# Teachers' perceptions on the use of Information and Communication Technology for teaching Biology in Lesotho

**BY**

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**DECLARATION**

I, Bobojane Makuru, declare that the dissertation for the Master's Degree in Education I submitted at the University of the Free State is my independent work. I have indicated all the sources I used and acknowledged them by means of complete references. I further declare that I have not previously submitted this work at another university for any qualification.

Signed: B. Makuru Date:

... ...................... 28/09/2020

## ABSTRACT

A plethora of benefits that information and communication technologies (ICTs) have for teaching and learning has long been proven. In the light of this, influence of teachers' perceptions on their incorporation in teaching should not be disregarded. However, only a few empirical studies have focused on teachers' perceptions on the integration of ICTs, and even fewer on such integration in a particular subject that is important to career choices such as biology. Therefore, this study aimed to examine, through the lens of technological pedagogical content knowledge (TPACK), the teachers' perceptions on the use of ICTs in the teaching of biology in Lesotho secondary schools. The objectives were to investigate the ICT tools that teachers commonly use, describe the practices that characterise the patterns of use and determine the correlation between teachers' perceptions and their use of ICTs for teaching. A descriptive, non-experimental survey variety of a quantitative research design, following a deductive strategy, was employed. A total of 107 respondents, selected by a systematic probability sampling technique, completed a questionnaire comprising close-ended items that were measured on a Likert scale. Data were analysed using the Statistical Package for Social Sciences (SPSS) program. The findings revealed that Lesotho secondary school biology teachers perceived themselves as being moderately competent in ICT applications and their incorporation into teaching-learning experiences. Also, it was found that teachers held positive perceptions on the educational use of ICTs. Nevertheless, they reported irregular use for teaching and most commonly used ICTs were found to be printers, the Internet, computers/laptops and projectors. Teachers' irregular ICT practices were more inclined towards supporting their traditional teaching methods and improving their own knowledge. The commonest practices included lesson preparations, searching for information on the Internet, preparing handouts and assessing learners through tests. Furthermore, the results presented a weak, positive and generally statistically significant Spearman rank order correlation between teachers' perceptions and their use of ICTs in teaching biology. The study recommended teacher development programmes to improve ICT competences and also necessary interventions by the relevant education authorities in terms of investment and policies.

**KEYWORDS:** Biology education; science education; Information and Communication Technology; TPACK; Teachers' perceptions; curriculum implementation; Lesotho education.

## DEDICATION

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CK: | Content knowledge |
| ECoL: | Examinations Council of Lesotho |
| ICT: | Information and Communication Technology |
| LGCSE: | Lesotho General Certificate of Secondary Education |
| NCDC: | National Curriculum Development Centre |
| NUL: | National University of Lesotho |
| PCK: | Pedagogical content knowledge |
| PK: | Pedagogical knowledge |
| TK: | Technological knowledge |
| TCK: | Technological content knowledge |
| TPACK: | Technological pedagogical content knowledge |
| TPK: | Technological pedagogical knowledge |
| UFS: | University of the Free State |

# CHAPTER 1. ORIENTATION OF THE STUDY

## 1.1 Introduction

The idea of a shift from the educational practices that change learners from passive recipients of knowledge into those that consider themselves active knowledge constructors, originated nearly a century ago and was inspired by the great educational philosophers, such as Jean Piaget (1952) and Lev Vygotsky (1978). The advocacy for active participation of learners has since been on the rise and continues to receive attention, even to date. For instance, some countries have experimented with the gradual shift from teacher-centred to learner-centred approaches by incorporating information communication technologies (ICTs) (Vietnam's National Assembly, 2000, 2005 as cited in Nguyen, Williams & Nguyen, 2012). The introduction of ICT in instruction contributes to moving, to a certain extent, accountability for learning from teachers to learners (Naqvi, 2018). In reality, the use of ICTs continually transforms the environment of schooling to learner-centredness (Zosh, Lytle, Golinkoff & Hirsh-Pase, 2017). Therefore, the advent and advancement of ICT have become vital to modern-day instruction. There are now instructive applications for smart phones and tablets, some of which are intended to encourage lively, engrossed, expressive, and communally synergistic scholarship (Hirsh-Pasek, Zosh, Golinkoff, Gray, Robb, & Kaufman, 2015). This is supported by Jääskelä, Häkkinen, and Rasku-Puttonen (2017), whose study revealed that technology was seen as an instrument for learning that is active, shared, and exceptional, can blend with continuous assessment, and be learner-paced with no overt learning intents.

This chapter presents the rationale for examining biology teachers’ perceptions and practical employment of ICTs in Lesotho schools. It articulates the worth, aims and intent of the research, as well as the research questions. The theoretical framework, planned research approach and design are discussed, as deemed necessary by Maree (2016). A concise description of the employed research techniques for accomplishing the study is also put forward, which include the selection of the respondents, method of data collection and data analysis.

## 1.2 Background

Currently, biology is taught at junior secondary level, commonly known as the Junior Certificate (JC) and at senior secondary level, known as the Lesotho General Certificate of Secondary Education (LGCSE). At JC level, it is part of the integrated sciences, which comprise the three science disciplines, namely biology, chemistry and physics. At LGCSE level, it is an independent subject, even though it is not offered to all learners in the country. In some high schools, it is a compulsory subject for all learners, while other schools offer it as an elective, or not at all. LGCSE biology builds on the basics laid by Lesotho JC Science (National Curriculum Development Centre (NCDC) & Examinations Council of Lesotho (ECoL), 2014), therefore, a reasonable grasp of JC Science is deemed important for one to study biology at LGCSE level.

My research interest arises from a careful analysis of the aims of the biology curriculum in Lesotho, which encourages the use of technology, and the need to adequately equip learners with a variety of cognitive skills in order for them to become self-assured citizens in the world of technology (NCDC & ECoL, 2014). Additionally, the curriculum seeks to develop skills and capabilities appropriate to the learning and practice of biology, to promote efficient and safe practices, and for effective communication. The biology curriculum articulates the need to advocate attitudes such as inquisitiveness, to promote awareness that the co-operative activities of both groups and individuals have given rise to the development of scientific ideas and methods, and lastly, to promote understanding that the learning and practice of biology is dependent on social and technological influences and their confines (NCDC & ECoL, 2014). These aims present a solid argument for a study to determine how the aims of this curriculum that encourages ICT integration in the teaching of the subject are realized by the biology teachers.

Some research has previously been done, vis-à-vis integration of ICT in teaching within the African milieu. Bahufite (2017) did a study, where the focus was on the implementation of constructivist instructional strategies through ICTs in Zambia, though not specifically in biology. Despite being complete, “deep, detailed, and intensive” (Mustafa, 2008:6), and thus intensifying our perception and providing noticeable insights, as argued by Kothari (2004), Bahufite’s study poses some challenges. The major constraint of the study is that it was limited to only three schools in the same city, Lusaka. In South Africa, Jita (2016) studied the individual competences of trainee teachers to instruct science using ICTs. However, the focus of Jita’s study was not on practising and experienced teachers, and also not specifically on the teaching of biology.

Lisene and Jita (2018) used a quantitative approach to investigate the incorporation of recent technologies to instruct physical science in Lesotho. Kalanda and De Villiers (2008) also undertook a comparative case study in Lesotho and South Africa to examine the integration of computer use and e-learning in the teaching and learning of science. They focused on science in general in two semi-urban schools. Subsequently, Kalanda and De Villiers (2013) used participatory action research to investigate how successful the use of e-learning and the incorporation of ICT could be for science (in general) lessons in high schools. Chere-Masopha’s (2011) and Olatokun and Ntemana’s (2013) studies dealt with teachers’ ICT integration but were limited to secondary and university levels respectively and neither focused specifically on any particular school subject. The former used mixed methods and the latter quantitative research methods. However, perceptions of the teachers were not the focus in all these cited studies.

A few studies measured teachers’ perceptions on the application of ICTs in the teaching of biology. Šorgo, Verčkovnik and Kocijančič (2010) examined the use of ICTs in biology teaching in Slovenian secondary schools. They found that the correlations between the use of computers in a school, its perceived importance for school work and proficiency in such work were highly significant. Teachers’ perception of the value of an application and teachers’ skills were more important obstacles to the wider use of computers. In Brazil, Rolando, Salvador and Luz (2013) used an online questionnaire to survey the in-service biology teachers’ usage of internet tools for teaching and learning. They found that the biology teachers made inadequate use of the internet and ICTs for pedagogical purposes.

In Kenya, Mwanda, Mwanda, Midigo and Maundu (2017) undertook a descriptive survey designed to examine the integration of computer technology in teaching and learning biology in secondary schools in the Rachuonyo South Sub-County. These studies were more inclined to review computer use for personal growth and the use for instruction processes was low. Teachers mostly used ICTs in instructional processes for communicating with students and online learning, while the majority of teachers did not use PowerPoint presentations during lessons.

From these studies, gaps in terms of focal points and/or weaknesses in methodologies were identified. For instance, none of them specifically focused on biology and ICT integration in the context of constructivist instruction. This, therefore, is what the current study seeks to accomplish, over and above examining the experienced teachers' perceptions of ICT integration in biology instruction, which have not been sufficiently assessed in previous studies.

## 1.3 Problem statement

Performance in biology in Lesotho schools has generally been unsatisfactory (Lebata & Mudau, 2014). Studies reveal that this poor performance is a problem, not only in Lesotho, but also in other countries, such as Kenya (Samikwo, 2013), Nigeria (Arokoyu & Chukwu, 2017; Adewale, Nzewuihe & Ogunshola, 2016), and Zimbabwe (Mwangu & Sibanda, 2017), and at tertiary level in South Africa (Tom, Coetzee & Heyns, 2014). This problem is attributed to the learning challenges, such as the abstract and conceptual nature of biology, lack of well-resourced laboratories and lack of qualified teachers (Elliot, Wilson & Boyle, 2014; Koseoglu & Efendioglu, 2015; Ukoh & Adejimi, 2018), as well as the teaching strategies implemented by the teachers (Brown, Friedrichsen & Abell, 2013; Arokoyu & Chukwu, 2017).

Failure to obtain decent grades disqualifies biology students from admission into institutions of higher learning to further their education in the related fields of study. The National University of Lesotho (NUL), for example, admits only students with a minimum achievement level of 4 (60-69%) in biology or physical sciences in addition to other requirements of the Faculties of Science and Health Sciences (NUL, 2018). According to Lekhetho (2013:385) “Few students (less than 22% in 2012) qualify for tertiary education, and a dismal performance in mathematics and science, resulting in only a small percentage that secures admission into science-based programmes”. For the same subjects, the University of the Free State (UFS) set 60% as the minimum admission requirement for entry to the Faculty of Health Sciences (UFS, 2018). Rammala (2009) found that in the Limpopo province (South Africa), only a few grade 12 learners in his sample schools passed with exemption/bachelor, which was a set criterion for university entrance. Similarly, in the Nyakach district (Kenya) Albert, Osman, and Yungungu (2014) found that from 2006 to 2011, more than a third of the candidates were unable to achieve the level that would allow them to pursue careers and courses where biology is a requirement at tertiary institutions.

The researcher has 11 years’ experience tutoring at an educational centre that prepares learners for the additional examinations. Learners from schools in different districts enrol with this remedial educational centre, and every year, distressing revelations as regards knowledge and skills learners acquired, emerge. Without laboratories and other infrastructure, the centre does not provide an appropriate environment for teaching biology and other natural sciences. Therefore, the teachers are compelled to improvise. They usually resort to technology: PowerPoint, videos, digital simulations, and other ICTs, all of which necessitate using computers, Liquid Crystal Display (LCD) projectors, and the Internet. With these improvisations, the centre has been able to assist many learners to reach their targets. This confirms the assertion by Rahman and Akter (2015) that, as support to didactic processes, technology can reinforce attempts to raise the excellence of pedagogy employed in classrooms; in fact, they deem classroom use of ICTs as capable of guaranteeing quality teaching. Hence, the endorsement by countries with distinct economic inequalities to use modern technologies as teaching tools in various subjects (Cubukcuoglu, 2013). Bingimlas (2009), Jita (2016), and Kelleher (2000) also argue that ICTs enable learners to deeply comprehend science ideologies and concepts.

Research also indicates that learners' academic performance can be improved through the implementation of constructivist strategies such as discovery and cooperative learning, which prioritise learner-centeredness and active participation in knowledge construction. These approaches accommodate ICT-enhanced teaching (Peeraer & Van Petegem, 2011; Van Rooy, 2012; Koseoglu & Efendioglu, 2015; Lisene & Jita, 2018). Mikre (2011) indicates that ICT provides worthy education in alignment with constructivism. ICTs greatly facilitate the acquisition and absorption of knowledge. Van Rooy (2012), in an Australian study on ICT use in biology instruction, argues that learners' performance improves when ICT tools are integrated.

However, my experience at the remedial centre where I am teaching has piqued my interest in studying perceptions of biology teachers on the use of ICTs to enhance teaching and learning. Hence, the study opted to examine their perceptions and use of ICTs in instructional practices. Teachers' views tend to significantly shape their instructional activities (Pajares, 1992; Richardson, 1996) and individual technology incorporation habits (Ertmer & Ottenbreit-Leftwich, 2010; Asamoah & Oheneba-Sakyi, 2017). Nonetheless, only a few empirical studies, such as by Šorgo, et al. (2010) and Francisca and Samsudin (2018), have focused on teachers' perceptions on the integration of ICTs, and even fewer on such integration in a particular subject such as biology that is important to career choices. Hence, it was necessary to examine the teachers' perceptions on the use of ICTs in the teaching of biology in Lesotho schools.

### 1.4 Purpose and significance of the study

The study examines the LGCSE biology teachers' perceptions on the contribution of ICTs to constructivist educational practices. The study focuses mainly on schools in places where there are tools, services and infrastructure (electricity, computers, smart phones, communication network services, etc.) that permit ICT-enhanced constructivist instruction. My research-authenticated argument is that through ICT-aided constructivist instructional practices, more learners would perform better in biology and a smaller number would spend their time and money to rewrite and achieve what they wish for. Ahammed (2018), Olumide (2018), and Ghavifekr and Rosdy, (2015) confirm that ICT incorporation in lessons heightens the learning practice and learners' aptitude in participative learning.

The study presents crucial information concerning the current status of the use of ICTs and constructivist practices in biology classrooms, as reflected in the teachers' perceptions. This research will assist the authorities in the Department of Education and the national curriculum developers to revise the formulation and execution of ICT policies in schools. ICT policy clearly charges the educational institutions with the responsibility to contribute to advancing the teaching and learning systems, and the quality of education (Lesotho Government, 2005). Thus, the necessary interventions can be made to improve the quality of educational practices concerning active learner participation in knowledge construction. It will also provide advice to the learners, parents and the administrators at schools, in districts, and the Ministry of Education, besides drawing attention to critical issues concerning ICT integration. The study will provide an opportunity for the participating teachers to reflect on their own instructional practices as regards ICT integration.

## 1.5 Research questions

To achieve the described purpose, this study is guided by the main research question: What are the teachers' perceptions on the use of information and communication technology for teaching biology in Lesotho secondary schools?

To answer this question, the study seeks to respond to the following sub-questions;

(a) What are the perceptions of Lesotho biology teachers on the use of ICTs?
(b) Which ICT tools do Lesotho biology teachers commonly choose to use?
(c) Which practices characterize the patterns of ICTs use by biology teachers in Lesotho?
(d) What is the correlation between teachers' perceptions and use of ICTs in teaching?

## 1.6 Aims and objectives

The primary aim of the study is to determine the teachers' perceptions on the use of information and communication technology for teaching biology in Lesotho secondary schools.

The study seeks to achieve the following objectives:

(a) Determining the perceptions of Lesotho Biology teachers on the use of ICTs.

(b) Investigating the ICT tools that Biology teachers commonly choose to use.

(c) Describing the practices that characterize the patterns of ICT use by Biology teachers.

(d) Determining the correlation between Biology teachers' perceptions and their use of ICTs for teaching.

## 1.7 Theoretical framework

The study was conducted within the confines of the technological pedagogical content knowledge (TPACK) framework developed by Mishra and Koehler (2006). Koehler and Mishra (2009), and Mishra and Koehler (2006) describe TPACK as a framework that underscores teacher's understanding of the productive application of technologies, especially ICTs, as pedagogical instruments.

### 1.7.1. Technological pedagogical content knowledge (TPACK) model

This framework is a derivative and extension of Shulman's (1986) descriptions of pedagogical content knowledge (PCK) (Koehler & Mishra, 2009). It extends PCK to describing the knowledge necessary for teachers to successfully teach subject matter with ICTs in ways tailored to meet learners' needs (Mishra & Koehler, 2008; Mishra & Koehler, 2006). The first proponents of the framework were Mishra and Koehler (2006), but subsequently many scholars have also followed suit (Koh, Chai, Benjamin & Hong, 2015; Koehler & Mishra, 2015; Koehler, Mishra & Cain, 2013; Lin, Tsai, Chai & Lee, 2013;

Schmidt, Baran, Thompson, Mishra, Koehler & Shin, 2009; Koehler & Mishra, 2009; Mishra & Koehler, 2008).

Schmidt, et al. (2009) state that TPACK is a productive framework for contemplating what perception teachers need to incorporate technology into instruction and ways to extend this knowledge. Also, its application as a frame to assess teaching expertise could determine the nature of guidance and professional growth practices planned for preservice and in-service teachers. The details of the model and its applications in the present study are explicated in Chapter 2 of this dissertation.

This study, therefore, uses the framework as a way to reflect on and measure the variables of the current study, i.e., teachers' perceptions on ICTs use, and the consequent use of ICT in pedagogical practices. It also offers theoretical lenses for the researcher to make sense of the practice of teaching via ICT (Koehler & Mishra, 2015).

## 1.8 Methodology

### 1.8.1. Research approach, design and paradigm

The study applied a quantitative approach and took a positivist's stance to examine the teachers' perceptions on the use of ICTs for teaching biology in Lesotho schools. A descriptive, non-experimental survey variety of a quantitative research design, following a deductive strategy, was used as it is a common practice with positivist studies (Bhattacherjee, 2012; Crowther & Lancaster, 2012; Creswell & Creswell, 2017).

### 1.8.2. Data collection

Data collection was accomplished using a questionnaire adapted from instruments used in similar studies: "Information and Communication Technologies (ICTs) in biology teaching in Slovenian secondary schools" by Šorgo et al. (2010); "An exploration of teachers' skills, perceptions and practices of ICT in teaching and learning in the Ghanaian second-cycle schools" by Buabeng-Andoh (2012a), and "Are biology pre-service teachers ready to implement 21st century skill in teaching and learning in Nigeria?" by Francisca and Samsudin (2018). Details of the structure are provided in section 3.5.

### 1.8.3. Population and sampling

The population comprised the Lesotho junior and senior secondary schools' biology teachers. A sample of 107 biology teachers was selected from eight districts using a systematic probability sampling technique (Creswell & Creswell, 2017; Maree & Pietersen, 2016). The initial step in the sampling procedure involved randomisation to guarantee external validity, enabling generalisation of the conclusions made to the population that generated the sample (Bhattacherjee, 2012; Creswell & Creswell, 2017). The details of the sampling process are stated in section 3.7.

### 1.8.4. Data analysis

After collection, the data were cleaned, coded, and then captured in Microsoft Excel. They were then transferred and handled using the Statistical Package for the Social Sciences (SPSS) software to generate frequencies from demographic data, and descriptive statistics meant to address the research questions. Version 26 of the software was used.

A Likert scale survey enabled the analysis of data to provide frequencies, correlations, and descriptions on the use of ICTs to teach biology. The summarised descriptive data for mean and standard deviation were presented in tables and bar charts for interpretation. The inferential statistics were used to make inferences from the sample and generalise them to the population.

## 1.9 Delimitations of the study

The study focused solely on the teaching of biology, and hence sampled biology teachers only, besides the fact that the subject is not offered in every secondary school. This could pose the challenge of a low response rate, hence the sample size. The drawbacks that could result were avoided by distributing more questionnaires than the targeted minimum of 100 respondents, and 107 responses were obtained.

## 1.10 Limitations of the study

Due to randomisation of sampling, the researcher happened to locate schools whose biology teachers could not provide much of the expected data. This could probably be ascribed to the fact that teachers were not using ICTs for various reasons, such as lack of technological tools and expertise, lack of professional development, and low level of self-efficacy. Travelling has cost the researcher much, both in terms of finances and time, especially because he is still a full-time employee. The mountainous terrain of Lesotho and distribution of schools added to the travelling challenges when distributing the questionnaires. In some areas the schools were far apart, which made it difficult to reach some places. This might have affected the representation of the characteristics of the population of Lesotho biology teachers. However, to avoid significant sampling biases that could result, 8 out of 10 districts were covered by the research, making sure to include highlands and lowlands.

## 1.11 Definition of key terms

### 1.11.1. Biology

Ramalingam, Pereira and Pereira (2010) define biology as the science of the physical life of animals and plants. It refers to a science discipline that studies living organisms at different levels of organisation, from molecular level to their relationships with one another and their surroundings, as also explained by Senthilkumar, Sivapragasam and Senthamaraikannan (2014). According to Shulman (1986:9), biology can be expressed as:

> *(a) a science of molecules from which one aggregates up to the rest of the field, explaining living phenomena in terms of the principles of their constituent parts;*
>
> *(b) a science of ecological systems from which one disaggregates down to the smaller units, explaining the activities of individual units by virtue of the larger systems of which they are a part; or*

*(c) a science of biological organisms, those most familiar of analytic units, from whose familiar structures, functions, and interactions one weaves a theory of adaptation.*

### 1.11.2. Information and Communication Technology (ICT)

In the context of this study, ICTs refer to digital and electronic technologies, such as computers, laptops, iPods, handheld digital cameras, printers, photocopiers, projectors, flash drives, smartboards, interactive whiteboards, software programs, and online implements. That is, the electronic tools used in teaching and learning processes for the purposes expressed by scholars such as Meleisea (2007), Olugbenga and Adebayo (2010), and Vozikis, Ypofanti and Papadopoulos (2010). It implies diversities of expertise that are applied to process, transmit, save, create, display, distribute or trade information electronically (Meleisea, 2007). Similarly, Olugbenga and Adebayo (2010) define it as gathering, recovery, application, storage and imparting information using computers and micro electronic system. Also, it is defined "as the tools that facilitate communication, processing, and transmission of information and the sharing of knowledge by electronic means" (Vozikis, et al., 2010).

The ultimate goal of the use of these technologies is to achieve fruitful teaching and learning in and out of the classrooms and/or premises designated for educational activities. According to Livingstone (2012), ICTs bring the conventionally unconnected instructive tools such as audio, books, databases, games, internet, phones, photography and videos together. Thus, ICTs link varieties of information and literacy, and also interconnect areas (such as home, school and work) where learning occurs.

### 1.11.3. Technological pedagogical content knowledge (TPACK)

Koehler and Mishra (2009), and Mishra and Koehler (2006) describe TPACK as a framework that underscores teachers' understanding of the productive application of technologies, including ICTs, as pedagogical apparatus. It is basically a kind of knowledge that prescribes teaching of the subject matter by means of technology in a manner that makes learning easier.

#### 1.11.4. Teachers’ perceptions

Teachers’ perceptions are generally implicit and mostly instinctive suppositions that teachers hold with regard to learners, classrooms, and the educational matter (Kagan, 1992). In this study, the teachers’ perceptions refer to the subconscious thoughts, reasonings or deductions that biology teachers possess or make regarding teaching and learning. Also, the deep-rooted inferences teachers hold concerning the manner in which ICTs aid them in infusing their pedagogical beliefs into classroom undertakings. The teachers’ ability to use the ICTs are also included.

