident in TPACK but identifies classroom resource challenges	**85%**	Matches perception

In Table 18, the perceptions of the preservice teachers were analysed against their actual teaching practice during the minilesson observations, to determine whether what they had articulated during the interviews matches their practice for TPACK readiness. All participants' perceptions matched their actual TPACK scores. Those who felt confident performed well, and those who expressed struggles had lower scores. **Sino** struggled the most with TPACK, and she also self-reported difficulty in using technology effectively. **Nandi**, despite a strong CK score, also expressed difficulties in technology selection, which is reflected in her lower TPACK score.

TABLE 19: Summary of Findings

Key Factor	Main Findings
Prior Teaching Experience	Strongly linked to higher TPACK readiness (Mbali and Thabo had higher scores).
Content Knowledge (CK) vs. TPACK Readiness	High CK does not guarantee high TPACK readiness (e.g., Sino had high CK but low TPACK).
Technology Confidence vs. Performance	Participants' self-perceptions matched their actual TPACK scores.
Barriers to TPACK Development	Lack of hands-on training, prior experience, and classroom exposure are key barriers.

TABLE 20: Summary of findings and their alignment to the two conceptual frameworks.

Findings	TPACK Elements	SQD Elements	Interpretation
Lesson planning and peer feedback support pedagogy and content knowledge	PK (Pedagogical Knowledge), CK (Content Knowledge)	Instructional Design, Collaboration	The program supports PK and CK development but lacks consistent integration of TK for full TPACK development.
Limited use of technology in subject-specific teaching	Weak TK, TPK, and TCK	Absence of Modelling, Limited Authentic Experience	Lack of lecturer modelling limits the development of TPACK intersections, particularly TPK and TCK.
Students feel confident in CK and PK but unsure about digital tools for science	CK, PK, weak TCK and TPK	Inadequate Feedback and Reflection	Indicates a partial TPACK profile; insufficient support for developing TPACK fluency in science-specific teaching contexts.
Lack of lecturer modelling of ICT use in Life Sciences	Weak TPK and TCK	Absence of Role Modelling	Students are not observing effective technology use by educators, which hinders TPACK growth.
Minimal guidance during teaching practice	All TPACK intersections underdeveloped	Weak Feedback, Reflection, Collaboration	Lack of structured mentoring and reflection reduces integration of TPACK in real classroom settings.
Time constraints and unequal tech access in schools	Limited TK application	Structural Barriers (Not SQD element per se)	Contextual challenges prevent pre-service teachers from transferring theoretical knowledge into practice.

4.4. Chapter Summary

This chapter focused on the presentation and analysis of the findings of the study. The purpose of my study was to find out how does the teacher education program, which is the Life Sciences PGCE program prepares the preservice teachers for their TPACK at a South African university. The study followed a qualitative approach and the results were collected using qualitative research instruments as discussed in the previous chapter. The results gathered from the 3 instruments (semi-structured interviews, content analysis and observation) were presented and showed that both the lecturers and the preservice teachers have a strong confidence on the influence done by the Life Sciences PGCE program for TPACK preparedness, as this has been interpreted and discussed in more details in the next chapter of this paper. The study found that while PGCE students had access to online platforms like Ulwazi and Microsoft Teams during coursework, these platforms were not embedded meaningfully into subject-specific pedagogy. The lack of role modelling from lecturers—a critical SQD element—was frequently cited. Students reported limited exposure to seeing their lecturers model the use of technology in Life Sciences instruction, which impeded their ability to transfer theory into practice.

Chapter 5: Discussion & Conclusions

5.1 Introduction

In this chapter I will provide a broad explanation and interpretation of the findings from the study. Again, it is imperative to remember that the purpose of this study was to explore the influence of the PGCE Life Sciences program on the preparation of the preservice teachers for their TPACK at a South African University. The lens of the TPACK as the conceptual framework was employed in this study in order to establish the understanding of the perceptions of the preservice teachers as well as the lecturers for the preparedness of their TPACK as a crucial skill for science teaching in the 21st century. Additionally, the SQD model by Tondeur (2012) was also incorporated to determine how the use of technology by the lecturers during the PGCE program has influenced the preparedness of the preservice teachers' TPACK.

Preservice teachers were not merely studied to get their understanding of the TPACK as an educational theory, but instead their level of preparedness to integrate all these knowledge components for effective teaching in a science classroom. A qualitative research design was used for that purpose, getting a more in-depth experience of the preservice teachers on their TPACK readiness, as well as the lecturers' perspectives on this. Having shown or presented the results on chapter 4, I am now going to show how the research questions were addressed by the findings. The main research question was- *How do the PGCE teacher education programs support the readiness of Life Sciences pre-service teachers for their TPACK?* The main research question was to determine the support that the program provided to the preservice teachers and to what extent did that enhance their TPACK levels of readiness for future teaching practice, in order to get more information from the participants, four research sub-questioned were followed and answered in this study;

- *What interventions are employed in the PGCE teacher education programs to support the readiness of Life Sciences pre-service teachers for TPACK?*
- *What do Life Sciences pre-service teachers perceive to be the effective methods used in the PGCE teacher education for TPACK readiness in the science classrooms?*
- *What are the difficulties faced by pre-service teachers in relation to TPACK development during their training?*
- *How can TPACK readiness in the PGCE teacher education influence the Life Sciences pre-service teacher future classroom practices?*

This discussion showed the interpretation of the findings and how they answered the research questions. So, this chapter was structured around the research questions and how the findings have addressed those research questions from the semi-structured interviews, the content analysis and the minilesson observation. Table 21 shows the summary of the findings of the study as presented in chapter 4 together with their interpretations, how they link to existing literature and their implications.

