Exploring Preservice Teachers' Preparedness to Integrate ICT during Life Sciences' Teaching Experience: A Case Study at a South African university.

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By

Timeyo Kanyinji

(Student No. 1524122)

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Supervisor:

Dr Portia Kavai

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DECLARATION

I, **Timeyo Kanyinji** (student No. **1524122**) declare this Masters Research Report is my own original, unassisted work. Wherever other peoples' work was used, they have been correctly referenced. It is being submitted for the Degree of Master of Education by Coursework and Research Report at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.

Timkanyinji

_____ **PROTOCOL NUMBER: 2020ECE010M**.

(Signature of candidate)

___**30**____day of **April** __**2021**__at University of the Witwatersrand, Johannesburg

ABSTRACT

In this present digital generation, technology has become a learners' everyday universal language that teachers can incorporate into their teaching to maximize learners' participation in accessing and evaluating new knowledge. However, teachers often seem to be novices to technology which widens the gap between how they deliver knowledge and how learners acquire it. Research shows that that integrating technology in the teaching and learning remains a challenge for many teachers. Furthermore, research also shows that preservice teachers (PSTs) do not feel sufficiently equipped to incorporate ICT into their classrooms because they often claim that they are not adequately prepared during their teacher training (Enochsson & Rizza, 2009). According to studies, if teachers are introduced to ICT usage and learn ICT skills during their teacher training program, they are more likely to incorporate ICT into their teaching subjects (Jita, 2016); Chikacha, et al, 2014). In this regard, the main purpose of the research was to explore how prepared were the PSTs at a South African university to integrate ICT in their teaching practices in the teaching of Life Sciences. To understand the PSTs' preparedness to integrate ICT, a TPACK framework and the research questions which guided the study were considered. A mixed methods research approach was adopted, and data was collected using a questionnaire and an interview to the PGCE and 4th year BEd PSTs who enrolled for Life Sciences at a South African university. The findings revealed that the majority of PSTs at this South African university believed they had capabilities in TK, TCK, TPK, TPACK, and modelling of technology relating to the teaching and learning Life Sciences. It was revealed that lecturers' ICT modelling and previous interactions with ICT usage contributed to PSTs' ICT capabilities and preparedness to use ICT in their teaching practices.

DEDICATION

I dedicate this research to the Almighty God, who has shown me His grace, mercy, and provision. I also dedicate this work to my family: my wife, Asiyatu and my daughters, Esther and Ruth who have encouraged me throughout this study irrespective of being affected by this quest. Thank you and God bless you.

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Chapter 1: Introduction

1.1. Background

In reference to the developmental demands of the 21st century, "information and communication technology" (ICT) has become a useful tool in schools worldwide and an increasing number of teachers have integrated it into their teaching methodologies in order to effectively impart knowledge to learners (Bilici, Guzey &Yamak, 2016). Padayachee (2017) reveals that use of ICT in the teaching and learning can bridge the abstract and practical knowledge. Furthermore, effective use of ICT in the classroom can provide problem-based learning that allows student to advance their critical thinking abilities and transforming the learning environment to be learner-centred, which also allows for a deeper learning experience (Mbodila, Jones & Muhandji, 2013). However, research has also revealed that teachers can only use ICT if they have a good understanding of ICT and how it can be synchronized with teaching methods, and content knowledge (Hennessy, et al, 2010). This means that successful implementation of ICT use depends on the teachers' ability to structure teaching and learning environments in modern ways that incorporate ICT with new teaching strategies as opposed to traditional approaches (Hennessy, et al, 2010).

Literature reveals that a significant proportion of lecturers use ICT to scheme or plan their lessons and also prepare notes for their learners; but there is a much smaller percentage of work in which they integrate technology when they teach their courses (Greher, 2011). According to Teo (2011) successful integration of technology into teaching and learning starts with the lecturer's or instructor's capability to model its use for teaching and learning. Teo (2011) argues that when lecturers are knowledgeable in the use of technology, part of the teacher preparation program intentionally regards technology to be an instrument available to them as part of the pedagogical process of instruction. Banks (2017) observes that most often preservice teachers (PSTs) tend to model what they have seen during their teacher preparation program. Banks (2017) further argues that the ability of lecturers to model teaching while integrating technology in their instructions, offers an authentic learning experience to the PSTs to understand the appropriate approaches of integrating technology into their teaching and learning practices. Furthermore, Jita (2016) noted that the more lecturers or mentor teachers make use of ICT tools in their teaching, the more PSTs also learn to utilize ICT tools in their own teaching. On the other hand, failure to integrate ICT by the teachers into their instructions may suggest that they are not prepared to do so. Banister and Vannatta (2006) cited by Banks (2017) report that in

most cases, PSTs are not sufficiently given the essential technology modeling in order to be successful in technology integration. According to MacKinnon (2010) developing technological frameworks for teacher preparation which include authentic experiences for PSTs in which technology empowers the instructional process, has shown to be difficult.

1.2. Problem Statement

The South African government calls upon the higher education institutions for teacher development programs to equip teachers with ICT knowledge and skills who can enhance teaching and learning and raise the educational standards of the country (Meyer & Gent, 2016; Isaacs, 2007). However, research shows that integrating technology into the teaching practices remains a challenge for many teachers (Voogt & McKenney, 2017; Hennessy, et al, 2010). Furthermore, research also shows that PSTs do not feel adequately prepared to integrate ICT into their classrooms, which creates a crisis in their lesson delivery for the fact that the current generation of learners are digital natives who bring their casual use of technology into classrooms which seem to hinder learning if not under the check of the teacher (Enochsson & Rizza, 2009). According to Tondeur, et al (2012) insufficient access to ICT, lack of time and lack of ICT skills are some of the factors that contribute to teachers' feeling of unpreparedness to use ICT in their classrooms. This shows that teachers can only provide guidance to the learners if they themselves are equipped with ICT skills. This suggest that teachers should be in a position to provide instructions, support, and orientation about what it means to use technology for academic purposes to learners.

According to research, there is a gap between what PSTs learn in their teacher training and how they can use ICT in the classroom (Tondeur, et al 2012). This suggests that PSTs are exposed to insufficient authentic ICT integration learning experiences during their teacher training that are relevant to practical ICT integration in the classroom. As stated above, teachers who are not exposed to technology use during their teachers' training, are likely to be unprepared for ICT integration in their classrooms. Tondeur, et al 2012 suggest that PSTs need regular practice on technology use to develop a positive attitude towards ICT integration in their classroom.

At this South African university, all PSTs are offered a computer literacy course in their first year only that is designed to expose them to computer skills. Secondly, all students at this university are not allowed to submit handwritten assignments for their courses and they submit through a platform called Ulwazi, which was introduced in March 2021, but previously the

platform was called Sakai that served the same purpose. Ulwazi is web-based course-management system designed to allow students and faculties interact among other uses. For example, through this platform, all instructors are able to provide students with course materials, assignments, virtual chats, online quizzes, assessments feedbacks, host online conferences and more and students are also able to submit their assignments and write their online quizzes, attend online lectures and more. The university has students' computers in the labs and library with free internet access for students' use. Each lab has computer assistants that provide technical support to students. The lecture halls have computer PowerPoint projector facilities that lecturers and students use for their teaching and learning purposes. The university also provides free Wi-Fi to all students to access internet for their social and academic purposes. For me it appears that the university assumes that at the end the four years of the teacher's program, all the PSTs should have had some exposure to computer literacy and probably be able to use the skills in their pedagogical practices. However, as the teacher preparation program at this university does not include explicit use of ICT for the purpose of teaching and learning, it is not clear if such an exposure to ICT facilities prepares PSTs for ICT integration into teaching practices at the end of their training.

The South Africa government through the Department of Education (DoE) provides some guidance about ICT integration by reiterating that student currently in higher education institutions should be fast-tracked to bring them to at least the adoption level by the end of their studies (Meyer & Gent, 2016; Hindle, 2007; Isaacs, 2007). Furthermore, the Council on Higher Education (CHE) (2006) report recommends that the new generation of teachers graduating from higher educational institutions must be equipped with a better understanding of how to incorporate and use ICT in their teaching subjects in schools in order to realize the national's goal on ICT integration. It is quite clear that the South Africa government through the DoE and CHE emphasize the need for higher institutions to integrate ICT in their teacher preparation programs in order to equip new teachers with ICT skills. In views of this, the Department of Higher Education and Training (DHET) (2013) in its policy guidelines regarding the teacher preparation program classifies ICT as a crucial learning area that all South African graduating teachers should be competent in. However, Mooketsi and Chigona (2014) found that teachers' practices in schools are different from South Africa government's expectations in terms of ICT use that many teachers do not use ICT in their classrooms. The DoE (2015b) in its Action Plan to 2019 report laments that the technology-enhanced learning has not progressed in the country as expected, probably because most teachers lack the ICT knowledge and skills essential to meet learners' needs. In this present digital generation, technology has become a learners'

everyday universal language that teachers can incorporate into their teaching to maximize learners' participation in accessing and evaluating new knowledge. However, teachers often seem to be novices to technology which widens the gap between how they deliver knowledge and how learners acquire it (Loboschefsky, 2016). Jita (2016) and Chikacha, et al (2014) argue that teachers are likely to integrate ICT in their teaching subjects if they experience ICT skills just like learners themselves during their teacher preparation programmes. On the contrary, studies in South Africa have found that although in-service teachers (including new graduates) get training through government and non-government initiatives on how to use ICT in their teaching subjects, but majority of teachers in schools are still incompetent to use ICT in their classrooms (Jita, 2016; Mlitwa & Kesewaa, 2013; Ndlovu & Lawrence, 2012).

In order to meet the needs of diverse learners, PSTs who are preparing to become teachers are expected to be equipped with ICT skills to incorporate into their instructions to engage and empower personalized learning experiences for learners. The South Africa government has declared ICTs integration as a priority in schools envisaging that all the learners should be exposed to technology including PSTs (Meyer, & Gent, 2016; Cross & Adam, 2007; Isaacs, 2007; DoE, 2003). However, little is known regarding how much ICT knowledge and skills Life Sciences preservice teachers acquire or go out with before they go into schools where they will use it for the purposes of teaching and learning in their subjects especially Life Sciences that requires a lot of representations using ICT to clarify or explain abstract concepts for students' understanding. The question therefore is: how prepared are the Life Sciences preservice teachers to integrate ICT in their instructions during teaching experience?

1.3. Purpose of the study

The level of ICT skills, self-efficacy, pedagogical beliefs, perceived usefulness of ICT and the attitudes of teachers are some of the factors that influence teachers' ability to use ICT in their classrooms (Joo, et al, 2018); Apeanti, 2016; Lee & Lee, 2014). However, the purpose of this study was to explore the Life Sciences preservice teachers' preparedness to integrate ICT during Life Sciences' teaching experience: a case study at a South African university.

1.4. Objectives of the study

The objectives of the study were outlined as:

a. To explore the preparedness of Life Sciences preservice teachers to integrate ICT into their classroom pedagogical practice during their Teaching Experience.

b. To find out how according to the pre-service teachers, ICT knowledge play a role in their confidence towards its integration in Life Sciences teaching.
c. To establish the preservice teachers' perceived benefits of ICT integration in the teaching and learning of Life Sciences.
d. To find out how the lecturers' modelling influences the disposition of Life Sciences preservice teachers towards integrating ICT into their own classroom practices.

In order to explore the Life Sciences preservice teachers' preparedness, the following research and sub-questions guided the study:

1.5. Research Questions

Primary research question

How prepared are the preservice teachers to integrate ICT during Life Sciences' Teaching Experience?

Sub-research question

1. How do Life Sciences preservice teachers perceive themselves prepared to integrate ICT into their classroom pedagogical practice?
2. How does ICT knowledge play a role in the Life Sciences preservice teachers' confidence towards ICT integration?
3. What are the Life Science preservice teachers' perceived benefits of ICT integration in the teaching and learning of Life Sciences?
4. How does the lecturers' modelling influence the disposition of Life Sciences preservice teachers towards integrating ICT into their own classroom practice?

1.6. Justification and significance of the study

In the present digital age, the teaching of science subjects with ICT integration demands knowledge, skills, and abilities for effective integration with the goal of maximizing students' participation and achievement. In respect of this need, institutions of higher learning have redesigned their teacher preparation programs to include ICT knowledge and skills needed by teachers in the methodology courses or ICT courses to implement the government's policy of producing ICT literate graduates. It is with this assumption that PSTs at the School of Education, South African university had had an opportunity to learn how to use ICT to teach Life Sciences concepts and have been equipped to implement the ICT integration policy in their teaching and learning of Life Sciences. However, the level of preparedness of these PST to

integrate ICT in their teaching instructions has not yet been established. It is worth examining their preparedness in order to understand whether the teacher's preparation programs align with the government's expectations of integrating ICT in the teaching and learning.

Magliaro and Ezeife (2007) observe that many school managers and in-service teachers expect and look unto new teachers to be knowledgeable and conversant with the current technology in order to fill the gap available in schools and to effectively integrate it into the curriculum to enhance the teaching and learning. It is with this assumption that the study seeks to provide some insights regarding ICT knowledge and skills preservice teachers acquire during their teacher preparation program, which could be an opportunity to evaluate if the teacher preparation program aligns with the national's expectations. The argument in this study is that the process of effective use of ICT in schools needs to start in the teacher preparation programs because this preparation stage is the best time to equip the PSTs with ICT-based skills related to teachers' work in schools. PSTs in this regard should be able to demonstrate their technological skills through their pedagogical practices as one of the indicators of showing preparedness to integrate ICT during their teaching experience and beyond.

1.7. Definition of terms

In this research report the following terms were used:

Authentic learning experience: This refers to the learning experience in which the teacher's instructional approach is modelled in a way that students are given a chance to explore, construct, and connect concepts to the real world.

Dispositions: The National Council for Accreditation of Teacher Education (NCATE) (2006) defines dispositions as "the values, commitments, and professional ethics that influence behaviors toward students, families, colleagues, and communities and affect student learning, motivation, and development as well as the educator's own personal growth" (NCATE, 2006, pg.53.)

ICT integration: In this context, the term ICT integration refers to "the appropriate selection and use of technology within a science lesson or unit to facilitate or enhance student learning of the content" (Rehmat et al, 2014, pg. 745).

Information and communications technology (ICT): It refers to the use of electronic devices such as computers, projectors, interactive smartboards, smartphones, tablets as a form of sharing, receiving, designing, delivering and/or developing information and content for different purposes such as educational purposes. These electronic devices or applications that can be used in the teaching and learning, have also been called **ICT tools.**

In-service teachers: These are professionals who have qualified as teachers and are working either fulltime or part-time as teachers in schools, districts, or other institutions of education such as technical institutions.

Lecturers: In this context, these are teacher educators at institutions of higher learning who teach preservice teachers "during their teacher preparation program" of study at a university.

Methodology courses: This refers to courses that preservice teachers pursue who specialize in specific subjects at FET, senior or intermediate phases.

Paradigm: It is defined as "a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them, especially in an intellectual discipline" (Göktürk, 2005, pg. 2). According Feilzer (2010) a paradigm "directs research efforts, it serves to reassert itself to the exclusion of other paradigms to articulate the theories it already established" (Feilzer, 2010, pg. 7).

Preparedness: It refers to the "state of being ready or prepared" to do something. In this study, preparedness to integrate ICT underlines the "attitudinal aspect of being prepared" to use ICT in the teaching practices.

Preservice teachers (PSTs): These are future or prospective teachers who are studying to be teachers as undergraduate or postgraduate students. In this study the PSTs are the fourth year Bachelor of Education and Postgraduate Certificate of Education (PGCE) enrolled for Life Sciences as their teaching subject.

Self-efficacy: It has been defined as the "the belief (or perception) that one has the necessary skills and abilities to perform the behaviour (or task)" (Banas & York, 2014, pg. 730).

Teacher preparation program: This refers to the program of study offered at a higher education institution, typically for students who intend to be future teachers and enroll for a Bachelor of Education Degree or undertake postgraduate studies at a postgraduate level such as a postgraduate Diploma in Education (PGDE) or postgraduate Certificate in Education (PGCE).

Teaching experience: This refers to the period when student teachers practice what they have learned in their teacher preparation program in schools. It is usually accompanied by observation by peers or in-service teachers who usually act as their mentors and lecturers or tutors who assess these students before they can qualify as teachers. It is also called teaching practice.

1.8. Abbreviations

The following abbreviations have been used in this research report:

CHE: Council on Higher Education.

CK: content knowledge.

DHET: Department of Higher Education and Training.

DoE: Department of Education.

ICT: information and communications technology.

PCK: pedagogical content knowledge.

PGCE: Postgraduate Certificate in Education.

PGDE: Postgraduate Diploma in Education.

PK: pedagogical knowledge.

PSTs: preservice teachers.

SPTKTT: Survey of Preservice Teacher Knowledge of Teaching and Technology questionnaire

TCK: technological content knowledge.

TE: teaching experience

TK: technology knowledge

TPACK: technological pedagogical content knowledge

TPK: technological pedagogical knowledge

UNESCO: United Nations Educational, Scientific and Cultural Organization

1.9. Overview of the Research Report

This research report is divided into five chapters:

Chapter 1:

This chapter gives background information that highlights the role of ICT in education and introduces the research study. The chapter also states the overall argument why the research study was undertaken and then introduces the problem statement, purpose and the significance of the study. This is followed by the research question and the sub-questions that guided the study. The chapter concludes by the definitions, abbreviation of terms that were used in the research report and then an overview section of the research report.

Chapter 2

This chapter examines the literature review that pertaining to the topic of study. The chapter gives a brief account of the benefits and barriers of ICT integration among preservice teachers, preservice teachers' perceptions of ICT integration, preservice teachers' sense of preparedness to integrate ICT and it concludes by the TPACK Conceptual Framework.

Chapter 3

This chapter describes the study's research methodology, which is a mixed methods research design. There is also a brief description of mixed methods research and a case study design. This is accompanied by a description of how participants were sampled, data collected and analysed. This chapter also explains how the study's ethical considerations were addressed. Lastly, the study describes how the study's validity and reliability were achieved.

Chapter 4.

This chapter presents the analysis of data and presentations of results of the study. The results are organized according to order of research questions.

Chapter 5

This chapter discusses the findings the study. The discussions are organized according to the order of research questions. The chapter is followed by recommendation that based on the findings discussed in the chapter. The last part of the chapter is conclusions and limitations of the study.

Chapter 2: Literature Review and Conceptual Framework

2.1. Introduction

In this section as part of literature review on the topic of "exploring Life Sciences preservice teachers' preparedness to integrate ICT into their instructions during teaching experience: A case study at South African university", the following topics were used: role of ICT integration in schools and the challenges of ICT integration; ICT integration preservice teachers' perceptions of ICT integration in their classroom instructional practices and technological pedagogical content knowledge (TPACK), a conceptual framework of the study that informed the ICT integration in the teaching and learning. In the last section of this chapter, I will briefly discuss the self-efficacy theory, which helps to understand how teachers' attitude and competence in ICT can influence the use of ICT integration in teaching and learning.

2.2. The role of ICT in the education system.

According to UNESCO (2011) the modern societies are growingly depending on ICT and as such they need to continually support and embrace ICT in their education systems in order:

- *To build workforces which have ICT skills to handle information and are reflective, creative and adept at problem-solving in order to generate knowledge,*
- *To enable citizens to be knowledgeable and resourceful so they are able to manage their own lives effectively, and are able to lead full and satisfying lives,*
- *To encourage all citizens to participate fully in society and influence the decisions which affect their lives and*
- *To foster cross-cultural understanding and the peaceful resolution of conflict. (*UNESCO (2011, pg.7).

This statement shows that UNESCO considers education with ICT use is an instrument that could advance the social and economic goals of a country. In this regard, it appears UNESCO expects teachers to be equipped with ICT knowledge and skills to enable them to execute and fulfil the above roles. Meyer and Gent (2016) point out that the use of technology in teaching and learning has changed the face of education in the sense that instead of focusing on improving learner marks, now the focus is on a broader perspective of preparing learners to participate in the socioeconomic activities of their communities, country. Makgato (2012) adds that technologies in schools provide an array of influential tools that have capacity to transform

the traditional teacher-centred and text-bound classrooms into rich, student-centred, and interactive knowledge classrooms. Makgato (2012) asserts that these benefits of ICT use in education are enough to convince schools and teachers to embrace ICT use for their teaching and learning processes.

2.3. ICT integration

Information and communications technology (ICT) refers to the use of electronic devices such as computers, projectors, interactive smartboards, smartphones, tablets as a form of accessing, gathering, receiving, designing, manipulating, presenting, sharing, or developing information and content for different purposes such as educational purposes (Llyod, 2006). The word "technologies" include hardware (e.g. computers, tablets, smartphones and other devices), software applications (e.g. Microsoft Word and PowerPoint; Adobe; Internet browsers, such as Google chrome and Firefox; Zoom; Microsoft Teams and WhatsApp) and connectivity (e.g. access to internet, local networking infrastructure) (Lloyd, 2006).