### 1.12 Summary

In this chapter, the researcher described the purpose to undertake a descriptive quantitative study to investigate the biology teachers’ viewpoints and practical integration of ICT in teaching biology in Lesotho. The problem statement was put forth. The research purpose, significance, research questions, and objectives were expressed. The researcher also described the planned methodology, including the research design, instruments for data collection, population and sampling, data collection and their analyses. The conceptual framework, ethical issues and the limitations and challenges were also described.

# CHAPTER 2. : LITERATURE REVIEW

## 2.1. Introduction

This chapter focuses on existing literature on the teaching of biology globally and in the context of Lesotho. The review of literature in this report is organized into three main sections. The first section concentrates on the theoretical framework employed in the study, its origin and history, nature of the framework, and how it is used in this particular study. The second section gives a conceptual analysis of biology as an academic subject, the rationale for teaching and learning biology in high schools, and the basis for the decision to focus the study on the subject. It also examines the biology learners' performance globally, and factors attributed to it, followed by the use of ICTs to teach biology. The third section reviews the teachers' perceptions on the use of ICTs for teaching. It entails commonly used ICTs and their availability. The purposes for which ICTs are used and the practices that characterise patterns of technology use are also reviewed. Finally, the correlation between the teachers' perceptions and the self-reported use of ICTs is explained.

## 2.2. Theoretical framework: Technological pedagogical content knowledge (TPACK) model

The study was conducted within the confines of the technological pedagogical content knowledge (TPACK) framework developed by Mishra and Koehler (2006). TPACK is described as a framework that underscores teachers' appreciation of the rewarding usage of technologies, especially ICTs, as pedagogical implements (Koehler & Mishra, 2009; Mishra & Koehler, 2006).

### 2.2.1. Origin and development of the model

This framework is a derivative and extension of Shulman's (1986) descriptions of pedagogical content knowledge (PCK) (Koehler & Mishra, 2009). It extends PCK to describe knowledge that is necessary for teachers to successfully teach subject matter with ICTs in ways tailored to address learners' needs (Angeli, Valanides & Christodoulou, 2016; Mishra & Koehler, 2008; Mishra & Koehler, 2006). Schmidt, et al. (2009) indicate that the idea of content, theory and technology existed prior to both PCK and TPACK, which was situated in educational software design context, as referred to in Mishra (1998). Schmidt, et al. (2009) also indicate that the now popular association between content, pedagogy and technology has been portrayed by a number of researchers, such as Pierson (1999,2001); Keating & Evans (2001) and Zhao (2003). Related concepts were dealt with by various scholars, even though they used different labels, such as "integration literacy" (Gunter & Bumbach, 2004, as cited in Schmidt, et al., 2009:124); information and communication (ICT)-related PCK (Angeli & Valanides, 2005; Angeli & Valanides, 2014), technological content knowledge (Slough & Connell, 2006); and electronic PCK or e-PCK (Franklin, 2004; Irving, 2006).

Ertmer and Ottenbreit-Leftwich (2010) concur and indicate that various expressions have been used by different researchers to label the integration of ICTs with classroom instruction. According to Ertmer and Ottenbreit-Leftwich (2010:259), some of these terms include:

> *technological pedagogical content knowledge, (TPCK) (AACTE, 2008; Pierson, 2001), pedagogical technology integration content knowledge (PTICK) (Brantley-Dias, Kinuthia, Shoffner, DeCastro, & Rigole, 2007); and ICT-TPCK (a strand of TPCK that specifically emphasizes relevant knowledge of information and communication technologies (Angeli & Valanides, 2009).*

All these models stem from a shared belief that fruitful technology use is dependent on the relationships between content, pedagogy and technology (Angeli & Valanides, 2009)

The first proponents of the framework were Mishra and Koehler (2006) but afterwards many scholars have also expressed it (Koh, Chai, Benjamin & Hong, 2015; Koehler & Mishra, 2015; Koehler, Mishra & Cain, 2013; Lin, Tsai, Chai & Lee, 2013; Schmidt, Baran, Thompson, Mishra, Koehler & Shin, 2009; Koehler & Mishra, 2009; Mishra & Koehler, 2008; Koehler, Mishra & Yahya, 2007). However, TPACK was instituted to academic research society as a framework for technology incorporation, and of awareness of teachers' prerequisite knowledge for them to instruct via ICT in 2005 (Angeli, et al., 2016).

Niess (2005) (as cited in Angeli & Valanides, 2014:V; Angeli, et al., 2016:14) proposed the term TPCK to refer to technology-enhanced PCK .

### 2.2.2. Nature of TPACK

TPACK is a framework, according to Koehler and Mishra (2008), and Mishra and Koehler (2006), that establishes the interactions and complications between all the primary knowledge domains and the use of ICTs. It portrays a model relating stability between content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK), which are its major components. These are usually presented in the form of three intersecting circles forming a Venn diagram (as illustrated in Figure 1) in the middle of which lies the TPACK. This generates six domains in all: besides CK, PK and TK, the other three are pedagogical content knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK). Blending all six generates TPACK, which prescribes knowledge areas that every subject teacher should have for effective incorporation of technology to teach the subject matter. The TPACK domain proffers further awareness and expertise that develop and overlap with those described by Shulman (1986) to assist teachers to integrate ICT to enhance pupils' learning (Ertmer & Ottenbreit-Leftwich, 2010).

The dotted circle labelled "contexts" highlights the awareness that the central components (content, pedagogy and technology) are expressed in particularized learning and teaching circumstances, not in nothingness (Koehler, et al., 2013). Therefore, the instructional decisions regarding technologies to be used to teach content by showing a video clip may depend on the type and number of available ICT tools. In one classroom, a few computers may be used whilst in another classroom, just one computer with a projector would be enough. Logistics involved will differ.

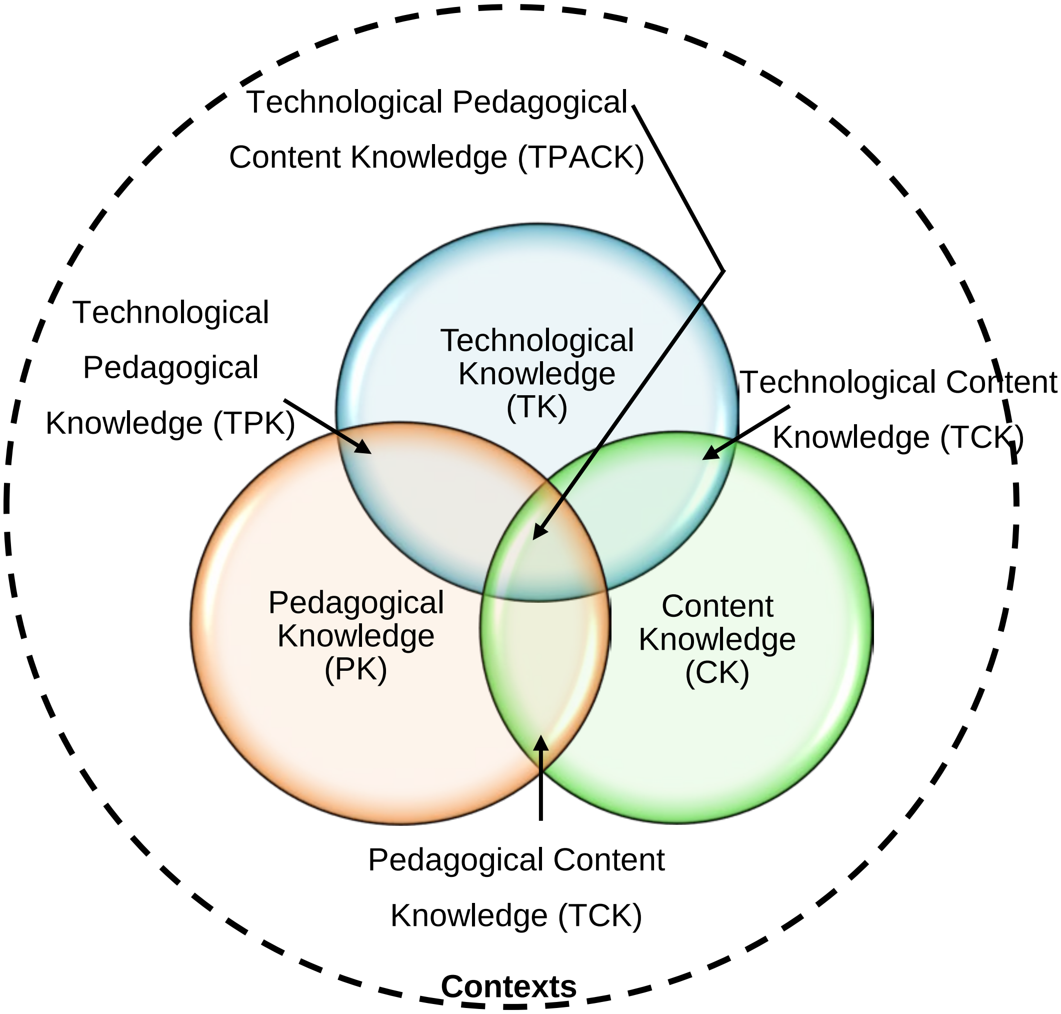


**Figure 1:** The TPACK framework and its knowledge components (adapted from Koehler & Mishra, 2009:63)

The model has seven components in total, which are discussed in the following sub-sections.

### 2.2.3. Content knowledge (CK)

As conceptualized by Shulman (1986:9), CK is "the amount and organization of knowledge per se in the mind of the teacher". Koehler, et al. (2013), and Koehler and

Mishra (2009) define CK as the teachers' understanding of the subject matter, such as biology or chemistry, to be studied or instructed. It involves the extent of understanding the concepts, theories, topics, facts, practices and strategies set up to increase understanding basics, such as scientific conventions, vocabulary, and terminology methods (Shulman, 1986). However, teachers should note that the contents of a discipline differ for diverse situations, stages or ages and levels (Shu, 2016).

Shulman (1986) contends that good thinking about CK should surpass familiarity with concepts or facts of a discipline to appreciating the formations of the subject, basically substantive and syntactic structures. Substantive includes the diversity of styles by which the fundamental subject's concepts and ideologies are sorted out to integrate its particulars. Hence, biology teachers may organise the subject in different systems, for example, into ecology, classification of organisms and molecular biology. Syntactic structure refers to a set of approaches to establish falsehood or truth, validity or invalidity. It is necessary for teachers to be able to justify why a certain proposition is considered right ot worth knowing, and to show its relationship with others both within and oustide the discipline–both in theory and in pratice.

In line with Shulman's contention, Koehler, et al. (2013) emphasize that it is vital for teachers to be aware of the great disparity in the nature of the knowledge of and inquiry into various subjects Therefore, they need profound bases of knowledge in their fields. For example, for biology and other practical subject teachers, these essentials would include terminology, conventions, scientific methods, evidence-based reasoning, units of measurement, theories, facts, and laws. The conceptions of terms may be diverse in different areas. For instance, the terms concentration and solution are understood in a particular way in biology and chemistry, but different meanings are attached to them in other areas. Therefore, teachers must be well-grounded in the content of their subjects to be able to make those necessary distinctions. Unqualified teachers without a comprehensive content knowledge foundation (and even the qualified but incompetent teachers) impart erroneous information to their learners and develop misconceptions.

The lack of qualified teachers has already been listed among issues related to poor learners' performance in biology. Ademulegun (2001), as cited in Alafiatayo, Anyanwu and Salau (2016) opine that learners trained by more practised and expert teachers, with regard to subject matter knowledge, would perform better than learners who are educated by less experienced knowledgeable teachers. Teachers' limitations in terms of content knowledge restrict learners' acdemic progress and achievement.

### 2.2.4. Pedagogical knowledge (PK)

Academics (Koehler & Mishra, 2015; Koehler, et al., 2013; Schmidt, et al., 2009) define pedagogical knowledge (PK) as the level of understanding of or familiarity with different instructional processes, practices or methods to support pupils' learning. This knowledge domain comprises and applies to issues such as overall educational purposes, values, and aims, classroom management abilities, learner assessment, lesson planning, and how pupils' learning occurs. It also encompasses awareness i.e. the strategies or approaches used in the classroom, characteristics of the intended audience, and the methods for appraising learners' understanding (Koehler, et al., 2013).

Pertinent to the context of the current study, Arokoyu and Chukwu (2017) confirm the assertions of the said academics in their study of "Biology teachers' methods of teaching and academic performance of secondary school students in Biology". They found that teaching methods affected the Nigerian learners' performance in biology. Accordingly, they recommended that teachers should select learner-friendly teaching methods as these would promote the learners' assimilation and achievement in their examinations. These findings confirmed those of an earlier and similar research on the impact of teaching techniques on learners' performance by Akinfe, Olofinniyi and Fashiku (2012), who also discovered that only efficient instructional techniques can result in successful learning. However, they reported that teaching tactics of many practical-based science subjects such as biology, physics and chemistry were predominantly boring, leading to increasingly poor learners' performance in the subjects, especially biology. Thus, teachers ought to be inventive, resourceful and self-motivated in respect of the methodologies they select to use to guarantee improved learners' achievement in the subject.

Ajaja (2013) undertook a study to determine the most suitable method between "concept mapping, cooperative learning and learning cycle methods" (p 18) by comparing their effectiveness. He found that the learners taught using learning cycle and cooperative learning appreciably outperformed those that were taught using concept mapping on the achievement and retention tests. This further confirms the significance of pedagogical knowledge as one of the determinants of learner achievement.

### 2.2.5. Pedagogical content knowledge (PCK)

Koehler, et al. (2007) liken PCK to Shulman's (1987) conception of expertise of pedagogy necessary and appropriate to teach a given subject matter. The key concern is honing the subject matter for teaching, which transpires when the teacher inteprets it and traces different ways to demonstrate it, then reworks and matches the teaching materials to alternative understanding and existing learners' knowledge brought to the classroom (Shulman, 1986 ).

The PCK domain therefore encompasses awareness of what complicates or simplifies concepts, how pupils learn, learners' existing knowledge, general misconceptions and how to address them, alternative instructional methods, diversity of learners and how to tailor instruction to suit all in a particular subject matter, all of which are requisites for fruitful instruction. PCK involves the crux of curriculum, instruction, learning, evaluation, and reporting (Koehler & Mishra, 2015; Koehler, et al., 2013; Koehler, et al., 2007).

According Mishra and Koehler (2006), PCK symbolises the combination of content and pedagogy to comprehend how to arrange, modify and represent certain components of content for instruction. It is important for teachers to understand this overlap or interplay between content and pedagogy domains of knowledge and that it is a different knowledge area from either of them (Koehler, et al., 2013). That is, PCK differs from the subject specialist knowledge and from the pedagogical knowledge that is common to all teachers across subjects (Koehler, et al., 2007). Therefore, with good apprehension of PCK, the teachers would be able to teach specific content using appropriate strategies in their own contexts. Subjects differ in nature and are unlikely to be taught via identical methods (Mishra & Koehler, 2008). In other words, PCK recognizes the fact that the type of the matter itself prescribes the suitability of the teaching strategy (Koehler, et al., 2013). For instance, comprehension skills in English language may not be taught the same way as diffusion of glucose molecules into the cells in biology. Considerations for selection of instructional materials to be used to represent the taught material, the appropriate learning environment and assessment of learning should definitely differ. The teachers ought to be familiar with the modern innovations in teaching to enable them to decide on the best strategy for delivery of a specific subject matter within their own settings.

### 2.2.6. Technological knowledge (TK)

Most scholars refer to TK as an understanding that covers the traditional and contemporary technologies, and the diverse modes they offer for representing subject matter in instructional contexts (Koehler & Mishra, 2015; Koehler, Mishra, Akcaoglu & Rosenberg, 2013; Koehler, et al., 2007; Schmidt, et al., 2009; Mishra & Koehler, 2008). Examples of traditional technologies are books, chalk and blackboard, whilst the contemporary technologies include the Internet, digital video, interactive whiteboards, computer hardware and software programs, and presentation tools. Shu (2016) emphasises current media and network technologies applied in subject teaching. It encompasses the skills to learn and adjust to recent technologies (Koehler, et al., 2013). Therefore, acquisition of TK allows one to use various technological tools to formulate diverse ways of completing assigned tasks.

### 2.2.7. Technological content knowledge (TCK)

TCK refers to the mutual comprehension of the connection between technology and content (Koehler & Mishra, 2015), that is, understanding the effect and constrain that technology and content have on each other (Koehler, et al., 2013). This means that it is inadequate for teachers to only have mastery of the biology content, they should also significantly grasp how technology can be used to groom it. They ought to be aware of the unique technologies most suited for teaching the subject matter or rather how the specific subject matter determines the type of technology to be used to teach it. The technology options that the teachers have, suggest and restrict the type of biology content that they can teach. In the same way, the selection of certain subject matter controls the choice of technologies that can be integrated to teach it.

### 2.2.8. Technological pedagogical knowledge (TPK)

Koehler, et al. (2013) point out that TPK is a knowledge area that acknowledges the mutual connection between pedagogy and technology. In addition, it enables understanding of what technology affords for specified instructional objectives and aids teachers to choose a fitting tool for a teaching strategy. Schmidt, et al. (2009) and Mishra and Koehler (2006) describe TPK as the awareness of the presence, elements and potentialities of multiple ICT tools as applied within teaching-learning contexts, whilst equally being conscious of the possible effects of using specific technologies on teaching.

TPK encompasses being aware of the existence of a variety of tools for a specified educational experience, capacity to select an apparatus for its suitability, techniques for taking advantage of the ICT implement's features and benefits, awareness of teaching tactics and capability to organise them for technology integration (Mishra & Koehler, 2006).

It is with this knowledge that technology can afford modern teaching approaches and avenues for instruction, and simplify execution of specific classroom undertakings. Therefore, teachers have a variety of options, some of which are outlined in sections 2.3.4 and 2.3.5, to handle most of the problems ascribed to the biology learners performing unsatisfactorily.

### 2.2.9. Technological pedagogical content knowledge (TPACK)

The manner in which the TPACK framework creates relationships between teachers' grasp of content, pedagogy, and technology to produce successful teaching has been emphasised by Koehler, Mishra, Kereluik, Shin and Graham (2014).

Hughes (2005) and Zhao (2003) contend that excellent teaching necessitates a grasp of how technology links to content and pedagogy, and that expertise of technology may not be dealt with as context-free. Later, a similar argument was made by Koehler, et al., (2007: 741) who argued that:

> *intelligent pedagogical uses of technology require the development of a complex, situated form of knowledge we call Technological Pedagogical Content Knowledge (TPCK). At the heart of TPCK is the dynamic, transactional relationship between content, pedagogy and technology. Good teaching with technology requires understanding the mutually reinforcing relationships between all three elements taken together to develop appropriate, context specific strategies and representations.*

Angeli and Valanides (2009) concur with this contention and add that for the described use of technology to occur, teachers need to understand the technology tools themselves, together with their particularized affordances, which accelerate learning of complex concepts when applied to teach the subject matter. Therefore, the consequential achievement of learners in the subject is realised. It remains to be tested if with TPACK, the abstract and conceptual nature of biology, which has been listed as one of the hitches causing poor performance, could be taken care of.

The challenge to all stakeholders is to ensure that teachers' TPACK is improved. So, relevant measures have been taken towards achieving this in some states. For instance, in Taiwan, Lai (2010:511) examined the "secondary school teachers' perceptions of interactive whiteboard (IWB) training workshops" and found that teachers appreciated the gains of using IWBs for instruction and acknowledged the need for guiding workshops. In addition, teachers highlighted how critical and profitable being conscious of practical uses of the tool had been in assisting them to resourcefully integrate IWB into their instruction.

It should be understood that individually, every component of TPACK is a critical feature of teaching that any subject teacher must possess. Still, constructive teaching surpasses each one of them. What is imperative for the teacher with TPACK is the synthesis of the knowledge of content, pedagogy and technology, which may be employed for the planning of pupils' learning practices (Koehler, et al., 2013).

### 2.2.10. Rationale for using TPACK in this study

Koehler, et al. (2013: 4) point out that "the TPACK framework also functions as a theoretical and a conceptual lens for researchers and educators to measure pre-service and in-service teachers' readiness to teach effectively with technology". Koehler and Mishra (2015) also state that the TPACK framework offers various conceptual lenses for scholars to grasp the phenomenon of instructing via technology. Therefore, the role of TPACK in this research is to offer the lens to appreciate the two phenomena, namely integration of ICTs to teach biology and teachers' perceptions of this integration. This framework offers a way to think about and measure the variables of the current study; teachers' perceptions on using ICTs and the consequent use of ICTs in constructivist pedagogical practices.

As Koehler and Mishra (2015) state, TPACK provides the concepts, structure and terminology to describe the phenomena of interest; the relationship of teachers'perceptions on technology use and their use to teach high school biology. It provides language to express, conceptualise and investigate connections between these phenomena.

Apart from the descriptive lens, TPACK also affords and inferential lens; it is meant to assist the reseacher beyond just appreciating the teachers' perceptions on teaching biology using ICTs, but also drawing conlusions, forecasting and making inferences about contexts within which the constructs of the study interact.

## 2.3. Biology education

Biology is a science subject that focuses on studying living creatures; their anatomy and physiology, their interactions with one another and their interactions with the surroundings (Rahman & Akter, 2015). Senthilkumar, et al. (2014) conceptualise biology as a science discipline that studies living organisms at different levels of organisation, from molecular level to their relationships with one another and their surroundings. Akinfe, et al. (2012:109) also share a similar conception that “Biology is the science that deals with the study of varieties of living organisms including ourselves (plants and animals). It also studies the way our environment evolved from triple organisms and this is intimately part of our environment”. Okwo and Tartiyus (2004), as cited in Araoye (2013;1), define biology as a “natural science subject consisting of contents from microscopic organisms to the biosphere in general, encompassing the earth’s surface and all living things”. Ramalingam et al. (2010) define it as the science of physical life of animals and plants.

### 2.3.1. Rationale for focusing the study on biology education

Rahman and Akter (2015) argue that in many spheres, an understanding and awareness of biology is necessary for one to pursue a career in the medical, agricultural and industrial fields. Rahman and Akter (2015) further highlight that the subject also aims to cultivate scientific inquiry and problem-solving abilities in learners. Akinfe, et al. (2012) point out that the study of diseases, their causes, cure and the action of drugs is biology-based. Moreover, it attempts to reduce human distress and to discover ways of dealing with hereditary abnormalities such as haemophilia and Down’s syndrome. They continue to emphasize the critical role biology plays in managing environmental issues such as pollution, and also manipulating crop yields by applying knowledge acquired from the field of plant genetics. Therefore, high school biology is evidently fundamental and a prerequisite for a wide range of science-related areas, such as medicine, pharmacy, nursing, agriculture and biochemistry, offered by tertiary institutions. This is an articulation of the significance of biology in the universe, which also reflects the uniqueness of the position it holds in the school curriculum.

Maduabum and Iwuala (1985), as cited in Ahmed and Abimbola (2011), declared biology as a doorway to professions such as agriculture, dentistry medicine, and pharmacy. Rahman and Akter (2015) also point out that good academic achievement in the subject earns learners entrance opportunities to institutions of higher learning for further studies and eventually become manpower resources in biology-based careers. Thus, substandard performance in the subject results in scarcity of professionals in medical and veterinarian sciences, dentistry, agriculture and forestry, which no country would like to experience.

In the light of poor performance in biology in Lesotho as reported by Lebata and Mudau (2014), the researcher found it necessary to conduct a study on the use of ICTs in teaching biology, and has not come across any other study reporting a different performance status in biology in the country. The researcher therefore deemed it necessary for a follow-up study. An analytical view of the described significance of biology in comparison with the reported performance in the subject justify a resolute interest and worry. Moreover, research has indicated the potential impact of (a) ICT-enhanced teaching strategies on teaching and learning, which in turn affect learners'performance and (b) of teachers' perceptions on the use of ICT. Hence, a study on the teachers'perceptions on the use of ICT for teaching biology.