TABLE 21: Summary of findings and interpretations and synthesis

Theme/Key Finding	Interpretation	Connection to Literature	Implication	Recommendation
Pre-service teachers demonstrate strong content knowledge but struggle with interactive technology use.	PGCE training enhances content mastery, but there is a lack of hands-on digital training beyond PowerPoint.	Mishra & Koehler (2006) emphasized the need for balanced TPACK integration. Chai et al. (2013) stressed the importance of using interactive digital tools beyond PowerPoint.	Limited digital pedagogical training in PGCE programs affects teachers' ability to create engaging, technology-integrated lessons.	Introduce structured hands-on workshops focusing on interactive tools such as simulations, virtual labs, and inquiry-based digital learning.
Teaching experience positively influences TPACK readiness.	Pre-service teachers with prior teaching experience are more confident in integrating technology into lessons than those without experience.	Agyei & Voogt (2012) and Admiraal et al. (2017) found that teachers with prior experience are better at selecting and integrating technology effectively.	New teachers may struggle with TPACK application if they do not have prior classroom experience.	Increase mentorship and peer-teaching opportunities in PGCE programs to support those with no prior experience.
Limited student engagement through technology.	Technology is mostly used for delivering content rather than for interactive, student-centered learning.	Tondeur et al. (2017) and Valtonen et al. (2018) highlight that many teacher education programs focus more on digital literacy than on pedagogical application.	Without training in interactive technology use, teachers may struggle to implement engaging lessons.	Incorporate problem-based learning and gamification techniques into PGCE technology courses.
Challenges in accessing digital tools and lack of structured guidance during Teaching Experience (TE).	Schools where pre-service teachers are placed often lack sufficient technological resources, and guidance on using technology in TE is minimal.	Kavai & Nyamupangedengu (2021) and Ramnarain et al. (2021) highlight infrastructure limitations in South African schools as a barrier to TPACK implementation.	Teachers may not develop strong digital pedagogical skills if they do not have access to necessary resources during TE.	Improve school-university partnerships to ensure pre-service teachers are situated in well-resourced schools for TE and receive better support from mentors.
TPACK readiness influences pre-service teachers' future classroom practices but is limited by school infrastructure.	Teachers trained in TPACK may not be able to fully implement technology-integrated lessons due to disparities in school infrastructure.	Ramnarain et al. (2021) argue that resource disparities affect teachers' ability to apply TPACK effectively.	Many newly qualified teachers may struggle to integrate technology due to limited access to resources.	Advocate for policy changes to provide equitable digital resources in schools and create professional development programs for new teachers.

The qualitative data provided deep understanding on how the preservice teachers think the program has influenced their preparedness for TPACK. In response to research question 1, all the 5 preservice teachers and the 2 lecturers were confident on the interventions provided by the PGCE Life Sciences program for supporting their TPACK. According to the lecturers, there are a lot of interventions in place to help develop the preservice teachers in terms of their TPACK readiness, such as modelling the use of technology, this was also supported by Tondeur (2012) SQD Model as it showed that the lecturers as role models in emulating and showing the preservice teachers how technology can be used for teaching during the program and incorporating assessment tasks that require teaching with technology. This was also supported by the preservice teachers themselves as they believed the lecturers played a crucial role in their TPACK preparedness in the program. One participant said *"Almost every week, we had to prepare a digital lesson using technology."* Which was also supported by another one stating that *"We were given assignments to create lesson plans integrating videos, simulations, and other tech tools."* This confirmed that the interventions asserted by the lecturers were significant in ensuring that the program was preparing the preservice teachers' TPACK. The SDQ Model (figure 2) also speak of instructional design, and as stated by the preservice teachers, they were developing lesson plans integrating videos, simulations, and other various technological tools that they would use for their teaching practice. But it was surprising to note that another participant did not hold the same opinion about this. **Sino** said "*The PGCE did not teach me anything about how to use technology"*. The analysis of those two first interview responses, aligns with 2 of the 6 key principles of the SQD Model of technology integration (Tondeur, 2012; Admiraal et al., 2017; and Tondeur et al., 2017).

5.2. Discussion of findings related to Research Question 1

The study found that the PGCE program offers structured content knowledge development, lesson planning exercises incorporating technology, and microteaching opportunities. However, digital pedagogy training remains superficial, as most pre-service teachers rely on PowerPoint presentations and projectors rather than interactive tools such as simulations and virtual laboratories. This finding aligns with Mishra and Koehler's (2006) TPACK framework, which highlights the need for integrating technological, pedagogical, and content knowledge effectively in classroom settings. Similarly, Chai et al. (2013) argue that technology training should go beyond basic presentation tools and focus on inquiry-driven and interactive digital strategies. Angeli and Valanides (2009), also emphasize that effective TPACK training should involve direct exposure to interactive and inquiry-based technology use.

Pre-service teachers acknowledged the role of lesson planning in developing their TPACK competencies. One participant stated, *"The PGCE helped us to plan lessons that integrate technology,*

but when it came to actually implementing them, we lacked proper training on how to use those tools effectively." This finding is consistent with Tondeur et al. (2017), Valtonen et al. (2018), and Admiraal et al. (2017), who highlight that many teacher education programs introduce theoretical TPACK knowledge without providing sufficient hands-on experience.

Moreover, triangulated data further emphasized that pre-service teachers with prior teaching experience were better at integrating technology into pedagogy than those without experience. This reinforces Agyei and Voogt's (2012) assertion that exposure to real classroom dynamics enhances pre-service teachers' ability to adapt digital tools effectively. Additionally, the study confirms Ramnarain et al.'s (2021) observation, Archambault et al. (2009), and Schmidt et al. (2009) that South African PGCE programs often struggle to provide pre-service teachers with hands-on digital teaching experiences due to infrastructural constraints, and thus the study intended to address this research gap.

Supporting evidence from interviews and lesson observations indicated that pre-service teachers with teaching experience found it easier to use technology for lesson delivery and classroom engagement. One participant explained, *"Having prior experience meant I was more comfortable incorporating digital tools, even though we weren't explicitly taught how to use them effectively in the PGCE program."* This showed that having prior experience before enrolling the PGCE program enhanced the upskilling of those participants for TPACK, as another participant expressed, *"We had lectures about using technology in teaching, but we never really got to try it ourselves in a structured way."* This also aligns with the findings of Diamah et al. (2022), Yeh et al. (2014), and Tiba and Condy (2021), who stressed that structured, hands-on digital training leads to stronger TPACK competency. In contrast, those without experience reported challenges in selecting and using appropriate digital tools, as it was illustrated by another participant who stated, *"I often didn't know which technology to use or how to integrate it meaningfully into my lessons."*

Other findings from the mini-lesson observations indicate that all pre-service teachers demonstrated strong content knowledge (CK), ensuring accuracy and relevance in their lessons. This also explained the importance of the high standards set in the Life Sciences PGCE program, as the prospective PGCE students in this University had to match the 80% subject knowledge mastery before they could be considered as proficient and eligible to stand a much better chance at integrating the soon-to-be learned pedagogies with it, and incorporating technology effectively (Shulman, 1986). That can be also considered as another intervention to support the preservice teachers' TPACK development.