Lloyd (2006) observes that the word "integration" is often used interchangeably with the word "use". For examples "Pisapia (1994) defines ICT integration as the *"use of learning technologies to introduce, reinforce, supplement, and extend skills"* (Pisapia, 1994, pg. 2). According to Lloyd (2006) there is no clear definition of ICT integration to stress its significance. However, Lloyd suggests that ICT integration should reflect a transformation in pedagogical practice to make ICT less detached to schooling and more fundamental to student learning. Lloyd (2006) proposes that ICT integration should be thought of as an equation made up of three components: information literacy, information policy and knowledge management. As an equation, ICT integration should be thought of as different from an operational use of the devices (hardware such as computer, tablet) and the software applications such as Microsoft Word (Lloyd, 2006). For example, using a computer in class to enter test scores into an excel spreadsheet or Microsoft Word is not ICT integration because it does not improve teaching and learning. Secondly, it should not be defined but rather be thought as part of the teacher's implicit knowledge of using ICT in their pedagogical practices. Lastly, ICT integration should relate to "how" and "when" the teacher uses ICT in the classroom for purposes of teaching (Lloyd, 2006). This study is understood in the lens of the technological pedagogical content knowledge (TPACK) framework of Life Sciences PSTs, ICT integration will be defined as "the appropriate selection and use of technology within a science lesson or unit to facilitate or enhance student learning of the content" (Rehmat, et al, 2014, pg. 745).

2.4. ICT integration in South Africa

Borrowing a leaf from the international community, South Africa has introduced several strategies and policies to bring ICT knowledge and use into schools and declared ICT integration as a priority in schools (Jita, 2016) in order to maximise the benefits of ICT to the country. Nkula and Krauss (2014) claim that learning with or through use of ICT encourages learners to generate new knowledge and skills that are intertwined into the curricula. However, Nkula and Krauss point out that ICT integration does not simply mean to place computers in classrooms or to support the conventional teaching strategies, but it means to use ICT in order to facilitate the teaching and learning in which learners learn with or in the course of learning ICT use. ICT integration according to Wilson-Strydom et al (2005) cited by Nkula and Krauss (2014) involves two things: adoption of ICT and ICT use. The ICT use involves learning about computer or representational use, and learning with or through computers, which is reported to be a challenge in South African schools because many teachers do not have essential skills needed to integrate ICTs into their teaching and learning (Nkula & Krauss, 2014). According to Meyer and Gent (2016) the use of ICT in education in South African schools is often not approached from the perspective of being in support of a model of teaching and learning which makes it difficult for teachers to understand the value and impacts of ICT integration in terms of capacity to teach and learn with ICT.

Furthermore, Meyer and Gent (2016) observe that in South Africa, the purpose of ICT use in schools seems to mainly aim at improving learners' marks, which places more focus on the learner's outcomes rather than looking at it as a tool that supports the teaching and learning. This shows the policy for ICT integration in classrooms is diverting from focusing on the capacity of the system to teach with ICT and integrate ICT in support of teaching and learning to merely using ICT to improve grades. Despite lack of a clear policy on how to technologically prepare teachers in the country, Scheerens (2016) suggests that teachers still need to be deliberately trained technologically to make them understand the different ways of teaching and assessing their subject matter using ICT because the capacity to use ICT tools on top of the teacher's subject matter is deemed to be a critical skill in this 21st century of digital age and it needs to be developed (Jita, 2016). UNESCO (2011) ICT Competency Framework for Teachers further adds that teachers have a duty to assist learners to become collaborative, creative, and problem solvers using ICT so that they will be productive and effective citizens in the country and workforce.

2.5. Barriers of ICT integration among preservice teachers

Ertmer (1999) model describes two types of barriers that hinder ICT integration into the teaching and learning: first-order barriers (extrinsic barriers**),** which include technical support, lack of access to appropriate resources such as software, hardware, and internet access, inadequate training, and lack of time provided to the teacher. The second-order barriers (intrinsic barriers**),** which are associated with the teacher. These barriers are embedded in the teachers' attitudes, pedagogical beliefs and philosophy about teaching and learning. Ertmer (1999) points out that the intrinsic barriers are difficult to overcome because they are concealed and personal than the extrinsic barriers. The second-order barriers can impede ICT use in the classroom more than the first first-order barriers because it depends on how the teacher feels about using technology in the classroom, how comfortable the teacher is when using technology, and how useful the teacher perceives is the ICT tool for learning (Durff & Carter 2019).

Durff and Carter (2019) summarize three influences of ICT integration, which determine whether the teacher will integrate ICT or not: attitude barriers, socio-cultural barriers, and pedagogical barriers. The socio-cultural barriers, which include school administration, school culture, teacher's self-efficacy and teacher's subject matter knowledge, influence the ICT use in the classroom. For example, school administrators can support the teacher to integrate ICT or hinder the teacher from integrating ICT. The pedagogical barriers develop during the teacher preparation programs and through experiences in classrooms. For examples, as preservice teachers become engaged and used to ICT use to demonstrate the learning in their teacher preparation program, they are likely to use ICT in their future teaching practices (Durff & Carter, 2019). Ertmer et al. (2012) found that teachers' beliefs and attitudes towards ICT, besides their current knowledge and skills on CT, persist to be barriers for the use of ICT in teaching and learning.

2.6. Preservice teachers' perceptions of ICT integration

Aslan and Zhu (2015) find that preservice teachers' perceived ICT competence significantly predicts their ability to integrate it in their teaching practice. In that study PSTs indicated that their prior experiences regarding ICT use had a positive effect on their ICT integration in the teaching practices. Furthermore, most participants in that study perceived that their ICT

competence skills were insufficient; arguing that their ICT use training was not enough during the teacher preparation program to enable them to use it in their teaching practice. However, most of the participants in the study indicated that in addition to having ICT competence, pedagogical knowledge was essential to enable them integrate ICT into their teaching practices. Those participants in Aslan and Zhu (2015) study indicated that having ICT competence and pedagogical knowledge complement each when it comes to ICT integration into the teaching and learning. This implies that successful integration of ICT into the teaching and learning calls for the teachers' understanding of how technology, pedagogy and content knowledge interact.

2.7. Preservice teachers' sense of preparedness to integrate ICT

According to Cheal and White (2012) a sense of preparedness to integrate ICT in classrooms among PSTs is influenced by access, capabilities, and attitudes to ICT, understanding, ICT experiences, time, and the workload of their teacher preparation program. In addition, preservice teachers' recognition and understanding of the benefits of ICT for student learning influences their intents and persistence regarding its integration into teaching and learning (Anderson, Groulx & Maninger, 2011). Gill and Dalgarno (2008) add that the likelihood that PSTs will use ICT in their pedagogical practices depends on the technology-related training they received as it helps to develop the teachers' competency on computer applications and influences their attitude to ICT use.

A study by Irmak and Tüzün (2019) on technological pedagogical and content knowledge (TPACK) dimensions among preservice science teachers found that they had the lowest technological knowledge score of all the TPACK dimensions and that affected their ability to use it in classrooms. The study concluded that teacher's education programs need to offer more opportunities to preservice science teachers that allow them to acquire content knowledge in parallel with the technological knowledge in the science field. Jita (2016) found out that the technological content knowledge among preservice science teachers at a South African university was high and many were familiar with different ICT tools to teach science but to use those tools in their actual teaching practice was a challenge to them. Participants indicated that the challenge to use ICT tools to teach science content was due to lack of knowledge of how to use them to deliver a science lesson. The study also reports that although PSTs develop technological knowledge in the teacher preparation programme, they encounter challenges to put into practice and share knowledge during teaching practice because they do not have access to resources at the schools. However, Jita (2016) reveals that the majority of preservice science

teachers indicated they were motivated by their university lecturers to use ICT in teaching and learning. This suggests that lecturer's model of ICT use in classrooms may influence preservice teachers' adoption and use of ICT in their pedagogical practices in classrooms.

2.8. The TPACK Conceptual Framework

Since 1986 when Shulman developed a pedagogy content knowledge (PCK) model, researchers have examined teachers' knowledge of teaching (Raygan & Moradkhani (2020). Raygan and Moradkhani argue that teachers often tend to have a depth of content knowledge of their subject matter, but the ability to effectively teach the content to learners in a meaningful way depends on their ability to select appropriate instructional strategies. Hence, Shulman (1986) suggests that teachers' professional knowledge of pedagogy needs to be blended with their subject matter knowledge, which forms a domain called pedagogical content knowledge (PCK). Regarding integration of technology into teaching (pedagogy), it is crucial to focus on how the PCK can be synchronized in this integration. With regards to technology, Angeli and Valanides (2009) came up with an ICT-related PCK concept called "technological knowledge". They argue that for teachers to use any ICT tool in an educational context, they should be able to combine their technological knowledge and its use in the educational framework. It can be summarized that effective technology integration into teaching a specific subject matter entails the blending of three important knowledge domains: technology knowledge (TK), pedagogy knowledge (PK) and content knowledge (CK). According to Mishra and Koehler (2006) the combination of these three knowledge domains results into four knowledge domains: technological content knowledge (TCK), technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK) and technological pedagogical and content knowledge (TPACK) at the intersection of three knowledge domains as shown in the figure below:

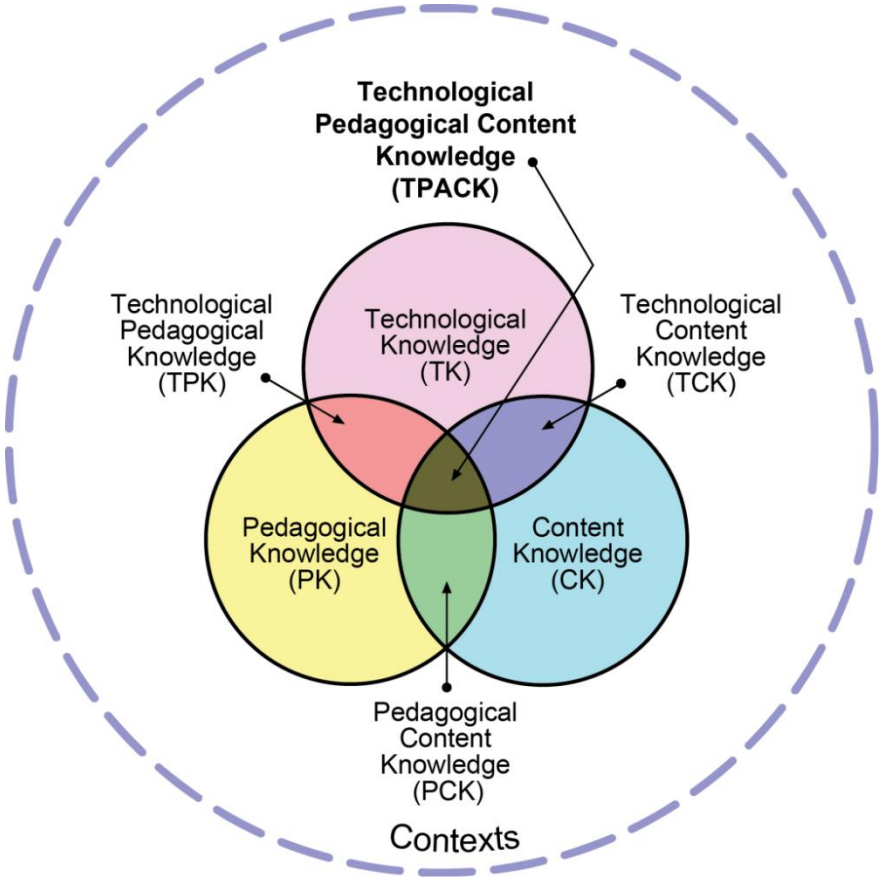


Figure 1: The domains of the TPACK framework (Source: http://tpack.org)

The Technological Pedagogical and Content Knowledge (TPACK) conceptual framework (Mishra & Koehler, 2008) argues that technological knowledge, pedagogical knowledge, and content knowledge exist as interrelated components that PSTs need to understand. The framework highlights that future teachers should not only know about how to use ICT but also know about the specific knowledge engaged in the pedagogical use of ICT, and to understand the impact of the ICT on the learning process (Brun, & Hinostroza, 2014).

Schmidt, et al (2009, pg 125) define the seven domains of TPACK:

> **Content Knowledge (CK)** which refers to the knowledge about actual subject matter that is to be learned or taught. Teachers must know about the content they are going to teach and how the nature of knowledge is different for various content areas; **Pedagogical Knowledge (PK)** as the methods and processes of teaching and learning. It includes knowledge of classroom management, assessment, lesson plan development, and student learning; **Technological Knowledge (TK)** as the knowledge about various technologies, ranging from low-tech technologies such as pencil and paper to digital technologies such as the internet, digital video, interactive whiteboards, and software

programs; **Pedagogical Content Knowledge (PCK)** as the knowledge that deals with the teaching process (Shulman, 1986). PCK is different for various content areas, as it blends both content and pedagogy with the goal being to develop better teaching practices in the content areas; **Technological Content Knowledge (TCK)** is defined as the knowledge of how technology can create new representations for specific content. It suggests that teachers understand that, by using a specific technology, they can change the way learners' practice and understand concepts in a specific content area; **Technological Pedagogical Knowledge (TPK)** is defined as the knowledge of how various technologies can be used in teaching, and the understanding that using technology may change the way teachers teach; **Technological pedagogical content knowledge (TPACK)** as the knowledge required by teachers for integrating technology into their teaching in any content area.

Teachers' understanding of TPACK that it is a complex interplay between the three basic components of knowledge (CK, PK, TK) when teaching content using appropriate pedagogical methods and technologies. Jita (2016) supports TPACK conceptual framework by arguing that PSTs are not only required to understand their subject matter, but they are also expected to practice the use of different technologies in their subject matter to better represent the content knowledge to their learners in a more effective manner. Jita further argues that in developing countries the teaching of science is very abstract due to lack of appropriate teaching equipment that can be used to demonstrate and represent systems, processes, and reactions. In these circumstances, the use of technology is crucial to bring meaningful teaching and learning. However, Brun and Hinostroza (2014) found that PSTs lack of confidence to integrate ICT in their upcoming teaching comes from the lack of pedagogical authentic activities during their teacher education program, claiming that they lack previous experiences of how to apply into curriculum when they go to schools. Furthermore, Brun and Hinostroza (2014) observe that many PSTs themselves believe that they are not fully prepared to use ICT in the teaching arguing that their ICT knowledge is not enough as they did not major in ICT.

In this study, the TPACK provides the lens of understanding the development of technological pedagogical and content knowledge of Life Sciences PSTs, which affect their ability to integrate ICT into their pedagogical practices. To justify this, Nkula and Krauss (2014) argue that it depends on the teacher's ability to bring together TPACK domains to realize ICT implementation and integration into the teaching. For example, Joo, Park and Lim (2018) find that teachers whose TPACK is developed are more confident and willing to use ICT in

appropriate ways in their instructional strategies than those who are not. This concurs with Naicker (2010) who found that teachers with high self-efficacy are usually open to new ideas and are willing to incorporate new teaching strategies and seek improvements in their instructions. About PSTs, their self-efficacy to use ICT grows as their TPACK develops, which in turn affects their capacity to integrate ICT in their instructions (Naicker, 2010).

When Mishra and Koehler (2006) introduced the TPACK framework as a conceptual lens for researchers to examine how teachers use technology in the classroom, the first generation of TPACK research was primarily concerned with identifying and conceptualizing the seven TPACK constructs listed above (Schmidt-Crawford, et al 2016). Recent research, on the other hand, have switched their focus to understanding teachers' knowledge of using technology to support and enhance their teaching using the framework (Schmidt-Crawford, et al 2016). Despite this, the majority of studies exploring teachers' TPACK development have relied on self-report data extracted from questionnaires (Schmidt-Crawford, et al 2016). According to Kilickaya (2009) while teachers' self-reported data from questionnaires may provide information about their TPACK development, there is a possibility that teachers may forget about their TPACK experiences when filling out the questionnaire, and the data may not reflect their actual technology integration practices in the classroom. In order to better understand teachers' TPACK, Harris et al (2010) and Schmidt-Crawford, et al (2016) recommend that self-report data should be triangulated with external data of teachers' TPACK, which may be obtained through interviews and observations. It is with these reasons that the TPACK framework was the suitable lens in this study to better understand preservice teachers' TPACK development through their self-report data, which was obtained through a questionnaire and the external data which was collected through an interview.

2.9. The Self-Efficacy

Bandura (1977) developed a self-efficacy theory in which he describes how an individual views his or her own ability to successfully execute a specific behavior based on social learning and modeling. Self-efficacy is defined as the individual's belief in his or her ability to manage and implement actions to perform the assigned tasks (Bandura, 1977). Bandura notes that people tend to avoid tasks and situations they perceive surpass their abilities, but they tend to carry out and perform confidently activities they perceive themselves able of handling. Additionally, Bandura observes that the stronger one's self-efficacy is the more vigorous and persistent is his or her effort. In this study, the theory of self-efficacy provides a better understanding on their

confidence of to use ICT during their teaching practice develops. Furthermore, Govender and Govender (2009) assert that the use of ICT in schools improves the teaching and learning, but teachers are slow to implement it. In this regard, Govender and Govender (2009) suggest that teachers' self-efficacy beliefs towards ICT integration perhaps underlie many of their actions. They observe that self-efficacy beliefs control a person's decision-making process, agreeing with Bandura (1977) who notes that self-efficacy is connected to one's confidence, attitude, and belief about performing a task as to whether one will succeed or not. Studies have shown that successful adoption and use of ICT for teaching and learning largely depends on teachers' attitudes (Joo, Park & Lim, 2018).

Derosier and Soslau (2014) conclude that teachers with high levels of self-efficacy regarding teaching with ICT are more likely to participate and proceed in ICT-related tasks unlike teachers with low levels of self-efficacy. This agrees with Kersaintet, et al (2003), and Heath (2017) who found that teachers with positive attitudes on technology are more comfortable using it, and they usually integrate it into their teaching and learning. Song (2018) found out that PSTs teachers who were exposed to service learning at the elementary school using technologies improved their self-efficacy. Song (2018) also concluded that preservice teachers' attitudes in technology use for those who were exposed to technology improved at the end of the learning program and they were willing to integrate technology in their future classroom instructions.

In conclusion, literature reveal that PSTs exposure to technology use improves and increases their confidence to using it for teaching and learning purposes. Secondly, perceived usefulness of ICT and ease of use of ICT also contribute preservice teachers' willingness to integrate ICT in their teaching practices.

The next chapter describes the research methodology, data collection and analysis, validity and reliability and ethical considerations that were followed in the study.

Chapter 3: Research Methodology

3.1. Research Design

The main paradigms of understanding reality that have traditionally been presented as opposing views are positivism and constructivism (Feilzer, 2010). Positivists advance the notion that there is a single reality out there waiting to be discovered by an objective and value-free inquiry approach (Feilzer, 2010). As such positivists subscribe to a quantitative research approach being the best way of obtaining the truth. On the other hand, constructivists oppose positivists that there is no single objective reality out there because humans construct and interpret "their reality" in multiple ways. In this regard, constructivists argue that the subjective inquiry is the only way to obtain the truth (Feilzer, 2010). Consequently, constructivists subscribe to a qualitative research approach as the best ways to discovering the truth (Feilzer, 2010). However, pragmatism is a deconstructive paradigm that discards both positivism and constructivism positions. Instead, pragmatism as a paradigm takes what comes at a middle road through positivism and constructivism assumptions (Morgan, 2014). With regards to reality, pragmatists argue that even though there is a reality that exists apart from human experience, it can only be discovered through human experience (Morgan, 2014). Thus, pragmatists "believe that the world is both real and socially constructed" (Morgan, 2014, pg. 15). Hence, pragmatism as a paradigm advocates for the use of mixed methods in research as an inquiry process to combine both the diverse strengths of quantitative and qualitative approaches (Morgan, 2014; Feilzer, 2010). This study adopted a mixed methods design to utilize the benefits of both quantitative and qualitative approaches better understand the preparedness of the Life Sciences PSTs to integrate ICT in their teaching practices.

3.2. Mixed Methods Research Design

A mixed methods research design is defined as a systematic integration of quantitative and qualitative data in a single study that are interlinked to produce a more comprehensive picture and deeper understanding of the research problem (Halcomb & Hickman, 2015; Johnson, et al 2007). The advocates for mixed methods research design do not favour either of the two paradigms mentioned above (positivism or constructivism) but rather strive for an integration of the two because it offers deep understanding of the problem under study (Creswell & Creswell, 2018). In this regard, Creswell and Creswell (2018) argue that the mixed methods research design to research balances the limitations from both kinds of data collection

(quantitative and qualitative) because it dwells in the middle of these two approaches; hence it integrates elements of both approaches. For example, Johnson and Onwuegbuzie (2004) state that results of qualitative research may be partial towards the investigator's individual predispositions, and hence quantitative data enhances the reliability and validity of research results. On the other hand, quantitative data alone does not bring out in-depth understanding of the observed phenomenon and hence the inclusion of qualitative data enhances a deeper understanding of the observed phenomenon (Johnson & Onwuegbuzie, 2004). Auerbach and Silverstein (2003) argue that qualitative research paradigm provides the means to learn about participants' subjective experiences as they are asked about it and listen to what they say because people always talk about their experiences in a story form. This study adopted the mixed methods research design to get an in-depth understanding of the phenomenon by utilizing both quantitative and qualitative data. The participants were allowed to provide their own perceptions without interference through the filling in of the questionnaire that was based on TPACK to gather the quantitative data and secondly participants were also interviewed to gather the qualitative data also based on TPACK. The interviews gave me a chance to interrogate participants' perceptions regarding ICT use. The two data sets were then triangulated to better understand participants' preparedness to use ICT in the teaching of Life Sciences as participants' quantitative perceptions were justified through their narratives in the interviews. As discussed above, the approach was preferred to get an in-depth understanding of how PSTs perceived their preparedness to use ICT in the teaching of Life Sciences.