### 2.3.2. Learners' performance in biology

Research indicates that for many years, substandard performance of learners in biology has been of great concern globally, and not only in Lesotho. Regarding Nigeria, Ahmed (2008), Ahmed and Abimbola (2011) and Olabintan and Badru (2018) have indicated that performance in biology has been poor at senior secondary school level. This was corroborated by the West African Examinations Council's (W.A.E.C) Chief Examiner's Report 2010-2014, as cited by Arokoyu and Chukwu (2017), which also reported a poor biology learners' performance in the Abia State in Nigeria. In Kenya, the Examination Council's report 2002-2007 indicated a disappointing academic achievement in the subject, notwithstanding the evident lack of interest in it, as most secondary schools made it a compulsory subject (Samikwo, 2013). Zimbabwe's Schools Education Council (ZIMSEC) also reported unsatisfactory performance in the biology Paper IV in 2014 (Mwangu & Sibanda, 2017). Adewale, et al. (2016) discovered a broad variation in academic success in biology regarding overall school marks and those attained by the candidates in the Owerri Municipal of the Imo State, Nigeria. As indicated already, Lesotho high school learners have also exhibited low achievement in biology (Lebata &

Mudau, 2014), mathematics, and science (biology included) in general (Lekhetho, 2013). This diversity of achievement was attributed to various factors.

### 2.3.3. Factors attributed to poor performance in biology

The academic achievement of learners in biology depends upon various determinants ranging from the nature of the subject and/or learners' attributes to both human and material resources.

Cimer (2012) identified the major challenges biology learners were faced with in the Rize district in Turkey. These challenges include the nature of the subject, teachers' teaching techniques, learners' learning styles and their attitudes towards biology, and inadequate resources. As regards the nature of the subject, Durmaz (2007) and Lazarowitz and Penso (1992) point to abstract topics, phenomena, facts and biological organisation levels. Elliot, et al. (2014) also concur, attributing difficult learning of biology to its abstract and conceptual nature.

Mwangu and Sibanda (2017:50) point out that the shortage of teaching materials such as "laboratories, chemicals, models, apparatus, local specimens and shortage of textbooks" inhibit performance in biology. In actual fact, their study revealed that inadequate teaching time, resources, facilities and overcrowding in classrooms presented teachers with difficulties in biology practical sessions in some schools in Bulawayo, Zimbabwe. Similarly, in Ethiopia, factors that reduce learners' enthusiasm towards practical activity, and thus affecting their inclination to science instruction were found to be a lack of independent and fully-furnished laboratories for every science discipline, science teachers not making an effort to use locally available materials to prepare elementary activities, and little interest in the prevailing problem from both the government and school administration (Muleta & Seid, 2016). Also, Ahmed and Abimbola (2011), Akinfe, et al. (2012), and Arokoyu and Chukwu (2017) empirically affirmed learners' performance as being a result of biology teachers' lack of relevant qualifications, instructional approaches and learners' attitudes. This is because, as Akinfe, et al. (2012) state, productive teaching and learning can only be practical with contemporary teaching aids. Furthermore, teachers' professional qualification is a vital attribute through which academic performance in biology can be promoted.

Samikwo (2013) found that learners with optimistic attitudes towards the subject scored higher in examinations, and also that availability of teaching-learning materials had a fruitful influence on their performance. Kirima (2000), as cited in Samikwo (2013), holds teachers responsible for the learners' substandard performance owing to their lack of relevant qualifications, creative instructional approaches or media, and for not inspiring learners. For instance, rare exposure of learners to practical activity by science teachers has been reported in South Africa's Limpopo province (Dekkers, 2005), in Kenya (Kapting'ei & Rutto, 2014) and in Zimbabwe (Mwangu & Sibanda, 2017). This is consistent with the statement by Brown, et al. (2013) that despite the teachers knowing their learners' learning challenges, they still prefer transmitting information to them rather than adopting modern instructional approaches such as computer assisted instruction (CAI), which are effcient for teaching science.

According to Adewale, et al. (2016), teachers', schools', students' and parents' factors were, in that order, responsible for disparities in academic performances in the sampled schools.

### 2.3.4. Teaching biology using ICTs

Numerous studies on the use of ICTs in the teaching of science subjects in general (including biology) have been carried out around the globe. This section articulates the use, intents, benefits and practices of various ICTs in different parts of the world.

In Rio de Janeiro, Brazil, Rolando, Salvador and Luz (2013) discovered that the in-service biology teachers infrequently used the Internet and ICTs for instructive intents. Teachers reportedly used Internet tools such as social networks only for societal communications. The leading use of electronic mail, search, and download implements was to acquire information circulated on the network. They found that there was a high likelihood that teachers were ignorant of the possible application of the tools for instruction. Hence teachers probably use technology mainly to develop their TCK, to keep updated with societal issues which might have little or nothing to do with teaching and learning.

In Australia, Van Rooy (2012) sought to analyse the value of “digital technologies for learning and teaching biology”. He recorded the learning and teaching of molecular genetics concepts and the pedagogical dependence on digital technologies, and then built up a theory on the learning and teaching of such concepts, using high school biology learners. The findings were that the digital technologies facilitated extensive learners’ engagement with the subject matter, and their correct and focused incorporation with content benefitted teachers as support for learning complicated content transpired. Also, the private mobile devices permitted learners to create their own synergetic illustration of genetic concepts, and made them accessible to others when needed. The study confirmed that learners who are interested in both ICT and genetics can collaborate without compromising the way biology is taught. Van Rooy (2012) concluded that the matchless possibilities for instruction in the high school biology programme have resulted from the omnipresence, accessibility and exponential development of digital information and ICTs. These technologies are reported to facilitate teaching of emergent subject knowledge and comprehension of processes in biology that were formerly too small, too big, too slow or too rapid to comprehend. The digital formats of figurative or symbolic forms of biological sciences make teaching successful.

Van Rooy’s (2012) findings corroborate Stith’s (2004) contention that animations result in a better grasp of partiular cell biology concepts than motionless representations, probably because they are more precise represenions of certain processes learnt in cell biology. Therefore, developing them to include the use of simulation would profit every area of biology. Also, as a ploy to deal with diversity in learning tactics, teaching cell biology using animation has been gradually accepted as learners can retrieve animations using ICT tools even outside the classrooms. That is, the use of ICT seems to enable flexibility in terms of learning spaces, as learners can continue learning anywhere they are. The fact that this area of biology is diverse, fast moving, and typified by a persistent outburst of fresh information, teaching it can be quite overwhelming (Cooper & Hausman, 2000). Hence it is necessary to find a solution to this challenge.

Öztap, Özay and Öztap (2003) established that biology teachers in Turkey thought various teaching aids, such models, diagrams, pictures, laboratory activities and videos, could be used alongside textbooks to aid in the teaching of topics perceived difficult, such as meiosis. Despite the teachers' knowing that these tools would enhance learning ability amongst learners, they are seldom used as they were not easily accessible. The problem of lack of laboratories or laboratory materials for hands-on pratical work in Turkey was solved by some teachers by engaging learners in virtual experiments, and computer animations and simulations made possible via modern advancements in information technology (Tüysüz, 2010). Learners are presented with options to create and grasp difficult concepts by collaborative educational settings wherein learners integrate animations and simulations to enthusiastically participate in the learning of abstract biology content. Tüysüz (2010) found that virtual applications positively impacted learners' performance and attitudes better than customary teaching approaches.

To overcome the challenges articulated concerning teaching and learning of biology thus far, Cimer (2012:70) proposed that:

> *Teachers teach biology through the use of visual materials, conducting practical experiments, connecting the topics with daily life, and making biology teaching interesting and also, learners [should] use various study techniques in order to be successful in biology.*

Most of these propositions are achievable via direct use of technology or ICT-enhanced improvisation.

A study carried out by Ozerbas and Erdogan (2016) in Turkey, found that the academic achievement of learners taught using digital technologies is significantly higher than that of learners taught in the classroom without them.

Use of e-learning software or virtual laboratories to augment biology instruction was confirmed in a few schools in Zimbabwe (Mwangu & Sibanda, 2017).

Constructivist teaching methods can help a great deal in overcoming the challenges of teaching biology. They underscore the active learners' responsibility in constructing knowledge and sense of information (Kalpana, 2014) by experiencing and reflecting on their experiences (Chand, 2017). Therefore, constructivist teaching is characterised by learner-centredness in which learners are not passive recipients of knowledge. Chand (2017) contends that the use of various ICTs for collaborative learning acknowledges and promotes the learners' independence and inventiveness. The ICT-integrated cooperative learning methods, facilitated by the teachers, assist learners to enhance subject understanding, critical thinking, and analytical abilities.

In a review study, Mikre (2011) also concludes that ICTs aids instruction structures to give excellent education that is in harmony with constructivism, which is a modern concept of education. In their research to establish the impacts of a constructivist learning approach on learners' academic achievement in Turkey, Ayaz and Şekerci (2015) found that the approach has positive effects in a number of subjects, including biology.

In Spain, Gómez-Pablos, Del Pozo and Muñoz-Repiso (2017) showed a positive assessment of project-based learning (PBL), a constructivist tactic, by teachers who had participated in projects that integrated digital technologies. Most participants had perceptions that the projects enhanced learners' active involvement, and stimulated them to learn and gain different subject learning skills.

According to Li (2011), contemporary teaching aids, such as videos, slide projectors, computers and multimedia have supreme benefits over other aids. Within a short space of time, they can clearly display the undoubtedly difficult to observe organisms, life processes and phenomena, thus enhancing swift understanding of abstract biological information. Also, they can successfully arouse learners' thirst for information and lure them to actively participate in the educational process. Practice confirms that learners' attention in class can be attained by revolutionizing teaching aids.

In Nigeria, Gambari, Yaki, Gana and Ughovwa (2014:78) undertook a study on “improving secondary school students’ achievement and retention in biology through video-based multimedia instruction”. They found that in general, learners taught using multimedia achieved better than their classmates in the traditional teaching method. Starbek, Starčič Erjavec and Peklaj (2010), in their study on “Teaching genetics with multimedia results in better acquisition of knowledge and improvement in comprehension” found that learners taught through multimedia that incorporated computer animations gained enhanced knowledge and finer comprehension skills than learners taught in a conventional lecture and only by reading text. This is probably because availability of multimedia resources permits considerably diverse learning experiences to arise (Elliot, et al., 2014). The results of a study on “Science learning via multimedia portal resources: The Scottish case” (Elliot, et al., 2014), confirm that multimedia technology transforms learning of science.

In summary, using ICTs in teaching makes the educational environment inventive and learner-centred. Thus, it arouses both problem solving and high-level thinking abilities, and promotes lively, cooperative and discovery learnings (Bangert, 2008; Smeets & Mooij, 2001). Smeets and Mooij (2001) indicate that such use is achieved by modifying subject matter and learning activities to the particular learners’ requirements and abilities, by enabling teamwork, and by preparing productive environments and tasks that are as realistic as possible. Moreover, ICT use assists teachers to save time, to make difficult concepts clear, keep learners active, and their job simple (Mwalongo, 2011).

## 2.4. Perceptions

### 2.4.1. Teachers’ perceptions on the use of ICTs

Integration of ICTs into teaching and learning is determined by external factors such as the state of infrastructure, adequacy of technology and technological tools, effectiveness of professional development, and internal factors such as the teachers’ perceptions and level of self-efficacy (Harrell & Bynum, 2018; Ertmer, 2005; Ertmer, 1999). For the purpose of this study, the researcher decided to review literature on teachers’ perceptions regarding effects of ICTs on learners’ attributes, teaching and learning processes.

The learning environment is perceived to have been enhanced by computers and multimedia as they raise learners' interest in the subject in which they are used (Razavi, Ghanizadeh & Akbari, 2015; Valdez, McNabb, Foertsch, Anderson, Hawkes & Raack, 1999). In the context of this literature review, this perception harmonizes with Wellington's (2005) opinion that multimedia induce inspiration to learn science through visualisation and comprehension of theoretical concepts. This is probably the case as an ICT-enhanced learning environment encourages learning by inducing theoretical change, permitting involvement of learners in challenging intellectual activities, and affording teachers the chance to concentrate on probing and constructing understanding with learners (Webb, 2005). Additionally, Jones & Liu (1997) indicate that multimedia are capable of presenting a resourceful learning milieu to various types of learners by generating a more practical learning setting via its various media and enabling learners to be in charge of their learning.

Regarding teaching, Ruthven, Hennessy and Brindley (2004 ) indicated that teachers greatly valued ideas such as technology facilitated presentation of more difficult subject matter and customisation of learners' work to their personal needs. They conclude that incorporating computer-aided instruction has changed a teacher-centred classroom to learner-centred to a constructivist clasroom, in which the teacher assumes a coaching role rather than just transmitting knowledge, and where the learners work together in groups. On the capability of technology to present options to adjust learning material and activities to match the particularized learners' needs and abilities, Mooij & Smeets (2001) concur, adding that it is also an instrument for curriculum differentiation and proffers learner-customised feedback. Furthermore, many teachers agree with the perception that computers are instruments for learners that assist them to learn, afford ways to elaborate and use acquired knowledge, increase inspiration by supporting teachers to make the subject more  fascinating and raise learners' zest for it (Hadley & Sheingold, 1993). In Saudi Arabia, Khawaji (2016) found that with adequate technology knowledge and practice, learners' motivation and collaboration with others would possibly increase. In addition, several teachers have the perception that technology integration is valuable for designing lessons and for instruction itself (Cox, Preston & Cox, 2000). Thus, being aware of all these benefits may promote the teachers' use of ICT in teaching. Research indicates that perceived usefulness of technology affects one's decision to use (Burda & Teuteberg, 2014; Buabeng-Andoh, 2012b).

Literature reveals teachers' perceptions about important effects that ICTs have on the attributes of learners, which are critical to successful learning. One perception is that ICT supports dynamic learning and higher-level thinking (Chand, 2017; Roschelle, Pea, Hoadley, Gordin, & Means, 2000; Jonassen & Wang, 1999). It has already been indicated that learners' inspiration is another attribute that teachers perceive to be increased by use of technology in teaching and learning settings (Abdullah, Abidin, Luan, Majid & Atan, 2006).

Howard, Cornuel, Thomas and Thomas (2012) emphasise benefits of modern social and digital technologies such as "their immediacy, reach and flexibility" (2012:365). Thus, together with traditional instructional methods, they can assist teachers and promote learning. In addition, these tools afford learners a number of opportunities such as establishing connections with compatible international learners, creating essential communities and catching on wide-ranging resources without difficulty.

In Taiwan, Wu, Pan and Yuan (2017) examined "attitudes towards the use of information and communication technology in management education". They found that learners and teachers perceived the ICT tools of collaboration and social media to be useful in learning. Wu, et al., (2017), therefore, contend that learners' participation could be improved by incorporating these tools in instruction and lesson plan.

In Sweden, Lim, Grönlund and Andersson (2015) examined beliefs and perceptions of primary and high school principals toward cloud computing. They found that principals believed the key advantages of cloud computing to be enabling smooth acess to information and software, as well as facilitating exchange of learning resources and information anywhere and anytime through the internet. Other perceived educational benefits include the ability to promote learning processes, such as classroom learning, distance learning, independent learning, peer-to-peer learning and virtual laboratories (Ding, Li, Liu & Shi, 2012;) .

Teahers' perceptions towards use of ICTs depends on certain factors. Harrell and Bynum (2018) point out that low or lack of confidence in the usage of ICT tools lead to decreased teachers' perception of its worth. Consequently, the tools do not get to be used to their full potential.

Teachers' attitudes and beliefs regarding the worth of technology incorporation have been found to have a  considerable positive relationship with modern technology use (Pittman & Gaines, 2015).

In Lesotho, Kalanda & De Villiers (2013) established that most science teachers had perception that the modern e-learning technologies permitted them to illustrate numerous scientific activities to their learners. Furthermore, the majority of science teachers believed that animations and simulations enhanced learners attainment of scientific skills.

### 2.4.2. Commonly used ICTs

Since the use of technology in teaching is influenced by a number of determinants such as availability of both hardware and software tools, and their perceived usefulness, it is important to review literature on these factors.

### 2.4.3. Availability of ICTs

Research shows conflicting views regarding availability of ICT tools and their likelihood of being used in teaching. For instance, Scrimshaw (2004) draws attention to a belief by teachers that having personal laptops and the right to use computers would stimulate them to incorporate ICT into their instruction, and that it may possibly allow teachers adequate time to organize materials and surf the Internet. A similar contention is presented by Abdullah, et al. (2006), that making laptops, projectors, and computer software available to teachers would inspire them and their learners in the teaching and learning practice. This is probably due to the teachers' view that possessing laptops is one of the optimistic factors that encourage the smooth application of ICT in teaching-learning situations (Cox, et al., 2000). Therefore, easy right of entry to the technology rooms and the presented tools is imperative (Forgasz, 2006).

In Slovenia, secondary schools are generally well-resourced with computers for teaching in computer science and informatics, but not for biology instruction (Šorgo, et al., 2010). Nonetheless, most biology teachers have one computer available for use in the preparation room at school, though not for learners, and also at home. In South Africa, George & Ogunniyi (2016) found that despite ICTs not being optimally used, the majority of the sampled schools had few fundamental ICT-tools in the science classrooms.

### 2.4.4. Purposes of use of ICTs

Various ways of using technology for a variety of purposes have been in force as revealed by research (Bhalla, 2013; Hadley & Sheingold, 1993). Three categories of application of technology have been recognised by Kellenberger and Hendricks (2000) and Martin Ofori-Attah (2005), as cited in Bhalla (2013: 176). The three categories are:

> *for teaching purposes (to impart knowledge, create variety, and to give confidence to teachers), administration purposes (in preparation of job-related materials and to ensure safe-keepings of data and information about students), and personal purposes (to engage teachers' free time in a beneficial and fruitful manner).*

Technology is brought into the teaching-learning process not because it is a necessity. It is because of its capabilities and affordances in the contemporary world that is progressively dependent on its application for all-encompassing communication and distribution of knowledge (Rahman & Akter, 2015). It has presented teachers with a worthy tool for supporting and ensuring high quality teaching and learning (Rahman & Akter, 2015; Rahman & Rahman,2015; MacCallum, Jeffrey & Kinshuk, 2014; Cubukcuoglu, 2013; Ajjan & Hartshorne, 2008). Hence, countries and schools around the globe have taken measures towards technology integration (Cubukcuoglu, 2013; Cakir, 2012). For instance, investments were made on improving the schools' ICT infrastructure, such that generally, the "secondary and high schools have two smart rooms that include an interactive whiteboard and scanner and almost all schools have an Internet connection" (Cubukcuoglu, 2013:51). Despite such commitment, Al-Zaidiyeen, Mei and Fook (2010) revealed a low-level ICT use for educational purpose by teachers in Jordan.

For years now, research has been disclosing use of modern technologies for various outcomes concerning scholarship and pedagogical habits of learners and teachers respectively. For instance, videos, demonstrations, simulations, and internet can be used to bring practical problems to the classroom and thus generate productive environments to support and enhance learning (Bransford, Brown & Cocking, 2000). Moreover, literature indicates that these contemporary technologies enable both synchronous and asynchronous networking of the users-learners, their teachers and subject specialists (Bransford, et al., 2000; Rolando, et al., 2013), thereby present possibilities to enhance feedback (Bransford, et al., 2000). Bransford, et al., (2000) add that the said technologies resolve teachers' challenge of inadequate time for assessing learners' academic achievements and giving feedback. Furthermore, one other important contribution the modern-day technologies bring to education is the opportunities for creating learning communities, which entail communication and on-line learning for teachers with their peers having similar educational interests and requirements. They facilitate classroom-to-classroom interaction in the same school or globally, and also between parents, tertiary scholars, and subject specialists, to mention a few.

In Australia, it was found out that ICT was most regularly used for electronic mail, Internet research, PowerPoint, and Word processing. The online discussion groups, palmtop computers, and web page designing were the least regular ICT uses (Dawson, 2008). Electronic mails are in regular use because they are essential for correspondence in and outside schools (Lee & Mautz, 2012).

The long-established internet tools, for instance electronic mails, chats and search websites stay commonly used so far in America (Pew Internet & American Life Project, 2008 as cited in Rolando, et al., 2013) despite the surfacing of modern digital implements and associated practices that potentially have instructive roles (Martin, Diaz, Sancristobal, Gil, Castro & Peire, 2011). Still in America, the documented teachers' computer use included: delivery of more difficult content to learners, providing them raised special attention as well as allocating increased autonomous tasks, and being more of a coach and facilitator in the classroom, all of which impacted on the teaching exercise (Hadley & Sheingold, 1993). Moreover, computer technology is helpful in improving high-order critical thinking skills, analysis and scientific inquiry (Roschelle, Pea, Hoadley, Gordin, & Means, 2000). Šorgo, et al., (2010) conclude that the Slovene Biology teachers use computers mainly as sophisticated typewriters and for exchange of ideas. Most use is at home due to limited access in schools. These computer uses align with the contention that they assist teachers to devise and provide high calibre teaching and learning (Dawson, 2008; Wallace, 2000), and also associate with constructivist, collaborative, and inquiry-based learning and also didactic revolution (Scrimshaw, 2004). ICTs generally guarantee "quick and easy access to superior photographs, images, diagrams and other two-dimensional (2D) representations along with three-dimensional (3D) simulations, animations and video clips for teachers and students" (Van Rooy, 2012:66) and thus affording learners learning activities not presented by other approaches (Wellington, 2005).

In Tanzania, Mwalongo (2011:36) established a number of purposes teachers used ICT for; "teaching, administration, professional development and personal use". For teaching, ICT was used to prepare notes, arrange teaching-learning materials and examinations, and to search educational materials with learners. Non-educational purpose encompassed communicating with friends, stroring resources, fun and online application.

### 2.4.5. Practices that characterise the patterns of technology use

Research shows that internet users have access to plenty of implements such as Ask, Bing, Google, and Yahoo search engines for researching; Gmail, MSN Chat or Groups and Skype for synchronised and unsynchronised communication; YouTube, Flickr, Dropbox and Google Drive for sharing files (Rolando, et al., 2013). In the context of this study, Wallace (2000) pointed out that teachers turned internet into a source that featured in their teaching approaches and which they use mainly to discover and pick out resources, develop them into activities and perform them, as well as to assess learners' work. He further stated that through internet, teachers handle issues relating to knowledge of content and of learners, following learners' advancement, and devising a logical sequence of ideas. However, Rolando, et al., (2013) confirm that in Brazil, very little didactic application of Internet instruments takes place, which rather largely inclined to looking for biology contents for personal gain and downloading resources to hand out to learners.

In their study to "examine the ways teachers enact technological, pedagogical and content practices in mathematics and science lessons and to document the change with teachers involved in a year-long technology integration initiative", Dawson, Ritzhaupt, Liu, Rodriguez and Frey (2013: 395) found that presentation software and Internet browsers were the predominantly used in their teaching-learning activities amongst many different technologies.

In India, it was found that teachers only sometimes used computers, for teaching, pre-teaching, non-teaching and self-instructional purposes (Bhalla, 2013). Teaching purposes included lessons for the entire class, learner tasks controlled by teachers, teachers' own learning, pre-teaching included lesson planning, seeking and producing content for teaching, non-teaching included learners' grades measuring achievement, communication and maintaining records, whilst self-instructional included drill and practice exercises, simulations and problem-solving practices. Teachers regularly used computers to bring their content knowledge and teaching expertise up to date, make lesson plans, and organize supplementary teaching material, and set up item banks. Once a month, they would use them to illustrate things in class, produce exam papers, simulations and learners' homework. About 50% hardly ever or not al all used computer for delivery of the whole lesson, communicating with parents, issuing assignments, administering tests, or keeping information-attendance/ assignments/grades.