5.3. Discussion of results related to Research Question 2

This study was further guided by Research Question 2, which explored Life Sciences pre-service teachers' perceptions of the most effective methods used in PGCE teacher education for TPACK readiness. As presented in Chapter 4, Table 7 (page 38), the findings revealed that structured lesson planning, microteaching sessions, and exposure to classroom teaching experiences were considered the most beneficial aspects of their training. Pre-service teachers emphasized that lesson planning helped them integrate technology into their instructional design, while microteaching sessions provided opportunities to practice digital tool usage in a controlled setting before entering real classrooms. Additionally, teaching experience (TE) placements allowed them to apply their TPACK knowledge in authentic learning environments. However, they also noted that digital technology integration was largely theoretical rather than practical, aligning with studies by Tondeur et al. (2017) and Valtonen et al. (2018), which found that many teacher training programs focus more on digital competence knowledge rather than practical pedagogical application.

Microteaching sessions helped participants reflect on their TPACK competencies, reinforcing the idea that self-reflection is essential for developing teaching proficiency (Admiraal et al., 2017). Reflection as emphasized on the SQD Model, is crucial for helping pre-service teachers analyse their digital teaching practices and refine their TPACK skills (Tiba & Condy, 2021; Agyei & Voogt, 2012). Findings revealed that structured reflection was included in the PGCE program, but it did not specifically focus on technology integration. One Participant noted: *"We reflected on what went well in our lessons, but we didn't always discuss how technology impacted learning."* A lecturer similarly admitted: *"We encourage students to reflect on lesson effectiveness, but we don't explicitly require them to analyse their tech usage."*

These aligns with Admiraal et al. (2017) and Ramnarain et al. (2021), who emphasize that structured reflection on digital pedagogy enhances TPACK development. However, despite acknowledging the importance of digital technology, many pre-service teachers struggled with selecting appropriate tools, supporting the findings of Archambault et al. (2009), who identified that new teachers often lack confidence in aligning technology with content-specific pedagogy. A participant shared, *"Microteaching was the only opportunity I had to practice using technology in a lesson, but we didn't get much guidance on how to do it effectively."* This highlights the need for more structured training sessions where pre-service teachers receive explicit instruction and feedback on TPACK integration.

One participant shared, *"Microteaching helped me understand how to integrate technology into my lesson, but I wish we had more opportunities to practice with real classroom technology."* This supports

the literature emphasizing the role of scaffolded digital training in teacher preparation (Admiraal et al., 2017). Another participant mentioned, *"Watching videos on how technology is used in science lessons was helpful, but actually using it myself in a class would have been even better."* This aligns with the findings of Archambault et al. (2009), who noted that new teachers often lack the confidence to implement technology in real-world classrooms due to insufficient practice during training.

Additionally, the semi-structured interviews indicated that some pre-service teachers found peer collaboration and mentorship from experienced educators helpful in developing their TPACK skills, which aligns with the findings of Yeh et al. (2014). One participant expressed, *"I learned a lot from my peers who had more experience with digital tools. We helped each other figure out how to use them in lessons."* Similarly, this was also highlighted in the research by Angeli and Valanides (2009) suggests that mentorship and practice-based digital learning opportunities improve teachers' ability to implement TPACK in real-world settings. This again aligns with the key principle of the SDQ Model, the collaboration. The program encouraged collaborations among preservice teachers which allowed pre-service teachers to share ideas, explore digital tools together, and build collective confidence in TPACK implementation (Tondeur et al., 2017; Yeh et al., 2014). Findings revealed that peer discussions on technology use were informal and not formally embedded in the PGCE program. One **pre-service teacher** noted: *"I learned about different digital tools through conversations with my classmates rather than from the course itself."* A **lecturer** similarly stated: *"We don't have structured peer-learning sessions on technology use, but students do share ideas among themselves."* These findings align with Angeli and Valanides (2009) and Schmidt et al. (2009), who highlight that structured peer collaboration enhances TPACK mastery. However, participants in this study expressed the need for more practical, hands-on training with digital tools, reflecting the broader concerns raised in literature about the gap between TPACK theory and practice in teacher education programs (Tiba & Condy, 2021), particularly the PGCE teacher education program.

Overall, in response to research question 1, the participants have expressed what methods they believed to be the most effective for the preparedness of the TPACK of preservice teachers in the PGCE program at the sampled University. It can be concluded that, most of the participants were confident on the use of microteaching or minilessons which played a significant role to their TPACK readiness at this University. These claims were also confirmed during their minilessons, which were observed and analysed as presented in Table 20.

5.4. Discussion of Results Related To Research Question 3

As previously stated, Research Question 3 aimed to determine the difficulties pre-service teachers encounter in developing TPACK during their PGCE training. With this part of the probing, it was also important to note that the main objective was not to identify the difficulties faced by the preservice teachers as a hindrance for their TPACK, instead it was to get an understanding if those challenges were met, and how the program met those challenges. Several challenges were identified, which included ***limited exposure to interactive digital tools***, ***minimal guidance on technology integration*** during Teaching Experience (TE), and ***insufficient institutional resources***. The reliance on PowerPoint and projectors rather than simulation-based learning indicates that PGCE programs may not be fully equipping pre-service teachers with advanced digital pedagogical skills. Studies by Kavai and Nyamupangedengu (2021) support this finding, stating that South African teacher training institutions face challenges in providing access to modern educational technology.

limited exposure to interactive digital tools

Many pre-service teachers during the minilessons primarily relied on PowerPoint and projectors rather than more dynamic technological tools such as virtual simulations, interactive whiteboards, and online labs as others had spoken about them in their interview responses. This limited exposure may suggest that PGCE programs may not have provided sufficient hands-on training with a variety of educational technologies or the observation was conducted before the preservice teachers could be confident enough to implement them.

Drawing from the interview response, many pre-service teachers expressed frustration with their lack of hands-on experience with educational technology. One participant stated, *"We were shown how to use technology in theory, but we never had enough opportunities to practice with the tools ourselves."* This aligns with findings by Tondeur et al. (2012) and Angeli and Valanides (2009), who argue that teachers develop stronger digital competencies when they actively engage with the technology rather than passively learning about it. Similarly, Valtonen et al. (2018) found that limited exposure to hands-on technology training reduces teachers' confidence and competence in integrating technology into pedagogy.

Another participant noted, *"I wanted to use simulations in my lesson, but I didn't feel confident enough because I had never actually worked with them before."* This is consistent with the findings of Kwangsawad (2016), which emphasized that hands-on training is crucial for TPACK development and that lack of experience leads to avoidance of technology use in classroom settings.