3.3. A Case Study

A case study is described as a comprehensive systematic study of a single subject, group, or any other unit where the researcher explores in-depth data relating to many variables (Heale & Twycross, 2018). The aim of a case study is to provide a summary of the case that is as complete and accurate as possible (Cronin, 2014). In using a case study, the preparedness of Life Sciences PST to integrating ICT in their pedagogical practices was explored at a South African university with the lens of TPACK conceptual framework. A case study within a mixed methods design was preferred to gain a deeper understanding of the phenomenon (preparedness of Life Sciences PST to integrate ICT). According to Kitchenham (2010) mixed methods research works explicitly well for case study as it allows the investigator to gather the rich empirical data generated from the case study through the quantitative and qualitative methods and enhance the credibility of the study. Since qualitative analyses provide descriptive precision and quantitative

analyses provide statistical precision, the combination of the two (mixed methods approach) increases credibility (Kitchenham, 2010).

3.4. Data collection

The following instruments were used to collect data: questionnaire and semi-structured interviews. According to Creswell (2018) questionnaire survey approach provides an opportunity to collect attitudes, behaviours, beliefs, and the practices of the participants. In this study, the quantitative data was collected through a five-point Likert Scale questionnaire adapted from the Survey of Preservice Teacher Knowledge of Teaching and Technology (SPTKTT) (Schmidt et al., 2009).

The SPTKTT questionnaire is designed for preservice teachers to self-evaluate their TPACK components (CK, PK TK, PCK, TCK, TPK and TPACK) which are described in chapter 2, pages 14-17 through agreeing or disagreeing with the question statements. Each TPACK statement (questions 1-34) was rated from "strongly disagree" to "strongly agree" that participants had to choose from (see appendix 1). The SPTKTT questionnaire was appropriate for this study because it is designed for participants to self-evaluate their TPACK components without the researcher's interference. I was interested in exploring how participants perceived their own TPACK abilities that related to the teaching of Life Sciences and as such the SPTKTT questionnaire captured participants' TPACK abilities that related to teaching of Life Sciences. The SPTKTT questionnaire also had two open-ended questions (question 35 and 36) that were designed to collect preservice teachers' qualitative data. The open-ended question 35 was meant to collect data from participants on how they had perceived lecturers' modelling of the TPACK in the teaching of Life Sciences. The open-ended question 36 was designed to collect participants' experiences on how they had integrated ICT in their own Life Sciences lessons.

Furthermore, the qualitative data was also collected through interviews. An interview is a systematic mode of talking and listening to people with an intention of collecting data from them through the conversation (Kajornboon, 2005). Kajornboon explains that through an interview, the interviewee gets involved and talks about his or her views, perceptions, and interpretation regarding a given situation. In this study, a semi-structured interview, which is a non-standardized interview as opposed to structured interview, was used. In semi-structured interview, the researcher is free to ask questions considered fit and appropriate without following any order of questions and can prompt and probe deeper into the given situation for

the interviewee to clarify further of any point if necessary (Kajornboon, 2005). It is the researcher who has a list of questions and key themes or issues to be covered. The semi-interview questions were designed to generate a deeper understanding of how the Life Sciences PSTs perceived their preparedness to integrate ICT during their teaching experience program (see appendix 2). The semi-structured interviews are preferred as they offer an opportunity to probe and deepen participants' responses (Adams, 2015). In this study, the interview questions were designed to explore preservice teachers' TPACK, but they were supplemented with extra probing questions depending on the participant's response. The data from interviews was collected and analysed to reflect preservice teachers' perceptions based on their knowledge of TPACK.

3.5. Approach to data collection during lockdown

Due to the COVID-19 pandemic, face to face meetings were prohibited by the government and the university. In that regard, the SPTKTTquestionnaire was set up on online in a Google Forms that was linked to the researcher's email through which research participants completed it. A link to the Google Forms was sent to the participant through their emails and the completed questionnaires on Google Forms from participants were automatically received by the researcher.

With regards to interviews, they were conducted telephonically through Microsoft Teams application platform and were audio-recorded with the interviewees' consent and they lasted 15 to 20 minutes. I planned to interview 10% (10 Life Sciences PSTs) of the total population (99 Life Sciences PSTs). However, out of 18 participants (12 Bachelor of Education and 6 PGCE), only 7 participants (5 PGCE and 2 Bachelor of Education) expressed willingness to be interviewed. The interviews were audio-recorded to ensure that no information was missed and that they could later be listened to again and transcribed to get a deeper understanding of the participants' voices regarding their preparedness to integrate ICT during their teaching experience for the teaching of Life Sciences.

3.6. Population and sampling of participants

The choice of the School of Education, South African university was based on convenience since I am a student at this university. Secondly, the university has students who were on a teacher preparation program that I wanted to explore their preparedness to teach with ICT

during their Life Sciences teaching experience program. The target population at this institution were the 72 fourth year Bachelor of Education degree program and 27 Postgraduate Certificate of Education (PGCE) Life Sciences PSTs who enrolled at a South African university teacher education programme in the 2020 academic year. All the 99 Life Sciences preservice teachers were invited through their emails to complete a SPTKTT questionnaire that was set on online Google Forms which was accompanied by a consent form to be signed by all participants before filling in the questionnaire. However, only 60 Life Sciences PSTs filled in the questionnaire.

Using the signed consent forms, 18 participants were randomly selected and invited for interviews. Out of 18 participants, 12 (4 males and 8 females) enrolled for a BEd and 6 (2 males and 4 females) enrolled for a PGCE program. The target sample of participants to be interviewed was 10 participants. However, only 7 expressed willingness to be interviewed.

3.6.1. Demographic information of participants

The first question in the SPTKTT questionnaire was designed to collect the demographic information of the participants had enrolled for the Life Sciences course in the 2020 academic year. Tables 1-3 summarise the demographic information of the participants.

The BEd student teachers who enrolled for Life Sciences in the 2020 academic year were 72 (13 males and 59 females). Those who responded to the questionnaire were 34 (4 males and 30 females representing 47.2% response rate. The PGCE student teachers who enrolled for Life Sciences in the 2020 academic year were 27 (6 males and 21 females) and those who responded to the questionnaire were 26 (6 males and 20 females) representing 96.3% response rate. The total participants who were invited for the survey questionnaire were 99. Those who participated in the survey questionnaire were 60 (10 males and 50 females) representing 60.6% response rate as shown in the table 1 below.

Participants	**Males**	**Female**	**Total**
BEd	4	30	34
PGCE	6	20	26
Total	**10**	**50**	**60**

Table 1: Gender of the research participants

In total there were 34 Bachelor of Education Life Sciences student teachers of which 32 were in the range of 20-25 years of age and 2 were in the range of 26-30 years of age and 14 PGCE

Life Sciences student teachers who were in the range of 20-25 years of age, 9 in the range of 26-30 years of age, 2 in the range 30-35 years of age and 1 was in the range of 36+ year participated in answering the SPTKTTquestionnaire as shown in table 2 below.

Age range	BEd	PGCE	Total
20-25	32	14	**46**
26-30	2	9	**11**
30-35	0	2	**2**
36+	0	1	**1**
Total	**34**	**26**	**60**

Table 2: Age range of the research participants

Interview participants

As mentioned above, 18 participants were invited for interviews and only 7 accepted the invitation to be interviewed. Five participants enrolled for PGCE program (1 male and 4 females) and two female participants enrolled for Bachelor of Education program and were all specializing in Life Sciences as their teaching subject. Pseudonym names were used to represent voices of the interviewees as follows:

Pseudonym Name	Gender	Program of study
Angeline	Female	PGCE
Hannah	Female	PGCE
James	Male	PGCE
Sarah	Female	PGCE
Susan	Female	PGCE
Patricia	Female	BEd
Rose	Female	BEd

Table 3: Interviewees and their program of study

Dr. Mary (pseudonym) is a lecturer who was often mentioned in the interviews as having modelled technology on a regular basis in the teaching of Life Sciences.

3.7. Data analysis

The quantitative data were summarized using descriptive statistics. According to Banks (2017) descriptive statistics provide opportunities to review the data in many ways such as measures of central tendency (mean, median, and mode), measures of variability (standard deviation), or measures of relative standing (percentiles). In this study, I used the relative standing to evaluate

the participants' overall perception of the TPACK statements. Since the SPTKTT a questionnaire used a 5-point Likert Scale, I decided to group the positive responses (strongly agree and agree) to form a positive percentile and in the same way the negative responses (strongly disagree and disagree) were grouped to form a negative percentile. That was done to show the participants' general perception of the TPACK domains that provided the lens of assessing participants' preparedness to integrate ICT for the teaching of Life Sciences. The not decided (not agree or disagree) responses on the TPACK domains were also reported as percentiles. The data was presented numerically in the tables and graphs in chapter 4 accompanied by narrative descriptions to increase understanding of the domain.

The qualitative data collected by the two open-ended in the SPTKTT questionnaire (question 35 and 36) and the interviews was analyzed thematically. The answers that participants provided in the open-ended were read repeatedly to find common themes in participants' answers based on the purpose of the question to answer the research questions. The purpose of question 35 was to assess how participants perceived the modelling of TPACK (combining content, technology, and teaching strategies) by their lecturers. Question 36 sought to understand the Life Sciences preservice teachers' experiences of ICT integration during their teacher preparation program.

The qualitative data were also collected through interviews. The first step to analysing interview data was transcription. I manually transcribed each audio-recorded interview into a separate transcript. Secondly, all the transcripts were repeatedly read to familiarization with the data. Thirdly, the data was openly coded according in the order of questions that participants were asked. For example, I asked participants: *"Why is it necessary to integrate ICT in the teaching of Life Sciences?"* which was meant to address research question 3. Participants gave the following reasons: **Angeline:** "*We are moving into a world which is more technological and I think teachers have to do the same because if students are going to move into the world, they learn and work with computers"*. **Hannah***: "For me, it is just a natural thing because of the world that we live in and the technology that we work with every day*". *And learners, even if they don't have a smartphone, are familiar with the kind of technology they see on TV".* In those responses I coded "technological world" and "preparing students to fit into the world" as codes. My interest was to understand how PSTs perceived the need to integrate ICT in the teaching of Life Sciences, which is an aspect of TPACK. As pointed out in chapter 2, pg 15, PSTs should not only know about how to use ICT but also know about the specific knowledge engaged in the pedagogical use of ICT and to understand the impact of the ICT on the learning

process (Brun, & Hinostroza, 2014). Fourthly, the coded data was presented in a table form under each question highlighting common aspects. The codes that unified and related to the research questions were categorized into themes while some codes that directly related to the research questions were also categorized as themes which are presented in chapter 4. In the above example of coding, the codes "technological world" and "preparing student to fit into the world" were categorised into "the world's demands to use ICT" and "catering the needs of the current technological generation" themes respectively as some of the participants' perceived reasons to integrate ICT in their teaching practices. The participants' perceived usefulness of ICT integration in the teaching and learning of Life Sciences, which was related to research question 3. Lastly, the themes were presented in tables with examples of participants' episodes as evidence to support the themes for better understanding in chapter 4. This was done to show, support and justify how the themes were derived.

3.8. Validity and Reliability

3.8.1. Validity

Validity refers to "the extent to which an instrument measures what it purports to measure" (Kimberlin & Winterstein, 2008, pg. 2278). It is concerned with whether the findings are trustworthy and whether they are reflecting participant's views (Zohrabi, 2013). In quantitative research statistical data has been used to valid findings (Crewell & Crewell, 2018). However, to achieve validity in qualitative research, Kimberlin and Winterstein (2008) suggest that researchers can use existing instruments that have been proved to be reliable and valid in different studies. Secondly Creswell and Creswell (2018) suggest that validity can be achieved through triangulating the different findings from different instruments such as questionnaires, interviews, observations to construct coherent justification of the themes. Thirdly, allowing data collection instruments to be reviewed by research experts (Zohrabi, 2013). Fourthly, allowing peer to comment on findings, which helps to reduces biases interpretation of findings (Zohrabi, 2013). Fourthly, being aware of biases and trying to gather, analyse and interpret the findings in an impartial manner (Zohrabi, 2013).

In my study, to achieve validity, I adapted a standardized SPTKTT questionnaire designed by Schmidt et al. (2009) to ensure that the collected data was valid and reliable. The questionnaire is developed to evaluate PSTs' TPACK abilities that enable them to use ICT into their teaching practices, which has been proved to be valid (Sahin, (2011). Secondly the data in the survey and interviews were triangulated to provide a full picture of the PSTs preparedness to integrate

ICT in their teaching practices based on both data set. Thirdly, before the instruments (questionnaire and interviews) were administered for data collection purposes, they were reviewed by lecturers who provided feedback on how best to use the instruments. Furthermore, the questionnaire was piloted to peers for purposes of checking clarity and ambiguity of items before it was administered. Lastly, I also ensured that the qualitative results included direct comments of participants to ensure that the themes or ideas reflects those of participants to advance the claims.

Reliability

Reliability refers "to consistency and repeatability, thus, to what extent does a diagnostic test produce the same results?" (Jansson & Nordgaard, 2016, pg. 15). In addition, reliability "involves the consistency, or reproducibility of test scores i.e., the degree to which one can expect relatively constant deviation scores of individuals across testing situations on the same, or parallel, testing instruments" (Lakshmi & Mohideen, 2013, pg. 2753). In quantitative research reliability is easily established by statistical figures but in qualitative research it is not straight forward procedure because is demanding procedure (Zohrabi, 2013). According to Zohrabi (2013) to achieve reliability, the researcher needs to explain the procedures or processes that were used to arrive at findings; the researcher should use triangulation; thus, different data collection methods should be used such as questionnaire, interviews, and observations.

In my study, I tried to achieve reliability by using a standardized questionnaire to collect quantitative data and analysed it statistically. Secondly, I used a thematic analysis procedure to code and analyse qualitative data obtained from interviews. The interviews were first transcribed, secondly, I read the transcripts repeatedly to familiarized myself with data; thirdly I openly coded the data based on the order of questions participants were asked. Fourthly I wrote the codes in a table form to spot the common codes. Lastly, common codes were categorized as themes to explain the phenomenon under investigation as explained above.

3.9. Ethical consideration

I am a postgraduate student at this South African university where the study was conducted, and I followed all the university's ethical guidelines. The university subscribes to the research integrity standards as set out in the Singapore Statement (2010). According Resnick and Shamoo (2011) it is the responsibilities of the researcher to understand the fourteen things when doing research as spelt by the Singapore Statement Research Integrity (2010) which include:

"integrity, adherence to regulations, research methods, research records, research findings, authorship, publication acknowledgement, peer review, conflict of interest, public communication, reporting irresponsible research practices, responding to irresponsible research practices, research environments and societal considerations" (Resnick & Shamoo, 2011, pg. 73-74). Resnick and Shamoo (2011) observe that that research often involves collaborations among researchers and institutions from different places or countries and as such it is important for the researcher to establish and follow international integrity standards in order to adhere to ethical research practices. Thus, the research integrity standards guide the researcher to do the right thing and protect the research participants during the research. For examples under these standards, it is emphasized that researchers should take responsibility to ensure that their research is trustworthy and adhere to guidelines and procedures that relate to research (Resnick & Shamoo, 2011).

In this regard, permission for the study was sought from the School of Education, University of the Witwatersrand through the Research Ethics Committee, The University Registrar and Head of School. All the fourth year Bachelor of Education and PGCE student teachers who had enrolled for Life Sciences were invited to participate in the study through a formal email before any instrument of data collection were applied. I informed all the participants that the research was being conducted for academic purposes only and would not affect their livelihood in any way. I assured them of confidentiality and anonymity and that they could withdraw from participating at any stage of the study. Research participants' consent was requested through the signing of the consent form that was sent to them through a formal email before taking part in the research. During interviews, participant's consent to audio-record the interview was sought before commencing the interview.

As stated earlier, only willing participants completed the online questionnaire set on the Google Forms through a link that was sent to them. Only the selected interviewees were interviewed telephonically through Microsoft Teams application to ensure that they were not exposed to COVID-19 virus. Fortunately, all participants had internet data that the university had provided during the COVID-19 pandemic and hence the online interviews on Microsoft Teams were done without problems. Interviewees were asked open-ended questions approved by the Research Ethics Committee. Each participant was requested to have the interview recorded for the purposes of transcription and data analysis evaluation. Participants' names remained anonymous throughout the study and any information provided was kept confidential and their individual privacy was maintained in all the written work. In the research report, pseudonym

names were used to represent participants' views. In cases where lecturer's names were mentioned, they were reported represented by pseudonyms.

The next chapter presents the results that were collected through the SPTKTT questionnaire and interviews. The results were presented in the order of research questions, starting with quantitative results, and followed by the qualitative results.

Chapter 4: Data Analysis, Presentation and Results

4.1. Introduction

The purpose of this study was to explore Life Sciences preservice teachers' preparedness to integrate ICT during Life Sciences' teaching experience: a case study at a South African university. In order to explore the Life Sciences PSTs preparedness to integrate ICT, the following sub-questions were asked to guide the study:

1. How do Life Sciences preservice teachers perceive themselves prepared to integrate ICT into their classroom pedagogical practice?
2. How does ICT knowledge play a role in the Life Sciences preservice teachers' confidence towards ICT integration?
3. What are the Life Sciences preservice teachers' perceived benefits of ICT integration in the teaching and learning of Life Sciences?
4. How does the lecturers' modelling influence the disposition of Life Sciences preservice teachers towards integrating ICT into their own classroom practice?

As I explained in chapter 3, mixed methods approach was adopted in the study and questionnaires and interviews were used to collect data to address the research questions. The rationale for a mixed methods approach was to get a deeper understanding of the Life Sciences preservice teachers' preparedness to integrate ICT in their pedagogical practices. The SPTKTT questionnaire was used to collect both quantitative and qualitative data. To collect the quantitative data, the Life Sciences PSTs self-evaluated their TPACK domains as in the tables presented below. In addition to the two open-ended on SPTKTT questionnaire, the qualitative data was also collected through interviews in which participants were asked about their experiences relating to their preparedness to integrate ICT in the teaching and learning of Life Sciences. Both quantitative and qualitative questions were designed to explore participants' preparedness to integrate ICT in their pedagogical practices for the teaching and learning of Life Sciences during teaching experience.

4.2. Results of the study

4.2.1. Research question 1:

"How do Life Sciences PSTs perceive themselves prepared to integrate ICT into their classroom pedagogical practice?"

4.2.1.1. The results from SPTKTT questionnaire

Research question 1 was answered by both quantitative and qualitative data. I considered four domains of TPACK in the SPTKTT questionnaire to be related to the research question 1: technological knowledge (**TK**) question 1-7, technological content knowledge (**TCK**) questions 20-21, technological pedagogical knowledge (**TPK**) questions 22-26 and **TPACK** questions 27-31. These domains were considered to relate to research question 1 as I discussed in chapter 2 that ICT knowledge influences the use of ICT in the teaching and learning.

In chapter 2, **TCK** was defined as "the knowledge of how technology can be used create new representations for specific content" (Schmidt, et al, 2009, pg. 125); **TPK** was defined as the "knowledge of how various technologies can be used in teaching and the understanding that using technology may change the way teachers teach" (Schmidt, et al, 2009, pg. 125) and **TPACK** was defined as the "intersection of teacher's knowledge of content, pedagogy, and technology" (Schmidt, et al, 2009, pg. 125). These three TPACK domains speak to the participants' technological abilities to integrate ICT in their pedagogical practices in classrooms.

However, as the study was informed by the TPACK conceptual framework that argues that technological knowledge, pedagogical knowledge, and content knowledge exist as interrelated components that PSTs need to understand for their effective teaching, and in that sense, I also explored participants' content knowledge (CK), pedagogical knowledge PK and PCK to gain an understanding of all the domains of the TPACK and to justify the claim that teachers whose CK, PK and TK is high, are likely to integrate these domains in their teaching practices. Tables 4, 5 and 6 shows participants' perceptions on their PK, CK and PCK.

It was observed (Tables 4, 5 and 6) that the majority of participants perceived to have the ability in their PK, CK, and PCK evidenced by the high positive response rates that ranged from 81.7% - 97.6%, 88.3% - 96.6%, and 96.7% on questions 8-14, 15-18 and 19 respectively towards the teaching of Life Sciences. The negative responses for PK, CK and PCK ranged from 1.7% - 6.7%, 0% - 3.4% and 1.7% respectively on each question.

Item	"Survey question"	Strongly disagree	Disagree	Not decided	Agree	Strongly agree	Percent negative	Percent Positive
8	"I know how to assess student performance in Life Sciences"	1.7%	3.3%	8.3%	56.7%	30%	5%	86.7%
9	"I can adapt my teaching based upon what students currently understand or do not understand"	1.7%	0%	6.7%	55%	36.7%	1.7%	91.7%
10	"I can adapt my teaching style to different learners"	1.7%	0%	1.7%	55%	41.7%	1.7%	96.7%
11	"I can assess student learning in multiple ways"	1.7%	1.7%	6.7%	48.3%	41.7%	3.4%	90%
12	"I can use a wide range of teaching strategies in a classroom setting"	1.7%	0%	1.7%	50%	46.7%	1.7%	96.7%
13	"I am familiar with common student understandings and misconceptions in Life Sciences classrooms"	1.7%	5%	11.7%	56.7%	25%	6.7%	81.7%
14	"I know how to organize and maintain classroom management".	1.7%	3.3%	11.7	61.7%	21.7%	5%	83.4%

Table 4: Pedagogical Knowledge (PK)

Item	Survey question	Strongly disagree	Disagree	Not decided	Agree	Strongly agree	Percent negative	Percent positive
15	"I have sufficient content knowledge in Life Sciences"	3.3%	0%	6.7%	41.7%	48.3%	3.3%	90%
16	"I can use a scientific way of thinking"	1.7%	0%	1.7%	43.3%	53.3%	1.7%	96.6%
17	"I have various ways and strategies of developing my understanding of Life Sciences"	0%	0%	3.3%	48.3%	48.3%	0%	96.6%
18	"I am comfortable responding to questions about topics in Life Sciences"	1.7%	1.7%	8.3%	35%	53.3%	3.4%	88.3%

Table 5: Perceptions of the Life Sciences PST related to (CK)

Item	Survey question	Strongly disagree	Disagree	Not decided	Agree	Strongly agree	Percent negative	Percent positive
19	"I can select effective teaching strategies to guide students' thinking and learning in Life Sciences"	0%	1.7%	1.7%	51.7%	45%	1.7%	96.7%

Table 6: Perceptions of the Life Sciences PST related to PCK

As indicate above the TK, TCK, TPK, and TPACK domains of TPACK gathered the quantitative data that was related to research question 1.