In Trinidad and Tobago, Maharaj-Sharma, Sharma and Sharma (2017) studied the use of ICT-based technologies in classroom science teaching, and discovered that the majority of teachers extensively used PowerPoint whereas the animations and hands-on practical activities were less commonly used. Virtual laboratories, computer-aided simulations and Smartboard were used by a small number of teachers. The information was obtained via lesson plans.

The literature reviewed reveals that teachers generally use ICTs for searching and sharing of information, organising, filing or recording; for fun, communication, presentation, preparing learning and teaching material (handouts), and also for writing or typing.

Palak and Walls (2009) and Cuban (2001) found that the most frequently used technology was for preparation, management and administrative purposes and rarely for aiding learner-centred pedagogy. This was the case even with teachers who embraced learner-centred beliefs and had access many of the ICTs in their schools. Most would rather use ICTs to back their teacher-centred teaching practices.

### 2.4.6. Correlation between perceptions and use of technologies (ICTs)

Studies have examined the association between teachers' perceptions on the use of ICT and their actual classroom ICT activities. They reveal that various factors influence teachers' willingness to apply, keep on developing or sharing creative practice, amongst these, perceptions regarding ICT utility to support, increase and stimulate learners' thinking, are found to be prominent (Cox, 2004). In Bowling Green, in the United States, Li, Worch, Zhou and Aguiton (2015) found a considerably positive relationship between the teachers' classroom technology use and their perceived computer competencies in addition to self-efficacy, technological backing and access technology. In Spain, Sangrà & González-Sanmamed (2010) discovered a relationship between teachers' perceptions and ICT tools, application and innovation.

Research found a positive relationship of teachers' beliefs regarding application of technology in teaching and excellent classroom habits (Albion, 1999). This outcome is consistent with the corroboration that the most important determinants of teachers' use of technology are personal, mainly their beliefs regarding teaching and learning processes (Cuban, 2001; Mumtaz, 2000; Valdez, McNabb, Foertsch, Anderson, Hawkes & Raack, 2000; Ertmer, 1999) and the perception that technology should add value to the educational practices in force (Hennessy, Ruthven & Brindley, 2005; Cox, et al., 2000; Kent & McNergney, 1999). The latter was validated by George & Ogunniyi (2016), Burda & Teuteberg (2014), Cakir (2012) and ChanLin, Hong, Horng, Chang & Chu (2006) who also conclude that perceived helpfulness of ICTs appeared to be the leading factor for the teachers' resolution to put technology, such as computer-assisted learning (CAL) into practice. Asamoah and Oheneba-Sakyi (2017) share a similar contention that the teachers' willingness to teach through technology stems from their perception of its effectiveness, the ease of use, individual nature, their computer skills, age, gender and organisational inspirational policies. Karaseva, Siibak and Pruulmann-Vengerfeldt (2015) also found that the science (biology included) teachers were optimistic regarding ICTs' worth in instruction.

In a study to determine the link between the teachers' level of constructivism and the extent to which they use technology, Overbay, Patterson, Vasu and Grable (2010) discovered the major forecasters of its use were the constructivist beliefs and actions. Teachers who were more inclined to constructivist teaching activities showed higher probability of using technology, as were those with a firm belief that IT was a helpful tool for learner-centered teaching. This discovery corroborated Judson's (2006), whose data implied correspondence between teachers' learner-centered beliefs about teaching and the kind of their technology incorporated teaching.

Deaney and Hennessy (2007) and Veen (1993) also confirm that the uppermost determinants inspiring maintenance of educational practice include teachers' self-belief, competency and passion for ICT use, ingrained beliefs and inclination towards certain instructional methods.

Abdullah, et al. (2006) reported positive attitudes of most Malaysian participants who were also very enthused to make use of computers to teach and indeed used them for didactic intents. Similarly, Al-Zaidiyeen, et al., (2010) reported a substantial positive relationship between rural school teachers' attitudes regarding ICT and the extent to which they use ICT. Also, Rahman and Rahman (2015) concluded that people with positive attitudes towards ICT use in education were more eager to practice usage even if they were not adequately ICT savvy.

In West Virginia-USA, Palak & Walls's (2009) findings alluded to teachers' attitudes towards technology use being the primary belief aspect for their choices regarding classroom technology use. The teachers' attitudes concerning technology notably forecast their capability to exploit it along with various teaching techniques. Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur and Sendurur (2012), and Bakar (2007) also teachers' attitudes in addition to computer competencies, main concerns and preferences of teaching (Bakar, 2007), and beliefs, perception and abilities (Ertmer, et al., 2012) as the principal facilitators of technology integration.

On the contrary, Judson (2006) assessed teachers' beliefs and attitudes on teaching with teachnology using a questionnaire, and then used classroom observation to examine their correlation with their teaching activities and operation of technology. The study revealed that teachers' beliefs as regards teaching did not reflect in their practices as they incorporated technology.

Palak and Walls (2009) ascertained that teachers' beliefs are not the strong predictors of their practices. Rather, the leading forecaster for teachers' use of technology and diverse teaching tactics seemed to be their attitudes towards technology. However, the outcomes of their study implied no swing in the teachers practice despite being comfortable with technology, having technological support, access to technology and optimistic attitudes towards it.

In Turkey, Cakir (2012) used interviews to systematically analyse school leaders'and teachers' opinions about technology incorporation; and questionnaires to solicit administrators' attitudes towards technology use, and the computer teachers concerning their knowledge of Web 2.0 technologies. The administrators gave negative anwers to some questions despite their attitudes being mainly positive. And only few teachers considered using Web 2.0 technologies despite being conversant with them. In Tanzania, teachers' were found to be ineffectively incorporating ICT in teaching despite their attitudes towards appliation of ICT as a pedagogical instrument being positive (Ndibalema, 2014). The main hindrance was their low or lack of ICT expertise.

These conflicting research findings open eyes to the fact that having positive attitudes, beliefs and perceptions does not validate or forecast use of  ICT for teaching. This inconsistency necessitate further research, hence the researcher found it fit to extend it to the Lesotho context with focus on Biology teaching for the reasons already expressed (in sections 1.3, 1.4 and 2.2.2).

From the above review, it is clear that the effective teaching of biology has a great deal of requisites. In the context of this study, contextual requisites include physical factors such as ICT infrastructure, and non-physical factors such as ICT-policies and services at both school and state levels and also expertise of the teacher. The teacher should be well-versed mainly in content, pedagogical and technological knowledge areas. The responses solicited in the questionnaire will be helpful in providing information regarding these requisites and help the researcher to access the reality of the respondents' world and accordingly describe it. Bransford, et al. (2000:188) argue that:

> *Outstanding teaching requires teachers to have a deep understanding of the subject matter and its structure, as well as an equally thorough understanding of the kinds of teaching activities that help students understand the subject matter in order to be capable of asking probing questions.*

### 2.5. Summary

The review of related literature commenced with an exploration of the theoretical framework chosen for the study, namely the TPACK model. Details of the origin and development of the model and its nature were presented, followed by a discussion of all seven of its modules. An account of application of TPACK in the present study was given. As the focus of the study was on biology as subject, the review presented the aims of the Lesotho biology curriculum and also articulated the rationale for focussing the study, particularly on the discipline. Learners' performance in the subject was examined, as well as factors attributed to it, followed by teaching of biology using ICTs. The chapter also reviewed some literature with regard to the teachers' perceptions on the use of ICTs to teach biology: commonly used ICTs, their availability and purposes of use, along with the extent to which they are used. The practices that characterise the patterns of technology use were also reviewed. The review closed with an inspection of the relationship between the teachers' perceptions and educational use of the modern technologies to teach biology.

# CHAPTER 3. METHODOLOGY

## 3.1. Introduction

This chapter explains the methodology used to gather data to answer the research questions raised in Chapter 1. The paradigm of the study is outlined and the chapter also discusses the research approach and research design employed. It describes the target population, as well as the chosen sampling procedure, data collection instruments and data analysis strategies. An account of the measures taken to guarantee reliability, validity and ethical considerations for the study are also presented.

## 3.2. Research paradigm

It is through the selection of a paradigm that the researcher sets down the objective, drive and hopes for the study which, once done, presents a foundation for the consequent preferences concerning methodology, approaches, literature or study plan (Mackenzie & Knipe, 2006). A particular paradigm statement thus arouses anticipation for these preferences, which are described in the next sections.

The researcher sought to look for and establish logical and dependable statistical evidence (Maree, 2016) on the frequently used ICTs and practices that characterise the patterns of their use, and then determine the relationship between the teachers' perceptions on ICT integration and the teaching of biology. Therefore, the study was conducted within the positivist philosophical worldview; a paradigm which is founded on truthfulness and evidence, and formulates assertions regarding absolute reality by establishing generality and universal laws (Nieuwenhuis, 2016). It embraces the thinking that only impartial, perceptible details might be the keystone for science (Jansen, 2016). Consistent with this, Collins (2017) understands positivism as a belief system involving distinct, discernible particulars and related actions in a controlled, noticeable and orderly manner.

Positivism is linked with the 19$^{th}$ century French intellectual, Auguste Comte, who is also the earliest philosopher to use the word for a philosophical stance (Beck, 1979). It is “based on the rationalistic, empiricist philosophy that originated with Aristotle, Francis Bacon, John Locke, August Comte, and Emmanuel Kant" (Mertens, 2005:8).

## 3.3. Research approach

The study applied a quantitative approach to allow generalisation of its outcomes to all Lesotho biology teachers, through logical and impartial processes using statistical information gathered from the chosen sample (Creswell & Creswell, 2017; Maree & Pietersen, 2016). A quantitative study is a methodical and unbiased procedure that uses statistical information from a chosen sample of the population to generalise to the target population that is being investigated (Creswell, 2014; Maree & Pietersen, 2016; Creswell & Creswell, 2017). This definition harmonises with Das’s (2015) declaration of the reliance of positivism on verified observations which generates numerical evidence.

The researchers’ conception of positivism set the researcher to act as an analyst (Giddens, 1979) in the study. The researcher thought of the social world “as if it were a hard, external and objective reality” (Cohen, Manion & Morrison, 2007:8). Therefore, the study was primarily quantitative and focused on investigating the connections and consistency amongst constructs of interest; teachers’perceptions and use of ICTs. This means the researcher’s task was to gather and intepret the numerical data to measure these constructs, and eventually determine their relationships and answer the research questions.

Kothari (2004) concurs that this approach produces numerical information, which can be put through a systematic statistical dissection in a recognised and rigid manner as this study did. From this statistical data pedestal, Creswell and Creswell (2017), Maree and Pietersen (2016), and Kothari (2004) all assert that features of a population can be deduced following examination of a represenative sample. The measurement of teachers’ perceptions requires an examination of their technology uses and reasons for those uses (Ottenbreit-Leftwich, Glazewski, Newby & Ertmer, 2010). Also, “quantitative research focuses upon patterns, regularities, causes and consequences in which there is an application of the principles of positivism, that the patterns of the social world have their own ‘real’ existence” (Scott & Morrison, 2006:185). Therefore, the study examined the ICT practices that exemplify patterns of use of these technologies. With this approach, the study sought to establish logical and dependable statistical evidence (Maree, 2016) on the impact of the teachers’ perceptions on their ICT use in teaching biology.

### 3.4. Research design

Kumar (2019) defines a research design as a methodological scheme a scholar implements to answer questions justifiably, impartially, rightly and inexpensively.

A descriptive, non-experimental survey design following a deductive strategy was used as it is a common practice with positivist studies (Bhattacherjee, 2012; Crowther & Lancaster, 2012; Creswell & Creswell, 2017). The intention was to not influence the respondents’ perceptions, but only measure them and examine their impact on ICT integration via statistical techniques (Bhattacherjee, 2012), whilst they were still in their ordinary, concrete contexts (VanderStoep & Johnston, 2009). A realistic measurement of the teachers’ perceptions could thus be gained. The researcher preferred the descriptive non-experimental survey design because it is adjustable and flexible. This design can be managed in various ways (Maree & Pietersen, 2016) besides allowing for representative samples to be used to examine the entire population (Mulwa, Kyalo, Bowa & Mboroki, 2012).

According to Bhattacherjee (2012:6), a “descriptive research examines the what, where, and when of a phenomenon”. The researcher’s intention was to draw on fresh experiential facts to check perceptions and patterns acquired from theory and also to upgrade and develop that hypothesis. This is the case with the current study; fresh data were collected to study the phenomenon: Lesotho teachers’ perceptions on integration of technology in the teaching of biology. The practices that characterise the use of ICTs and the commonly used ICTs were also examined.

### 3.5. Data collection

Cohen, et al. (2007:8) advise that “Investigators adopting an objectivist (or positivist) approach to the social world and who treat it like the world of natural phenomena as being hard, real and external to the individual will choose from a range of traditional options– surveys, experiments, and the like”. Consistent with this assertion, the researcher decided to use a questionnaire to collect relevant data.

The initial plan was to adapt the questionnaire created by Schmidt, et al. (2009) to fit the study appropriately, especially because the study was conducted within the boundaries of the TPACK theoretical framework. However, it was later dropped due to a seemingly greater misalignment, than had been unanticipated, with the data the researcher needed to respond to the research questions. So, too many changes had to be considered in addition to the questionnaire being originally meant to gather data from pre-service rather than in-service teachers.

In order to collect data intended to answer the research questions, the I decided to adapt questionnaires used in similar studies, such as those by Buabeng-Andoh (2012a), (Ghana), Fransisca and Samsudin (2018) (Nigeria), and Šorgo, et al. (2010) (Slovenia).

A questionnaire is defined as a textual, typed or printed list of a number of items given to respondents to read, comprehend and then write their responses in the provided spaces (Kumar, 2019; Kothari, 2004) so as to create data that may be measured using a variable-by-case data matrix (Marsh, 1982 as cited in Scott & Morrison, 2006). Kothari (2004) advises that this quantifying instrument be made simple to operate, by paying due thought to appropriateness of its design, which may include plain but simple instructions for the respondents to ensure it is filled successfully and without difficulty. According to McMillan and Schumacher (2001:602), “the assessment of the current status, opinions, beliefs and attitudes by questionnaires from a known population” defines a survey research. Therefore, this data collection method was considered to be appropriate for the current study.

The questionnaire comprised three sections **A**, **B** and **C**. Section **A** had three categorical items intended to collect the respondents' biographical data: gender, teaching experience and the highest educational qualification.

Section **B** was meant to answer the research question 'What are the perceptions of Lesotho biology teachers on the use of ICTs?' It consisted of 14 close-ended items measured on a five-point Likert scale with the alternatives; "strongly disagree (SD)", "disagree (D)", "Neutral (N)", "agree" (A), and "strongly agree" (SA). These items form sub-scales measuring the teachers' perceptions on the use of technology regarding usefulness to teaching processes (6 items), impact on learners' attributes (6 items) and usefulness on learning processes (2 items).

The last section (**C**) was meant to determine whether the listed ICT tools were available at the respondents' schools and homes. If yes, they were asked to indicate if they use them for teaching or non-teaching purposes, and the frequency of use. This component was intended to identify the commonly used ICTs, the patterns of use, and the ICT practices that characterise the patterns of use and thus reflecting some assessment of their seven knowledge domains; TK, CK, PK, PCK, TCK, TPK and TPACK.

The information obtained in section **C** was scrutinised against that obtained from section **B** to establish the relationship, and thus addressing the last research question, 'What is the correlation between the teachers' perceptions and their use of ICTs?'

The questionnaire was administered to 107 biology teachers in high schools that offer biology as a separate subject. They were delivered and collected as soon as the researcher could after they were filled in. Teachers' perceptions are manifested in the instructional strategies which are likely to be habitual over time and with diverse classes and learners (Kagan, 1992).

The researcher used the questionnaire for a number of reasons. Questionnaires could yield a statistical account of teachers' perceptions (Creswell & Creswell, 2017); proffer the benefit of selecting a sizeable random sample (VanderStoep & Johnston, 2009) of biology teachers to measure their perceptions over and above being relatively low-cost; and its effectiveness in terms of time, personnel and funds (Kumar, 2019; VanderStoep & Johnston, 2009).

Furthermore, a questionnaire proffers better confidentiality and hence it raises the possibility of finding reliable information even when handling presumably sensitive or humiliating issues (Kumar, 2019), which respondents might otherwise be hesitant to talk about. Also, questionnaire use is based on the positivist philosophical world view and is empiricist in nature, meaning it is underscored by the belief that we can research simply what is compliant to our senses and possible to measure (Scott & Morrison, 2006). Most importantly, the researcher intended to ultimately determine the correlation between the biology teachers' perceptions and their use of ICTs to teach. Scott and Morrison (2006) maintain that questionnaires are useful surveys ascertaining links between variables.

### 3.6. Reliability and validity of the instrument

According to Cohen, et al. (2018:268), "reliability is essentially an umbrella term for dependability, consistency and replicability over time, over instruments and over groups of respondents"and is "concerned with precision and accuracy". They indicate that the main types are "stability, equivalence and internal consistency" (p 268). With regard to this conception of reliability, Kumar (2019) also concurs, indicating that "if a research tool is consistent and stable, hence predictable and accurate, it is said to be reliable". Crowther and Lancaster (2012:30) define reliability as "the extent to which a data collection or measurement technique yields the same results on different occasions". According to George and Mallery (2020:371),

> *alpha also, coefficient alpha or α is a measure of internal consistency ... . The alpha value is inflated by a larger number of variables, so there is no set interpretation as to what is an acceptable alpha value. A rule of thumb that applies to most situations is: α > .9—excellent, α = .8—good, α = .7—acceptable, α = .6—questionable, α = .5—poor, α < .5—unacceptable.*

The present study has considered reliabiltiy, as internal consistency, called Cronbach's alpha, which is often called alpha coefficient of reliability or just alpha. Alpha is suitable for scales with many items amongst which it guages internal consistency (Cohen, et al., 2018). Besides, it is a popularly used quantification of trustworthiness in research writings (Morgan, Leech, Gloeckner & Barrett, 2004).

A pilot study was conducted with 10 in-service biology teachers within easy reach of the researcher. This was done for the purpose of improving dependability and validity of the instrument. Also, as indicated in section 3.5, instruments used in similar studies were adapted for the current study. Most of the multiple-item Likert-type scales from those instruments had their reliability already established and reported in the form of Cronbach's alpha. The same was done with the results of the pilot study. After collecting the data for the pilot phase, the Cronbach's alpha was determined to measure the reliability of each of the following scales and sub-scales: teachers' perceptions on the use of ICTs for teaching, teachers' perceptions on the use of ICTs for learning and learner attributes, teachers' self-perceived ICT competence, frequency of use of ICTs; and practices that characterise patterns of use of ICTs.

The alpha coefficients of reliability obtained in the pilot study and the other studies similar to the this study were generally more than acceptable. Thus, the instrument arranged for the current study was employed with a high level of confidence. Leech, Barret and Morgan (2015:303) affirm that "using existing measures that have already been tested indicates that the data are reliable and can help to increase the chances of the new data being reliable". Having ensured reliability of the data collection instrument for this study through the articulated means, the researcher partly secured validity as well. Cohen, et al., (2018: 245) indicate that "reliability is a necessary but insufficient condition for validity in research; it is a necessary precondition of validity".

According to Leech et al., (2015) it is imperative to evaluate reliability of data before running inferential statistics. Therefore, the researcher calculated the Cronbach's coefficient alpha for the Likert-type items to determine the internal consistency of different scales used in this study. The values are presented in relevant sections in Chapter 4.

As defined by Crowther and Lancaster (2012:31), validity is “the extent to which a data collection or measurement technique measures what it is supposed to measure”. This conception of validity harmonises with that of De Vaus and De Vaus (2013:53): “a valid measure is one which measures what it is intended to measure”. Kumar (2019:146) lists the three types of validity in quantitative research as “face and content validity; concurrent and predictive validity; construct validity”.

The adopted questionnaire was presented before a team of members of the School of Education Studies at the University of the Free State. The team comprised the researcher’s peers and authorities (including supervisors) who could recognise and anticipate issues that might result in misinterpretation or confusion. The presentation was done prior to distribution of the questionnaire for the panel to veto it for face and content validity (Bhalla, 2013). Consistent with this practice, Morgan, et al., (2004) argue that “Content validity can also be checked by asking experts to judge whether your items cover all aspects of the domain you intended to measure and whether they are in appropriate proportions relative to that domain”.

### 3.7. Population and sampling

A target population is defined as a complete collection of objects, persons, groups and communities being studied (Crowther & Lancaster, 2012; Kumar, 2019) or the entire affiliates of a specific group of individuals (Ary, Jacobs & Sorensen, 2006) to which generalisation from the selected sample can be made (VanderStoep & Johnston, 2009). The population for this study comprised the Lesotho junior and senior secondary schools’ in-service biology teachers. They teach in inequitably-resourced school environments, are of different gender, age groups, teaching experience and educational qualifications.

A sample of 107 biology teachers was obtained from different districts (including highlands, foothills and lowlands) using a systematic probability sampling technique. It was selected because it is relatively simple, cheaper and can be handily employed even with a large population size (Kothari, 2004). The technique was applied as described by Creswell and Creswell (2017), Maree and Pietersen (2016), and De Vaus and De Vaus

(2013). Firstly, the sampling interval *k* was determined as the whole number to the ratio *N/n*; then, a random integer number *s* between *0* and *k was picked.* Finally, the sample consisted of the units

$$s, s + k, s+2k, s + 3k..., s + (n-1) k \text{ in the sample frame.}$$

The pass lists for the past two years indicated that around 223 schools offered biology. Since not all schools offer the subject every year, as indicated by a principal of one of the schools used in the pilot study, the number of schools was estimated at 220 (*N*). The researcher had proposed at least 100 respondents from these schools. Therefore, the number of schools required was put at 37 (*n*). In the pilot sample, most schools had about 3 biology teachers. So, the projected number of respondents' became111. The sampling interval, *k*, was 6. The selected random starting integer, *s*, was 5, making every $6^{th}$ school be selected from the $5^{th}$ in the list of 220 schools.  Due to travelling challenges, Mokhotlong and Qacha's nek schools that were selected were not eventually visited, and hence some schools in Berea and Maseru districts were conveniently selected and added to the sample. Therefore, A questionnaire was administered to biology teachers in eight (8) districts of Lesotho, namely Butha-Buthe, Berea, Leribe, Maseru, Mafeteng, Mohale's Hoek, Quthing and Thaba-Tseka.

This randomisation guarantees external validity, enabling generalisation of the conclusions made to the population that generated the sample (Bhattacherjee, 2012; Creswell & Creswell, 2017).

### 3.8. Pilot study

Questionnaires were distributed to 11 biology teachers that were within easy reach of the researcher for participation in a pilot study, though one of them did not complete it on time for it to be used. The questionnaires and the analysed results were then presented before a panel of members of the School of Education Studies at the University of the Free State. The panel comprised peers and experts (including supervisors) who could identify and foresee issues that could lead to misinterpretation or confusion.

The rationale of testing the questionnaire was to augment its reliability, validity and its realistic use (Cohen, et al., 2007) and also to raise the quality of the items (Creswell, 2014). In addition, the purpose was for the researcher to rehearse the actual study using similar items and phrasing, to test the instrument and recognise its weaknesses as well as those of the survey procedure (Kothari, 2004; Oppenheim, 1992) so that the necessary amendments could be made (Morgan, et al., 2004) and thus ensure validity and effectiveness in gathering the appropriate data. This practice is consistent with the assertion of Cohen, et al. (2018:278) that “there is a need, therefore, to pilot questionnaires and refine their contents, wording, length, etc., as appropriate for the sample being targeted”. Also, pilot testing the process helped the researcher to better prepare for the coding process.