Minimal guidance on technology integration

Pre-service teachers reported that they did not receive adequate support from lecturers or mentor teachers on how to effectively incorporate technology into their lessons. This lack of structured guidance made it difficult for them to experiment with technology in real classrooms, leaving them unprepared to integrate digital tools effectively. They indicated that they received little support from mentor teachers and university lecturers on how to integrate technology effectively during their TE which could have been due to time constraints. One participant explained, *"When I asked my mentor teacher for help with incorporating technology, they told me to just use the textbook instead."* This is supported by Agyei and Voogt (2012), who found that many mentor teachers are not equipped to guide pre-service teachers in technology integration, leading to missed opportunities for TPACK development. Schmidt et al. (2009) similarly argue that mentorship plays a crucial role in helping novice teachers bridge the gap between theory and practice.

Additionally, another pre-service teacher stated, *"The university only visited once during TE, so there was no one to give real-time feedback on my use of technology in lessons."* This finding aligns with research by Diamah et al. (2022), which highlights that regular feedback and structured support during TE are essential for developing TPACK skills.

Insufficient institutional resources

A common challenge identified was that many schools where pre-service teachers conducted their TE lacked adequate technological infrastructure. One participant reflected, *"The school I was placed in only had one projector, and it was not working, so I had to rely on chalk and talk."* This supports the argument by Ramnarain et al. (2021) that disparities in technological resources in South African schools limit teachers' ability to implement TPACK-based lessons. Similarly, Yeh et al. (2014) found that teachers in under-resourced schools often struggle to integrate digital tools, not because of lack of knowledge but due to infrastructural constraints.

Another pre-service teacher noted, *"Even when there were computers, they were outdated, and the internet was too slow to use online resources."* This aligns with the findings of Archambault et al. (2009), who emphasize that technological infrastructure must be improved for TPACK frameworks to be effectively implemented in teacher training programs.

These challenges suggest that while PGCE programs may introduce pre-service teachers to TPACK concepts, they fall short in providing the necessary real-world practice and support needed to build

confidence and competence in technology integration. By addressing these challenges through increased hands-on training, structured mentorship and better resource allocation in schools where pre-service teachers conduct their teaching practice, PGCE programs can significantly improve pre-service teachers' ability to integrate technology into their pedagogy effectively.

Moreover, findings revealed that pre-service teachers with no prior classroom experience had lower TPACK scores and struggled to engage learners using technology. This is consistent with the work of Diamah et al. (2022), which emphasizes that novice teachers require structured mentorship and guided practice to develop digital pedagogy (TK) confidence.

One pre-service teacher stated, *"During my Teaching Experience, I wanted to use digital simulations, but the school didn't have the necessary tools, so I had to rely on traditional teaching methods."* This aligns with research by Kwangsawad (2016), which highlights that access to resources significantly affects teachers' ability to develop TPACK skills. Another participant noted, *"We were taught about different technology tools, but we never really got to use them. It was mostly just discussions."* This supports the argument by Diamah et al. (2022) that novice teachers require structured mentorship and hands-on experience to develop digital pedagogy confidence. Other findings crucial to note was the voicing of the little time that the program offers the preservice teachers to complete all the necessary TPACK skills and knowledges before they can be ready to effectively teaching in a formal science classroom.

5.5. Discussion of results related to Research Question 4

Just to recap, Research Question 4 looked at how TPACK readiness in the PGCE teacher education can influence the Life Sciences pre-service teachers' future classroom practices. The findings suggest that while PGCE training strengthens content knowledge and lesson structuring skills, the limited interactive use of technology may hinder future classroom innovation. Pre-service teachers who scored higher in TPACK demonstrated a stronger ability to integrate technology into pedagogy, reinforcing the findings of Yeh et al. (2014), which indicate that teachers with strong TPACK skills create more dynamic, engaging learning environments.

However, participants noted that resource constraints in South African schools often limit technology use, aligning with Ramnarain et al. (2021), who found that disparities in school infrastructure significantly impact teachers' ability to implement TPACK strategies effectively. This underscores the need for policymakers to ensure that new teachers are placed in well-resourced schools where they can fully apply their training as already mentioned on the previous section.

However, participants noted that resource constraints in South African schools often limit technology use, aligning with Ramnarain et al. (2021), who found that disparities in school infrastructure significantly impacts teachers' ability to implement TPACK strategies effectively. One participant noted, *"Even if I develop strong TPACK skills, the reality is that most schools don't have the resources to support this kind of teaching."* This underscores the need for policymakers to ensure that new teachers are placed in well-resourced schools where they can fully apply their training.

To enhance the reliability of the findings, data from semi-structured interviews, content test analysis, and mini-lesson observations were triangulated. This provided a comprehensive understanding of pre-service teachers' TPACK readiness. Firstly, the alignment between semi-structured interviews and mini-lesson observations highlighted the following;

i. Interviews indicated that pre-service teachers were confident in their content knowledge but lacked sufficient practical exposure to digital tools.
ii. Mini-lesson observations supported this by showing that technology was primarily used for information delivery rather than interactive engagement. One participant stated, *"I used PowerPoint slides in my lesson, but I wasn't sure how to make it more interactive using technology."*

Secondly, Content Test Analysis and actual Teaching Performance when they were contrasted, it was not surprising to observe that pre-service teachers scored well in content tests, demonstrating strong subject knowledge as they were expected to have strong content knowledge as presented in Table 5. This was acclaimed by **Lecturer 2** *"what they have is the content,,,,"* which is supported in the work by Ramnarain et al. (2021). However, high content knowledge scores did not always correlate with strong TPACK performance. For example, **Sino** had the highest CK test score but the lowest mini-lesson performance, highlighting challenges in applying content knowledge through technology.

And lastly, the relationship correlation between teaching experience and technology integration was established. Both interviews and observations confirmed that pre-service teachers with prior teaching experience had better TPACK performance. Those with no prior classroom experience struggled to integrate technology meaningfully into their pedagogy, highlighting the need for structured digital training.