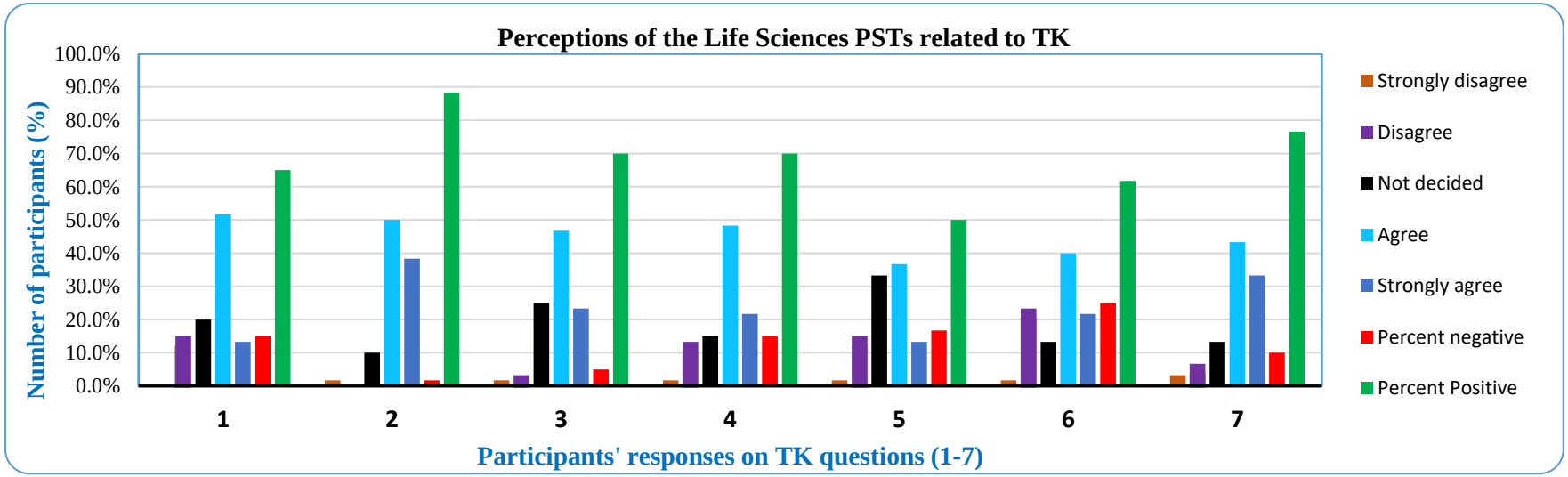
Technological knowledge:

The domain asked to evaluate their TK abilities towards the teaching of Life Sciences. Based on table 7 below, the results on TK question 1 showed that 65% of participants perceived positively to have the ability of solving technical problems of technology and 15% of participants indicated lack of technical skills to deal with technical problems. The results on question 2 showed that 88.3% of participants perceived to have the ability to learn technology easily and 1.7 % indicated they could not learn technology easily. The results for both questions 3 and 4 showed 70% of participants perceived positive that they keep up with new technologies and frequently play around with technology respectively and negative responses of 5% and 15% respectively. The results on question 5 showed that 50% of participants perceived positively to have knowledge of different technologies and 16.7% indicated they do not know a lot of technologies and 33% of participants were undecided to indicate if they knew more technologies or not. The results for question 7 showed that 76.6% of participants indicated they had a chance to work with different technologies and 10% indicated they had no chance. The table 7 and graph 1 below summarises participants' perceptions on their TK that relate to the teaching and learning of Life Sciences.

Item	Survey question	Strongly disagree	Disagree	Not decided	Agree	Strongly agree	Percent negative	Percent Positive
1	"I know how to solve my own technical problems"	0%	15%	20%	51.7%	13.3%	15%	65%
2	"I can learn technology easily"	1.7%	0%	10%	50%	38.3%	1.7%	88.3%
3	"I keep up with important new technologies"	1.7%	3.3%	25%	46.7%	23.3%	5%	70%
4	"I frequently play around with the technology"	1.7%	13.3%	15%	48.3%	21.7%	15%	70%
5	"I know about a lot of different technologies"	1.7%	15%	33.3%	36.7%	13.3%	16.7%	50%
6	"I have the technical skills I need to use technology"	1.7%	23.3%	13.3%	40%	21.7%	25%	61.7%
7	"I have had sufficient opportunities to work with different technologies"	3.3%	6.7%	13.3%	43.3%	33.3%	10%	76.6%

Table 7: Perceptions of the Life Sciences PSTs related to TK

For comparisons purposes, the responses for each TK domain question were graphically presented in below in graph 1



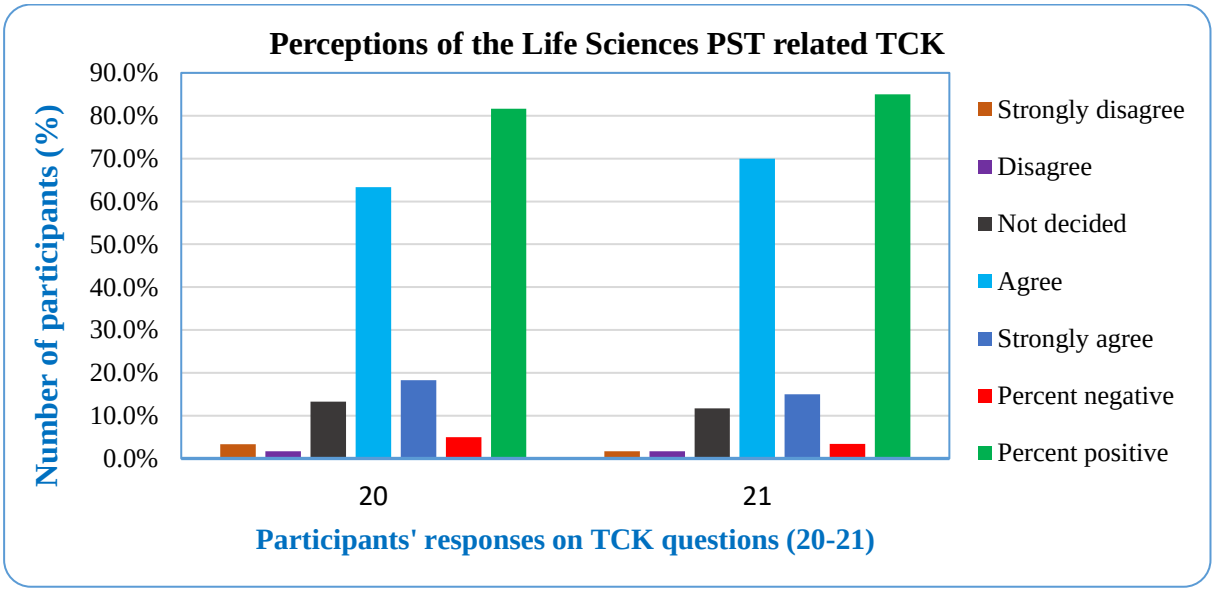
Graph 1: Perceptions of the Life Sciences PSTs related to TK

In the table 8 below, Life Sciences PST perceived to have knowledge of technologies that can be used in the teaching of Life Sciences with a positive response of 81.6% and 5% of participants perceived not to have the knowledge (question 20). The results of question 21 showed that participants perceived to have ability to select technologies that could enhance the teaching of Life Sciences with a positive response rate of 85% and 3.4% perceived it negatively that they could not select technologies that can enhance the teaching of Life Sciences.

Item	Survey question	Strongly disagree	Disagree	Not decided	Agree	Strongly agree	**Percent negative**	**Percent positive**
20	"I know about technologies that I can use for understanding and learning Life Sciences"	3.3%	1.7%	13.3%	63.3%	18.3%	5%	81.6%
21	"I can select technologies that enhance what I teach in Life Sciences"	1.7%	1.7%	11.7%	70%	15%	3.4%	85%

Table 8: Perceptions of the Life Sciences PST related TCK

The graph 2 below further compares participants' responses on each TCK question to better understand how participants perceived each question.



Graph 2: Perceptions of the Life Sciences PST related TCK

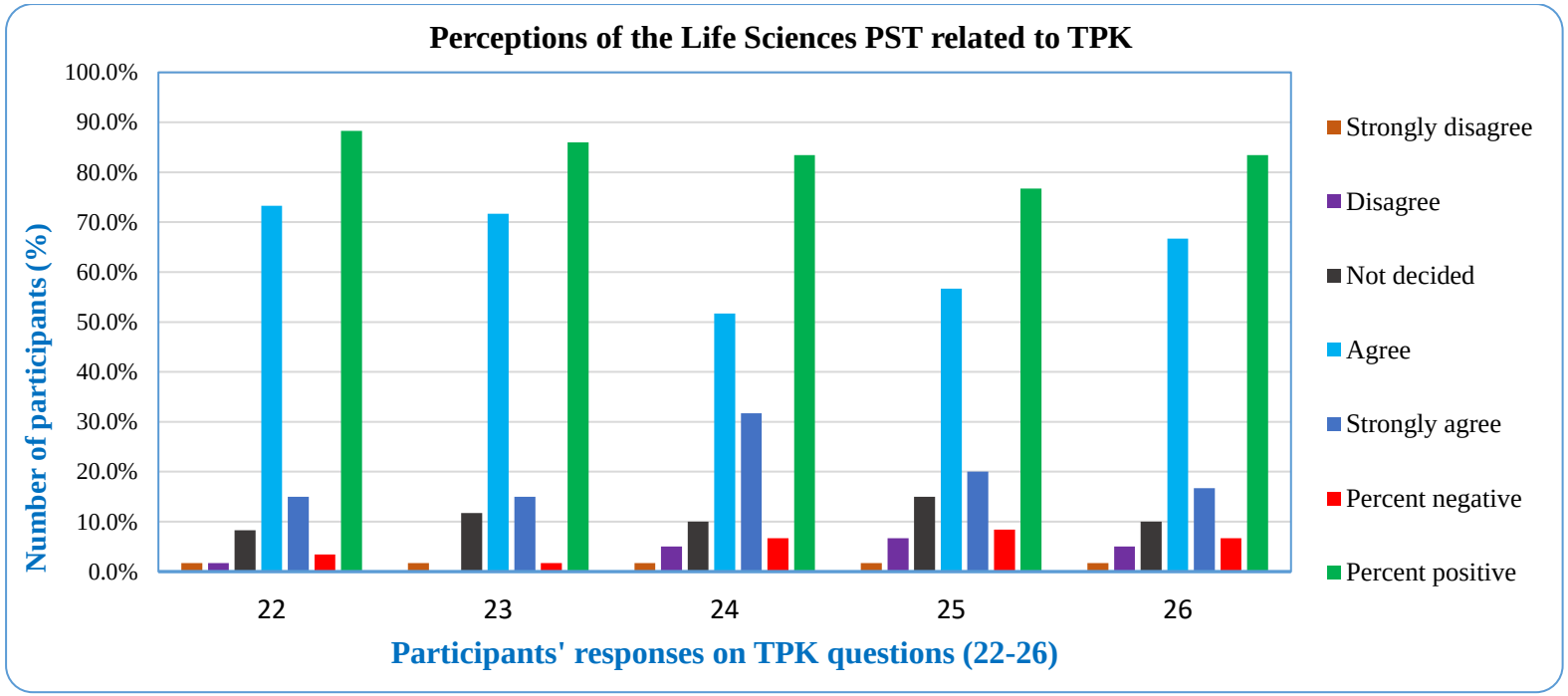
Furthermore, questions 22-26 on TPK domain in the SPTKTT questionnaire were also related to answering research question 1. These questions were meant to determine how the participants perceived their abilities to select technologies that would enhance the teaching strategies for

Life Sciences. The overall assessment of TPK component of the TPACK conceptual framework of the participants showed that the Life Sciences PST perceived themselves to have capability to select technologies that would enhance their teaching strategies for Life Sciences lessons as shown in table 8. In the table 8 it was observed that question 22 had the highest positive responses of 88.3% and 3.4% negative responses. Question 24 of TPK domain was interesting as it linked to participants' abilities to their lecturers' contribution towards how technology could influence the teaching strategies in Life sciences. Interestingly, 83.4% of participants responded question 24 positively while 6.7% responded negatively. Question 25 showed that 76.7% positive response of participants that they could think critically on how to use technology in their classrooms while 8.4% responded negatively on the question and 15% of participants were undecided. Finally, on the TPK domain, question 26, 83.4% of participants responded positively that they could adapt the use of technologies they learn to different teaching strategies and 6.7% of participants responded negatively.

Item	Survey question	Strongly disagree	Disagree	Not decided	Agree	Strongly agree	Percent negative	Percent positive
22	"I can select technologies that enhance the teaching approaches for a Life Sciences lesson"	1.7%	1.7%	8.3%	73.3%	15%	3.4%	88.3%
23	"I can select technologies that enhance students' learning for a Life Sciences lesson"	1.7%	0%	11.7%	71.7%	15%	1.7%	86%
24	"My lecturers in education program have prepared me to think more deeply about how technology could influence the teaching approaches I use in my Life Sciences classroom"	1.7%	5%	10%	51.7%	31.7%	6.7%	83.4%
25	"I think critically about how to use technology in my classroom"	1.7%	6.7%	15%	56.7%	20%	8.4%	76.7%
26	"I can adapt the use of the technologies that I am learning about to different teaching activities"	1.7%	5%	10%	66.7%	16.7%	6.7%	83.4%

Table 9: Perceptions of the Life Sciences PSTs related to TPK

The information in table 9 was further presented in graph 2 below for comparison purposes of the participants' perceptions relating question 22-26 of TPK. It showed that the majority of participants perceived positively to have the ability in the TPK when teaching Life Sciences as summarized in the graph by each question below.



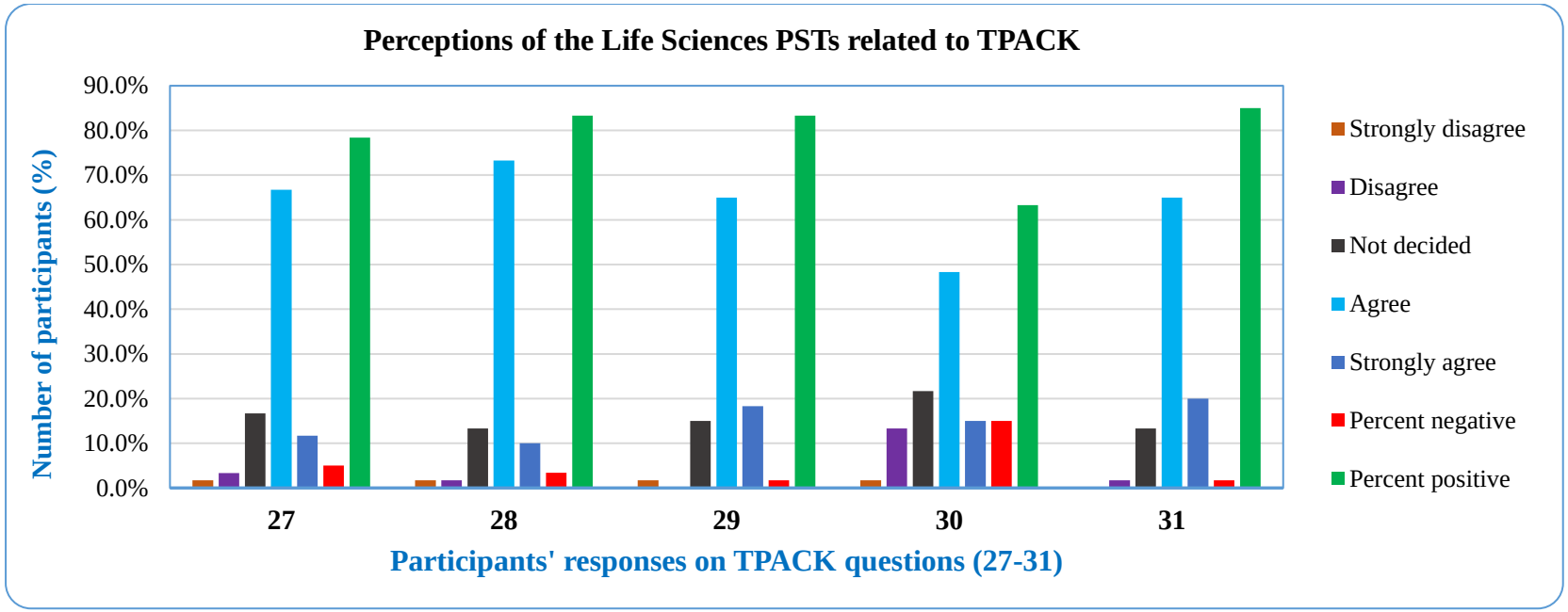
Graph 3: Perceptions of the Life Sciences PST related to TPK

The SPTKTT questionnaire also contained questions 27-31 meant to ask research participants to self-evaluate their perceived level of abilities related to TPACK. Question 27 asked participants' perceived abilities to integrate Life Sciences content, technologies, and teaching strategies (pedagogies) in a lesson. The results from the question showed that 78.4% of participants had positive perception and 5% of participants had a negative perception why they self-evaluated their TPACK.

Question 28 asked participants if they could choose technologies for a lesson to enhance "what to teach", "how to teach", and "what students can learn". The results showed that 83.3% of participants perceived positively to have the ability of selecting technologies that could enhance the teaching of Life Sciences and 3.4%of participants perceived not to have the ability. Question 29 aimed at determining the participants' ability to combine the Life Sciences content, technologies, and teaching strategies they had acquired in their teacher's preparation program. The results from this question showed that 83.3% of participants perceived it positively and 1.7% perceived it negatively. Question 30 asked explored participants' leadership skills regarding helping others (teachers) to combine Life Sciences content, technology, and teaching strategies at their different respective schools. The results showed that 63.3% of participants perceived positively to have the ability to perform the leadership role of leading (helping) others to use technology and 15% perceived not to have the ability to lead others technologically. The results on question 30 also had the highest number of participants (21%) who were not decide of their leadership role. Question 31 on the TPACK domain that asked how participants perceived their effectiveness towards use of technology in teaching using variety of teaching strategies. The results showed 85% of participants perceived to be effective in using technology to teach Life Sciences when using variety of teachings methods and 1.7% perceived not to be effective when using technology to teach Life Sciences using variety of teaching methods. Table 10 below summarizes above narrative. And the results in the table 10 below were also presented graphically to compare the responses on each question of the TPACK domain to increase understanding of participants' perceptions.

Item	Survey question	Strongly disagree	Disagree	Not decided	Agree	Strongly agree	Percent negative	Percent positive
27	"I can teach lessons that appropriately combine Life Sciences content, technologies, and teaching strategies".	1.7%	3.3%	16.7%	66.7%	11.7%	5%	78.4%
28	"I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn".	1.7%	1.7%	13.3%	73.3%	10%	3.4%	83.3%
29	"I can use strategies that combine Life Sciences content, technologies, and teaching approaches that I have learned in my teacher training course".	1.7%	0%	15%	65%	18.3%	1.7%	83.3%
30	"I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school".	1.7%	13.3%	21.7%	48.3%	15%	15%	63.3%
31	"I can use technology to teach Life Sciences effectively using a variety of teaching strategies".	0%	1.7%	13.3%	65%	20%	1.7%	85%

Table 10: Perceptions of the Life Sciences PST related to TPACK



Graph 4: Perceptions of the Life Sciences PSTs related to TPACK

The graph summarized participants' perceptions relating to their TPACK in the teaching and learning of Life Sciences. As indicated by responses on each TPACK question, it showed that the majority of participants had a positive perception regarding the TPACK domain.

As previously stated, the SPTKTT questionnaire included open-ended questions to collect qualitative data from participants. Question 36:

"Describe a specific episode where you effectively demonstrated or modelled combining content, technologies, and teaching approaches in a classroom lesson. Please include in your description what content you taught, what technology you used, and what teaching strategies you implemented. If you have not had the opportunity to teach a lesson, please indicate that you have not").

The aim of the question was to explore participants' own experiences with ICT integration during their teacher training program. The question was in relation to research question 1. Four participants did not respond to the question, two could not recall whether they had integrated content, technology, and teaching strategies, six suggested they had no opportunity to integrate content, technology, and teaching strategies, and four gave vague answers that did not indicate the content, technology, or teaching strategies that were used. In total, 16 participants did not answer to the question, while 44 participants answered the question.