With consideration of comments and suggested adjustments by the panel and also the performance of the questionnaire, the researcher then made changes to the content of the instrument, including rephrasing and adjusting the length as Cohen, et al. (2007) advises. For example, one of the alternatives in the scale meant to measure the self-perceived ICT competence had to be changed from “incompetent” which the researcher was made aware sounded too strong (for any of the respondents to select), to “cannot use”. It had actually attracted no one for all the listed ICTs though it was anectodally known that very few respondents were unfamiliar with database programs such as Microsoft Access.

### 3.9. Data analysis

As indicated by Maree (2016), the statistical methods considered for examining the research questions in a quantitative study should be clarified. After collection, the data from each respondent were captured into a google form, which was a recreation of the questionnaire used. The google form simultaneously generated a spreadsheet for all the collected data. After capturing, the spreadsheet was downloaded as a Microsoft Excel document. The Microsoft Excel spreadsheet was uploaded into and handled using the Statistical Package for the Social Sciences (SPSS) software to generate frequencies from the demographic data, and the descriptive statistics meant to address the research questions. As suggested by Creswell and Creswell, (2017), the figures and percentages showing a description of the respondents and non-respondents were tabulated.

A Likert scale survey enabled the analysis of data as to provide frequencies, means, standard deviation, correlations, and descriptions on the use of ICTs to teach biology. The summarised descriptive data for mean and standard deviation were presented in tables and graphs/charts for interpretation. The inferential statistics were used to make inferences from the sample and generalise them to the population. Spearman's correlation coefficient ($r_s$) was found to be more suitable to determine the strength of the relationship between Lesotho biology teachers' perceptions and their use of ICTs for teaching as both variables were rated at ordinal level (George & Mallery, 2020; Aldrich & Cunningham, 2016; Morgan, et al., 2004).

### 3.10. Ethical considerations

Consent to conduct the research was granted by the University of the Free State's ethics committee. The researcher's application for ethical clearance was approved on January 21, 2020 and the Ethical clearance number is UFS-HSD2019/1854/2101. The researcher pledged to maintain respondents' anonymity in the study by assigning pseudonyms or fictitious code numbers to them and their schools and also removing any distinguishing indicators from the associated papers (Marshall & Rossman, 2014). The rights of involvement consent and confidentiality form was attached to the questionnaire for the respondents to complete. The respondents were assured that they would not be exposed to any harm and that the information they shared would remain private and not be used for purposes outside the study. Respondents were informed that only the researcher and his supervisor would access the records that identify them; for future research, copies of the questionnaires they filled would be locked in a safe place whilst electronic information would be password-protected in computers for five years. However, their anonymous data provided might be used for research reports, journal articles and conference presentations whilst ensuring they are not recognizable.

### 3.11. Summary

The chapter has articulated the procedures followed towards answering the research questions and hence achievement of the objectives of the study. It deliberated on the paradigm, research design and method employed. Moreover, the researcher has described the sampling, data collection instrument and data analysis techniques used. The reliability, validity, as well as ethical considerations were also discussed.

# CHAPTER 4. : PRESENTATION AND ANALYSIS OF RESULTS

## 4.1. Introduction

This chapter presents and analyses the findings from the data that were collected. The presentation and scrutiny of data follow a descriptive design and are structured in line with the research questions proposed to examine the teachers' perceptions on the use of ICTs for teaching biology in Lesotho junior and senior secondary schools. The demographic data of the respondents are also presented. Firstly, teachers' perceptions on the educational use of ICTs: the perceptions are divided into two main scales, namely "usefulness" and "perceived self-competence". Secondly, the commonly used ICTs: this first looks into availability of the ICT tools both at the workplace (schools) and at home, as well as whether each tool is used for teaching or non-teaching purposes along with the measure of its use. The frequency is measured on a five-point Likert scale ranging from "never used" to "used very frequently (almost daily)". Lastly, the practices that characterise the patterns of use of ICTs by the biology teachers.

The frequencies, means and standard deviations of the collected data were computed by a descriptive statistical approach using IBM SPSS statistics 26. Then, the correlations between teachers' perceptions and their use of ICTs are presented.

## 4.2. Respondents' demographic data

The demographic data comprising gender, number of years as a teacher and the highest educational qualification are recorded in Table 1, to show their categories, occurrences and percentage.

**Table 1:** Respondents' demographic data

| Variable | Category | Frequency (n=107) | Percentage (%) |
|---|---|---|---|
| **Gender** | Female | 60 | 56.1 |
| | Male | 47 | 43.9 |
| | Other | 0 | 0 |
| **Number of years as a teacher** | 0- 5 | 20 | 18.7 |
| | 6-15 | 47 | 43.9 |
| | 16- 25 | 23 | 21.5 |
| | Above 25 | 17 | 15.9 |
| **Highest qualification in education** | Diploma in Secondary Education (DSE) | 19 | 17.8 |
| | Bachelor of Science (BSc) | 2 | 1.9 |
| | Bachelor of Science Education (BSc.Ed.) | 46 | 43.0 |
| | Postgraduate Certificate in Education (PGCE) | 6 | 5.6 |
| | Bachelor of Education (B.Ed.) Honours | 6 | 5.6 |
| | Postgraduate Diploma in Education (PGDip) | 23 | 21.5 |
| | Master of Education (M.Ed.) | 5 | 4.7 |

All the respondents were biology teachers and the sample comprised predominantly females (56.1%). The majority of the respondents were fairly experienced teachers (6-15 years of experience, 43.9%). The novice teachers (0-5 years of experience, 18.7%) and the veteran teachers (above 25 years of experience, 15.9%) constitute the lowest ratios. Almost all the respondents hold a teacher education qualification, with the majority holding a Bachelor of Science in Education (43.0%) and only 1.9% being Bachelor of Science degree holders without a teacher education qualification. A total of 37.4% have postgraduate educational qualifications (PGCE= 5.6%, B.Ed. Honours (20%) and PGDip=21.5%). These data show that the respondents are generally well-qualified teachers. Therefore, they presumably have both the required pedagogical skills and biology content knowledge. The entry point for secondary school teachers requires possession of at least a diploma in secondary education (Ministry of Education and Training (MOET), 2019). According to MOET (2019:10), such teachers are "expected to apply basic pedagogic skills of curriculum and assessment, implement curriculum learning programmes, classroom management and provide guidance/counselling to learners".

## 4.3. Teachers' perceptions on the use of ICTs for teaching biology

Two scales were used to measure the biology teachers' perceptions on the use of technologies to teach. One scale focused on the general perceptions and the other on the perceived ICT competence.

### 4.3.1. General teachers' perceptions

The general perceptions of biology teachers on the use of ICTs for teaching biology were assessed using 14 items (4-17). The scale focused mainly on the value of the ICTs to teaching and learning processes. Therefore, for analysis, this scale was divided further into two sub-scales. One sub-scale considered usefulness to teaching processes, and the other usefulness to the learning processes, which included impact on learners' attributes. The items were measured on a five-point Likert scale with the options; "1= strongly disagree", "2= disagree", "3= neutral", "4=agree" and "5= strongly agree".

Regarding biology teachers' perceptions on the value of using ICTs for teaching, the findings in terms of descriptive statistics for mean and standard deviation are displayed in Table 2.

All 107 (100%) cases were considered valid. The reliability statistics indicated that for the six (6) items in this sub-scale, the Cronbach's alpha was 0.668, and 0.684 was reported based on the standardised items.

**Table 2**: Perceptions on ICTs usefulness to teaching biology

| Variables | N | Mean | Std. Deviation |
|---|---|---|---|
| Creative and lively use of technology tools can enhance the teaching activities or processes and thus understanding of biology. | 107 | 4.76 | 0.452 |
| Technology makes teaching biology a faster, easier and enjoyable experience. | 107 | 4.64 | 0.539 |
| Technology allows me to modify resources so as to present more organised lessons that concentrate on the relevant biology content. | 107 | 4.32 | 0.695 |
| ICTs are impressive instruments that can visually illustrate biology concepts that would otherwise remain abstract, thus promoting learners understanding. | 107 | 4.53 | 0.619 |
| Technology accommodates and encourages modern educational approaches such as cooperative learning, inquiry learning | 107 | 4.24 | 0.750 |
| ICTs offer opportunities for me to address my professional development needs e.g. collaboration with peers, searching for new ideas and educational resources for use in classroom | 107 | 4.50 | 0.744 |

Cronbach's alpha= 0.668, and based on standardised items = 0.684

The means for all six (6) items exceed 4, and most of them can be rounded off to 5. This shows that generally, the respondents strongly agree that ICTs are useful to teaching.

The majority of the respondents perceived that creative and lively use of technology tools can enhance the teaching activities and thus understanding of biology [Mean (M)=4.76, standard deviation (SD)= 0.452]. This item scored the highest mean with the lowest variance.

Based on the six (6) items in this sub-scale, the respondents seem to perceive the use of ICTs for teaching positively. This finding is in agreement with what Buabeng-Andoh (2012a) found for teachers in Ghanaian second-cycle schools. If positivity of the perceptions were a reliable predictor of use of ICTs for teaching, then one can already anticipate that the results showing the frequency and patterns of use of ICTs would corroborate the findings from this scale. That is, one would expect high frequency of use and great extent of use of technology for teaching. This is one proposition that is tested later in this chapter.

Moreover, the finding that most respondents agree that technology allows them to modify resources so as to present more organised lessons that concentrate on the relevant biology content (M=4.32, SD= 0.695) corroborates the consideration by TPACK, as illustrated by figure 1 in section 2.2.2, that teachers operate in particular contexts. This variable also assumed that teachers work in an environment where techonolgy use is possible. Indeed, the results presented in section 4.4.1 indicate that the respondents in this study practise in settings where they generally have access to the probed ICT resources. Also, in settings with ICT resources, most respondents had a perception that teaching biology becomes a faster, easier and enjoyable experience (M=4.64, SD= 0.539). Thus, they have opportunities to address their professional development needs such as collaboration with peers, searching for new ideas and educational resources for use in classroom (M=4.50, SD= 0.744).

Regarding biology teachers' perceptions on the value of using ICTs for learning and on the impact of ICTs on learners' attributes, the findings in terms of descriptive statistics for mean and standard deviation are displayed in Table 3.

Out of the 107 cases, six (6) (5.6%) were excluded and hence 101 (94.4%) were considered valid. According to Morgan et al. (2004:57), this 101, "listwise N only includes the respondents with no missing data on any variable requested in the output". The listwise deletion was based on all variables in the procedure. The reliability statistics indicated that for the nine (9) items in this sub-scale, the Cronbach's alpha was 0.727, and the same 0.727 was reported based on the standardised items.

**Table 3**: Perceptions on ICTs usefulness to learning processes and learners' attributes

| **Variables** | **N** | **Mean** | **Std. Deviation** |
|---|---|---|---|
| Creative and lively use of technology tools can enhance the learning activities or processes and thus understanding of biology. | 107 | 4.76 | 0.452 |
| Technology makes learning biology faster, easier and enjoyable for me and my learners. | 107 | 4.52 | 0.604 |
| ICTs can be used to enhance learners' grasp of difficult biology content | 106 | 4.43 | 0.633 |
| ICT can enhance learners' critical thinking skills. | 107 | 4.15 | 0.775 |
| Technology increases learners' interest and concentration in the learning process | 107 | 4.47 | 0.718 |
| Social media platforms e.g. Whats-App, Facebook, Twitter, etc. are helpful for discussions and sharing information with peers to both learners and teachers. | 107 | 4.17 | 0.830 |
| ICT can enhance learners' participation, and feedback to teachers | 106 | 4.15 | 0.701 |
| ICT can enhance teacher and student interaction, and collaboration among learners | 103 | 4.18 | 0.776 |
| ICT can enhance learners' scientific and practical skills (e.g. observational, experimental, data handling etc) | 107 | 4.22 | 0.914 |
| Valid N (Listwise) | 101 | | |

Cronbach's alpha= 0.727, and based on standardised items = 0.727

None of the nine (9) items in this sub-scale scored a mean that is less than 4. In fact, most of them can be rounded off to 4. This indicates that generally, the respondents agree that use of ICTs benefits learning processes and impacts positively on the investigated learners' attributes. Most respondents strongly agreed that "Creative and lively use of technology tools can enhance the learning activities or processes and thus understanding of biology" (M=4.76, SD= 0.452) and "Technology makes learning biology faster, easier and enjoyable for learners" (M= 4.52, SD=0.604). These two (2) items scored the highest means with the smallest standard deviations in this sub-scale. Two perceptions scored the same lowest mean; "ICT can enhance learners' critical thinking skills" (M= 4.15, SD=0.775) and "ICT can enhance learners' participation and feedback to teachers (M= 4.15, SD=0.701). These means are lowest only relative to others that have been investigated. It is therefore important to note that the respondents positively perceive ICTs as tools that develop learners' analytical thinking abilities, participation and feedback to teachers. Looking at the performance of the variable "Social media platforms e.g. Whats-App, Facebook, Twitter, etc. are helpful for discussions and sharing information with peers to both learners and teachers" (M= 4.17, SD=0.830), it is evident that majority of the respondents and probably their learners, have access to internet connectivity. For teachers in particular, this is corroborated by the results displayed by figures 2 to 5 in section4.4.1. These results reflect the ICT- resourced nature of the context in which the respondents work. Therefore, the aforesaid knowledge domains could be expected to be seen to interact in this context.

On the whole, the respondents' perceptions on the use of ICT in the teaching and learning of biology were highly positive. The mean of five (5) indicates that the respondents strongly agreed that ICTs are useful to teaching. They agreed that ICTs are useful to learning as well and affect the investigated learners' attributes positively. Thus, if one assumes that there is a strong linear positive relationship between perceptions and extent of use of technology in teaching-learning experiences, one could already expect at least satisfactory use of technology in educational activities.

### 4.3.2. Teachers' self-perceived ICT competence

The teachers’ perceived ICT skills, as listed in Table 4, were examined and rated on a four-point Likert scale with the options; “1= cannot use”, “2= slightly competent”, “3= moderately competent”, and “4= very competent”. The findings are presented in Table 4.

Out of the 107 cases, 13 (12.1%) were excluded due to missing data on some variables requested in the output. Therefore, 94 (87.9%) were considered valid. The listwise deletion was based on all variables in the procedure. The reliability statistics indicated that for the 13 items in this scale, the Cronbach’s alpha was 0.933, and the same 0.933 was reported based on the standardised items.

**Table 4**: Teachers' self-perceived ICT competence

| Teachers' perceptions on their ICT competence (Variables) | N | Mean | Std. Deviation |
|---|---|---|---|
| Word processor (e.g. Microsoft Word) | 105 | 3.15 | 0.806 |
| Presentation of information/ lessons (e.g. Microsoft PowerPoint) | 106 | 2.75 | 1.049 |
| I can use spreadsheet (e.g. Microsoft Excel) to process data and report results. | 107 | 2.67 | 1.062 |
| I can use technology resources to facilitate higher order and complex thinking skills, including problem solving, critical thinking, informed decision-making, knowledge construction, and creativity. | 105 | 2.59 | 0.895 |
| I can use content-specific tools (e.g., Internet, software, simulation) to support learning and research. | 105 | 3.08 | 0.917 |
| I can use technology tools (e.g. email, WhatsApp Messenger) and resources (e.g. computers, mobile phones) for managing and communicating information. | 107 | 3.32 | 0.820 |
| I can evaluate and select new information resources and technological innovations based on their appropriateness to specific tasks | 105 | 2.61 | 0.882 |
| I can troubleshoot common computer problems. | 106 | 1.97 | 1.028 |
| I am proficient in the use of common input and output devices; I can solve routine hardware and software problems; I can make informed choices about technology systems, resources, and services. | 107 | 1.99 | 0.966 |
| I can use technology to locate, evaluate, and collect information from a variety of sources. | 107 | 2.67 | 0.959 |
| I can use technology tools and information resources to increase productivity, promote creativity, and facilitate academic learning. | 102 | 2.68 | 0.935 |
| I can choose learning and technology resources. | 105 | 2.96 | 0.843 |
| I can use a variety of media and formats, including telecommunications, to collaborate, publish, and interact with peers, experts, and other audiences. | 107 | 2.67 | 0.988 |
| Valid N (Listwise) | 94 | | |

Cronbach's alpha= 0.933, and based on standardised items = 0.933

Most respondents rated themselves as slightly competent when it comes to troubleshooting common computer problems (M =1.97, SD=1.028) and proficient in the use of common input and output devices, solving routine hardware and software problems, and making informed choices about technology systems, resources, and services (M=1.99, SD= 0.966). The lowest means were registered for these two (2) items. This is because for these skills (variables), the distribution curves were strongly positively skewed. That is, the option “cannot use” registered the highest frequency that was closely followed by the option “slightly competent”. For a few more competencies, these two options (together) were registered for a noteworthy percentage (> 45%) of the respondents: “use of Microsoft PowerPoint to present lessons”, “use of Microsoft Excel to process data and report results”, “use of technology resources to facilitate higher order and complex thinking skills, including problem solving, critical thinking, informed decision-making, knowledge construction, and creativity”, “evaluating and selecting new information resources and technological innovations based on their appropriateness to specific tasks”, “using technology to locate, evaluate, and collect information from a variety of sources”, “using technology tools and information resources to increase productivity, promote creativity, and facilitate academic learning” and “using a variety of media formats, including telecommunications, to collaborate, publish, and interact with peers, experts, and other audiences”.

On the other hand, the majority of respondents reported that they could use technology tools (e.g., electronic mail, WhatsApp, and Messenger) and resources (e.g., computers, mobile phones) for managing and communicating information (M=3.32, SD= 0.820). This item scored the highest mean with the second smallest standard deviation. Word processing (M=3.15, SD= 0.806) scored the second highest mean with the smallest standard deviation. Therefore, most respondent teachers seem to be fairly comfortable with the use of Microsoft Word, and use of technology tools and resources to manage and impart information. To a certain extent, it could be argued that the result reflects the moderate level of TPK of the respondents.

The means for the items on self-perceived competence generally average out at 2.70, implying moderate competence.

## 4.4. The commonly used ICT

This section presents findings on commonly used ICTs, their use for teaching and non-teaching purposes, and also on the practices that characterise the patterns of use.

### 4.4.1. Availability of ICTs

The respondents were requested to indicate the ICT tools that were available for use in their schools and/or homes. The probed information and communication technology tools were a computer/laptop, electronic mail, Internet, flash drive, mobile phone, printer, projector, and videos and simulations. However, the respondents were at liberty to add more tools that they use, if not on the list. The findings are displayed in figures 2 and 3 for school and home respectively. Figure 2 shows the percentage of the respondents who reported that they had access to the indicated ICT tools at school.

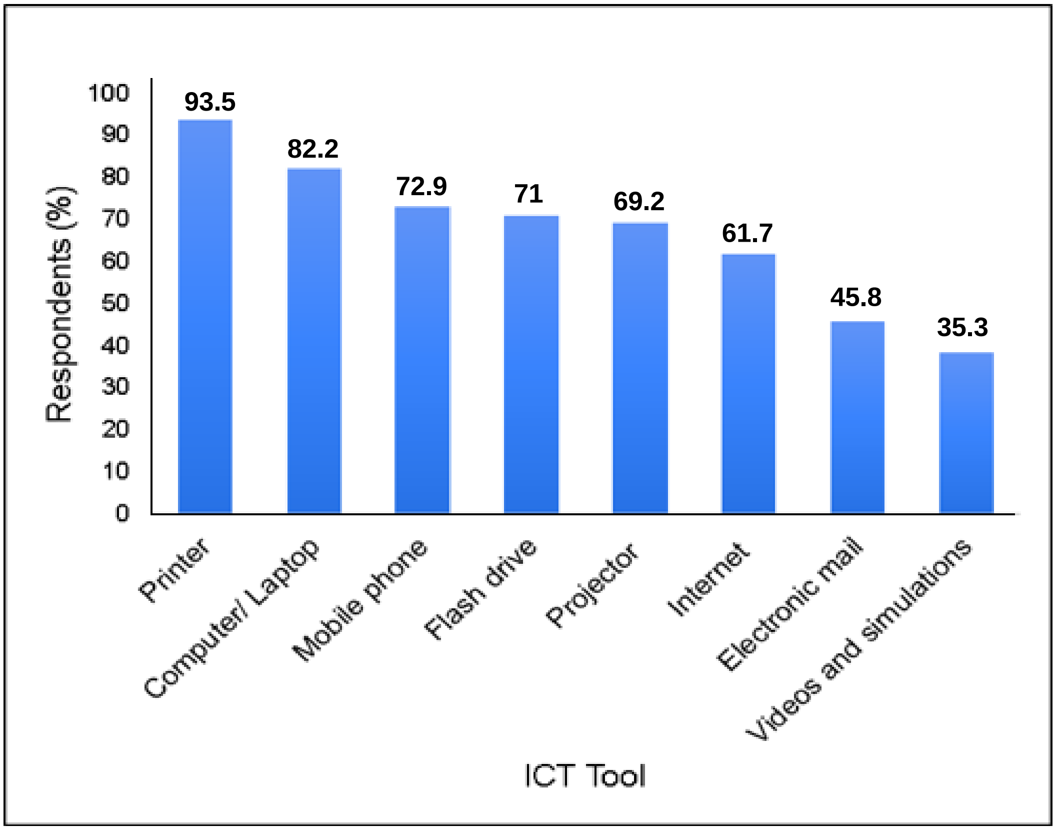


**Figure 2:** Availability of ICT tools at school

The findings show that the majority (over 60%) of the respondents have computers, electronic mail, flash drives, access to the Internet, mobile phones, printers and projectors available for their use at school. The most accessible ICT tools appear to be the printer (93.5%) and computer/laptop (82.2%). A minority of respondents reported that they had access to electronic mail (45.8%), and videos and simulations (38.3%).

Figure 3 shows the percentage of the respondents who reported that they have access to the indicated ICT tools at home.

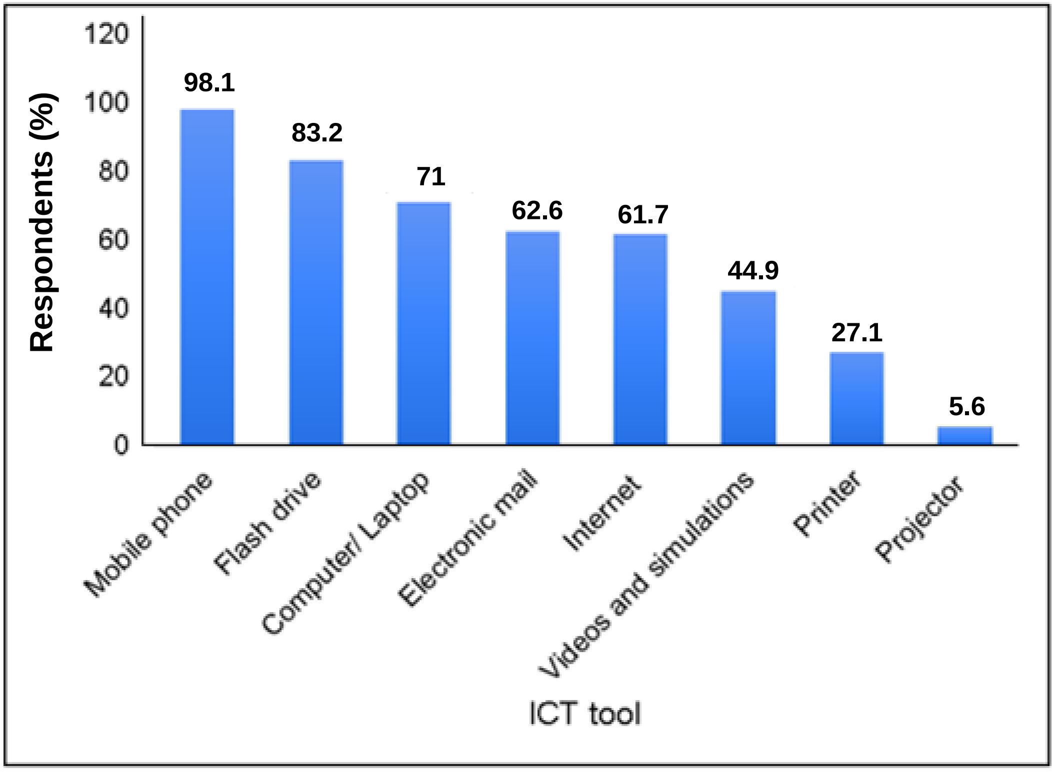


**Figure 3:** Availability of ICT tools at home

The findings show that the majority (over 60%) of the respondents have computers, electronic mail, flash drives, Internet and mobile phones available for their use at home. The most accessible ICT tools at home are a mobile phone (98.1%) and flash drive (83.2%). The minority reported that they had access to a printer (27.1%) and projector (5.6%) at home.