5.6. Summary of results discussion

The study explored the influence of the PGCE Life Sciences program on pre-service teachers' TPACK readiness by analysing data from semi-structured interviews, content test analysis, and mini-lesson observations**.** The findings highlighted both strengths and areas for improvement in the integration of technology, pedagogy, and content knowledge. Below are the key discussions and implications, also presented on Table 21, drawn from the findings of this study in addressing the research question and achieving the purpose of this study.

i). **Strong content knowledge but limited pedagogical and technological integration**

The content test analysis demonstrated that pre-service teachers possessed strong mastery of Life Sciences content knowledge (CK), with high scores across assessments (see Table 15). However, mini-lesson observations revealed that strong content knowledge did not always translate into effective classroom practice. For example, Sino had the highest CK test score but the lowest TPACK performance, indicating difficulty in integrating content with pedagogy and technology. This aligns with studies by Mishra and Koehler (2006) and Koehler et al. (2013), who emphasize that knowledge of subject matter alone is insufficient for effective teaching—it must be interwoven with pedagogical strategies and technological tools to enhance student engagement.

ii**). Prior teaching experience enhances TPACK readiness**

Pre-service teachers with prior teaching experience (e.g., **Mbali** and **Thabo**) had stronger TPACK performance in their mini-lesson observations. Findings from interviews analysis also confirmed that those with experience felt more confident in integrating technology, while those without struggled with selecting and using digital tools effectively. Agyei and Voogt (2012) argue that teaching experience enhances a teacher's ability to integrate technology effectively, as exposure to classroom realities allows for practical experimentation with digital tools. Admiraal et al. (2017) further emphasize that teachers who have previous experience in educational settings are more adept at applying TPACK principles, supporting the findings of this study.

iii). **Technology integration was mostly passive (PowerPoint & projectors)**

Mini-lesson observations showed that most pre-service teachers relied on PowerPoint and projectors rather than interactive digital tools such as simulations, virtual labs, or educational apps. The responses from the interviews revealed that technology training in PGCE was mostly theoretical, with limited hands-on practice, making it difficult for teachers to implement student-centered digital learning

approaches. This finding is supported by Tondeur et al. (2017) and Valtonen et al. (2018), who argue that teacher education programs often focus more on digital literacy than on the pedagogical application of technology. In addition, Polly et al. (2010) highlighted that preservice teachers need structured exposure to technology-rich environments to effectively integrate digital tools into their instructional design**.**

***iv).* Barriers to effective TPACK implementation**

Limited access to technology in schools during Teaching Experience (TE**)** hindered pre-service teachers' ability to apply what they learned. Lack of structured guidance from lecturers during TE meant that many pre-service teachers had to rely on self-learning when integrating technology. Some participants lacked confidence in selecting appropriate digital tools**,** highlighting the need for explicit training in digital pedagogy. Kavai and Nyamupangedengu (2021) argue that South African schools face significant disparities in technological infrastructure**,** making it difficult for newly qualified teachers to implement technology-integrated teaching methods**.** This aligns with the findings of Ramnarain et al. (2021), who note that many developing countries struggle with providing equitable access to educational technology, impacting teacher training outcomes.

v). **The need for more hands-on digital pedagogy training**

Across all data sources, pre-service teachers expressed a need for more practical training on integrating technology with teaching strategies**.** Microteaching was identified as useful, but participants wanted more direct feedback and structured mentorship**.** Again, Polly et al. (2023) in their work highlighted that hands-on training and guided digital teaching practice are crucial for developing TPACK competency. The study suggests that TPACK-focused workshops and technology-driven classroom simulations could enhance PGCE training. Koehler and Mishra (2009) emphasize that pre-service teachers benefit most from learning opportunities that require active engagement with technology in real instructional settings**.**

***vi).* Future classroom practices will be limited by school resources**

Interviews revealed that pre-service teachers felt prepared to integrate technology, but many feared that schools lacked the necessary resources. This highlights a disconnect between teacher preparation and real-world classroom conditions, reinforcing literature suggesting that disparities in school infrastructure affect teachers' ability to apply TPACK effectively (Ramnarain et al., 2021). One participant remarked, *"Even if I improve my TPACK skills, the reality is that most schools lack the necessary technology to*

support this kind of teaching." Angeli and Valanides (2009) argue that without institutional support and school-wide technological investment, teachers will struggle to implement TPACK-driven instruction effectively**.**

5.7. Conclusion

As a reminder, the purpose of this study was to explore how the PGCE Life Sciences program influenced the preservice teachers' TPACK preparation, using the TPACK conceptual framework as a lens through which to understand the preparedness of their preservice teachers in terms of TPACK instruction. To better understand the preparedness of the preservice teachers, a qualitative study design was employed to address the following research questions:

- *What interventions are employed in the PGCE teacher education programs to support the readiness of Life Sciences pre-service teachers for TPACK?*
- *What do Life Sciences pre-service teachers perceive to be the effective methods used in the PGCE teacher education for TPACK readiness in the science classrooms?*
- *What are the difficulties faced by pre-service teachers in relation to TPACK development during their training?*
- *How can TPACK readiness in the PGCE teacher education influence the Life Sciences pre-service teacher future classroom practices?*

This study explored how the PGCE Life Sciences program shapes pre-service teachers' TPACK readiness Drawing from semi-structured interviews, mini-lesson observations, and content test analysis, the study provided a holistic understanding of how PGCE training supports or hinders technology integration in Life Sciences education. The findings underscore the need for PGCE programs to enhance hands-on digital tool training, aligning with literature that emphasizes experiential learning as key to developing TPACK competencies (Diamah et al., 2022). While findings indicate strong content knowledge, technology use remains largely passive, limiting its influence on student engagement.

The findings reveal that while pre-service teachers demonstrate strong content knowledge (CK), they struggle with effective technology integration (TK) and student-centered pedagogical applications (PK). Many relied on PowerPoint and projectors for instructional delivery, rather than engaging students through interactive digital simulations or inquiry-based technology tools. This aligns with previous studies (Mishra & Koehler, 2006; Tondeur et al., 2017), which indicate that teacher education programs often introduce theoretical TPACK concepts without sufficient hands-on experience.

The study further highlighted that prior teaching experience played a significant role in shaping TPACK readiness. Participants who had classroom experience before the PGCE program demonstrated greater confidence in using technology compared to those without experience. This finding is consistent with Agyei and Voogt (2012) and Ramnarain et al. (2021), who argue that authentic classroom exposure allows teachers to develop a more intuitive understanding of how to integrate technology into lesson delivery effectively.

Another major challenge was the limited access to technological resources in schools during the Teaching Experience (TE). Several pre-service teachers noted that they were unable to apply their TPACK knowledge due to lack of smartboards, unreliable internet, or outdated computer systems. This finding reflects the broader issue of digital inequality in South African schools, as highlighted by Yeh et al. (2014) and Kavai and Nyamupangedengu (2021), who stressed that technology availability significantly affects teachers' ability to implement digital pedagogies effectively. Another challenge was the fact that 1 year is not enough to complete the PGCE qualification and be confidently ready to effectively teach, according to the preservice teachers' point of view.