To analyse the responses, I considered three things that related to research question 1: the content taught, the ICT tool and the teaching strategies that were used. In the analysis of the taught content taught, ICT tool used, and teaching strategies, I counted the number of participants who mentioned it. The number in the bracket represents the number of participants who mentioned the content, ICT tool used and the teaching methodology. For a particular topic, some participants mentioned more than one ICT tool and teaching strategy they had used to teach the topic. I also included few participants' comments about their lessons which I thought provided more understanding of the participants' ICT integration experiences and abilities during their teacher preparation program. In the participant' response, I highlighted the ICT tool(s) that was used by yellow colour, the content taught (blue colour) and in some instances the reasons why the technology (green colour). This was done to show the participant's ICT integration experiences they had during their teacher preparation program they had included in response to question 36. The table 11 below shows detailed results of question 36 on the content, ICT, and teaching methods that participants had used in their own lessons which relate to their TPACK:

Content taught	**ICT tool used**	**Teaching methods**	**Participants' comments on their lessons**

• Mitosis (10) • Human circulatory system (6) • DNA (4) • Genetics (3) • Human breathing system (3) • Eyes (2) • Ear (2) • Experiment (2) • Viruses (2) • Speciation (1) • Kidney stones (1) • Thermoregulation (1) • Eye defects (1) • Evolution (1) • Cellular respiration (1) • Reproduction (1) • Biodiversity (1) • Photosynthesis (1) • Natural selection (1) • Homeostasis (1)	• PowerPoint Projector (29) • Videos (14) • Smartboard (4) • Simulation (2) • DNA Model App (1) • WhatsApp (1) • Bluetooth speakers (1) • online games (2) • animated video (1) • gaming app (1)	• Explanation (18) • Demonstration (11) • Discussion (6) • Question & answer (5) • Representation (4) • Discovery (3) • Group work (2) • Experiment (2)	• *"I used a simulation that demonstrated the path of light through the pupil and onto the retina. This allowed for learners to understand an abstract concept more thoroughly".* • *"I went beyond to play videos that show how cell division take place….to cater for learners' diversity. Playing videos, showing pictures, using diagrams helps to understand mitosis".* • *"When I was teaching mitosis, I used online games to enhance learner's participation"…* • *"Alongside accompanying videos with Bluetooth connected speakers and a projector to enhance clarity and audibility. This catered for numerous learning styles and enhanced the learners' learning experience and inspires attentiveness"* • *"I had the opportunity to send the slides to the students via WhatsApp in order to use technology".* • *"I used videos of the experiments…. because the school didn't have all the equipment for the experiments to be carried out in person with the students. The students then wrote up a scientific report…"* • *"I incorporated technology by making a quiz on Kahoot where learners did a MCQ assessment…. I timed the MCQ to teach learners time management..."* • *When I was teaching about gaseous exchange in mammals, I used PowerPoint and projector to present my lesson to my peers* • *"During TE I taught heart using PowerPoint slides on a projector. I used…the slides to explain its structure and to engage learners".* • *"During TE I used the PowerPoint and projector when I taught to about the ear to grade 4s". I showed them the picture of the inside ear which I think helped them to see how sound goes into the ear".*

			• *"I used a smartboard during TE when I taught grade 9, breathing system. I put pictures to show the flow of air in the system".* • *"During that lesson about viruses, I started the lesson by a short video explaining the content I was teaching. My lesson was an inquiry based".* • *"I used PowerPoint slides, video and smartboard to teach reproduction… I used pictures to clarify point and to engage students like to show parts and their functions"*

Table 11: Participants' ICT integration experiences

As indicated above, the numbers in the bracket represent the numbers of participants that mentioned the content taught or ICT tool, and teaching strategy. The results on question 36 showed that the PowerPoint projector (29) was the most mentioned ICT tool to have been used in the teaching of Life Sciences. The videos (14) were the second most mentioned ICT tool to have been used in the teaching of Life Sciences. The other ICT tools that were also mentioned were smartboard (4), simulation (2), online games (2), DNA model App (1), WhatsApp (1), Bluetooth speakers (1), animated video (1) and gaming app (1) they had used in teach Life Sciences. Furthermore, the results also showed that the most used teaching strategies that participants used to teach Life Sciences PSTs were explanatory (18), and demonstration/illustration (11). Other teaching methods participants mentioned to have used were discussion (6), question & answer (5), representation (4), discovery (3) group work (2) and experiment (2).

In summary, the results on the open-ended question 36 that aimed at capturing participants' experiences of ICT integration in their teacher training program showed that participants who answered the question had experienced teaching with ICT tools during their teacher preparation program for purposes of enhancing the teaching and learning of Life Sciences as evidenced by their comments that captured the content, ICT tools and teaching strategies as shown above in table 11.

4.2.1.2. The interview results related to research question 1

As stated in the last paragraphs of chapter 2, section 2.8, page 18, that preservice teachers' TPACK development can be investigated through interviews in which participants are probed

to clarify their perception of TPACK constructs. In the study, interviews were designed to interrogate participants' perception of ICT integration related to TPACK. The interview data was analyzed following a thematic procedure discussed in chapter 3, section 3.7, and page 26-27.

In the interviews, the seven participants were asked if they were prepared to integrate ICT their teaching practices, which was related to research question: *"At the moment, do you think you are prepared to integrate ICT in your teaching and learning of Life Sciences*"? *"Why do think you are (or not) prepared to integrate ICT in the teaching of Life Sciences"?* The interest of the question was to explore participants' reasons of preparedness to integrate ICT in their teaching practices.

The analysis of participants' responses to the question above revealed that six participants perceived to be adequately prepared to integrate ICT into their teaching practices, while one participant indicated that she was partially prepared. Participants' responses were categorized into the following themes (reasons) which supported their readiness to integrate ICT in their teaching practices: prior experience to teaching with ICT; exposure to ICT use, knowledge of ICT; and ability to adapt and learn ICT tools easily, which showed their knowledge of TPACK. Table 12 below shows these themes supported by participants' episodes.

Themes	Evidence from participants' episodes.
• Prior experience to teaching with ICT	**Hannah:** *"I think because of my personal experience with technology and my previous teaching experience, I feel more equipped…."*
• Exposure to ICT use	**Patricia:** *"we have been exposed to ICT in our methodologies, we have been exposed to quite a lot of it… we went to the E-Zone and they taught us how to use a few apps and Microsoft Teams...And I think going to different schools…you learn a lot even from the teachers. So, I think I am adequately prepared".* **James:** *"I have seen almost every lecturer integrating ICT into their lessons almost on a daily basis…that itself is exposure because to become a teacher we learn from teachers…"*
• Knowledge of ICT	**James: "***I majored in computer science... I feel very well vested with technologies in general and I can try my best to use what I know prior to my PGCE to best influence my learners' learning experience".*
• Ability to adapt and learn ICT tools easily.	**Angeline**: *"I can figure out things, so it (technology) does not really intimidate me in any way… it is easy enough to learn, so I think am well prepared based on theory and a general sense of technology".*

Table 12: Factors that contributed to participant's preparedness

In summary, participants stated that they were prepared to integrate ICT into their teaching practices because they had previous experience and exposure to using ICT for teaching and learning of Life Sciences; they had technological knowledge of ICT tools needed in the teaching; they had the ability to adapt and learn ICT easily. Those reasons suggested to have increased participants' confidence in their ability to integrate ICT into their teaching practices as shown in table 12 above. For example, **James** stated that he was well-versed in technologies that could influence learners' learning experiences, suggesting that his confidence in using technology was attributed to his technological abilities.

On the other hand, one participant (**Sarah**) indicated that she was not fully prepared to integrate ICT in her teaching practice because she lacked some knowledge with some ICT tools such as simulations, 3D models, and smartboard when she was asked if you were ready to integrate ICT: *"…I wouldn't say 100% ready. I still need to learn those simulations, 3Ds. I just try* (to use) *some of those, someone was helping me to use them during microteaching. I am not fine with those…"* According to the quote, Sarah's lack of confidence in using ICT was also attributed to her lack of technological abilities.

4.2.2. Research question 2:

"How does ICT knowledge play a role in the Life Sciences preservice teachers' confidence towards ICT integration?"

The second research question 2 was designed to explore participants' confidence towards use of ICT and it was answered by the qualitative data obtained from interviews. In this study, participants were asked to evaluate their ICT abilities towards the teaching of Life Sciences. During the interviews, I asked participants to name the technologies they knew they could use to teach Life Sciences in order to gain a deeper understanding of their technical knowledge: "*Which ICT tools do you know that you can use or have used in the teaching and learning of Life Sciences? Why are you able to use ICT tool?"*

The table 13 below shows the ICT tools Life Sciences PSTs mentioned they could use or had used to teach Life Sciences. However, the aim of the question was not to compile a list of ICT tools, but to get an idea of what participants could do with them. In that regard, participants were asked to provide reasons why they used those ICT tool.

	Angeline	Hannah	James	Patricia	Rose	Sarah	Susan
ICT tools that participants could use	• PowerPoint projector • Microsoft Teams • Zoom	• PowerPoint Projector, • Microsoft Teams • Zoom	• PowerPoint projector • Microsoft Teams • Zoom	• PowerPoint Projector • Microsoft Teams • Zoom	• PowerPoint Projector • Microsoft Teams • Zoom	• PowerPoint Projector • Microsoft Teams • Zoom	• PowerPoint projector • Microsoft Teams • Zoom
		• **Smartboard**	• **Smartboard**	• **Smartboard**		• **Smartboard**	• **Smartboard**
	• Videos		• Videos		• Videos		• Videos
		• **Simulations**	• Simulations		• Simulation		
		• 3D Models	• 3D models		3D models		
		• Google classroom		• Google classrooms	• Google classrooms		
	• Animations		• Gamification	• Blogs • Website			

Table 13: ICT tools participants could use or had used

In the table 13 above, the same ICT tools that participants mentioned they could use or had used to teach life Sciences were highlighted in the same colour in table 11 above. The results showed that all the participants could use or had used PowerPoint projector, Microsoft Teams, and Zoom applications to teach Life Sciences. Participants mentioned the smartboard as the second most common ICT tool they could or had used to teach Life Sciences (as mentioned by **Hannah**, **James, Patricia, Sarah, and Susan)**. Videos were the third most common ICT tool that participants could use or had used to teach Life Sciences (as mentioned by **Angeline, James, Rose, and Susan**). 3D models, Google Classroom, and simulations also the third common ICT tools preferred by four participants (**Hannah, James and Rose and Patricia**). The least mentioned ICT tools that participants could use or had used to teach Life Sciences were animations, gamification, and blogs (only mentioned by **Angeline**, **James**, and **Patricia** respectively). It is only **Patricia** who indicated she had used the website to teach Life Sciences.

The results also revealed that participants had varying levels of technological knowledge, with some knowing more technological tools than others (see table 11 in chapter 4). For example, **Sarah** mentioned four ICT tools, which was the least number, she knew could use and she indicated in the interview that she needed more training on ICT tools such as 3D models and simulations help her teach with ICT tools.

As previously stated, the purpose of the question was not to compile a list of ICT tools, but to learn from them why they chose those ICT tools and how they would use them in the teaching process. I also asked to elaborate why they chose to use of those ICT tools mentioned: "*Why did you use or could use the ICT tool(s) you have mentioned in the teaching and learning of Life Sciences?''*. The aim of the question was to elicit participants' ICT knowledge and/or experience(s) with the ICT tool mentioned. However, it was discovered that some participants were answering research question 3 by answering question 6 of the interviews, which was intended to capture participants' perceptions of the benefits of ICT integration in the teaching of Life Sciences (*"Do you think is it necessary to integrate ICT in the teaching and learning of Life Sciences? Why?").* In that case, the participant responses were used to partially answer research questions 2 and 3. The analyses of the two questions and the related ones yielded the themes to better understand what motivated participants to use the ICT resources they mentioned and their perceived benefit in the teaching and learning of Life Sciences as presented in table 14 below. However, theme that came out that related to research question 2 that would increase ICT knowledge and in turn influence its usage were:

- their prior knowledge and experience of the ICT tools.
- their exposure to ICT tools.
- their perceived ease of use of the ICT tool.
- Their personal interest to use ICT.
- their perceived usefulness of ICT.

The themes in the table 14 below that related to research question 2 were highlighted in yellow in the first column and in column two are the extracts of the transcripts of participants that support the themes:

Themes	**Evidence from participants' stories that support the theme**
Prior knowledge and experience of the ICT tool	**Hannah:** "*I taught in Japan where they use technology in the classrooms...*" **James:** "*I majored in computer science. Coding, software engineering, website designing and that is what I do…I feel very well vested with technologies in*

	general and I can try my best to use what I know prior to my PGCE to best influence my learners' learning experience". **Hannah:** "*I have had experience using PowerPoint and …I'm able to incorporate the vast different virtual and audio aspects that PowerPoint can provide"* **Patricia:** *"Personally I prefer the smartboard. I have used it in physics like to show experiments and you can move things around and it is quite convenient.* **Rose:** "*...the most popular one is PowerPoint that everyone seems to use. …with Dr Mary (pseudonym), we used Microsoft Teams and Blue button and Zoom…"* **Rose:** *"In my teaching experience* (previous) *we used Google classroom, which I think was interesting to use especially for life Sciences learning because we could add all sorts of videos, and extra information for the learners".*
Exposure to ICT tools: • University's ICT related platforms such as Sakai, E-zone, • Availability of university's ICT tools in lecturers halls, labs (such as computers, smartboards, LCD projectors) • Lecturers modelled the use of ICT • Personal exposure to ICT	**James:** *"When we were taught things that were more abstract, we were either shown pictures on a projector or a video* (by lecturers) *…"* **Patricia:** *"…last year (2019) we went to the E-Zone and they taught us how to use a few apps and Microsoft Teams. If you had asked me to join a Microsoft Teams meeting in first year, I wouldn't have known how to do it, so I know how to use a few apps.* **James:** *"I think there is sufficient exposure to technology. For example, almost every lecture hall that you go to, where I had to attend classes in, has a smartboard or projector or some form of technological facets that can be used and every time we have to prepare our lessons and stuff…"* *"We also had to submit on Sakai, you have to use technology in order to do that…"* *"Here at (*university*) during the PGCE course, I have seen almost every lecturer integrating ICT into their lessons almost on a daily basis and that itself is exposure because to become a teacher we learn from teachers and to become lecturer we learn from lecturers. And to see lecturers doing that emphasizes the importance of being able to integrate technologies into your lessons. So I think there has been enough exposure".* **Patricia:** *"When I was at high school, my teachers used to have virtual classrooms, so a lot of experiments like that we used to do them virtually not physically…. So I keep looking for programs like that so I can integrate as well but the thing is as much as it does help and is a great resource to have"* (website). **Rose:** "*…with Dr Mary* (pseudonym), *we used Microsoft Teams and Blue button and Zoom...* **Sarah: "***I use it* (PowerPoint projector) *because our lecturers have been using it. I think it's easy to use..."*

Perceived ease of use of the ICT tool	**Angeline**: *"I like PowerPoint because I enjoy making interactive slides…, I might start a lesson with a video or in that lesson with a video embedded within the PowerPoint".* **Hannah:** *"I'm most comfortable with PowerPoint and projectors. A smartboard is an option because I have used a smartboard in the past... I'm very comfortable using computers and different software because that is all of my interest".* **Sarah:** "*I think it* (PowerPoint) *is easy and it saves time unlike when you use chalkboard or a chart. When you are using a projector, it is easy to put up a picture there or when you have a video it's easy to play it. It is user friendly".* **Susan:** *"I can show learners videos, and pictures on PowerPoint projector. One thing that I did on the zoom meeting, an online platform to teach about a skeleton, which had interactive games".*
Personal interest to use ICT	**Patricia:** (When doing TE in rural area) "*I made sure that I had a lot of data, in that sense I could still google things. I could show them videos and things…* *I have a personal mini projector, the best investment in my life, it's a battery powered one that you charge. It is literally smaller than the size of my phone, it projects maybe the size of an A3. So, I used that at the school*" (during Teaching experience). **Rose:** *"Dr Mary would try to integrate as much as she could and in that time it was a learning process for everyone so we had to figure out which platform was the best to use" …*(during the COVID-19 pandemic lockdown).
Perceived usefulness of ICT tool: e.g. • motivate learners, • clarify of concepts • represent abstract concepts • help learners visualize the concept being taught • Summarize the lesson • To cater for the different students' learning needs	**Hannah:** *"ICT use such as simulation incorporates different skills as the learner is not only learning about the topic but technology, computers and applying skills..."* **Hannah:** … "*Using simulations and anything like that can help them conceptualize that idea I'm trying to teach because they can see…"* **Angeline:** *"I like to use it (animations) very visually to help learners to…. get the simplest view of what I'm trying to explain".* **James:** *"They (ICT tools) are useful when you teach Life Sciences…to cater for the learning styles of your learners…*" **James:** *"Simulations allow people to see virtually and graphically… or hear as well what is happening…and then you blend that with your presentation..."I think in my eyes it emphasizes, it makes it more relatable to students especially in the era that we are living; it is a computer driven world…"* **Angeline:** *"If a school does not want to do dissections (*practical*) if it thinks it will take too long or if the learners have objections to a practical work where you dissect things…., you can have the virtual labs…"*

	James: *"ICT integration becomes most effective when you are dealing with abstract topics…"* ***Rose:*** *"I think a 3D dissection online or simulation is better than doing the physical dissection and probably cheaper for the school if they can't afford to buy things for dissections, they could get maybe one tablet because a lot of schools have been funded for tablets and things like that".* **Patricia:** *"The most obvious benefit* (ICT integration) *is that it interests the learners… There is a website; it is called cook dried. You put up questions and then they all join the same room and they answer the questions…The teachers loved it, students loved it and everyone loved it because they had to take out their phones to join…the kids were so interactive, they enjoyed the lesson and it made it easier to connect with them because they used something they were used to - their phones, internet".* **Rose:** *ICT use is also a great way to give learners extra information.*
Catering the needs of the current technological generation.	**Hannah:** *"Even if learners don't have a smartphone, they are familiar with the kind of technology they see on TV*". *So, it is sort of like a natural progression in teaching using technology".* **James:** *"Technology on its own is advancing in levels and strides that we didn't imagine previously. The generation that is growing up is being introduced to these technologies at a very young age and so us being able to integrate what they already know and love into teaching, I think it benefits them for their learning experience".* **Rose:** *"In this age now a lot of learners are very involved in social media and a lot of technological based apps. They are more virtual in the way that they take in the lesson. So, I would rather have a PowerPoint presentation or a poster than just writing on the board because they are likely to pay less attention when you are just writing on the board".* **Sarah:** *"These days most learners find it easier to learn when you use technology than when they're just told things without seeing that particular things like that. So, when you use technology learner have a feel of what you are talking about".*
The world's demands to use ICT.	**Angeline:** "*we are moving into a world which is more technological, and I think teachers have to do the same because if students are going to move into the world, they should learn and work with computers...* *The business world is getting more and more technological, so I think it will give learners skills they need in life instead of saying ok "here is pen and paper…"* **Hannah:** *"For me, it* (ICT integration) *is just a natural thing because of the world that we live in and the technology that we work with every day…*"

	Patricia: *"The world we are living in now, it is impossible not to integrate ICT. You can't teach without it. I don't think you would have a lot of meaningful learning if you didn't integrate".*
COVID-19 pandemic and technology	**Hannah:** *"using Google classroom and stuff like that has become normal this year...we had an enormous opportunity to engage with ICT in a lot of details because of the online teaching we had this year"* (2020). **Sarah:** *"I remember at of the beginning* (online learning during lockdown) *I was struggling to cope with online learning like the first week". I saw things I was not used to before such as Microsoft Teams, Zoom…there was this guy who used to help us with those tools* (ICT tools) *even our lecturers".* **Susan:** "*If I would teach in a lockdown, I would use that kind of tool (Zoom)… In the context of South African integrated technology has the ability to ensure continued learning in circumstances like lockdown…. Learners have a chance to try working on computers".*

Table 14: Influence of ICT use among Life Sciences preservice teachers

The results showed that the ICT knowledge played a role in the usage of the ICT tool in the teaching and learning of Life Sciences evidenced by participants' pedagogical reasoning towards the use of ICT tool as highlighted in table 14 above. For example, **James** indicated that *"simulations allow people to see virtually and graphically… or hear as well what is happening…and then you blend that with your presentation... I think in my eyes it emphasizes; it makes it more relatable to students especially in the era that we are living; it is a computer driven world…"* Furthermore, the comfortability of using the ICT tool is another element that plays a role in boosted the participants' confidence towards usage ICT as **Angeline** said *"I like PowerPoint because I enjoy making interactive slides… I might start a lesson with a video or in that lesson with a video embedded within the PowerPoint".*

These quotes also suggested that preservice teachers' self-confidence in integrating ICT into their teaching practices appeared to be enhanced by their knowledge of ICT and their perceived ease of use of the ICT which answered the research question 2.

4.2.3. Research question 3:

"What are the Life Sciences preservice teachers' perceived benefits of ICT integration in the teaching and learning of Life Sciences?"

Research question 3 was answered by qualitative data gathered from interviews. Participants were first asked participants to explain what "ICT integration" meant to them: *"What does ICT integration into the teaching and learning of Life Sciences mean to you"?*

Participants defined ICT integration as the: *"using ICT tools to enhance the lessons*" (**Angeline**); *"use of technology in teaching"* (**James)**; *"combination of face-to-face teaching with technology for learners to engage with it"* (the learning) (**Patricia)**; *"using and working with technology in our everyday work"* (**Rose**); *"use of technology to make learning easier"* (**Sarah**); and "*capability of using technology to enhance learning"* (**Susan**).