Irrespective of whether the focus is on availability at home or school, all eight ICT tools probed seem to be at least reasonably available for use by the biology teachers. It remains to be determined whether or not they use them for educational purposes or otherwise, and how often they use them, if at all.

### 4.4.2. Purposes for which ICTs are used

The respondents were requested to indicate whether they used the information and communication technology tools listed in the previous section for teaching or for non-teaching purposes. The findings are displayed in the bar charts in figures 4 and 5.

Figure 4 displays the frequency (count) of respondents who use the accessible ICTs for teaching purposes.

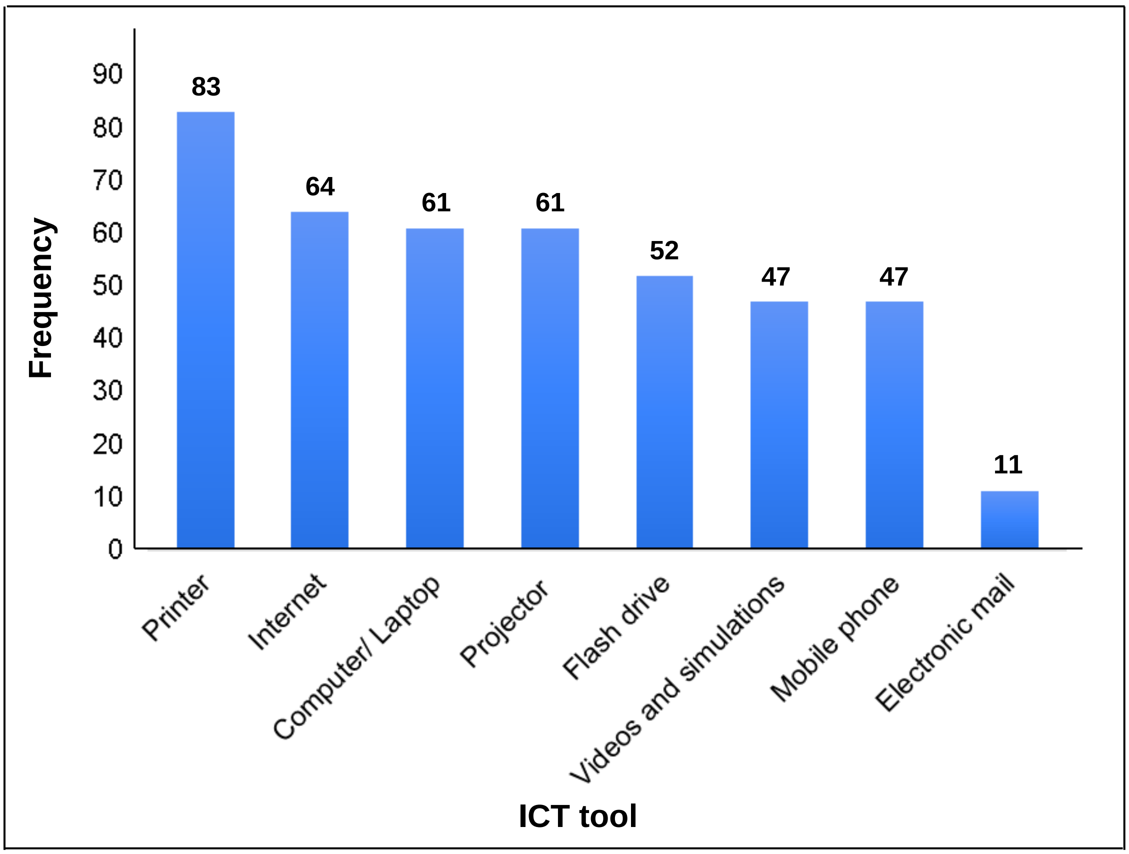


**Figure 4:**Use of ICT tools for teaching purposes

These findings reveal that the printer, Internet, computer/laptop and projector are the ICT tools that are used by most of the respondents for teaching intents. The majority (over 60%) of those who responded to the item indicated that they used a printer (83), Internet (64), projector (61) and computer/laptop (61) for teaching purposes. The ICTs that are most popularly used for teaching biology is printers, followed by the Internet and then almost equally popular are a computer/laptop and projector. The least commonly used are electronic mail (11) followed by mobile phones (47) and videos and simulations (47). As these data were collected before the Covid19 pandemic in the country; it would be interesting to see if the responses would be any different post-Covid19. A similar study may be necessary to determine if the numbers would change.

Comparing the results on the availability of ICTs to their purposes of use, the printer seems to be the most available tool for use in schools and also the most commonly used for teaching purposes. Correspondingly, videos and simulations are not commonly available and they are among the less popular used for teaching. Similarly, electronic mail is one of the less accessible at school though reasonably accessible at home. The findings displayed in Figure 4 indicate that electronic mail is the least used tool for teaching biology. Therefore, one could speculate that the availability of the ICT tools could forecast their use for teaching. However, the Internet is not even in the top four most accessible tools (as shown by figures 2 and 3), but it is the second most commonly used tool for teaching purposes. The data may suggest that the availability of the ICT tools might not be a reliable forecaster of their use for teaching. Perhaps other factors could be more confidently used to predict use of the technology tools for teaching intents. Another argument could be that the result for the Internet is just a discrepancy as there seems to be an overall direct relationship between availability and use of the tools.

The findings partly answer the proposition made in the previous section. They affirm that the available tools are certainly used for teaching ends as reported by the respondents. Nevertheless, some by far more respondents than others.

Figure 5 displays the frequency (count) of respondents who use the accessible ICTs for non-teaching purposes.

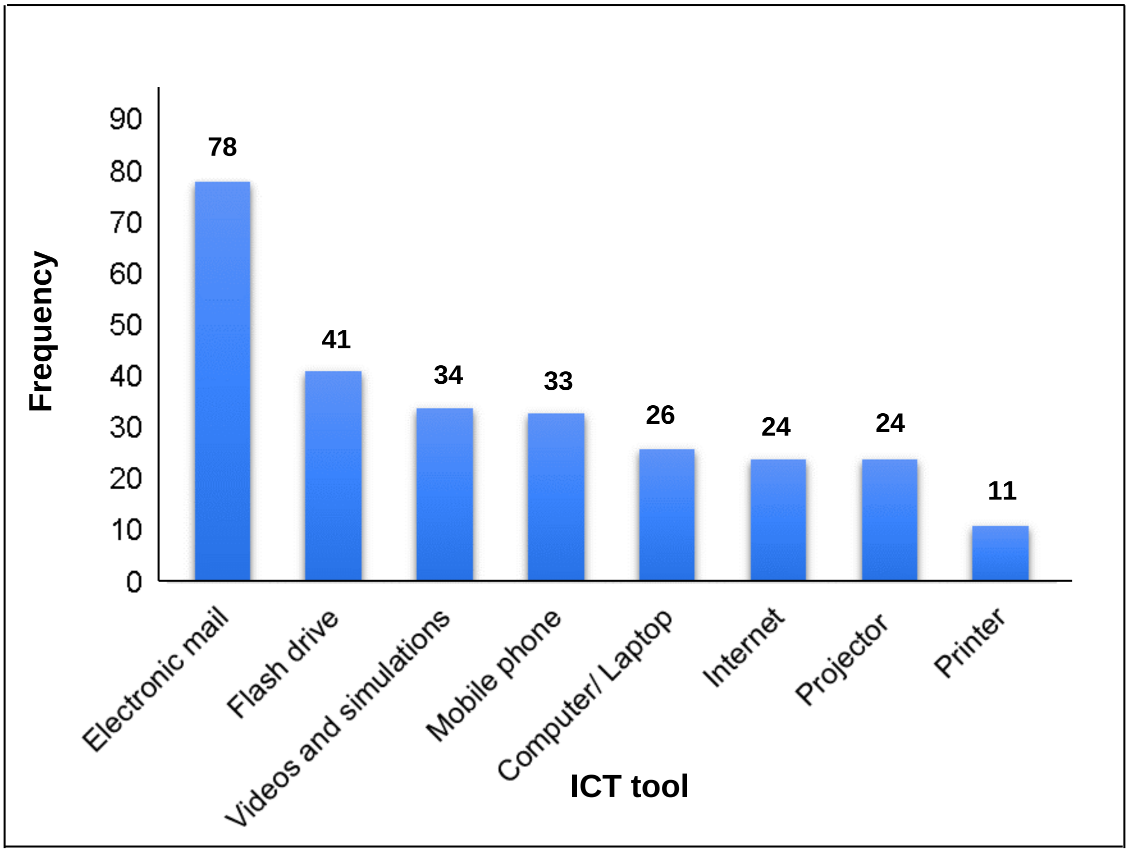


**Figure 5:**use of ICT tools for non-teaching purposes

With regard to non-teaching purposes, electronic mail is used by the majority of those who responded. They generally prefer using their electronic mail accounts (78) for non-teaching to teaching purposes. Electronic mail, flash drives, videos and simulations, and mobile phones are among the tools used by most respondents for non-teaching purposes. The least used technologies, for non-teaching ends, are the Internet (24), projector (24) and printer (11).

### 4.4.3. Extent of use of ICTs

The frequency of use of the listed ICTs was measured on a five-point Likert scale with the options; “1 = never used (not at all)”, “2 = very irregularly used (at least once a term)”, ”3 = irregularly used (at least once a month)”, “4 = regularly used (at least once a week)” and “5 = very regularly used (almost daily)”. The results are presented in Table 5.

Out of the 107 cases, 34 (31.8%) were excluded and hence 73 (68.2%) were considered valid. The 34 cases excluded had some missing data on the variables required in the output. The listwise deletion was based on all variables in the procedure. The reliability statistics indicated that for the eight (8) items in this scale, the Cronbach’s alpha was 0.717, and 0.713 was reported based on the standardised items.

**Table 5**: Descriptive data for the frequency of use of the ICT

| Frequency of use of the ICT tool | N | Mean | SD |
|---|---|---|---|
| Computer / laptop | 102 | 3.56 | 1.113 |
| Electronic mail | 88 | 2.61 | 1.393 |
| Flash drive | 98 | 3.32 | 1.232 |
| Internet | 101 | 3.98 | 1.183 |
| Mobile phone | 104 | 4.39 | 1.037 |
| Video and simulations | 93 | 2.51 | 1.449 |
| Printer | 103 | 3.55 | 1.250 |
| Projector | 92 | 2.05 | 1.270 |
| Valid N (listwise) | 73 | | |

Cronbach’s alpha = 0.717, and 0.713 based on the standardised items

The tools that are used most frequently are the Internet (M =3.98, SD =1.183) and the mobile phone (M = 4.39, SD =1.037). The standard deviations for the two ICT tools show that they are used with frequency ranging from at least once a month to almost daily. In fact, the histograms produced by SPSS to more accurately illustrate distribution of the options show that the “almost daily” use was the most common option for both ICTs. The other most frequently used, which also happen to be almost equally used technology tools, are computers/laptops (M= 3.56, SD =1.113) and printers (M = 3.55, SD =1.250). The least frequently used tools are the videos and simulations (M= 2.51, SD =1.449) and projectors (M= 2.05, SD =1.270). The standard deviations gave a hint that some respondents do not use either a projector or videos and simulations at all. In fact, the histograms seem to indicate that the highest percentage of respondents selected the “never used” option for both ICT tools. The overall mean score for the frequency of use of these eight ICTs was 3.25 and the average standard deviation was 1.241. The implication is that the overall use of these ICT tools ranges from very irregular to regular, but they are mostly irregularly used. That is, they are generally used at least once a month. Considering how positively the respondents perceived the value of ICTs in educational activities, this result is rather an anti-climax. Therefore, the will to maintain the proposition raised in section 4.3 lessened. Although, these results indicate the extent of use of the investigated technology tools, it is still unclear as to what teaching purposes the teachers actually use them for. The next section sheds light in this regard.

### 4.5. Practices that characterise patterns of use of ICTs

The respondents’ practices that typify their patterns of use of ICTs were measured on a five-point Likert scale with the options; “1 = never used (not at all)”, “2 = very irregularly used (at least once a term)”, ”3 = irregularly used (at least once a month)”, “4 = regularly used (at least once a week)” and “5 = very regularly used (almost daily)”. The scale comprised 20 items and the findings are presented in Table 6.

Out of the 107 cases, 23 (21.5%) were excluded and hence 84 (78.5%) were considered valid. The listwise N, 84, only includes the respondents with no missing data on any variable requested in the output. The listwise deletion was based on all variables in the procedure. The reliability statistics indicated that for the 20 items in this scale, the Cronbach’s alpha was 0.886, and 0.885 was reported based on the standardised items. For the purposes of analyses, the scale was divided into two subscales: one to show results for non-educational practices and the other to show results for educational practices. The latter was further divided into two subscales; one to display results for the extent of teachers' use of hardware and software and the other to show results for the extent of use of ICTs in teaching practices.

Table 6 shows the descriptive statistics for the use of hardware and software in educational practices. Out of the 107 cases, 14 (13.1%) were excluded because the respondents had missing data on some variables requested in the output. Thus, 93 (86.9%) cases were considered valid. The listwise deletion was based on all variables in the procedure. The reliability statistics indicated that for the 10 items in this sub-scale, Cronbach's alpha was 0.819, and 0.820 was reported based on the standardised items.

**Table 6**: Descriptive statistics for teachers' use of hardware and software

| **Practices that characterise patterns of use of ICTs** | **N** | **Mean** | **SD** |
|---|---|---|---|
| Searching for information on Internet, hard disk and compact discs (CD ROMs) to prepare for lessons. | 105 | 3.66 | 1.247 |
| Using computer programs such as Microsoft Picture It!, Paint, and Movie Maker to create pictures, posters, diagrams, or animations for use in teaching. | 107 | 2.19 | 1.260 |
| Using spreadsheets for recording test scores and other learners' information | 107 | 2.61 | 1.577 |
| Using Microsoft PowerPoint to present lesson content, show pictures, diagrams, videos, and simulations to teach or facilitate discussions | 106 | 2.08 | 1.336 |
| Using Microsoft Office Word for writing notes for learners | 107 | 2.09 | 1.363 |
| Using educational software to learn how certain biology topics can be approached | 107 | 2.48 | 1.216 |
| Using printers and scanners to produce handouts showing different representations (textual, graphical, diagrammatic etc) of biology content for learners | 106 | 3.24 | 1.404 |
| Using mobile applications such as WhatsApp Messenger, Facebook, SHAREit, Wi-Fi-Direct, etc. for teaching purposes, information exchange, and discussion forums with and for learners. | 107 | 3.05 | 1.376 |
| Receiving and sending emails to communicate with colleagues on issues related to teaching. | 99 | 2.55 | 1.473 |
| Using computers for drill-and-practice and tutorial software packages. | 104 | 1.76 | 1.102 |
| Valid N (Listwise) | 93 | | |

Cronbach's alpha 0. 819, and 0.820 based on the standardised items

The educational practice that scored the highest mean is "searching for information on the Internet and information storage devices to prepare for lessons" (M = 3.66, SD = 1.247). It is followed by "using printers and scanners to produce handouts showing different representations (textual, graphical, and diagrammatic) of biology content for learners" (M = 3.24, SD = 1.404). The latter scored almost equal mean as "using mobile applications such as WhatsApp Messenger, Facebook, SHAREit, Wi-Fi-Direct, etc. for teaching purposes, information exchange, and discussion forums with and for learners" (M = 3.05, SD = 1.376). The practices that scored the lowest means were "using computers for drill-and-practice and tutorial software packages" (M = 1.76, SD = 1.102), and "using Microsoft PowerPoint to present lesson content, show pictures, diagrams, videos, and simulations to teach or facilitate discussions (M = 2.08, SD = 1.336). To have a more detailed representation of the distributions of options for these variables, histograms were produced in SPSS. For the latter practice, the histogram revealed that the commonest option was "never used". Correspondingly, a similar result was obtained for the use of computer programs such as Microsoft Picture It!, Paint, and Movie Maker to create pictures, posters, diagrams, or animations for teaching. The rest of the practices had mean values ranging from 2.09 to 2.61.

The average of the mean values for all 10 items was computed and found to be 2.65. This outcome corroborates the findings displayed in Figure 4 in section 4.4.2, and those that are displayed in Table 5 in section 4.4.3. All these findings show more frequent use of a computer/laptop, the Internet and printers for teaching purposes than other ICTs. Furthermore, this average mean suggests a possible inclination towards use of ICTs to support traditional transmission of knowledge rather than to enhance learner-centredness. This inference is strengthened by the practices that earlier have been indicated to have scored the lowest means. These practices could also be used to promote the social learning constructivist approach. It is noteworthy that the average mean indicates a generally irregular use of hardware and software by the respondents. This result also counters the expectation or proposition raised earlier in section 4.3.1. Strong positive perceptions of ICT use may not necessarily imply that ICTs would be used to a great extent.

Table 7 shows the descriptive statistics for the listed teaching activities. Out of the 107 cases, 6 (5.6%) were excluded because the respondents had missing data on some variables requested in the output. Thus, 101 (94.4%) cases were considered valid. The listwise deletion was based on all variables in the procedure. The reliability statistics indicated that for the five (5) items in this sub-scale, Cronbach's alpha was 0.892, and 0.891 was reported based on the standardised items.

**Table 7:** Descriptive statistics for the teaching practices

| **Practices that characterise patterns of use of ICTs** | **N** | **Mean** | **SD** |
|---|---|---|---|
| Issuing class instructions and/or communicating with learners | 103 | 2.54 | 1.447 |
| Organizing class discussion, demonstrations and presentations | 105 | 2.73 | 1.463 |
| Assessing learners' learning through tests/quizzes | 107 | 3.12 | 1.465 |
| Conveying feedback to learners | 107 | 2.71 | 1.498 |
| Supporting collaboration among learners | 107 | 2.93 | 1.522 |
| Valid N (Listwise) | 101 | | |

Cronbach's alpha 0. 892, and 0.891 based on the standardised items.

The practice that scored the highest mean is "assessing learners' learning through tests/quizzes" (M = 3.12, SD = 1.465). It is followed by "supporting collaboration among learners" (M = 2.93, SD 1.522). The rest of the practices had mean values ranging from 2.54 to 2.73. The average of the mean values for all the five (5) items in this subscale is 2.80, which is approximately 3.0. Therefore, the results suggest that generally, the respondents' use of ICTs in teaching activities is irregular. That is, most of them use ICTs at least once a month. This was unexpected. For people who hold optimistic perceptions of ICT use for teaching like the respondents of the current study, a higher frequency of use of these eight tools would be logical. Based on this result, one can already anticipate a weak positive linear relationship between the perceptions and frequency of use of listed ICT tools.

Table 8 shows the results (descriptive statistics) for non-educational practices that characterise patterns of use of ICT. Out of the 107 cases, 4 (3.7%) were excluded as the respondents had missing data on some variables requested in the output. Thus 103 (96.3%) were considered valid. The listwise deletion was based on all variables in the procedure. The reliability statistics indicated that for the five (5) items in this sub-scale, Cronbach's alpha was 0.665, and 0.660 was reported based on the standardised items.

**Table 8**:Descriptive statistics for non-educational practices

| **Practices (activities)** | **N** | **Mean** | **SD** |
|---|---|---|---|
| Designing things like programmes for functions, invitation cards etc. | 107 | 1.55 | 0.914 |
| Organizing computer settings such as files, memory, system, etc. | 105 | 2.15 | 1.299 |
| Using Internet for fun, downloading and/or watching or listening to music, and other personal purposes such as shopping. | 107 | 3.63 | 1.384 |
| Playing games on computers. | 107 | 2.73 | 1.502 |
| Using mobile applications such as WhatsApp Messenger, Facebook for non-educational purposes such as chatting or socialising with other people. | 105 | 4.23 | 1.040 |
| Valid N (Listwise) | 103 | | |

Cronbach's alpha 0.665, and 0.660 based on the standardised items

"Using mobile applications such as WhatsApp, Messenger, and Facebook for non-educational purposes such as chatting or socialising with other people" (M = 4.23, SD = 1.040)" scored the highest mean. Actually, as indicated by the histogram generated to display the distribution of options for this variable, the commonest option was 'very regularly' followed by 'regularly'. It is the most frequently performed and common practice of all practices that were probed. This practice is followed by "using internet for fun, downloading and/or watching or listening to music, and other personal purposes such as shopping" (M = 3.63, SD = 1.384). The least common practice was "designing things like programmes for functions and invitation cards (M = 1.55, SD = 0.914). The average of the mean values for the five (5) items on non-educational practices is 2.86.

The average of the mean values for all 20 items on the practices that characterise patterns of use of ICT was found to be 2.70, also implying irregular use of ICTs in general. However, it is worthy of noting that the overall frequency of use of ICT tools for non-educational ends is very slightly higher than the overall extent of use for teaching intents.

Therefore, the use of ICT seems to be a bit more inclined to non-educational practices than teaching practices overall.

### 4.6. Reliability of the instrument

As indicated in section 3.6, Leech, et al. (2015) point out that it is imperative to evaluate reliability of data before running inferential statistics. Thus, the measurement of internal consistency involving items on teachers' perceptions and practices that characterise their patterns of use of ICTs was done. The purpose was to evaluate the reliability of the instrument employed in the current study. Table 9 summarises the results.

The alpha values average at approximately 0.80, which is considered good (George & Mallery, 2020) or "highly reliable" (Cohen, et al., 2018:774). Therefore, the instrument used to measure the teachers' perceptions and practices that characterise patterns of ICT use is reliable.

**Table 9**: Instrument's reliability statistics

| Scale/ sub-scales | No. of variables | Cronbach's alpha coefficient based on | |
|---|---|---|---|
| | | unstandardised items | standardised items |
| Perceptions on usefulness of ICTs to teaching biology | 6 | 0.668 | 0.684 |
| Teachers' perceptions on usefulness of ICTs to learning processes and learners' attributes | 9 | 0.727 | 0.727 |
| Teachers' self-perceived ICT competence | 13 | 0.933 | 0.933 |
| Use of hardware and software practices characterising patterns of ICT use | 10 | 0.819 | 0.820 |
| Teaching practices that characterise patterns of use of ICT | 5 | 0.892 | 0.891 |
| Non- educational practices that characterise patterns of use of ICTs | 5 | 0.665 | 0.660 |

## 4.7. Correlation between the teachers' perceptions and their use of ICTs

In order to determine if statistically significant relationships existed between the respondents' general perceptions on the use of ICTs for teaching biology and their extent of use of each of the eight (8) listed ICT tools, bivariate correlations were calculated. Since each of these constructs was measured at ordinal level, and consequently likely to be skewed and thus violate the assumptions of normality, non-parametric Spearman rho statistics were computed. According to Cohen et al. (2018:736), "If the distributions are too far away from a normal curve of distribution then it may be unwise to use statistics for parametric data; instead, statistics for non-parametric data should be used". Indeed, the histograms for most variables produced skewed distributions. The results are displayed in tables 10 and 11 for the two sub-scales for the general perceptions. Table 12 displays results for the scale on self-perceived ICT competence. Table 10 displays the results regarding the relationship between respondents' perceptions on the use of ICTs for teaching biology and their frequency of use of ICTs.