Despite these challenges, pre-service teachers recognized the potential benefits of technology in improving student engagement and conceptual understanding in Life Sciences. They expressed the need for more structured TPACK training, hands-on workshops, and mentorship during their TE. Literature supports this notion, with Schmidt et al. (2009) and Diamah et al. (2022) emphasizing that teacher education programs that provide structured digital practice yield more confident and competent teachers in technology-enhanced classrooms. Based on these insights, the study concluded that while the PGCE Life Sciences program equips pre-service teachers with strong foundational knowledge, it lacks sufficient practical digital training, structured mentorship, and access to technological resources. Addressing these gaps requires curriculum adjustments that prioritize hands-on TPACK development, better technological infrastructure in training schools, and stronger collaboration between universities and mentor teachers.

By implementing these recommendations as also mentioned earlier, PGCE programs can better prepare Life Sciences teachers to effectively integrate technology, pedagogy, and content in ways that enhance student learning experiences. Future research should further explore how specific digital interventions impact teacher development and how policy changes can improve technology-supported teaching in South African schools.

5.8. Recommendations from the study

Based on the key findings of this study, policies should ensure that TPACK-focused training is embedded in PGCE curricula, allowing pre-service teachers to engage in practical digital teaching strategies. Again, Universities should strengthen partnerships with schools to ensure that pre-service teachers are placed in well-resourced environments where they can develop their digital teaching skills effectively. To better prepare future educators, PGCE programs must strengthen digital training, promote interactive teaching strategies, and provide structured mentorship during Teaching Experience. These changes will ensure that Life Sciences teachers are equipped to implement effective, technology-integrated pedagogy in their future classrooms. Another common recommendation from the preservice teachers, was that the program should be extended, the 1year duration is not adequate. Lastly, structured mentorship programs should be introduced, where experienced teachers or lecturers guide pre-service teachers through the practical aspects of technology-enhanced teaching**.**

5.9. Limitations of the study

While this study provides valuable insights into the TPACK readiness of Life Sciences pre-service teachers in a PGCE program, several limitations should be acknowledged. Firstly, the study was conducted at a single South African university, which may limit the generalizability of the findings to other institutions with different resources, curricula, and technological access. Future research could expand the scope by including multiple institutions to compare variations in TPACK readiness across different contexts.

Secondly, the study also relied on self-reported data from semi-structured interviews, which may be subject to social desirability bias, as participants may have provided responses that they believed were expected rather than their genuine experiences. Triangulating this with actual classroom data during TE could have enhanced the richness of the findings. And finally, time constraints within the PGCE program meant that the study only captured a snapshot of TPACK development during one academic year. Longitudinal studies tracking pre-service teachers' growth in TPACK beyond their PGCE and into their professional teaching careers would offer deeper insights into how initial training translates into long-term practice.

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7. Appendices

7.1. Appendix A: Interview Schedule (Preservice Teachers)



INTERVIEW SCHEDULE

Semi-Structured Interview (Pre-service teachers)

FOCUS: The study title is " Exploring the influence of the PGCE Life Sciences program on the preparation of pre-service teachers for their TPACK at a South African University".

Purpose of the interview:

My name is Vincent Mhlongo. I am a Masters student in Science Education at the University of the Witwatersrand, Johannesburg. My supervisor is Dr. Portia Mabenge. I am conducting a research study about the influence that PGCE teacher education has on the preparation of Life Sciences Pre-service teachers for TPACK. The study title is " Exploring the influence of the PGCE Life Sciences program on the preparation of pre-service teachers for their TPACK at a South African University ".

Interview Questions

Category A: Pre-service teacher profile

1. Do you have any teaching experience prior to registering in PGCE? How many years and which area?

2. What undergraduate qualification do you hold and what were the majors?

3. Can you talk briefly about your undergrad background, have you interacted or done any module on technology?

4. From the range below, where does your age fall?

20-30	31-40	41-50	Not comfortable

5. In your opinion, what is the role of the teacher education training for science pre-service teachers?

Pre-service teachers' CK: mastery of the subject matter being taught

1. Can you confidently say that you have sufficient knowledge about Life Sciences subject matter?
2. Would you say you have good knowledge of the structure of the curriculum of Life Sciences?
3. Are you able to make relations to a topic you teach to everyday situations?
4. Can you explain or present the same concept of the subject matter you teach at different levels?

1

Preservice teachers' PK: Knowing how to teach and engage learners

1. Can you adapt your teaching style to different learners? If so, how?
2. Do you think you are in a position to know how to assess learners' performance in a classroom at multiple ways?
3. Can you organise and maintain classroom management during your teaching?
4. Are you able to use a wide range of teaching approaches in a classroom setting? Can you give an example?

Pre-service teachers' TK: Understanding how to use technology tools effectively

1. Do you think you know enough about technology? Why?
2. Can you say that PGCE Life Sciences has created sufficient opportunities or experiences for you to learn to use technology in teaching a specific topic?
3. Would you say that you can keep up with the important new technologies?
4. Do you have sufficient knowledge of the most recent technology and how to use it for teaching and learning?

Pre-service teachers' TPACK: Ability to make integrate the 3 components for effective teaching

1. Do you know how to select effective teaching approaches to guide learners scientific thinking and learning?
2. How would you use technologies for teaching and understanding Life Sciences?
3. How would you ensure that technology selected enhances learners' learning of a lesson?
4. Would you say that the PGCE Life Sciences program has caused you to think more deeply about how technology could influence the teaching approaches you can use in your science classroom?
5. Can you think of any form of assessment you could adopt in your lesson using technology to enhance or support learners' comprehension of the concept taught?
6. Are you in a position where you can effectively teach lessons that appropriately combine Life Science concepts, technologies and relevant teaching approaches?
7. Is there any example you can think of, where you can teach a Life Science concept using the technology tool that align with the objective of that lesson?
8. Why do you choose such technology tools, what makes you think it will be effective?
9. Any advantages and disadvantages of these technology tools to you and your learners?
10. Are you confident in your ability to use technology in every phase of your teaching and learning process in the science classroom?

2

7.2. Appendix B: Interview Schedule (Lecturers)

INTERVIEW SCHEDULE

Semi-Structured Interview (PGCE Life Sciences Lecturers)

FOCUS: The study title is " Exploring the influence of the PGCE Life Sciences program on the preparation of pre-service teachers for their TPACK at a South African University".