These definitions are consistent with the study's concept of ICT integration, which has been described as the ability of a teacher to use ICT resources to improve teaching and learning. The results suggest that participants were aware of what ICT integration in teaching and learning entails.

Participants were also asked to clarify why ICT integration was important in the teaching of Life Sciences related to TPACK. As previously stated, the aim of the question was to elicit participants' perceptions of the benefits of ICT integration. The results related to research question 3 in table 14 showed that participants used or could use ICT for the following benefits, which were divided into six themes:

- Enhancing teaching and learning of Life Sciences: The examples on the themes included motivation of learners; clarifying of concepts; representing abstract concepts; helping learners to visualize the concept being taught; and engaging learners with their learning better.
- Catering for the learners' diversity of learning needs: Some participants reported that some learners learn well through the use of ICT as **James** indicated that the use ICT diversifies the instructional strategies teachers can use to meet the learning needs of learners.
- Giving opportunity to students to acquire other life skills. Participants indicated that use of ICT provide other skills to the learners that that would need in future other than the content being taught as they interact with ICT tools.
- Supporting the current technological generation of students. Participants indicated that today's generation of students is more familiar with most of the technologies or applications through the social media, internet, and Television (TV) that can be integrated in the teaching and learning.
- Matching up with the demands of the world. Participants indicated that the world is getting more technological, and no one can succeed without the use of ICT and that teachers have also to use technology in the pedagogical practices to prepare learners better to fit into the that world.

- COVID-19 pandemic/lockdowns demand one to adapt or adopt ICT integration. Some participants such as **Sarah** indicated that before lockdown, she did not know how to use virtual ICT application tools such as Microsoft Teams and Zoom as such she struggled in the first two weeks when online learning was introduced at her university. She indicated that other students had to help her out on how to use these applications.

However, participants also expressed their fears and challenges in usage of ICT in the teaching and learning when they were asked. "*At his stage that you are about to go into the field and teach, what fears or challenges regarding use of ICT do you have?* The aim of the question was to learn about the challenges of ICT integration from the participants' perspective. Based on the responses of the participants, the challenges associated with the use of ICT among the PSTs were categorized into the following themes:

Theme evidence	**Evidence from participants' point of view**
• Classroom management when student use ICT	**Angeline**: *"If students are using their phones in class, it could create challenges with classroom management because I am an inexperienced* teacher"
• Inexperience with some technologies • Difficulty to Select appropriate ICT tools to use	**Hannah:** "*I think it's mainly inexperience with particular technologies, learning how to use them. For example, Google classroom is something that I haven't used before. So it may take some time to work it out… And also I guess knowing what is more appropriate for the learners because that also comes with experience".*
• Technical problems of ICT tools	**James:** *"I said you can't depend on technologies alone because they can have technical malfunctioning"* **Patricia**: *"…technical issues… always arise….sometimes technology can be unpredictable in terms of what you see …sometimes you can run through a program 10 times but the day you are doing it in front of your class, the mouse wouldn't work, the thing wouldn't move to the right space…"*
• Lack of training in school for ICT use	**Rose:** *"Many schools do not provide training* (on ICT use), *you just have to learn it by yourself***."**
• Lack of ICT resources in school e.g. ▪ Internet ▪ Electricity ▪ Computers ▪ Projectors ▪ smartboards	**Susan:** *"…the access to technology and learners' ability to use the technology …is another problem".* *If I find myself at a school where resources are available and learners are fairly capable of using it then I would obviously need to show that I can integrate it. If ICT resources are not there, then I will not be able to integrate".*

	Sarah: *"I was doing my practical in a rural area and the school was so dilapidated, like they have no resources, I was only using a chalkboard and few charts. Even those classrooms they don't have electricity that you can use",* **Rose:** *"…during the lockdown it was quite difficult without data and things like that".* **Angeline:** *"lack of connection, Wi-Fi is often bad wherever you go. And then I think if you go to a more rural school, you may not necessarily have access to these things* (ICT tools) *and if you do your students are not going to win at their homes".*
• Load shedding	**Rose: "***Sometimes we have load shedding and you can't upload anything".* **James**: *"there can be somethings that prevents the technology as simple as electricity going off…"*

Table 15: Challenges of ICT integration among PSTs

As indicated in table 15 above, participants perceived the following to be the barriers when using to ICT in the teaching practices: classroom management when student use ICT, inexperience with some technologies, difficulty to select appropriate ICT tools to use, technical problems of ICT tools, lack of training in school for ICT use, lack of ICT resources in school, load shedding. However, it appeared that perceived benefits outweighed the challenges in this cohort as **Hannah** said: *"ICT integration is definitely beneficial. We need to find ways to integrate as much as possible".* This quotation may suggest that the participant could perceive the usefulness of ICT outweighing the challenges.

The overall assessment of qualitative and quantitative findings for research question 3 suggests that participants' awareness of the benefits of ICT integration in teaching and Life Sciences was a motivation for their willingness to integrate it into their teaching practices.

4.2.4. Research question 4:

How does lecturers' modelling influence the disposition of Life Sciences preservice teachers towards integrating ICT into their own classroom practice?

The research question 4 was answered by both quantitative and qualitative data. The quantitative part was gathered through the SPTKTT questionnaire that had a question component on models of TPACK for Life Sciences preservice teachers (questions 32-34). The questions were designed to explore participants' perceptions towards the modelling of TPACK by their lecturers in Life Sciences, methodology and educational courses. The qualitative data was gathered through the open-ended question 35 in the SPTKTT questionnaire and interview

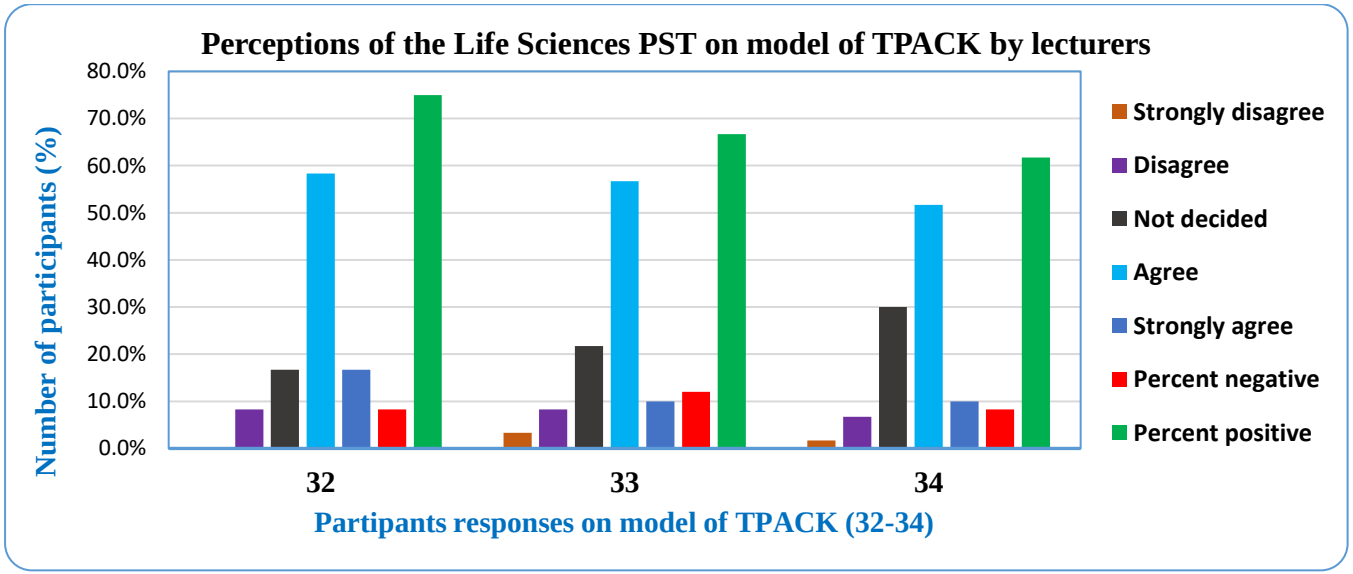
question especially question 14: "*During your teacher training program, have you observed or learnt any usage of ICT for teaching and learning from your lecturer(s) that you are likely to implement during your teaching experience instructions? If yes, which ICT? How did the lecturer(s) use it?"*

Question 32-34 explored participants' perceptions on the modelling of content, technology, and teaching strategies they had observed from their lecturers in Life Sciences courses, Life Sciences methods course and educational courses respectively. The results on question 32 showed that 75% of participants perceived positively that the Life Sciences lecturers appropriately modelled content, technology, and teaching strategies in their teaching practices and 8.3% indicated that lecturers did not appropriately model while 16.7% of participants were not sure if they had observed modelling or not. The results on question 33 showed that 66.7% of participants perceived positively that the methodology lecturers appropriately modelled content, technology, and teaching strategies in their teaching practices and 12% indicated that their lecturers did not appropriately model in their teaching practices while 21.7% of participants were not sure if they their lecturers modelling or not. The results on question 34 showed that 61.7% of participants positively perceived that the educational lecturers appropriately modelled content, technology and teaching strategies in their teaching practices and 8.3% perceived that lecturers did not appropriately model, content and pedagogies while 30% of participants were not sure of if lecturers' modelled or not. Table 16 below summarized the results:

Item	Survey question	Strongly disagree	Disagree	Not decided	Agree	Strongly agree	Percent negative	Percent positive
32	"My Life Sciences lecturers appropriately model combining content, technologies, and teaching approaches in their teaching"	0%	8.3%	16.7%	58.3%	16.7%	8.3%	75%
33	"My methodology lecturers appropriately model combining content, technologies, and teaching approaches in their teaching"	3.3%	8.3%	21.7%	56.7%	10%	12%	66.7%
34	"My Educational lecturers appropriately model combining content, technologies, and teaching approaches in their teaching"	1.7%	6.7%	30%	51.7%	10%	8.3%	61.7%

Table 16: Perceptions of the Life Sciences PST on models of TPACK by their lecturers

For comparison purposes of participants' responses on models of TPACK, were also presented in the graph 5 to increase understanding.



Graph 5: Perceptions of the Life Sciences PST on model of TPACK by lecturers

The qualitative data to answer research question 4 was gathered through question 35 in the questionnaire survey and interviews. Question 35 was designed to explore participants' perceptions of the lecturers' modelling of content, technology, and teaching strategies they had observed. 13 participants did not answer question 35, or the answer was vague. It was not easy to analyse the open-ended responses as some did not answer the question in full. For example, many participants only mentioned what the lecturer taught, or the technology they used or just a comment of how they felt about the lecture. Nevertheless, a closer look at the data from the 47 participants provided some insights on how the participants perceived the lecturers' modelling of content technology and teaching strategies. The question aimed at understanding participants' ability to observe how lecturers modelled ICT in their teaching practices, thus learning how their lecturers combined content, technology, and teaching strategies.

From the analysis of participants' responses, I noticed that participants gave examples from three courses based on the topic/concept the lecturer had taught and these were Life Sciences, Life Sciences methods, and Education courses. Table 17 below summarizes what lecturers taught, the ICT tools and the teaching strategies they had used. I also added participants' comments on the lecturers' lesson or how the ICT tool was used by the lecturer.

Topic/concept taught	**ICT tools used**	**Teaching strategies used**	**Participants' comment on lecture or usage of ICT tools**
Life Sciences: • DNA, • Meiosis • Nervous system • Reproduction • Ear • Eye • Kidney dissection • Evolution	• PowerPoint projector • Videos • Simulation • Voiceover slides • Pictures	• Demonstration • Explanatory • Presentation • Discussion • Discovery	• *"Our Lecturer used a simulator and videos PowerPoint … to show us how an impulse is changed into a reflex action from the stimulus to the brain".* • *"The Lecturer would play us videos on how the eye works or the ear".* • *"Lecturer used PowerPoint presentation that included a video play-clip" to engage us".* • *"The video* (on kidney dissection) *was provided with the explanation of the procedure and the lecturer let the lesson to be a discussion to let everyone learner share their ideas".* • *"When we were learning about the central nervous system and sense organs in 3rd year, the Lecturer always started a lesson and ended it with a video or video simulation which was helpful*".

			• *"She used PowerPoint and projectors to show the structure of DNA".*
Life Sciences methods	• Microsoft Teams • Wakelet • PowerPoint projector	• Demonstration • Participatory • Group work	• *"We practiced together as a class how to use the application* (Microsoft Team)*".* • *"We were showed how we could use these tools* (ICT) *in the classroom".* • *"Dr Mary taught lessons so well using technology that I learnt a lot about new technology and apps we can use in Life Sciences to enhance learning".* • *"It was a life Sciences methodology lesson… we had a whole lesson on the different types of technologies that can be used in a classroom including and Microsoft Teams applications and we were showed how we could use these in the classroom".*
Education: (History of SA curriculum)	• PowerPoint Projector • Video • Voiceover slides	Discussion, Presentation	• *"Lecturer used the video followed by class discussion to engage us on the topic"* (in History of SA curriculum). • *"There was a blending of presentation with PowerPoint slides and videos".* • *"During the 4th teaching block, in theory of Education B, the video representations were very interactive, the approach lecturers took. It was like you were having a conversation with him, even though the videos were pre-recorded".*

Table 17: Models of TPACK for PSTs

The results on this question showed that lecturers could model content, technology and teaching strategies evidenced by participants' episodes. The results also showed that lecturers in Life Sciences modelled the TPACK to introduce or summarize concepts, demonstrate how concepts work, engage students with their understanding, and clarify concepts. It can be summarized that lecturers modelled content, technology and teaching strategies to enhance the teaching and learning of in the Life Sciences course with a range of knowledge and skills. Lecturers in Life Sciences methods modelled the content, technology, and teaching strategies to equip student teachers with teaching techniques and technological skills as one participant indicated *"we practiced together as a class how to use the applications* (Microsoft Team, and

Wakelet) *in the classroom"*. It is in methodology course where participants reported that they worked together as a class to learn how to use ICT tools in the teaching and learning of Life Sciences. The findings also showed that in Life Sciences methods course students were taught and showed how they could use ICT tools to teach Life Sciences evidenced by participants' episodes as showed in table 17. Lastly, findings also showed that in lecturers in educational courses modelled content, technology and teaching methods to mainly to engage students with their learning students to increase understanding as one participant indicated *"Lecturer used the video followed by class discussion to engage us on the topic"* (History of the SA curriculum). The most mentioned ICT tool that lecturers used often in their teaching practices was the PowerPoint and projector as it was mentioned **33 times** compared to other ICT tools.

However, some participants perceived that the constant use of PowerPoint slides and projector by their lecturers was not an effective way of modelling TPACK. For example, one participant commented: "*my lecturers' teaching methods were always the same - PowerPoint with some text, maybe a picture or two, and a combination of teacher talk and class discussion. There are no lessons that stand out to me as unique, or as more effective than another in using TPACK".* Another one wrote: *"My lecturer often uses PowerPoint slides….and there is nothing new"*. These comments from some participants might have suggested dissatisfaction of the TPACK modelling they experienced in their teacher training program.

Additional qualitative data was obtained through interviews where participants were asked to give their experiences on the modelling of technology, they had experienced in their teacher preparation program that they would use in their own teaching practice: *"In your teacher training program, have you observed or learnt anything in the usage of ICT to teach Life Sciences from your lecturers that you are likely to implement in your teaching practice? What is that ICT tool and why"?*

The results on this question showed that five participants perceived to have learnt the usage of ICT from their lecturers that they would use in teaching of Life Sciences, which included: PowerPoint slides with voice notes or video and projector, Microsoft Teams, Zoom and use of videos. For example, **Hannah** and **Susan** indicated they had learnt how to insert voice notes and videos on PowerPoint slides and how they could do the online learning lessons using different apps such Microsoft Teams as **Susan** said**:** "*I have learnt how to do voice records on PowerPoint slides and that is something that I would do either for learners if something*

happens for learners to stay away from school... I would implement some like…either the online forum discussion... or the slides with voice records to help learners to stay on top of things". Furthermore, **Patricia** and **Rose** indicated that they had learnt how to use Microsoft Team and Zoom among other ICT tools. For example, **Patricia said**: *"Last year we went to E-Zone and she* (lecturer) *taught us…how to use…Microsoft Teams and other things". She* (lecturer) *taught us how to use them effectively, things I never thought I needed to know*".

Lastly, **James** indicated that during his teacher training program, whenever an abstract concept was taught, his lecturers showed pictures on a projector or a video and helped him to understand concepts as he said: "*When we were taught things that were more abstract, we were either shown pictures on a projector or a video of sorts. It felt like it made more sense to me when I could see a video that explained something from a point of view that I was not getting the theory by reading alone*". These quotations from participants' episodes suggest that lecturers had played a role to influencing preservice teachers' use of the ICT tools.

However, **Angeline** and **Sarah** two PGCE student teachers indicated they had not learnt any unusual ICT tool that they did not know during their teacher training program that they would implement in the teaching and learning of Life Sciences. For example, **Angeline** said: "*Honestly, all of my lecturers have used PowerPoint; they have never used anything else. So, I personally don't think I haven't seen anything that particularly I want to use because the way they do I can't afford, if I am teaching, I am not going to load the slides".* **Sarah** observed that*: "Lecturers were using normal presentations. I have never seen anyone using something that I was not familiar with before. But during our microteaching, it is when I have seen a lot of things* (ICT tools) *from my peers. They came up with different things … it was interesting, like simulations, 3D models*."

A closer look at Angeline and Sarah responses still suggested that lecturers modelled TPACK in their teaching practices as both mentioned that the lecturers used PowerPoint projectors except that it was so often. Nevertheless, Angeline and Sarah responses suggested that they were not satisfied with the modelling of TPACK by their lecturers.

In summary, results on research question 4 that emerged from both the quantitative and qualitative data seemed to converge and reinforced the conclusion that there was modelling of TPACK by the lecturers at this South African university for the Life Sciences PSTs.

In conclusion, the results indicated that the majority of PSTs at this South African university believed they had capabilities in TK, TCK, TPK, TPACK, and modelling of technology in relation to the teaching and learning Life Sciences. The results have also shown that preservice teachers' confidence to use ICT was attributed to their ICT abilities, perceived usefulness of ICT and exposure to ICT use. According to TPACK conceptual framework as argued by Joo, Park and Lim (2018), teachers with developed TPACK are more confident and willing to integrate ICT into their instructional strategies in effective ways than those who do not. On the overall, the results seemed to have answered the research question: "how prepared are the preservice teachers to integrate ICT during Life Sciences' Teaching Experience" considering the fact that participants demonstrated a well-developed TPACK to warrant them integration of ICT in their teaching practices.

The next chapter presents, discussion of results to provide a better picture of what they meant to the study. The discussions of results are in the order of the research questions' results, recommendation as based on the findings; conclusions and limitations of the study.

Chapter 5: Discussion, Recommendations and Conclusions

5.1. Introduction

The purpose of this study was to explore the Life Sciences preservice teachers' preparedness to integrate ICT in teaching and learning of Life Sciences during their teaching experience program at a South African university. To explore the preparedness of the Life Sciences PSTs to integrate ICT in teaching and learning of Life Sciences, a TPACK (technological Pedagogical Content Knowledge) conceptual framework was used as the lens of understanding the TPACK abilities of participants as essential skills to enable them to teach with ICT. According to Mishra and Koehler (2008) technological knowledge, pedagogical knowledge, and content knowledge exist as interrelated components of that PSTs need to understand if they are to integrate ICT in their teaching practices. A mixed methods research design was adopted as discussed in chapter 3 to get an in-depth understanding of the phenomenon under study by utilizing the quantitative data collected through the "Survey of Preservice Teacher Knowledge of Teaching and Technology" questionnaire (Schmidt et al., 2009) is abbreviated as SPTKTT, which is based on TPACK. The SPTKTT is designed to explore preservice teachers' experiences in ICT integration practices (Schmidt et al., 2009). In additional, the qualitative data was collected by open-ended questions in the SPTKTT questionnaire and interviews. The following were the research questions that guided the study:

1. How do Life Sciences preservice teachers perceive themselves prepared to integrate ICT into their classroom pedagogical practice?
2. How does ICT knowledge play a role in the Life Sciences preservice teachers' confidence towards ICT integration?
3. What are the Life Sciences preservice teachers' perceived benefits of ICT integration in the teaching and learning of Life Sciences?
4. How does the lecturers' modelling influence the disposition of Life Sciences preservice teachers towards integrating ICT into their own classroom practice?

In this chapter, I will discuss the findings that relate to each research question that relate to the preparedness of PSTs to integrate ICT in the teaching and learning of Life Sciences. A recap of the how the data was analysed to arrive at the results: the quantitative data was analyzed using descriptive statistics in which the positive responses were grouped into positive percentile and the negative responses were grouped into negative percentiles for purposes of

getting a general overview of participants' perceptions related to TPACK. The qualitative data obtained through interviews that were coded and analysed thematically. The quantitative and qualitative results were then integrated to provide a more comprehensive view of the phenomenon from both viewpoints. As such, I was able to get a better interpretation of how the results answered the research questions and made claims based on them that will be discussed in the subsequent sections.

5.2. Discussions of findings that related to research question 1

As mentioned in chapter 4, the TCK (technological content knowledge), TPK (technological pedagogical knowledge), and TPACK, which are the domains of the technological pedagogical content knowledge (TPACK) conceptual framework, were used to obtain the quantitative data in the SPTKTT questionnaire which was also related research question 1.