**Table 10:** Spearman correlations between teachers' perceptions on the use of ICTs for teaching and frequency of ICTs use

| Teachers' perceptions on use of ICTs for teaching | Frequency of use of | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | computer/ laptop | electronic mail | flash drive | Internet | mobile phone | videos and simulations | printer | projector |
| Creative and lively use of technology tools can enhance the teaching activities/processes and thus understanding of biology. | 0.15 | 0.06 | 0.02 | 0.14 | 0.10 | 0.08 | -0.02 | -0.04 |
| Technology makes biology teaching a faster, easier and enjoyable experience. | 0.19 | 0.26* | 0.14 | 0.18 | 0.33** | 0.01 | 0.24* | -0.07 |
| Technology allows me to modify resources so as to present more organised lessons that concentrate on the relevant biology content. | 0.23* | 0.28** | 0.12 | 0.12 | 0.15 | 0.20* | 0.09 | 0.16 |
| ICTs are impressive instruments that can visually illustrate biology concepts that would otherwise remain abstract, thus promoting learners understanding. | 0.14 | 0.21* | 0.08 | 0.20* | 0.13 | 0.26* | 0.11 | 0.21* |
| Technology accommodates and encourages modern educational approaches such as cooperative learning, inquiry learning. | 0.04 | 0.08 | 0.00 | 0.15 | 0.08 | 0.14 | 0.04 | 0.16 |
| ICTs offer opportunities for me to address my professional development needs e.g. collaboration with peers, searching for new ideas and educational resources for use in classroom. | 0.09 | 0.28** | 0.01 | 0.11 | 0.00 | 0.23* | 0.04 | 0.26* |

**. correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level(2-tailed)

The findings show that generally, the perceptions have weak positive correlations with the frequency of use of the investigated ICTs. Only two perceptions; “Creative and lively use of technology tools can enhance the teaching activities/processes and thus understanding of biology”, and “Technology accommodates and encourages modern educational approaches such as cooperative learning, inquiry learning” were found not to have statistically significant correlation with any of the probed ICT tools. The rest of the perceptions showed statistically significant correlations with the extent of use of at least three of the listed ICT tools. Also, a flash drive was found to be the only ICT tool whose extent of use had no statistically significant correlation with all the listed perceptions regarding teaching of biology. The perception “ICTs are impressive instruments that can visually illustrate biology concepts that would otherwise remain abstract, thus promoting learners’ understanding” has shown a statistically significant correlation with the extent of use of the highest number of ICTs (4). The calculated Spearman rho statistics were $r_s$ (86) = .21, $p$ = .050 with electronic mail; $r_s$ (99) = .20, $p$ = .047 with Internet; $r_s$ (91) = .26, $p$ = .014 with videos and simulations; and lastly, $r_s$ (90) = .21, $p$ = .048 with the projector. The average correlation is 0.22. It indicates that only about five per cent (5%) of the variance is mutual to the aforementioned perception and the frequency of use of any of the four ICT tools (electronic mail, Internet, projector, and videos and simulations). Despite being statistically significant, this correlation is too slight to be of much value in predicting the extent of use of the four tools from the perception that “ICTs are impressive instruments that can visually illustrate biology concepts that would otherwise remain abstract, thus promoting learners understanding” (Cohen, et al., 2018).

The greatest statistically significant correlation, $r_s$ (102) = .33, $p$ = .001, is found between the perception that technology makes biology teaching a faster, easier and an enjoyable experience, and the frequency of mobile phone use. This statistic means the holders of this perception tend to use mobile phones to a certain extent. Again, it shows a medium effect size as guidelines provided by Cohen, et al. (2018). The $r^2$ implies that about ten per cent (10%) of the variance in the extent of use of mobile phones can be forecast from the perception that technology makes biology teaching a faster, easier and an enjoyable experience. That is, 0.01 of variance in the frequency of the respondents' use of mobile phone might be credited to its direct association with the teachers' perception that technology makes biology teaching a faster, easier and an enjoyable experience.

The second greatest and almost equally statistically significant correlations are the those between the extent of use of electronic mail and each of the following perceptions: technology allows teachers to modify resources so as to present more organised lessons that concentrate on the relevant biology content, $r_s$ (86) = .28*, p* = .007; and ICTs offer opportunities for teachers to address their professional development needs, e.g., collaboration with peers, searching for new ideas and educational resources for use in classroom, $r_s$ (86) = .28*, p* = .009. The effect sizes are medium. For each one of them, the r squared value is 0.08, which is the quantity that the frequency of electronic mail use and the said perceptions have in common. That is, approximately eight per cent (8%) of the variance in frequency of use of electronic mail could be predicted from any of the two stated perceptions as they have a linear relationship. The holders of any of these perceptions tend to use electronic mail to some extent.

The third greatest statistically significant correlation is that between electronic mail and the perception that "technology makes biology teaching a faster, easier and an enjoyable experience", $r_s$ (86) = .26*, p* = .0014. Also, the correlation of the frequency of use of video and simulations with the perception that ICTs are impressive instruments that can visually illustrate biology concepts that would otherwise remain abstract, thus promoting learners' understanding, $r_s$ (91) = .26*, p* = .0014. The Spearman correlation of the perception that ICTs offer opportunities for teachers to address their professional development needs and educational resources for use in classroom with frequency of use of the projectors, $r_s$ (90) = .26*, p* = .0013, is among them. For each of the three correlations, effect size is medium. The r squared values indicate that approximately seven per cent (7%) of the variance in frequency of use of the stated ICTs (electronic mail, videos and simulations, and projectors) could be attributed to their propensity to fluctuate linearly with the aforementioned corresponding perceptions.

Concerning the teachers' perceptions on the impact of ICTs on learning and learner attributes, the Spearman correlations are listed in Table 11. The findings reveal that generally, the perceptions have positive correlations with the listed ICTs. However, most of the correlations were found to be weak as they are close to zero and only a few were found to be statistically significant. Out of the nine (9) listed perceptions, three (3) showed no statistically significant correlation with the frequency of use of all the listed ICT tools. These perceptions are "Creative and lively use of technology tools can enhance the learning activities/processes and thus understanding of biology", "Technology increases learners' interest and concentration in the learning process" and "ICT can enhance students' scientific and practical skills (e.g. observational, experimental, data handling etc)". Also, a flash drive was found to be the only ICT tool of which the extent of use had no statistically significant correlation with any of the listed perceptions regarding learning of biology and learner attributes.

**Table** 11: Spearman correlations between teachers' perceptions on impact of use of ICTs on learning and learner attributes, and frequency of their use of ICTs

| **Teachers' perceptions on impact of use of ICTs on learning and learner attributes** | **Frequency of use of** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **computer/ laptop** | **electronic mail** | **flash drive** | **Internet** | **mobile phone** | **videos and simulations** | **printer** | **projector** |
| Creative and lively use of technology tools can enhance the learning activities/processes, thus understanding of biology. | 0.15 | 0.06 | 0.02 | 0.14 | 0.10 | 0.08 | -0.02 | -0.04 |
| Technology makes learning biology faster, easier and enjoyable for me and my learners. | 0.26** | .21* | 0.16 | 0.28** | 0.12 | -0.03 | 0.21* | 0.05 |
| ICTs can be used to enhance learners' grasp of difficult biology content. | 0.13 | 0.00 | 0.09 | 0.09 | 0.21* | 0.30** | 0.09 | 0.07 |
| ICT can enhance learners' critical thinking skills. | 0.05 | 0.12 | 0.07 | 0.22* | 0.16 | 0.09 | 0.02 | 0.20 |
| Technology increases learners' interest and concentration in the learning process | 0.06 | -0.03 | 0.08 | -0.03 | -0.04 | 0.00 | 0.11 | 0.05 |
| Social media platforms e.g. WhatsApp, Face-book, Twitter, etc. are helpful for discussions and sharing information with peers to both learners and teachers. | 0.03 | 0.11 | 0.10 | 0.01 | 0.07 | 0.26* | 0.06 | 0.13 |
| ICT can enhance learners' participation, and feed-back to teachers | 0.09 | 0.25* | 0.07 | 0.07 | 0.03 | 0.39** | 0.19 | 0.35** |

| Teachers' perceptions on impact of use of ICTs on learning and learner attributes | Frequency of use of | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | computer/ laptop | electronic mail | flash drive | Internet | mobile phone | videos and simulations | printer | projector |
| ICT can enhance teacher and learner interaction, and collaboration among learners | 0.07 | 0.10 | 0.06 | 0.15 | 0.25* | 0.14 | 0.20* | 0.07 |
| ICT can enhance students' scientific and practical skills (e.g. observational, experi-mental, data handling etc.) | 0.17 | 0.18 | 0.11 | 0.05 | 0.02 | 0.03 | 0.03 | 0.15 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level(2-tailed)

Most of the perceptions showed statistically significant correlations with the extent of use of at least one of the listed ICT tools. Four (4) out of eight (8) ICT tools registered statistically significant correlations with the perception that technology makes learning biology faster, easier and enjoyable for the respondents and their learners. The four (4) tools were computer/ laptop, $r_s$ (100) = .26, $p$ = .001; electronic mail, $r_s$ (86) = .21, $p$ = .05; Internet, $r_s$ (99) = .28, $p$ = .00 and the printer, $r_s$ (101) = .21, $p$ = .04. The effect sizes for these are medium. The $r_s$ squared values indicate that approximately seven per cent (7%) of the variance in frequency of use of the computer/laptop and Internet and about four per cent (4%) in frequency of use of electronic mails and the printer could be predicted from this perception. The calculated correlations are close to zero, which suggests that holding this perception is of little help in predicting the respondents' frequency of use of either, the computer/laptop, electronic mail, Internet or printer.

The perception that ICTs can enhance learners' participation, and feedback to teachers recorded statistically significant correlations with three ICT tools; electronic mail, $r_s$ (86) = .25, $p$ = .02; videos and simulations $r_s$ (90) = .39, $p$ = .00; and the projector, $r_s$ (90) = .35, $p$ = .00. The latter two tools registered the best correlations in the whole scale with the same perception. The effect size for each one of these correlations is also medium. The $r_s$ squared values indicate that knowing to what extent teachers hold this perception positively may help predict approximately fifteen per cent (15%of the variance in frequency of use of the videos and simulations. Also, to predict about twelve per cent (12%) and six per cent (6%) of the variance in frequencies of use of the projector and electronic mail respectively.

The videos and simulations have correlated statistically significantly with the highest number (3) of perceptions. First, "ICTs can be used to enhance learners' grasp of difficult biology content", $r_s$ (90) = .30, $p$ = .00. Second, "ICT can enhance learners' participation, and feedback to teachers", $r_s$ (90) = .39, $p$ = .00. The third perception is "Social media platforms, e.g., WhatsApp, Facebook, Twitter, etc. are helpful for discussions and sharing information with peers to both learners and teachers", $r_s$ (91) = .26, $p$ = .01.

Table 12 shows the Spearman correlations for the respondents' self-perceived ICT competence and their extent of use of ICTs. Compared with the general perceptions, self-perceived competences show relatively stronger positive correlations with the eight ICTs.

**Table 12:** Spearman correlations between the teacher's self-perceived ICT competence and frequency of their use of ICTs

| **Teachers' perceptions of ICTs Competence** | **Frequency of use of** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **computer/ laptop** | **electronic mail** | **flash drive** | **Internet** | **mobile phone** | **videos and simulations** | **printer** | **projector** |
| Word processor | 0.40** | 0.21 | 0.25* | 0.09 | 0.12 | 0.24* | 0.01 | 0.35** |
| Presentation | 0.33** | 0.29** | 0.20* | 0.28** | 0.13 | 0.45** | -0.08 | 0.32** |
| Spreadsheet | 0.32** | 0.23* | 0.17 | 0.34** | 0.19 | 0.44** | -0.07 | 0.37** |
| Facilitation of higher order skills and complex thinking | 0.30** | 0.04 | 0.04 | 0.31** | 0.21* | 0.22* | -0.03 | 0.21* |
| Supporting learning and research with content-specific tools. | 0.34** | 0.18 | 0.03 | 0.36** | 0.29** | 0.28** | 0.02 | 0.25* |
| Managing and communicating information with technology tools and resources. | 0.26** | 0.16 | 0.24* | 0.19 | 0.15 | 0.24* | 0.08 | 0.15 |
| Evaluating and selecting new information resources and technological innovations. | 0.35** | 0.23* | 0.24* | 0.30** | 0.29** | 0.35** | -0.01 | 0.31** |
| Troubleshooting common computer problems. | 0.42** | 0.21 | 0.27** | 0.29** | 0.12 | 0.38** | -0.10 | 0.49** |

| Teachers' perceptions of ICTs Competence | Frequency of use of | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | computer/ laptop | electronic mail | flash drive | Internet | mobile phone | videos and simulations | printer | Projector |
| Using common input and output devices; solving routine hardware and software problems; making informed choices about technology systems, resources, and services. | 0.29** | 0.14 | 0.16 | 0.17 | 0.06 | 0.39** | -0.08 | 0.40** |
| I can use technology to locate, evaluate, and collect information from a variety of sources. | 0.40** | 0.16 | 0.09 | 0.36** | 0.27** | 0.34** | -0.02 | 0.23* |
| Using technology tools and information resources to increase productivity, promote creativity, and facilitate academic learning. | 0.34** | 0.16 | 0.15 | 0.34** | 0.28** | 0.33** | 0.02 | 0.22* |
| Choosing learning and technology resources. | 0.37** | 0.19 | 0.12 | 0.26** | 0.30** | 0.37** | -0.05 | 0.27* |
| Using a variety of media and formats, including telecommunications, to collaborate, publish, and interact with peers, experts, and other audiences. | 0.26** | 0.29** | 0.10 | 0.22* | 0.21* | 0.48** | -0.02 | 0.33** |

**. correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level(2-tailed)

The findings indicate that there are more statistically significant and stronger correlations between the respondents' perceptions of their ICT competence and the extent to which they use ICTs to teach than those shown in tables 10 and 11. Most perceptions correlate statistically significantly with the frequency of use of at least five (out of eight) ICT tools. The perception that the respondents can evaluate and select new information resources and technological innovations registered statistically significant positive correlations with frequency of use of seven ICT tools. It is followed by two perceptions, which both registered statistically significant positive correlations with frequency of use of six ICT tools. One perception is about respondents' abilities to present information/lessons (e.g., Microsoft PowerPoint), and the other concerns use of a variety of media and formats, including telecommunications, to collaborate, publish, and interact with peers, experts, and other audiences.

Two perceptions scored statistically significant correlations with the frequency of use of the lowest number (3) of ICT tools. Those are "I am proficient in the use of common input and output devices; I can solve routine hardware and software problems; I can make informed choices about technology systems, resources, and services" and "I can use technology tools (e.g. electronic mail, WhatsApp, Messenger) and resources (e.g., computers, mobile phones) for managing and communicating information".

The frequency of use of a computer/laptop, and videos and simulations are the only ICT tools that correlated statistically significantly with all thirteen (13) perceptions. They are followed by a projector, which did with twelve (12) perceptions, and the Internet with ten (10). This shows that the respondents tend to use computers more often when the perception of their competence is more positive. The extent of printer use did not statistically significantly correlate with any perception. The electronic mail did not correlate statistically significantly with nine (9) perceptions whilst the flash drive did not with eight (8) perceptions.

The strongest correlation was between the perception that the respondents were able to troubleshoot common computer problems and the extent of use of the projector, $r_s(89) = .49$, $p = .00$. It is followed by the one between the perception that respondents "can use a variety of media and formats, including telecommunications, to collaborate, publish, and interact with peers, experts, and other audiences" and the frequency of use of the videos and simulations, $r_s$ (91) = .48, $p$ = .00. The effect sizes are large for both. The $r_s$ squared values indicate that knowing how positively teachers hold the perception that they are able to troubleshoot common computer problems may help predict approximately twenty-four per cent (24%) of the variance in frequency of use of the projector. Also, twenty-three per cent (23%) of the variance of the extent of use of the videos and simulations can be predicted from knowledge of how positively teachers perceive their ability to use a variety of media and formats to collaborate, publish, and interact with peers, experts, and other audiences. These percentages are the amounts that the stated perceptions and the frequency of use of the said ICT tools have in common. They are large enough to help in predicting the extent of use of the tools from knowing the perceptions held.

Generally, there are weak correlations between the respondents' perceptions on the use of ICTs for teaching biology and the extent to which respondents use the investigated ICT tools. However, the correlations are generally positive. Therefore, the strongly positive perceptions of the teachers on the use of ICTs for teaching-learning activities may not be a reliable basis for assuming or expecting high frequency of use of ICT tools as proposed in section 4.3.1.

# CHAPTER 5. DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

## 5.1. Introduction

This chapter outlines the way the current study was carried out, and deliberates on its key findings and their implications. The discussion of the findings is articulated based on the research questions and aims stated in the first chapter. Recommendations derived from the findings of the study are provided, as well as recommendations for future studies. Finally, the conclusions of the study are presented.

## 5.2. Overview of the study

The principal purpose of the study was to examine Lesotho General Certificate of Secondary Education biology teachers' perceptions on the influence of ICTs on educational practices. It was planned to be achieved by responding to the primary question: 'What are the teachers' perceptions on the use of information and communication technology for teaching biology in Lesotho secondary schools?' This question was complemented by the following subsequent questions:

(a) What are the perceptions of Lesotho biology teachers on the use of ICTs?
(b) Which ICT tools do Lesotho biology teachers commonly choose to use?
(c) Which practices characterise the patterns of ICTs use by biology teachers in Lesotho?
(d) What is the correlation between teachers' perceptions and use of ICTs in teaching?

The technological pedagogical content knowledge model was implemented as the theoretical framework to guide the study as it is a common practice with ICT-related research. The framework offered conceptual lenses, descriptive and inferential, for the researcher to understand the phenomena being studied. It provided the concepts, structure and terminology to describe the relationship of teachers'perceptions on technology use and their use to teach biology (Koehler & Mishra, 2015). It provided the researcher with the appropriate language to express, conceptualise and investigate connections between these two phenomena. Furthermore, TPACK assisted the reseacher beyond just understanding the teachers' perceptions on teaching of biology using ICT, but also drawing conlusions, anticipating and generating inferences about contexts within which the teachers' perceptions and their frequency of ICT use interact (Koehler & Mishra, 2015).

The study used a quantitative approach and was conducted within the positivist paradigm. A descriptive, non-experimental survey design following a deductive strategy was used as it is a common practice with positivist studies (Creswell & Creswell, 2017; Bhattacherjee, 2012; Crowther & Lancaster, 2012). A questionnaire was administered to biology teachers in eight (8) districts of Lesotho, namely Butha-Buthe, Berea, Leribe, Maseru, Mafeteng, Mohale's Hoek, Quthing and Thaba-Tseka. The respondents had been selected using a systematic probability sampling technique. One hundred and seven (107) copies were filled and collected from the schools of the respondents. Following the collection, cleaning and coding, the data were analysed using the IBM SPSS Statisctics version 26 program for descriptive and inferential statistics.

## 5.3. Discussions of key findings and their Implications

The current study primarily aimed to determine the teachers' perceptions on the use of ICT for teaching biology in Lesotho junior and senior secondary schools. The discussion of the findings and their implications is organised in line with the four objectives the research sought to achieve:

(a) Determining the perceptions of Lesotho biology teachers on the use of ICTs,
(b) Investigating the ICT tools that biology teachers commonly choose to use,
(c) Describing the practices that characterise the patterns of ICT use by biology teachers, and
(d) Determining the correlation between biology teachers' perceptions and their use of ICTs for teaching.

### 5.3.1. Teachers' perceptions on the use of ICTs

The results show that the majority of teachers strongly agree that ICTs are useful to the teaching of biology. That is, teachers have strong positive perceptions on the use of ICTs for teaching as presented in Chapter 4 (section 4.3.1, page 60). Similarly, most respondents agreed that the use of ICTs benefits learning processes and impacts positively on the listed learners' attributes as presented in Chapter 4 (section 4.3.2 page 64).

The findings of this study concerning teachers' perceptions of ICT use are consistent with findings by Karaseva, et al. (2015) and Kalanda and De Villiers (2013) that the science (biology included) teachers held optimistic perceptions regarding ICTs' worth in instruction. Karaseva, et al. (2015) interviewed primary and secondary language and science (including biology) teachers in Estonia and Latvia. They "aimed to reveal how pedagogical beliefs and subject cultures shape the ways primary and secondary school teachers mediate students` use of digital technolog" (2015:1). They found science teachers to have optimistic opinions concerning ICTs' worth in instruction. Kalanda and De Villiers (2013) conducted their study in a Lesotho context. They established that most science teachers perceived the modern e-learning technologies as means to aid them to illustrate numerous scientific activities to their learners. Also, that the majority thought that animations and simulations enhanced learners attainment of scientific skills.

Based on this finding, one would expect that the teachers' use of ICTs for teaching would be high. The expectation stems from the research-supported premise that a resolve to use any technology is dependent on various factors and the perceived utility of that technology (Asamoah & Oheneba-Sakyi, 2017; George & Ogunniyi, 2016; Burda & Teuteberg, 2014). There is no doubt this result pronounces that respondents perceive ICTs as being instrumental to the teaching and learning of biology. The implication is that teachers view the use of technology as a means to making teaching and learning the subject quicker, easier and enjoyable. In addition, it is also regarded as a means to enhance learners' swift understanding of the subject's complex and abstract concepts, because ICTs can clearly show difficult to observe organisms, life processes and phenomena within a short period of time (Cohen, et al., 2018; Li, 2011). It is also a useful tool to boost learners' interest in the subject (Razavi, et al., 2015). Studies have confirmed better transformation of the learning of science (Elliot, et al., 2014) and improved achievement (Gambari, et al., 2014) with the use of ICTs than with traditional methods. For example, Starbek, Starčič, Erjavec and Peklaj (2010) found that learners taught genetics through computer animations gained enhanced knowledge and finer comprehension skills than their peers taught with traditional methods and by reading text only.

All these affordances, presented by technology use, are required to solve problems leading to poor performance in biology in Lesotho schools. Therefore, if the teachers truly strongly hold positive perceptions of technology use in teaching-learning experiences, it is only logical to expect them to at least use it frequently, particularly if the extent of use would be found to strongly correlate positively with the perceptions. Therefore, it was important for this study to test the proposition and determine if it would hold true for the sampled biology teachers or not. First, the study sought to establish the possibility of restricted or non-use of ICTs in instruction being attributed to perceptions. Subsequently, to think of other possibilities leading to limited ICT integration if that would be the case. The researcher wanted to determine the nature of the problem as stated in Chapter 1, section 1.3. Regarding the use of ICTs in education, teachers' partialities may arise from a collection of composite factors (Karaseva, et al., 2015). This study investigated the availability of technology tools, which is one of the factors found to affect their application in teaching (Abdullah, et al., 2006; Cox, et al., 2000). The researcher found that most respondents have reasonable access to technology, and thus, its potential effect has been eliminated. That is, little or no ICT integration in teaching may not be attributed to lack of resources in the context of this study.