Purpose of the interview:

My name is Vincent Mhlongo. I am a Masters student in Science Education at the University of the Witwatersrand, Johannesburg. My supervisor is Dr. Portia Mabenge. I am conducting a research study about the influence that PGCE teacher education has on the preparation of Life Sciences Pre-service teachers for TPACK. The study title is " Exploring the influence of the PGCE Life Sciences program on the preparation of pre-service teachers for their TPACK at a South African University ". The responses to these questions will provide insights into the effectiveness of the PGCE Life Sciences program in preparing and supporting the development of pre-service teachers TPACK as well as how it influences their preparedness according to the lecturers as role models.

Interview Questions

Category A: Lecturer profile

1. In your opinion, what do you think the role of the lecturer is in the preparation of preservice teachers for TPACK
2. How long have you been using technology in your teaching?
3. What do you think about the use of technology in Life Sciences education?

Category B: Lecturer's Role in the PGCE program for TPACK

1. In your own opinion what is the role of the PGCE teacher education in preparing pre-service teachers for TPACK??
2. Would you say that lecturers play the most significant role in ensuring that preservice teachers are prepared adequately for TPACK in the future teaching practices?
3. What types of technological tools or resources are introduced and discussed in the PGCE Life Sciences program?
4. As the lecturer, do you discuss about the use of technology with your students in the PGCE Life Sciences course?
5. What are some of the difficulties have you noticed or raised with the students in terms of TPACK readiness?
6. How do you ensure that pre-service teachers in the program are adequately prepared to integrate technology, pedagogy and content in their prospective teaching practices?

1

Category C: PGCE Life Sciences teacher education program interventions

1. What are the key objectives and learning outlines of the PGCE LS program?
2. What do you think are the main challenges or barriers that preservice teachers in the program face when integrating technology into their teaching practices?
3. What strategies or support are in place to help preservice teachers overcome these challenges or barriers in integrating technology into their teaching practices?
4. How is the development of TPACK of preservice teachers assessed in the program?
5. What specific instructional strategies or pedagogical approaches are emphasized in the PGCE L/S program to develop preservice teachers' TPACK?
6. In what ways do you believe the PGCE L/S program effectively prepares preservice teachers to integrate technology in their teaching practices?
7. What are the difficulties do you encounter as the Lecturer in ensuring that the preservice teachers are well prepared to make appropriate combinations of their pedagogy, content and technology knowledges for teaching Life Sciences?
8. After the preservice teachers' TE, do they get time to reflect on their level of TPACK and be assisted for areas they need to improve on? What were some of the suggestions from the refection?

2

7.3. Appendix C: Minilesson Observation

MINILESSON OBSERVATION SCHEDULE FOR MBALI

OBSERVATION CHECKLIST (Qualitative)

FOCUS: The study title is " Exploring the influence of the PGCE Life Sciences program on the preparation of pre-service teachers for their TPACK at a South African University".

Purpose: As part of the research methodology, a minilessons observation schedule has been developed to observe the teaching practices of the pre-service teachers who doing the PGCE Life Sciences program. The observation schedule outlines specific teaching components and technological integration methods that researchers aim to observe during the minilessons.

The observation schedule includes detailed criteria for evaluating technology integration, pedagogy, and content knowledge in pre-service teachers' teaching practices. This will involve examining technology usage, alignment of instructional strategies with learning objectives, and demonstration of content knowledge during lessons.

TPACK OBSERVATION CHECKLIST		Poor	Good	Very Good	Excellent	**Score**
Pedagogical Knowledge (PK)						
1.	Teacher knows essential pedagogical approaches for the lesson preparation & presentation	1	2	3	4	**3**
2.	Teacher displays understanding of different learning styles of learners	1	2	3	4	**4**
3.	Teacher structures the lesson to promote learning	1	2	3	4	**4**
Technological Knowledge (TK)						
1.	Teacher has essential technology tools for the lesson	1	2	3	4	**3**
2.	Teacher utilizes technology to support teaching strategies	1	2	3	4	**3**
3.	Teacher uses technology tools without any problems	1	2	3	4	**3**
Content Knowledge (CK)						
1.	Teacher exhibits a good mastery of subject matter knowledge	1	2	3	4	**4**
2.	Teacher provides a variety of reference for the learners to gain relevant content taught	1	2	3	4	**4**
3.	Teacher presents relevant and accurate facts in relation to the topic	1	2	3	4	**4**
Technological Content Knowledge (TCK)						
1.	Teacher uses technology to show complex ideas that would otherwise be difficult to learn	1	2	3	4	**3**
2.	Teacher uses technology to allow learners to observe things that would otherwise be difficult for the naked eye	1	2	3	4	**3**
3.	All teaching aids are attractive & support the lesson theme	1	2	3	4	**2**
Technological Pedagogical Knowledge (TPK)						
1.	The teacher introduces technology-based tasks that enable learners to engage in the learning process	1	2	3	4	**2**
2.	Teacher uses technology to interact and collaborate with learners in different activities	1	2	3	4	**3**

1

TPACK OBSERVATION CHECKLIST		Poor	Good	Very Good	Excellent	Score
3.	Teacher adapts the use of technology to promote problem-based learning approaches in teaching & learning activities.	1	2	3	4	**4**
Technological Pedagogical and Content Knowledge (TPACK)						
1.	Teacher teaches a lesson that appropriately combines subject content, technologies and teaching and learning approaches	1	2	3	4	**4**
2.	Teacher uses technology to promote learners learning of the topic being taught	1	2	3	4	**3**
3.	Teacher is well prepared and able to manipulate technology to present relevant lesson content	1	2	3	4	**3**
4.	Teacher uses technology to promote learners' collaborations and engage learners during the lesson	1	2	3	4	**3**
	Total score:					**63**

Actual Lesson: Teaching & Learning observation

Topic: Reproduction **Grade: 12** **Technology tool: PowerPoint slides**

Teachers' pedagogical approach in the lesson

Leading (includes lecturing, directing class activities)	
Facilitating/ assisting learners	×
Class control (classroom discipline and management)	
Other approaches:	

Teachers' use of technology in the lesson

Not evident		For groupwork	
For presenting lesson information	×	To demonstrate learners' task	
For modelling of a concept		For grading attendance or material prep	
Other uses:			

Students' response and participation in the lesson (one example of learner-teacher interaction):

The preservice teacher selected a tool that showed the learners the concepts she was trying to explain, that increased engagement as there was positive student's response..