One of the key findings drawn from the results presented in chapter 4, table 7 was that the majority of participants at this South African university had a positive perception of their TCK ability to use ICT to teach and learn Life Sciences in their teaching practices with positive responses of 81-85%. In a similar survey, Banks (2017) found that the majority of PSTs at a university in rural western North Carolina had an 88% positive perception of their TCK ability that they use to teach their subject areas. According to Banks (2017) the positive perception TCK abilities were attributed to the teacher preparation program as it was noted that the PSTs were introduced to technological-related trainings in their teacher preparation program that boosted their confidence to integrate technology in their teaching instructions. It has been argued that PSTs who are introduced to the ICT during their teacher preparation program are likely to integrate during their actual teaching practices (Gill, & Dalgarno, 2008). According to Gill and Dalgarno (2008) the likelihood that PSTs will integrate ICT in their pedagogical practices depends on the technology-related training they had received as it helps to develop their ICT literacy that influences their attitude to use ICT in the teaching and learning. In my study this was supported by **Patricia's** experiences as she said: *"We have been exposed to ICT in our methodologies, we have been exposed to quite a lot of it… we went to the E-Zone and they taught us how to use a few apps and Microsoft Teams...And I think, going to different schools…you learn a lot even from the teachers. So, I think I am adequately prepared".*
The excerpt suggests that Patricia's exposure and practice of ICT use during her teacher preparation program prepared her for ICT integration in her teaching practices.

Another key finding related to research question 1 was drawn from the results presented in table 8 and was that the majority of PSTs at this South African university perceived to have TPK abilities to use ICT in their instructional practices of teaching Life Sciences evidenced by their positive response rates that ranged from 76.7% - 88.3% on the domain. In chapter 2, TPK was defined as "the knowledge of how various technologies can be used in teaching, and the understanding that using technology may change the way teachers teach" (Schmidt, et al, 2009, pg. 125). This finding agrees with Ertmer and Ottenbreit-Leftwich's (2010) argument that in order to teach with technology, teachers must be able to select appropriate computer applications that meet the curriculum's instructional needs as well as their students' learning needs, as well as manage computer hardware and software.

The other key finding that was drawn from TPACK domain results that related to research question 1 was that the majority of participants perceived themselves to have the ability to teach their lessons that could combine technology, content and teaching strategies in Life Sciences. This finding agrees with Ertmer and Ottenbreit-Leftwich's (2010) argument that to use technology that support meaningful student learning, teachers must have the content they are required to teach, the pedagogical strategies that facilitate student learning, and specific strategies in which technology can support those pedagogical methods. However, within the TPACK domain, it was found that question 30 scored the lowest with a 63.7% positive response and 15% negative response and 21.7% were undecided regarding whether they could provide leadership roles or not in the teaching and learning. This could suggest that PSTs lacked confidence in their leadership roles that they were going to assume in their teaching career. Bond (2011) observes that despite the call for preservice teachers' leadership development to be included in their teacher preparation program, the teacher leadership component is often omitted. Bond notes that even when in-service teachers are asked about their leadership roles, they often claim that they were not prepared for leadership roles during their preservice programs but "they were prepared to teach", suggesting that teachers do not easily assume their leadership roles. Campbell-Evans, et al (2014) also found that PSTs find it difficult to perceive themselves as leaders despite being capable of describing the roles and responsibilities of teachers as leaders.

The overall finding derived from the quantitative data on the three domains of TPACK (TCK, TPK, and TPACK) suggest that the PSTs at this South African university perceived themselves to have the capability of integrating ICT in teaching and learning of Life Sciences during their

teaching practices. This finding addressed the research 1 that aimed at exploring the preparedness of the PSTs at a South African university to use ICT in their teaching practices. However, the quantitative data alone does not bring out an in-depth understanding of the observed phenomenon, but an inclusion of qualitative data enhances a deeper understanding of the observed phenomenon (Creswell & Creswell, 2018; Johnson & Onwuegbuzie, 2004). In this regard the qualitative data was also used to answer the research question 1.

As earlier stated in chapter 4, the qualitative data drawn from open-ended question 36 in the SPTKTT questionnaire and interviews helped to deepen understanding of the participants' preparedness to integrate ICT in their teaching practices based on their TPACK development. The findings drawn from the results in chapter 4, table 11 showed that participants had experienced ICT integration in their own lessons during their teacher preparation program for purposes of enhancing the teaching and learning of Life Sciences concepts. For example, one participant said: *"I used a simulation that demonstrated the path of light through the pupil and onto the retina. This allowed for learners to understand an abstract concept more thoroughly…"* Another participant said: *"I used PowerPoint slides, video and smartboard to teach reproduction… I used pictures to clarify points and to engage students like to show parts and their functions"* (human reproductive system). Both remarks from the two participants demonstrate participants' pedagogical reasoning ability to use ICT to clarify abstract concepts to enhance student learning by selecting appropriate ICT tool for their lessons. The excerpts also suggest that participants consciously used a particular ICT tool to accomplish a goal in their lessons. According to Holmberg, Fransson and Fors (2018), pedagogical reasoning is an important aspect of teachers' rethinking of teaching, instructional skills, and ICT use possibilities.

The other findings related to research question 1 were drawn from the interviews analyses as presented in table 12 in chapter 4. From the analyses, three key findings were found that justified participants' readiness to integrate ICT into their teaching practices:

- Prior experience and exposure to using ICT to teach Life Sciences.
- Knowledge of ICT tools that can be used to teach Life Sciences.
- Ability to adapt and learn ICT easily.

On the theme of prior experiences and exposure to ICT use, Rehmat, et al (2014) observe that PSTs that are exposed to technology in their teacher preparation program are more

knowledgeable about ICT use and have constructivist attitudes toward ICT use in their classrooms. This finding suggested that the exposure of PSTs to ICT use at this South African university played a role in equipping them for their future ICT integration in the teaching practices **James** commented: *"I think there is sufficient exposure to technology. For example, almost every lecture hall that you go to, where I had to attend classes in, has a smartboard or projector or some form of technological facets that can be used and every time we have to prepare our lessons and stuff…"* The excerpt suggests that this South African university has ICT facilities that allowed the PSTs to engage with during their teacher preparation program.

On the of knowledge of ICT tools and ability to adapt and learn ICT findings that justified PSTs readiness to integrate ICT in their teaching strategies, **Angeline** said: *"I can figure out things, so it* (technology) *does not really intimidate me in any way… it is easy enough to learn, so I think am well prepared based on theory and a general sense of technology".* According to this excerpt, it can be suggested that **Angeline's** positive self-efficacy to use ICT was linked to her technological skills, adaptive ability to use and learn technology and her comfort and drive to use technology. According to research, one of the most crucial and determining factors of teachers' actual use of ICT in the classroom is their self-efficacy beliefs about ICT integration (Lee & Lee, 2014). The findings also suggested that preservice teachers' self-efficacy beliefs about ICT use at this South African university had an influence in shaping their perceptions towards its use in their teaching space.

In response to the research question 1, the overall evaluation of quantitative and qualitative findings revealed that both data sets seemed to converge and complement each other. The findings seemed to suggest that the majority of PSTs at this university perceived to have an understanding of how technology, content and teaching strategies were connected. As a result, I concluded that the majority of Life Sciences PSTs at this South African university thought they could integrate ICT into their pedagogical practices in the classroom. According to Schmidt et al (2009) integrating ICT into teaching and learning requires a better understanding of the relationship between ICT, content, and teaching methods, and also how ICT could be used to help learner learning, which seem to have been demonstrated in this study.

5.3. Discussions of findings that related to research question 2

Just a reminder, research question 2 investigated whether preservice Life Sciences teachers' confidence in integrating technology into their classrooms is influenced by their knowledge of ICT. The key findings drawn from results in chapter 4, table 7 and graphs 1 was that participants perceived to have technological abilities they could use ICT to teach and learn Life Sciences. However, the finding did not provide sufficient information to address research question 2, nevertheless, literature suggest that teachers with a high level of technological literacy have more confidence in their ability to use technology in their teaching practices (Joo, Park & Lim, 2018; Ertmer, 2010). Heitink, et al (2016) and Ertmer (2010) argue that if teachers choose to teach with technology or equip their students to be technologically competent, they must first have a basic understanding of technology, as it has become one of the most essential teaching skills. In the same vein, Joo, Park and Lim (2018) observe that teacher's confidence to use of technology grows as their technological knowledge increases.

The findings drawn from the interviews' analyses appeared to provide a better understanding of participants' technological knowledge as participated provided their rationales for choice of ICT tools for their lesson (refer 13 and 14, chapter 4). It was found that participants were able to use PowerPoint projector, Microsoft Teams, and Zoom applications to teach Life Sciences among other ICT tools. As PSTs justified their rationales for the choice of the ICT tool(s) for their teaching practices, the following five factors (themes) emerged that seemed to have influenced them to use the ICT tool(s):

- Their prior knowledge and experience of the ICT tools.
- Their exposure to ICT tools.
- Their perceived ease of use of the ICT tool.
- Their personal interest in ICT use and self-efficacy
- Their perceived usefulness of ICT.

Prior knowledge, exposure, and experience of ICT

These findings were discussed above that PSTs who are exposed to technology in their initial teacher training program tend to be more knowledgeable about the use of ICT and have constructivist attitudes about use of ICT in their classrooms than those who are not exposed (Rehmat, et al, 2014). It confirmed that PSTs that are exposed to technology, their self-efficacy grows and their willingness to integrate it also grows. Thus, PSTs' prior knowledge, exposure and experience of ICT are predicators of ICT integration in their future teaching. The finding seemed to suggest that PSTs' confidence to use ICT were influenced by their prior knowledge, exposure, and experience with the technology.

Perceived ease of use and usefulness of the ICT tool

Perceived ease of use of ICT is defined as the degree to which users consider they will be able to use new technologies with little difficulty (Joo, Park, & Lim, 2018). On the other hand, perceived usefulness of ICT refers to how well the users believe new technologies can help them work better (Joo, Park, & Lim, 2018). According Teo (2011) as cited by Joo, Park, and Lim (2018) teachers are more likely to be willing to use technology when they perceive the ease use and usefulness of technology in teaching learning and teaching. According to Joo, Park, and Lim (2018) when PSTs see how easy it is to use technology, they will see how useful it can be to use it in their pedagogical practices. These assertions may support the findings of this research that participants' perceived ease of use and benefits of ICT influenced their willingness to use it in their teaching practices as said **Sarah:** "*I think it* (PowerPoint) *is easy and it saves time unlike when you use chalkboard or a chart. When you are using a projector, it is easy to put up a picture there or when you have a video it's easy to play it. It is user friendly"*. The perceived value of ICT as a motivator to integrate ICT in the teaching and learning will further be discussed in in the in section 5.3.

Personal interest in ICT use and self-efficacy

Interest in ICT and ICT self-efficacy have both been identified as motivating factors for ICT integration in the classroom (Chen & Hu 2020). ICT interest is defined as a motivational disposition that expresses a person's long-term preference for engaging with ICT-related tasks, whereas ICT self-efficacy is defined as a person's view about his or her own understanding of ICT and how to use it (Goldhammer, et al 2016). In this study, interest in ICT seemed to have played a role in influencing **Patricia** to integrate ICT in her teaching practices as she said: (When doing TE in rural area) "*I made sure that I had a lot of data, in that sense I could still Google things. I could show them* (students) *videos and things… I have a personal mini projector, the best investment in my life, it's a battery powered one that you charge. It is literally smaller than the size of my phone, it projects maybe the size of an A3. So, I used that at the school*". The excerpt shows that Patricia's personal interest and willingness to invest in ICT, might have influenced her to integrate ICT in her pedagogical practices. The overall findings revealed that the majority of participants perceived themselves to be technologically equipped with ICT skills to use in the teaching of Life Sciences, which appeared to have influenced their confidence and willingness to using ICT in their teaching practices.

5.4. Discussions of findings that related to research question 3

As a reminder, research question 3 aimed at exploring participants' perceptions of the benefits of ICT integration in Life Sciences teaching and learning. My assumptions were that PSTs would be motivated to use ICT by different reasons related to their TPACK development. The key findings on this aspect were categorized into six themes as perceived benefits of ICT integration in teaching and learning of Life Sciences:

- enhancing the teaching and learning.
- catering for the learners' diversity of learning needs.
- giving opportunity to students to acquire other life skills other than content.
- supporting the needs of the digital generation of students.
- matching up with the demands of the world.
- COVID-19 pandemic/lockdowns demand one to adapt or adopt ICT integration**.**

Enhancing the teaching and learning

This finding suggested that participants' awareness of the usefulness of the ICT integration in the teaching and learning of Life Sciences was a drive to reinforcing their preparedness and willingness to integrate in their teaching practices. Participants demonstrated through their episodes that they understood why they needed to use technology in their lessons as **Hannah** said: *"For me, I bring…in simulations…when teaching evolution because that is an abstract concept…learners find it difficult to engage with. So, using simulations…can help them conceptualize that idea because they can see simulations like processing, they can see features dying or passing on their genes and the population changing, or speciation happening"*. This excerpt seemed to suggest that it all depends on the teacher to judge the usefulness of the ICT tool before it can be used. Secondly, the excerpt also suggested that **Hannah's** usage of ICT (simulations) was linked to its perceived usefulness it would bring to the learner in the topic of evolution. This agrees with Joo, et al (2018) who state that teachers' intentions to use technology is greatly influenced by the perceived usefulness of the ICT tool. In addition, Apeanti (2016) observes that the success of ICT integration in science classrooms is also largely determined by teachers' perceived usefulness of the ICT in engaging learners to participate or achieve in science. Another observation from **Hannah's** excerpt is that it depends on the teacher's knowledge to select an ICT tool that would help learners to conceptualize abstract concepts. According to research, students often have difficulty visualizing scientific concepts that are abstract (Linn et al, 2006). However, according to Varma et al (2008), cited

by Walan (2020) science teachers need to use ICT to help students visualize abstract scientific concepts and give them better practical meanings. The argument seems to support **Hannah's** pedagogical reasoning for the use of the ICT tool.

COVID-19 pandemic/lockdowns and use of ICT.

This was the interesting finding for the fact the entire world has been affected COVID-19 pandemic including education that required new ways of doing things including teaching. Participants in their responses indicated that ICT has the capacity facilitate learning if there are lockdowns that contact lessons are not allowed as **Susan** said: *"…In the context of South African integrated technology has the ability to ensure continued learning in circumstances like lockdowns…. Learners have a chance to try working on computers…"* The comment suggested that the participant was well informed of the benefits of ICT in face of the COVID-19 pandemic. The finding could also suggest that the participant's TPACK was developed as they could see a learning opportunity through use of ICT while still under COVID-19 pandemic lockdown.

Another finding related to COVID-19/ lockdown was that it helped some participants to adapt to learning with ICT and improved their ICT skills. For example, **Sarah said:** *"I remember at of the beginning* (online learning during lockdown), *I was struggling to cope with online learning like the first week" … I saw things that I was not used to before such as Microsoft Teams, Zoom…. There was this guy who used to help us with those tools* (Microsoft Teams, Zoom) *even our lecturers"*. Because the COVID-19 pandemic lockdown affected every aspect of society and daily life, König, Jäger-Biela, and Glutsch (2020) note that people had to learn new ways of organizing communication and interaction, and that even new teachers had to adapt to online teaching during the COVID-19 school closures. They found that new teachers from the "digital native" age were quick to adapt to the online teaching obstacles posed by the COVID-19 pandemic lockdowns, as expected. The excerpt suggests both PSTs and their lecturers had to adapt to online teaching and learning, which in turn improved their ICT skills as they all of them had learn new ways of teaching and learning.

On the overall, these findings suggested that the Life Sciences PSTs perceived benefits of the ICT integration and their ICT self-efficacy influenced their willingness to integrate ICT in their teaching practices at this South African university

5.5. Discussions of findings related to research question 4

As a reminder, research question 4 was meant to see if lecturers' abilities to model the content, technology, and pedagogy, thus modelling TPACK, could influence PSTs' dispositions integrate ICT into their teaching practices.

The key finding drawn from the lecturers' abilities to model TPACK presented in chapter 4, table 16 and graph 5, was that the majority of participants perceived positively that their lecturers modelled TPACK in Life Sciences, Life Sciences methods and Educational courses. They were able not to tell how their lecturers modelled ICT use for teaching and learning purposes. However, it was reported that there was more lecturers' modelling of TPACK in Life Sciences course than other courses, which was expected as their subject of specialization. Participants were also aware that the research focus was on their preparedness to integrate ICT in their teaching subject (Life Sciences), which already created a bias towards it than other subjects.

It was found that the ICT tools that lecturers had mostly used in their teaching practices such as PowerPoint slides and projectors, videos, and Microsoft Teams were the very ICT tools that participants mentioned most to have used in their own lesson during their teacher preparation program (refer table 11 and 17 in chapter 4). This agrees with Banks (2017) who observes that most often PSTs tend to model what they have seen during their teacher preparation program. Banks (2017) further argues that the ability of lecturers to model teaching while integrating technology in their instructions, offers an authentic learning experience to the PSTs to understand the appropriate approaches of integrating technology into their teaching and learning practices.

Another finding was some PSTs learnt the usage of ICT tools more their peers than lecturers as **Sarah said:** *"Lecturers were using normal presentations* (PowerPoint presentations). *I have never seen anyone using something that I was not familiar with before. But during our microteaching, it is when I have seen a lot of things* (ICT tools) *from my peers. They came up with different things …it was interesting, like simulations, 3D models*." This claim seemed to agree with Admiraal, et al (2017) who find that in the classrooms, both peers and lecturers serve as role models and effective motivators for ICT integration. In this regard, I argue that it is how the teacher sets up to brings the platform that students can learn from each other. In this

case it was the microteaching that enabled the PSTs to learn from each other as they were required to teach their own lessons.

However, another finding was that there was a smaller percentage of PSTs who were not sure if they observed lecturers' modelling of TPACK in Life Sciences, Life Sciences, and Education courses in their teaching practices. That suggested that some participants at this South African university could not tell if their lecturers modelled ICT for teaching and learning purposes or not. The implication of this is that much as the majority of PSTs could indicate they witnessed lecturers' modelling of TPACK, but there is need for lecturers to consciously model TPACK more in their teaching practices to influence every PSTs disposition towards ICT integration in their future teaching practices. Banks (2017) argues that PSTs who have been exposed to TPACK modelling in which technology has been effectively integrated would potentially establish a disposition in which they believe they can effectively integrate it as well in their teaching practices. This seem to agree with the findings in this study as it was revealed that PSTs could use the same ICT tools their lecturers had used, which implied that they had learnt usage of ICT from their lecturers.

In conclusion, the overall findings of the study seem to contradict the widely held belief that new teachers lack confidence in their ability to use technology in their teaching practices because their TPACK capabilities are underdeveloped when they enter the profession. In this study, the findings have shown that the majority of PSTs at this South African university perceived to have capabilities in TK, TCK, TPK, TPACK and modelling of technology towards the teaching and learning of Life Sciences. This builds a claim that those PSTs at a South African university were prepared to integrate ICT in their teaching practices justified by those abilities discussed in this chapter.

5.6. Recommendations and future research.

Based on these findings, it is recommended that PSTs should be given opportunities for more practice to master the ICT integration process because they might perceive to be prepared to integrate ICT in classrooms, but they may not just be prepared with limited hands-on practice. This is also echoed by Mohamed (2018) who observes that PSTs tend to have a positive attitude and perceived preparedness to use ICT in their classrooms, but they need more practice and a more strategic approach to successfully integrate. For further studies, a similar research is recommended, with a participant follow-up plan to observe their actual pedagogical practices

in their actual teaching setups to validate their preparedness not just the perceived preparedness, which may not translate into actual pedagogical practice in the classroom.

The study found that few PSTs were not sure to have observed lecturers' modelling of ICT use, which suggested that some the modelling of ICT use was not explicitly done for PSTs' learning that every PST would emulate for their future teaching practices. This study recommends that lecturers should explicitly and effectively model ICT use for the PSTs to shift their dispositions towards ICT integration in their teaching practices.

5.7. Conclusion of the study

Just a reminder that the purpose of this study was to explore Life Sciences preservice teachers' preparedness to integrate ICT in their teaching practices, which was guided by the TPACK conceptual framework as the lens of understanding their PSTs' preparedness in teaching using ICT. In order to obtain a better understanding of PSTs' preparedness, a mixed methods study design was used to answer the following research questions:

1. How do Life Sciences preservice teachers perceive themselves prepared to integrate ICT into their classroom pedagogical practice?
2. How does ICT knowledge play a role in the Life Sciences preservice teachers' confidence towards ICT integration?
3. What are the Life Sciences preservice teachers' perceived benefits of ICT integration in the teaching and learning of Life Sciences?
4. How does the lecturers' modelling influence the disposition of Life Sciences preservice teachers towards integrating ICT into their own classroom practice?

The first research question asked participants about their perceptions of their ability to integrate ICT into their teaching practices. The key finding related research question 1 was that most Life Sciences PSTs at South African universities believed they had the potential to integrate ICT into their teaching practices. The participants' perceived to have adequate abilities in TCK, TPK, TPACK and modelling of TPACK towards the teaching and learning of Life Sciences.

Secondly, the study looked at the participants' ICT knowledge (TK) to see whether it provided them the confidence to use ICT in their teaching. The findings revealed that most of the participants believed they had the technological abilities to support the argument that technological knowledge influences teachers' confidence in ICT integration. Prior knowledge,

experience, and exposure to ICT use; perceived ease of use of ICT; perceived usefulness of ICT; and personal interest in ICT use were among the themes that justified participants' perceived Technological ability to use ICT in their teaching practices.

Thirdly, the study also looked at whether the benefits of integrating ICT into Life Sciences teaching and learning from the perspective of preservice Life Sciences teachers do influence teachers confidence to integrate ICT in their teaching practices. The perceived benefits of ICT integration that emerged were categorized into six themes: improving teaching and learning of Life Sciences; catering for learners' diverse learning needs; providing opportunities for learners to acquire other life skills; supporting the current technological generation of learners; matching up with the world's ICT demands and influence of COVID-19 pandemic to adapt the ICT use. Based on these findings, it was concluded that the participants' perceptions and acknowledgement of the benefits of ICT integration might have also influenced their willingness and preparedness to use ICT in the teaching of Life Sciences.

Finally, the study attempted to examine whether lecturers' technology modelling influences preservice Life Sciences teachers' attitudes toward integrating ICT into their own classroom practices. This was based on the premise that PSTs learn how to teach from their mentors, including how to teach with technology. The overall findings suggested that there was modelling of technology by the lecturers at this South African university for the Life Sciences PSTs. For example, the ICT tools that lecturers often used in their teaching practices, such as PowerPoint and projectors, videos, and Microsoft Teams, appeared to be the preferred ICT tools for PSTs' teaching practices. This might have suggested that PSTs' perceptions of integrating technologies into their own teaching practices were shaped by the lecturers' technology modelling for them.

In conclusion, findings of this study suggest that preservice Life Sciences teachers at a South African university perceived to be prepared to integrate ICT into teaching and learning of Life Sciences, even though they also admitted that there were limited opportunities for them to practice the ICT integration in the teacher preparation program. They also acknowledged that their TK, TPK, TCK and overall TPACK abilities was owed to the lecturers' modelling of ICT use and prior experiences to ICT use.

5.8. Limitations of the study

The findings of this study are limited to a South African university and may not be generalized to other contexts. Secondly, the sample size for the quantities data was not large enough to lead to conclusive generalizations. Thirdly, the study was conducted during COVID-19 pandemic lockdown when the students were not on campus which also limited the data collections process. Data could only be collected through to the online platforms because face-to-face meetings were prohibited due COVID-19 pandemic. As such, some participants could not easily be accessed to let them fill in the questionnaire or get interviewed, hence only those that were available and willing were interviewed. Furthermore, due to the COVID-19 pandemic, PSTs at this university did not attend their last teaching experience programs, in which they were expected to be observed in their real teaching practices for data collection purposes, which could have enriched the research data.

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Appendices:

Appendix 1: Questionnaire

Please tick the Box (✓)

Your Gender

Male	
Female	

Your Age

20-25	
26-30	
30-35	
36+	

Please indicate to which extent you disagree or agree with the following by ticking in the box (✓)

Technology Knowledge (TK)

Item	Statement	Strongly disagree	Disagree	Not decided	Agree	Strongly agree
1	I know how to solve my own technical problems					
2	I can learn technology easily					
3	I keep up with important new technologies					
4	I frequently play around with the technology					
5	I know about a lot of different technologies					
6	I have the technical skills I need to use technology					
7	I have had sufficient opportunities to work with different technologies					

Pedagogical Knowledge (PK)

Item	Statement	Strongly disagree	Disagree	Not decided	Agree	Strongly agree
8	I know how to assess student performance in Life Sciences.					
9	I can adapt my teaching based upon what students currently understand or do not understand.					
10	I can adapt my teaching style to different learners					
11	I can assess student learning in multiple ways					
12	I can use a wide range of teaching strategies in a classroom setting					
13	I am familiar with common student understandings and misconceptions in Life Sciences classrooms					
14	I know how to organize and maintain classroom management					

Content Knowledge (CK)

Item	Statement	Strongly disagree	Disagree	Not decided	Agree	Strongly agree
15	I have sufficient content knowledge in Life Sciences					
16	I can use a scientific way of thinking					
17	I have various ways and strategies of developing my understanding of Life Sciences					
18	I am comfortable responding to questions about topics in Life Sciences					

Pedagogical content Knowledge (PCK)

Item	Statement	Strongly disagree	Disagree	Not decided	Agree	Strongly agree
19	I can select effective teaching strategies to guide students' thinking and learning in Life Sciences.					

Technological Content Knowledge (TCK)

Item	Statement	Strongly disagree	Disagree	Not decided	Agree	Strongly agree
20	I know about **technologies** that I can use for understanding and learning Life Sciences					
21	I can select **technologies** that enhance what I teach in Life Sciences					

Technological Pedagogical Knowledge (TPK)

Item	Statement	Strongly disagree	Disagree	Not decided	Agree	Strongly agree
22	I can select **technologies** that enhance the teaching approaches for a Life Sciences lesson					
23	I can select **technologies** that enhance students' learning for a Life Sciences lesson					
24	My lecturers in education program have prepared me to think more deeply about how **technology** could influence the teaching approaches I use in my Life Sciences classroom					
25	I think critically about how to use **technology** in my classroom					
26	I can adapt the use of the **technologies** that I am learning about to different teaching activities					

Technological Pedagogical Content Knowledge (TPACK)

Item	Statement	Strongly disagree	Disagree	Not decided	Agree	Strongly agree
27	I can teach lessons that appropriately combine Life science content, technologies, and teaching strategies.					
28	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn					
29	I can use strategies that combine Life Sciences content, technologies, and teaching approaches that I have learned in my teacher training course.					
30	I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school					
31	I can use technology to teach Life Sciences effectively using a variety of teaching strategies					

Models of TPACK for Life Science preservice teachers

Item	Statement	Strongly disagree	Disagree	Not decided	Agree	Strongly agree
32	My Life Sciences lecturers appropriately model combining content, technologies, and teaching approaches in their teaching					
33	My methodology lecturers appropriately model combining content, technologies, and teaching approaches in their teaching					
34	My Educational lecturers appropriately model combining content, technologies, and teaching approaches in their teaching					

Please complete this section by writing your responses.

35. Describe a specific episode where a lecturer effectively demonstrated or modeled combining **content**, **technologies**, and **teaching strategies** in a classroom lesson. Please include in your description what **content** was being taught, what **technology (ies)** was used, and what **teaching strategy (ies)** were implemented.

36. Describe a specific episode (e.g. lesson) where you effectively demonstrated or modeled combining content, technologies, and teaching approaches in a classroom lesson. Please include in your description what **content** you taught, what **technology** you used, and what **teaching strategies** you implemented. **If you have not had the opportunity to teach a lesson, please indicate that you have not.**

Appendix 2: Semi- structured interview schedule

Appendix 2: **Semi-structured interview Schedule:**

Section A: Knowledge of ICT

1. Which ICT tools are do you know that you can use in the teaching and learning of Life Sciences?
2. Which ICTs have you used, or will you be able to use ICT in your teaching? Why?
3. How do you use ICT or how will you use ICT in the teaching and learning of life sciences?
4. What challenges have you experienced when using ICTs to teach?

Section B: Benefits of ICT use

5. What does ICT integration into teaching and learning of Life Sciences mean to you?
6. Do you think is it necessary to integrate ICTs in the teaching of Life Sciences? why
7. Where and when do you find the use of ICTs most productive in teaching life sciences?

Section C: Confidence to use ICT

8. Are you able to prepare an ICT integrated lesson?
9. What factors do you consider when preparing such a lesson?
10. Do you feel you are adequately prepared to integrate ICTs into your teaching? Why?
11. Do you have any fears when it comes to use of ICT during teaching experience? If yes, what are they and why? If no, why not?
12. What additional skills or knowledge would you need if you were to integrate ICTs into your teaching effectively?

Section D Modelled use of ICT

13. During your teacher training program, have you observed or learnt any usage of ICT for teaching and learning from your lecturer(s) that you are likely to implement during your Teaching Experience instructions? If yes, which ICTs? How did the lecturer(s) use it? For which topic(s), concept(s). In your case how are you going to use it?

Appendix 3: Ethics clearance Certificate

WITS SCHOOL OF EDUCATION

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

SCHOOL OF EDUCATION ETHICS COMMITTEE

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

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: 2020ECE010M**
PROJECT TITLE	Assessing Preservice Teachers' preparedness to integrate ICT during Life Sciences' Teaching Experience: A case study at a South African university
INVESTIGATOR	Timeyo Kanyinji
SCHOOL/DEPARTMENT OF INVESTIGATOR	WITS SCHOOL OF EDUCATION
DATE CONSIDERED	17 June 2020
DECISION OF THE COMMITTEE	Approved unconditionally
EXPIRY DATE	Date of submission of the project report

ISSUE DATE OF CERTIFICATE 29 June 2020 **CHAIRPERSON** _____ (Dr Paul Goldschagg)

cc: Supervisor: Dr P. Kavai

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** emailed to the Ethics Office: Matsie.Mabeta@wits.ac.za .

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

tkanyinji

_____

Signature **Date** 21/07/2020

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix 4: Consent form

A Consent Form

Title of research project:

Exploring Preservice Teachers' Preparedness to Integrate ICT during Life Sciences' Teaching Experience: A Case Study at a South African University.

Name of Researcher: Timeyo Kanyinji

I,..... agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

Please circle the relevant options below.

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his research report	YES	NO
I agree that the information I provide may be used anonymously by other researchers following this project	YES	NO

Signature.....

Name of participant.....

Date.....

Appendix 5: Participation information sheet

Participant Information Sheet.
Dear Sir / Madam,

My name is Timeyo Kanyinji. I am a Master of Education student in the School of Education, University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project. As such, I am doing a research entitled **Exploring Preservice Teachers' Preparedness to Integrate ICT during Life Sciences' Teaching Experience: A Case Study at a South African University**. The aim of this research project is to assess the technological pedagogical content knowledge (TPACK) of Life Sciences preservice teachers in order to ascertain their preparedness of using ICTs in their instruction.

As part of this project, I would like to invite you to take part in the research by answering the questionnaire and interview questions. Both the questionnaire and interview will take about 30-40 minutes each. Note that there are no correct or wrong answers and feel free to answer the questions. If you experience any distress or discomfort at any point in this process, you can stop answering the questionnaire or interview questions and resume another time.

You will not receive any direct benefits for participating in this research, and there are no disadvantages or penalties for not participating. You may leave out any question/s if you do not want to answer it. The answering of the questionnaire and interview questions will completely be confidential and anonymous as I will not be asking for your name or any identifying information, and the information you provide will be stored securely and will not be disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report should I use any quotes from responses to the questionnaire or interview. Note that after the research project, which will be completed in March 2021, the data will be destroyed

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website and I will report my research findings at a seminar presentation at the School of Education, University of the Witwatersrand. If you wish to receive a summary of this report, I will be happy to send it to you. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email Shaun.Schoeman@wits.ac.za

Yours sincerely,
Researcher name: Timeyo Kanyinji
Email: 1524122@students.wits.ac.za
Phone number: 0735453170

Supervisor Name: Dr Portia Kavai
Email: portia.kavai@wits.ac.za Phone number: 011 717 3246

Appendix 6: Data coding and Analysis

Data coding and themes

Themes Research themes	Angeline (PGCE)	Hannah (PGCE)	James (PGCE)	Patricia (BEd)	Rose (BEd)	Sarah	Susan	Categories
ICT tools that have been used for teaching L/S	• PowerPoint (PP) • Animations • YouTube videos • Virtual tools: Microsoft teams, Zoom	• PP, • Projectors, • 3D Models • Simulations • Smartboard Virtual tools: Google classroom, Zoom, MS Teams	• Simulations • Gamification • Videos • Projections • 3D models • Virtual tools: MS Teams, Zoom	• Smartboard • PP • Projectors Zoom, MS Teams, Blogs, google classrooms	• PP • Videos • 3D models • Simulation • Virtual: Zoom, MS Teams, Blue button google classrooms	• PP, • Smartboard Virtual platforms MZ Teams, Zoom	PP, projector, smartboard at Videos Virtual tool: Zoom, MS Teams	PP, MST Zoom,
Why are these ICT tools used Why integrate ICT in the teaching of L/S	• Prior knowledge and experience with ICT tool e.g. • PP is interactive • PP allows picture, video to be imbedded in the lesson • Animations to help learners to get simplest view of concepts • videos to summarize lessons • The world demands use of technology e.g business • Prepare learners to fit into the world • To motivate learners	• Prior knowledge and experience with ICT tool (taught in Japan using ICT tools. • Desire to try something new • • • ICT tool (simulations) help learners visualize the concept being taught • ICT use such Simulation incorporate different skills as the learner is not only learning about the topic but technology, computers and applying skills • To help learners visualize concepts • The world demands use of ICT	• Prior knowledge and experience with ICT, e.g. computer major • To cater the diverse learning needs of learners • To involve learners. • Simulations allow people to see visually, graphically what is happening, • It enables students to relate concepts and close gaps that teachers could present • The world is computer driven world. • computers are more important than before • The generation is introduced to technology at young age • Integration motivates their learning since its part of what they know	• Prior knowledge & experience with the tools. • Simple to use • To simulate concepts • To represent concepts • To save time • The world we are in demands use of ICT • ICT use motivate learners, students love their smartphones • Naughty learners can be motivated to participate • Lesson is more meaningful when you use ICT	• Prior knowledge and experience with the tools • Exposure to ICT from young age • ICT Tools provide extra information to learners e.g. In Google classroom videos can be uploaded for learners to use • ICT use helps learners to concentrate. • ICT attract students' attention • Virtual practical offer opportunity if you cannot physically carry out practical • ICT tools simplify concepts	• Prior knowledge of ICT • Observed Lecturers using it • Simple to use • Saves time than chalkboard or charts • To simplify the learning e.g. simulations, increase understanding • To teach abstract concepts • The world is technological, move with time, we can't rely on old manual things • Makes learning more Meaningful	• Prior knowledge with the tools • Easy to use • PP videos and picture can be incorporated • To engage learners with their learning task • Learners develop computer skills •	• Use of ICT is influenced by prior knowledge and experience of it • Exposure to technology influence use of technology Sakai, Ezone, • Taught with ICT Hannah • Benefits of ICT use • Desire to try something new • The generation we are in is technological one • The world demands use of technology e.g business

COVID-19 pandemic and use of technology	• Covid-19 calls for the use ICT tools			COVID-19 forced us to explore technologies to use for learning or teaching. Without COVID-19 we could have learnt more technologies	• COVID-19 demand use of ICT since learners are not at school. • COVID-19 gave opportunity to figure out the best virtual platform that could work. • Some lecturers were more interactive to using ICT which gave chance to student to learn how to use those ICT tools	COVID-19 improved the use ICT. COVID-19 helped to explore several applications Increased ICT knowledge. MS Teams, Zooms,	Technology enables learning to continue in circumstances like lockdowns.	Covid-19 and use of technology
ICT Use in low and Middle income schools		• It is easy to use technology in middle schools than low income schools		• Being used to teach at an ICT resourced school creates a challenge to shift & teach at non-resourced school.				
ICT is useful in L/science	• When teaching abstract concepts • Saves time e.g instead of drawing on board, PP can be used. • When teaching concepts that cannot be written • Can be used for virtual labs than actual labs	• When teaching abstract concepts. • ICT helps learners to conceptualize the concept.	• When dealing with abstract topics. • To better learner's understanding of topics that aren't easy to grasp as they are abstract		• When schools cannot afford to do physical practical work: 3D dissections and simulations are better • When Students cant not be at school • Use PP to do mind maps, • Virtual representation	• When teaching abstract concepts		
Challenges of ICT use	• Lack of connections and in many places Wi-Fi connection is bad	• Difficult to Select appropriate ICT tools to use • Limited exposure to ICT tools	Simulations and gamification require codes to be programmed which is not easy to create	• Lack of ICT resources • Lack of connectivity • Theft in underprivileged	• Lack of internet hinder use of some ICT tools e.g. Google classroom • Load shedding	Lack of ICT resources especially in rural areas No electricity	• Lack of resources • Lack of access to right resources	

	• Lack of resources especially in rural areas • Learners' lack of knowledge to use ICT in rural areas • Limited knowledge Know only few ICT tools use and hence	• Lack of practical exposure to practice ICT skills in schools • Lack of knowledge of ICT tools available in schools • Lack of resources in schools		schools hinder use of ICT • Load shedding • Naughty learners	• Lack of technical support in schools • Lack of data • Failure to learn and adapt to using ICT tools by some teachers		• Learners' ability to use technology	
Suggestion to deal with ICT use challenges	• Willingness to learn ICT	• Teachers should share available ICT tools	Being prepare for unforeseen situations. Always have a backup plan if technology fails	• Group learners in small groups to show videos on laptops • Download videos for learners to watch • Own a mini personal projector for teaching purposes • In rural schools bought more data to ensure learners learn something	• Willing to learn and adapt to using ICT	The university should offer a course on how to use technology to support students than just say "integrate ICT in your teaching"		
Ability to prepare an ICT integrated lesson	• Able to mainly use PP slides • Feels there was no enough time to get exposed to ICT use in schools	• Yes. Comfortable to use PP that incorporates videos, pictures	• Able to prepare it with use of videos, images, PP slides projector. • Helped others during microteaching to load PP, videos on projector for them to teach	• Able to prepare lessons because: • Been exposed to ICT in methodology courses • The e-zone platform helped her how to use different apps such as MS Teams, zoom • Went to teach to different schools and learnt from teachers how to use ICT tools	• Prepared because: During teaching experience did use ICT to teach life sciences. • Willing to try out other ICT tool learnt in the year	Yes but not 100%		

Factors to consider when preparing ICT integrated lesson	• Availability of resources • Type of lesson • context	• Appropriateness of ICT tool for the topic • Not to be used for fun but for its usefulness • Availability and accessibility of resources at the school for the lesson • The type of lesson /topic to be taught	• Understand how the technology works • When using ICT have a backup plan if technology fails to work	• Size of the class. Thinks ICT tools work best in small classes • Load shedding	Time factor: feels learners pay attention to shorter lessons than longer ones. PP should have virtual aspects to attract students' attention Students' ICT Prior knowledge of	• ICT resources • Electricity • connectivity	Availability and access to ICT resources Learners' ability to use ICT tools	
Confidence and preparedness to use ICT	• Prepared to use ICT because of: • Feels PCK is strong to incorporate any form ICT • Can always figure out what technology to use • Can easily learn new ICT tools	• Prepared to use ICT because of • Personal experience with ICT from previous teaching but not PGCE. • Taught in Japan where they use ICT tools in • Comfortable to use Computer and software. • Was able to help classmates how to use PP for class presentations	• Prepared to use ICT because of • majored in computer science, (software engineering, coding and website designing) • can try any ICT tool to help learners understanding • helped other students to use ICT during microteaching	• Very much prepared to use ICT because. • Exposed to different learning environments and learnt from other people	• Very prepared to use ICT because: Exposure to technology from an early age. • Can use different technological apps • Able to figure out and learn new technologies	• Partially prepared because: • Lack of knowledge with some ICT tools such as simulations, 3D models. • Have used smartboard only once	• Prepared to use ICT if tool are available • Fair ability of learners to use ICT	• Sufficient ICT Knowledge • Ability to learn new ICT tool for the teaching and Leaning • Has ever taught with ICT
Fear of using ICT	• No fears to use ICT, • Feel can create challenges of class management • Fear of teaching at an under resourced school	• Inexperience with ICT tools for learning such as Google classroom • Knowing what is appropriate ICT tool for learners • Lack of interaction with learners	• Technical malfunctioning of technology • Load shedding • Hence can't rely on technology	Technical problems of ICT tools	• Technical malfunctioning of technology • Load shedding • Unfamiliar with some ICT tools of learning. • Many schools do not provide training for ICT use	Lack of technology in some schools hinder usage of ICT	• Malfunctioning of technology • Fear of going wrong	
ICT use experiences during the teacher training program	• Equipped her with theory to teach • ICT skills were acquired during undergraduate not PGCE program.	• Don't feel PGCE was well structured to equip her with ICT skills. • PGCE only prepared her with	Lecturers used pictures, videos teach abstract concepts on a projector There is exposure at university to use ICT, e.g. every lecture hall has ICT	• Exposure to ICT learning from school and would like to implement the same	• Learnt how to use virtual tools e.g. MS Teams, Zoom, and Blue Button.	• Students learn more from classmates how to use ICT tools e.g. virtual representation	Learnt how to make voice records on PP slides Online learning platforms	Students learn from their lecturers mentors, and their peers how to use technology

	• Lecturers mainly used PP slides to deliver their lessons • Lecturers did not implement ICT use as they told students to use it.	educational aspects (how to teach. • Lack of sufficient to prepare for ICT integration • Learnt how to insert videos on PP from lecturer Anah.	tools (smartboard, projector or some form technology facet	• Lecturers mainly used common PP • E-zone taught how to use ICT tools effectively such as MS Teams Zooms	• Putting up voice over PP slides	• Dr Mary asked each student to teach and record lesson which in turn was evaluated by his/her mates. This gave chance to each student to learn fro others • Lecturers used usual tools (PP), did not use unfamiliar tool. • Have learnt use of MS Teams, zooms		
Additional ICT skills needed to better teach L/S	No additional skills needed	• Opportunity to apply the TPACK theory to the classroom can help to prepare for different contexts • Opportunity to improve computer skills	Very knowledgeable on ICT, but willing to learn more, especially with 3D representations that can used to teach reproduction	Need to learn the hardware of ICT tools such as smartboard, projector.	Knowledge to deal with technical issues	3D models, Simulations and apps that can allow to present the lesson	Making the ICT platforms more interactive and fun for learners such as slides,	