The benefit of technology to support pedagogy and content in the activity observed:

During the minilesson, the preservice teacher used technology tool clearly that supported the teaching approaches and skills selected, that seemed to have improved comprehension of the content she was presenting to the learners when they saw the colour 3D pictures, learners were able to label and describe the functions of the various organs shown.

2

7.4. Appendix D: Participant Information Sheet

Participant Information Sheet (PIS) PGCE lecturer

Dear Sir / Madam

My name is Vincent Mhlongo. I am a Masters student in Science Education at the University of the Witwatersrand, Johannesburg. My supervisor is Dr. Portia Mabenge. I am conducting a research study about the influence of the teacher education on the TPACK preparation of preservice teachers, specifically at the PGCE level. The study title is "***Exploring the influence of the PGCE Life Sciences program on the preparation of pre-service teachers for their TPACK at a South African University***".

I am inviting you to take part in this study by participating in an interview, TPACK Lesson observation and analysis of your students' tests scripts. If you decide to take part, your participation in the interview will last about 30 minutes. The interview will can place in either an online or face-to-face meeting any day from 15H00 or whichever time is convenient to your schedule and the lesson observation will take place during your TPACK lecture. The content analysis will be done after you have marked the tests scripts of the students.

With your permission, I would like to audio record the interview and the TPACK lesson observation. This data will be stored in a password protected computer for 5 years and/or deleted after 5 years. Only myself and my supervisor will have access to the data.

During the research activity, I will need to ask for some information about you, including years of educational background and/or years of teaching experience. I would also request for permission to have access to the course outline and the content test written.

The interview and observation answers will be confidential and anonymous. When I share the results of the research study, I will not include your name or anything else that could identify you. With your permission, other researchers may use the data collected from this research study, but your name and any personal information will not be used.

If you decide to take part in the research study, it should be because you want to volunteer. You do not have to take part. You can stop being in the study at any time. You do not have to answer any questions if you do not want to. You will not get any direct benefits if you choose to join the research study. You will not lose any services, benefits or rights you would normally have if you decide not to join. Taking part in the research study will not cost you anything. You will not be paid for being in this research study.

The risks for this research study are no more than what happens in everyday life. OR Some of the questions asked may make you feel sad or upset. If this happens, I will stop the interview and continue another time.

This research study will be written up as a research report. If you would like to receive a summary of this report, I will be happy to send it to you.

If you have any questions during or afterwards about this research study, feel free to contact me or my supervisor on the details listed below. If you have any concerns or complaints about the ethical procedures of this research study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Yours sincerely,
Vincent Mhlongo

Researcher:
Vincent Mhlongo, 817832@students.wits.ac.za, 079 981 2548

Supervisor:
Dr. Portia Mabenge, portia.mabenge@wits.ac.za, 011 717 3248

7.5. Appendix E: Consent Form

Participant Consent Form
(Semi-Structured Interview)

Title: Exploring the influence of the PGCE Life Sciences program on the preparation of pre-service teachers for their TPACK at a South African University.

Researcher: Vincent Mhlongo

I, ……, *(participant name and surname)* agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below to show your consent)

The research study was explained to me. I understand what this study is about.	YES	NO
I understand that I can volunteer to take part in the study	YES	NO
I agree that the minilesson observation may be audio and video recorded	YES	NO
I agree that direct quotations from my minilesson may be used by the researcher in their research report.	YES	NO
I agree that my participation will remain anonymous (my name will not be used by the researcher in their research report.	YES	NO
I agree that other researchers may use the information I provide in my minilesson (depending on their own ethics clearance being obtained) but my name and any personal information will not be used or passed on	YES	NO

…… (signature)
…… (Participant)
…… (date)

…… (signature)
…… (Researcher)
…… (date)

7.6. Appendix F: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | WSoE Wits School of Education

SCHOOL OF EDUCATION ETHICS COMMITTEE

CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER:** 2024ECE030M
PROJECT TITLE	Exploring the influence of the PGCE Life Sciences program on the preparation of preservice teachers for their TPACK at a South African University
INVESTIGATOR	Vincent Mhlongo
SCHOOL/DEPARTMENT OF INVESTIGATOR	WSoE
DATE CONSIDERED	10 June 2024
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	Minimal Risk
EXPIRY DATE	Date of submission of the Research Report
ISSUE DATE OF CERTIFICATE	15 July 2024
CHAIRPERSON	Dr. Lawan Abdulhamid

cc: Dr. Portia Mabenge

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature _____ Date 17 / 07 / 2024

7.7. Appendix G: Data Coding and Analysis Table (Interviews)

Participant Name	Raw Data (Quotes from Interviews)	Initial/Open Coding (Descriptive)	Axial Coding (Categories) (Conceptual)	Selective Coding (Themes)
Nandi	*"I understand the science concepts, but using technology in teaching is something I still struggle with because we didn't practice enough in the PGCE."*	Lack of hands-on tech practice Confidence issues in digital teaching	Barriers to TPACK development CK-TPACK performance gap	Limited hands-on technology training in PGCE
Tsholo	*"We did lesson planning using PowerPoint, but we didn't get to explore other tools like simulations or virtual labs."*	Reliance on PowerPoint for teaching Limited use of interactive tools	Passive vs. interactive tech use Lesson planning with limited tech exposure	Technology is used for content delivery rather than student-centered engagement
Mbali	*"Because I had some teaching experience before PGCE, I found it easier to use technology in my lessons, even though we didn't get much practical training."*	Prior teaching experience aids TPACK Self-taught digital tool usage	Role of teaching experience in TPACK Confidence vs. inexperience in tech use	Teaching Experience (TE) significantly influences TPACK readiness
Sino	*"The PGCE covered theory about digital tools, but we never really got to try them out in a classroom setting."*	Theoretical tech knowledge without practice Minimal classroom application of digital tools	Theory-practice gap in PGCE Barriers to digital pedagogy	PGCE focuses more on theoretical exposure to technology rather than hands-on training
Thabo	*"When I started using tech in my lessons, I realized I needed more guidance. The lecturers taught us about TPACK, but we didn't get step-by-step training on how to use it effectively."*	Need for structured tech training Lack of direct mentorship on digital tools	Need for scaffolded digital training Limited lecturer support during PGCE	Lack of structured training and mentorship on digital tool use

7.8. Appendix H: Turnitin Similarity Report and Score

Exploring the influence of the PGCE Life Sciences program on the preparation of pre-2.docx

ORIGINALITY REPORT

11%	8%	12%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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Chapter 1: Introduction to the Study

1.1. Background

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