With regard to the perceived ICT competence, managing and communicating information through computer and mobile phone applications, such as electronic mail, WhatsApp, and Messenger, were moderately mastered by the majority as it scored the highest mean. These applications involve texting or word processing. Correspondingly, word processing was among the applications that most respondents reported to be moderately competent in. It scored the second highest mean. This means the teachers have at least basic knowledge of word processing. This result agrees with the finding by Buabeng-Andoh (2012a) and Francisca and Samsudin (2018) that most biology teachers reported higher competency on the MS Word processing application than other computer applications. Šorgo, et al. (2010) also found that MS Word was the most frequently used tool for academic activities.

The finding that most respondents rated themselves as slightly competent in “troubleshooting common computer problems" and “proficiency in the use of common input and output devices, solving routine hardware and software problems, and making informed choices about technology systems, resources, and services” has serious implications to both teaching and learning of biology in Lesotho schools.

Firstly, literature has indicated that the level of competency, comfort or confidence in the use of technology directly affects the intention to integrate it in instructional processes. Deaney and Hennessy (2007) and Veen (1993) confirm that competency and passion for ICT use to be among the topmost determinants of use of ICTs in instruction. Harrell and Bynum (2018) also point out that low or a lack of confidence in the usage of ICT tools lead to decreased teachers’ perceptions of its worth. Consequently, the tools are not used to their full potential. Therefore, the irregular use of ICTs in teaching activities is more likely to be attributed to the reported moderate ICT competence of Lesotho biology teachers rather than their perceptions of the value of ICT use, especially because the latter has been found to be strongly positive. This has implications for in-service and preservice teacher training. The teacher training programs may have to be revised to empower the prospective teachers. Also, professional development programs for the practising teachers may have to be considered by either the teachers themselves or education authorities.

Secondly, with teachers having low TK or being slightly competent, the learners are deprived of the benefits that technology has been empirically confirmed to provide for the teaching and learning processes. Section 2.2.6 emphasised the necessity of TK in educational processes. The researcher contends it is of the utmost importance to cherish the opportunities and possibilities that diverse modes of modern technologies offer for representing subject matter in instrutional contexts, as indicated by Koehler and Mishra (2015), Koehler, et al. (2013), Koehler, et al. (2007), Schmidt, et al. (2009), and Mishra and Koehler (2008). In addition, this finding reflects low TPK, which, as discussed in section 2.2.8, was to encompass awareness of the existence of a variety of tools for a specified educational experience, capacity to select an apparatus for its suitability, techniques for taking advantage of the tool's affordances, knowledge of teaching tactics and capability to organise them for technology integration (Mishra & Koehler, 2006). This is consistent with the conclusion by Veen (1993) that the teachers' expertise in teaching with ICTs and/or suitably incorporating them form part of the determining factors. This means that the level of teachers' technological and pedagogical proficiency is also important. The result (moderate ICT competence) is in agreement with the finding by Lisene and Jita (2018) that Lesotho physical science teachers had a low TPACK. There are overlaps between the physical science teachers and biology teachers involved in Lisene's (2017) study and the current study, especially in terms of the districts and/or schools under study. The studies are likely to have common respondents.

Teachers need to be more than satisfactorily competent and knowledgeable for them to make informed decisions concerning technology systems, resources and services relevant to the successful teaching of biology. Therefore, there might be a need for the education authorities and relevant stakeholders in Lesotho to put some measures in place to remedy this situation. In fact, research shows that globally countries and schools have taken measures towards technology integration (Cubukcuoglu, 2013; Cakir, 2012). For instance, investments were made in Turkey to improve the schools' ICT infrastructure such that generally, the "secondary and high schools have two smart rooms that include an interactive whiteboard and scanner and almost all schools have an Internet connection" (Cubukcuoglu, 2013:51). School principals in Sweden assumed the duty of training learners in cloud computing (Lim, et al., 2015)

Kalanda and De Villiers (2008) report inadequate professional development to be among the obstacles to teaching with ICTs in Lesotho schools. Kalanda and De Villiers (2013) added that adequate hardware and software resources, and suitable professional development systems would markedly aid teachers to implement e- learning in their instruction. This study has revealed that there has not been much improvement in this regard. A notable percentage of teachers are only slightly competent in troubleshooting common computer problems, as well as in the use of common input and output devices, solving routine hardware and software problems, and making informed choices about technology systems, resources, and services.

The means a general average out at 2.70, which is approximately 3. Also, the standard deviation is very close to 1 for all the items. These statistics indicate that most of the respondents are moderately competent in ICT use. Only a few respondents are slightly competent or very competent whilst very few are unable to use technology.

### 5.3.2. Commonly used ICTs

The researcher decided to first determine which technology tools were available for use, the extent to which each tool is used, and the purposes of using it. This was done in the interest of completeness, more meaningful and corroborated results. Nonetheless, what matters for the purpose of the current study are the ones that are the most commonly used. It must be noted that the data collection instrument had made provision for the respondents to fill in the ICT tools they use but were not listed in the instrument. However, the eight (8) that were listed emerged to have been the ones that are in common use. Also, the instrument used for the pilot study had more tools, some of which did not do well and were therefore removed from the list in the final instrument used for data collection.

#### *5.3.2.1.* Availability

Irrespective of whether at home or school, the finding is that all eight (8) investigated ICT tools are at least reasonably accessible for use by the biology teachers. Findings indicate that the tools that are accessible at the workplace (schools), to a strikingly greater majority of respondents are the printer (93.5%) and computer/laptop (82.2%). On the other hand, findings indicate that at home, mobile phones (98.1%) and flash drives (83.2%) were the most used tools, which also happen to be the third and fourth most accessed in schools. Therefore, mobile phones, printers, computers/laptops and flash drives were found to be the topmost ICT tools available for general use. The rest are simply satisfactorily available.

#### ***5.3.2.2.*** **Purpose of use**

It has been established that the tools are at least reasonably accessible and the respondents have positive perceptions of their use in instruction. As indicated in sections 2.4.4 and 4.4.2, purposes of use are divided into teaching and non-teaching categories.

Regarding teaching purposes, the findings revealed that compared to others, the technology tool that is used by a significantly high number of respondents (N=107) is the printer (83). It is followed by the Internet (64) and then equally popular, computer/laptop (61) and projector (61). The projector and Internet moved to the top four from the fifth and sixth positions, respectively, in the list of those available in schools. They have taken the positions of the mobile phone and flash drive, which top the chart of availability of ICTs at home. Lisene and Jita (2018) also found Lesotho physical science teachers to commonly use computers and the Internet, as well as mobile phones, mostly for teaching. Considering the results for computer and printer, it may seem that there is a mismatch because printing is directed from a computer. So, the results for computer would logically be expected to match with results for printer. The likely explanation for the notable difference is that the printers are used for multiple functions such as photocopying and scanning as well, which were not even mentioned by the respondents.

For non-teaching purposes, electronic mail is used by the majority of those who responded although it is the ICT tool that is least used for teaching. Therefore, the implication is that the respondents have electronic mail accounts and can actually use them. They just prefer using their electronic mail accounts mostly for non-teaching rather than teaching purposes. This is in agreement with the finding that electronic mail was one of the ICTs most frequently used by Australian teachers, though for private communication rather than for teaching of science (Dawson, 2008), and by nearly 100% of Brazilian teachers (Rolando, et al., 2013). This is probably due to their significance in correspondence (Lee & Mautz, 2012). Contrary to this finding, 66.4% of Swedish school principals were found to use electronic mail and around 70% of schools used, or at least intended to use, electronic mail (Lim, et al., 2015).

For non-teaching purposes, the least used technologies are the Internet (24), projector (24) and printer (11). This could be expected because few respondents have access to a projector and printer at home. It is a bit unexpected that the Internet and mobile phone are used for non-teaching purposes by such low numbers of respondents, especially when they are accessible to so many at home. It is quite anecdotal knowledge that many teachers have mobile phones which they use to access the Internet. They use them for WhatsApp messaging, calling, Facebook, Twitter and other applications. Electronic mail is an Internet tool, so its use should tally with that of using the Internet. Besides, the Internet was found to be one of the ICTs most frequently used by Australian teachers (Dawson, 2008) and Lesotho physical science teachers (Lisene & Jita, 2018). However, the result for Internet use is consistent with the finding by Rolando, et al. (2013) that biology teachers inadequately use it for didactic reasons. Instead, they customarily use Internet tools, such as electronic mail, search, and download for social relations.

#### ***5.3.2.3.*** **Extent of use of ICTs**

The results reveal that all eight technology tools are used. The tools that are used most frequently are the mobile phone (M = 4.39, SD =1.037) and the Internet (M =3.98, SD =1.183). The standard deviations show that the tools are used with frequency ranging from at least once a month to almost daily. However, their means (approximately 4) indicate that the majority of the respondents use them regularly. That is, at least once a week. Almost equally used technology tools are computers/laptops (M= 3.56, SD =1.113) and printers (M = 3.55, SD =1.250). From these results, it is inferred that the teachers access the Internet predominantly on their mobile phones rather than from computers. The inference is strengthened by the fact that mobile phones are the most accessible tools at home and the third most accessed in schools.

The least frequently used are videos and simulations (M= 2.51, SD =1.449) and projectors (M= 2.05, SD =1.270). It is understandable to find both at the bottom of the list because videos and simulations would best be shown to learners using a projector. The standard deviations hint that some respondents do not use either the projector or videos and simulations at all. From these findings, one may posit that computers are used mainly for typing and printing materials, searching for information and sharing it on the Internet, or using it for lesson preparations and probably for administrative purposes. Šorgo, et al. (2010: 43) also confirmed that Slovenian biology teachers used "computers for school work mainly as typewriters, as a source of information and a communication tool, for their preparation, tests and administration outside the classroom, most often at homes". However, the practices that typify patterns of use (section 5.3.3) should better shed light in this regard.

The overall mean score for the frequency of use of these eight ICTs was 3.25 and the average standard deviation was 1.241. Thus, the frequency of use ranges mainly from very irregular to regular and the overall use of the ICTs is irregular. That is, they are mostly used at least once a month.

### 5.3.3. Practices that characterise patterns of use of ICTs

The practices that characterise patterns of use indicate what teachers actually do with these ICTs in teaching. Whether they use them to support traditional teaching strategies, learner-centred activities, or use them mostly for non-teaching purposes.

The practice "searching for information on the Internet and information storage devices to prepare for lessons" (M = 3.66, SD = 1.247) is regular to most respondents. The standard deviation shows that some respondents perform this activity irregularly, others very regularly, but most of them regularly (at least once a week). Šorgo, et al. (2010) found the same result, that Slovenian biology teachers search for information on the Internet at least once a week. The result is also in agreement with results of the study by Karaseva, et al. (2015) that science teachers treasured resources obtained ready to use on particular online platforms, which also had "lesson plans, worksheets and other learning materials suitable for their purposes” (p 7). The practice was followed by “using printers and scanners to produce handouts showing different representations (textual, graphical, and diagrammatic) of biology content for learners” (M = 3.24, SD = 1.404). The latter scored an almost equal mean as two others; “assessing learners’ learning through tests/quizzes” (M = 3.12, SD = 1.465), and “using mobile applications such as WhatsApp, Messenger, Facebook, SHAREit, Wi-Fi-Direct, etc. for teaching purposes, information exchange, and discussion forums with and for learners” (M = 3.05, SD = 1.376). The average of mean values for the last three practices is approximately 3. The standard deviations indicate that some respondents engage very irregularly (at least once a term) in the three practices, others regularly, whilst the majority use it at least once a month (irregularly). In the current study, the respondents’ use of ICT incline more to these four practices.

These findings correspond with the finding for the commonly used ICTs, or rather their extent of use. Therefore, the inference made in section 5.3.2.3 is confirmed. Computers are used predominantly for typing and printing materials, searching for information and sharing it on the Internet, or using it for lesson preparations. The use of computers, mobile phones, printers and the Internet as the most prevalent to the majority of the respondents has already been presented in the previous section and is substantiated by these findings. Correspondingly, Bhalla (2013) also found that the majority of Indian central school teachers used computers in didactic activities, either about once a week or once a month, to design their instruction, improve their learning, research instructional matter, and to find supplementary teaching matter. Thus, the implication might be that teachers use ICTs to support teacher-centred teaching strategies. It was found that, in Ghanian schools, teachers kept to their teacher-centered delivery of education despite the introduction of ICTs in teaching (Buabeng-Andoh, 2012a). This is why some teachers would use ICTs such as the Internet simply as a resource that plays a part in their instructional strategies (Wallace, 2000).

From the results discussed thus far, it is evident that Lesotho secondary school biology teachers are not using computers much in actual instruction. This is further substantiated by the practices of “using computers for drill-and-practice and tutorial software packages” and “using Microsoft PowerPoint to present lesson content, show pictures, diagrams, videos, and simulations to teach or facilitate discussions”. Despite respondents being moderately competent in PowerPoint presentations, these two are the most “very irregularly” performed practices by the respondents. Computer programs such as Microsoft Picture It!, Paint, and Movie Maker to create pictures, posters, diagrams, or animations for use in teaching were never used by the majority of the respondents. This indicates that videos and simulations, and animations, were never, or very rarely used. This confirms the finding presented in section 4.4.3 “least frequently used are the videos and simulations (M= 2.51, SD =1.449) and projector (M= 2.05, SD =1.270)”. This finding is consistent with Maharaj-Sharma, et al. (2017), who found that animations, hands-on practical activities, virtual laboratories, and computer-aided simulations were less commonly used ICT-based technologies in classroom science teaching. This corresponds with the finding by Mwanda, et al. (2017), that the majority of Kenyan biology teachers in the Rachuonyo South sub-county schools did not use PowerPoint presentations during their lessons. However, this finding is contrary to the ones made by scholars on other continents, for instance, Maharaj-Sharma, et al., (2017) in Trinidad and Tobago, and by Dawson (2008) in Australia. Maharaj-Sharma, et al. (2017) discovered that the majority of teachers used PowerPoint extensively in classroom science teaching. In an earlier study, Dawson (2008) had also found PowerPoint to be one of the most regularly used ICTs by science teachers, along with electronic mail, the Internet and word processing.

From the findings of the study, it seems that Lesotho biology learners have been deprived of certain benefits that ICTs have been found to offer. ICTs generally guarantee “quick and easy access to superior photographs, images, diagrams and other two-dimensional (2D) representations along with three-dimensional (3D) simulations, animations and video clips for teachers and students” (Van Rooy, 2012:66) and thus affording learners learning activities not presented by other approaches (Wellington, 2005). Starčič Erjavec and Peklaj (2010) found that learners taught genetics through multimedia that incorporated computer animations gained enhanced knowledge and finer comprehension skills than learners taught in conventional lectures and by only reading text. This is probably because using multimedia resources lead to greatly diverse learning experiences (Elliot, et al., 2014).

The rest of the practices had mean values ranging from 2.09 to 2.93. The average of the mean values for all 15 items on educational practices that characterise patterns of ICT use was found to be 2.65. This is indicative of overall irregular ICT-related practices. Therefore, the prevailing patterns of ICT teaching and learning practices continue to deny biology learners the plethora of benefits ICT adoption could afford them.

With regard to non-educational practices, most of respondents reported to regularly using mobile applications, such as WhatsApp, Messenger and Facebook for chatting or socialising with other people. This is consistent with the finding that the mobile phone is the topmost accessed ICT tool at home and third most accessed in schools. However, the mobile phone is one of the least used for teaching purposes, yet the fourth most used for non-teaching purposes. It is followed by a slightly less regular use of the Internet for fun, downloading and/or watching or listening to music, and other personal purposes such as shopping. The former practice is the topmost prevalent, and the latter the third most of all 20 listed practices. The results show that the majority of the biology teachers use the said mobile applications for socialising slightly more often than they use them for teaching purposes, information exchange, and discussion forums with and for learners. This is probably because the respondents can perform both practices via their mobile phones from home and at school.

### 5.3.4. Correlation between teachers' perceptions and their use of ICTs

The researcher has found that the Lesotho high schools biology teachers hold strongly positive percetions of the use of ICTs in teaching and learning, and also on the impact of ICTs on learners' attributes. In addition, they generally perceive themselves as being moderately competent in using ICTs. Their overall extent of use of ICTs in teaching-learning processes, which is also manifested in their ICT practices that characterise patterns of use, is irregular. This means ICTs are basically used at least once a month by the majority of Lesotho schools biology teachers. This finding affirms a discovery by Palak and Walls (2009) that teachers' beliefs are not the strong predictors of their practices. As corroborated by the findings of the current study, Palak and Walls (2009) and Buabeng-Andoh (2012a) established that teachers' ICT practices do not shift despite being comfortable with technology, having technological support, access to technology and optimistic perceptions towards it.

The results of this study have revealed a generally positive Spearman correlation coefficient between the teachers' perceptions and the frequency of ICT use. Though the correlation was found to be weak for most perceptions, it was moderately strong with a few perceptions of ICT competency. The correlation was also generally statistically significant. In an earlier similar study, Kalanda and De Villiers' (2013) outcomes of the analyses of statistical regression ($R^2 = .418$, $p = .005$) and Pearson correlation coefficient ($r = .42$) indicated a positive association between Lesotho science (in general) teachers' perception of ICTs use and their actual use of ICTs. The result was in agreement with Šorgo, et al., (2010) who also discovered a strong positive association between frequency of use of computers, their perceived worth and teachers' proficiency in the use of ICTs. Therefore, the findings indicate that the more the teachers realise the value of implementing ICTs in teaching, the more often they will use them in instruction.

## 5.4. Conclusions and recommendations

The high school biology teachers in Lesotho hold positive perceptions on the use of ICTs for teaching. Furthermore, the mean values indicate that the respondents rated themselves as moderately competent in the implementation of ICTs to teach biology. This means they are generally comfortable, at a basic level, to use technology tools and make ICT-related decisions in the teaching of the subject.

There are numerous skills of which a noteworthy number of teachers reported to have very low mastery. Therefore, meticulous effort and investment should be considered by relevant authorities in education to upgrade teachers' ICT competencies and maintain their perceptions positive. The schools' administrators, the Ministry of Education and

Training, and teachers themselves can organise teacher professional development programmes on the educational use of technology. According to Buabeng-Andoh (2012b:147), “Teachers’ professional development is a key factor to successful integration of computers into classroom teaching”. ICT policy and its implementation may have to be revised to ensure appropriate and effective implementation in secondary schools’ education, as well as in teacher-training programmes.

Future research may be required to investigate the status of TK, TPK and TPACK of Lesotho biology teachers, as well as factors attributed to it. The research-informed recommendations would be made as to how technology should be productively used to deliver the abstract and complex biology content. This may lead to the right measures ensuring that teachers are adequately knowledgeable and competent in the selection of the appropriate ICTs to effectively deliver specific biology content being taken.

If time would allow, the study could be extended to included direct observations on the ICT tools that the teachers use, how they use them and whether or not the use of ICT affects the planning and presentation of lessons. Convenience visits to selected schools could enhance the validity of data. Also, after the current study, extending studies; during and post COVID 19, would be recommended. In such future studies, triangulation of approaches (qualitative and quantitative) and data sources would be important to consider.

Despite the positivity of their perceptions on the usefulness of the use of ICTs to teach, their perceived capabilities in instructive use of ICTs, and also ICTs being available for use, the majority of teachers still have some resistance to change to the kind of ICT-aided instruction that is predominantly learner-centred. This has been evident in the results on the extent of use, which has been found to be irregular overall. Amongst many modern technologies useful in teaching and learning, only four (4) are reported to be in regular use by the majority of the biology teachers in Lesotho. These tools are the mobile phone, Internet, computer/laptop and printers. The reviewed literature has indicated the likelihood of these tools being used to support transmission of knowledge to learners.

The practices that characterise patterns of use seem to be inclined to supporting teachers' own teaching methods and improving their knowledge. Most teachers never use animations, simulations, videos and projectors in teaching, as portrayed by the histograms and also descriptive statistics. Therefore, the learners are deprived of the benefits such as affording learners learning activities not presented by other approaches (Wellington, 2005), enhanced comprehension of the abstract biological content (Starčič Erjavec & Peklaj, 2010), and a better grasp of particular cell biology concepts. These benefits are not achieved by motionless representations, as animations, videos and simulations more precisely depict certain processes learnt in cell biology (Stith, 2004).

The study has revealed a weak positive statistically significant Spearman correlation between the correlated variables. This means that the teachers who use ICTs tend to have positive perceptions regarding the benefits of ICT use for teaching. Therefore, the hypothesis of no association between the teachers' perception on the use of ICTs for teaching biology in Lesotho schools and the actual use of ICTs is rejected.

The findings of this study have revealed the ICT-related problem areas in the teaching of biology in Lesotho high schools; inadequate competencies and likely traditional teaching strategies. Adoption of the recommendations of this study may help curb the poor performance in mathematics and science as reported by Lekhetho (2013) and in biology as reported by Lebata and Mudau (2014).

## REFERENCES


Abdullah, N., Abidin, M., Luan, W., Majid, O. & Atan, H. 2006. The attitude and motivation of English language teachers towards the use of computers. *Malaysian Online Journal of Instructional Technology,* 3(1):7-67.

Adewale, A.M., Nzewuihe, G. & Ogunshola, F. 2016. Academic performance in biology at Secondary School Certificate Examination (SSCE) and the influencing factors among students in Owerri Municipal of Imo State, Nigeria. *International Journal of Education and Evaluation,* 2(1):1-10.

Ahmed, M. 2008. *Influence of personality factors on biology lecturers' assessment of difficulty levels of genetics concepts in Nigerian colleges of education.* (Doctoral dissertation). Ilorin: University of Ilorin, Nigeria.

Ahmed, M. & Abimbola, I. 2011. Influence of teaching experience and school location on biology teachers' rating of the difficulty levels of nutrition concepts in Ilorin, Nigeria. *Journal of Science, Technology, Mathematics and Education (JOSTMED),* 7(2): 52-62.

Ahammed, M. 2018. *The impact of using ICT on EFL learners' reading comprehension skills: A case study, semester seven, Batch (37), (2017)* (Doctoral dissertation). Gezira, Sudan: Universty of Gezira.

Ajaja, P. 2013. Which way do we go in biology teaching? Lecturing, concept mapping, cooperative learning or learning cycle? *International Journal of Science and Technology Education Research,* 4(2):18-29.

Ajjan, H. & Hartshorne, R. 2008. Investigating faculty decisions to adopt Web 2.0 technologies: Theory and empirical tests. *The Internet and Higher Education,* 11(2):71-80.

Akinfe, E., Olofinniyi, O. & Fashiku, C. 2012. Teachers' quality as correlates of students' academic performance in biology in senior secondary schools of Ondo State, Nigeria. *Online Journal of Education Research,* 1(6):108-114.

Alafiatayo, B., Anyanwu, R. & Salau, O. 2016. Effect of selected teachers' abilities on students' attitudes and academic performance in biology among secondary schools in Sabon-Gari Local Government Area, Kaduna State, Nigeria. *Journal of Research & Method in Education,* 6(2):24-29.

Albert, O., Osman, A. & Yungungu, A. 2014. An investigation of factors that influence performance in KCSE biology in selected secondary schools in Nyakach District, Kisumu County, Kenya. *Journal of Education and Human Development,* 3(2):957-977.

Albion, P.R. 1999. Self-efficacy beliefs as an indicator of teachers' preparedness for teaching with technology. In J. Price, J. Willis, D. Willis, M. Jost & S. Boger-Mehall (Eds.). Proceedings of SITE Society for Information Technology & Teacher Education International Conference. Waynesville, NC: Association for the Advancement of Computing in Education (AACE). (pp. 1602-1608).

Aldrich, J. O. & Cunningham, J. B., 2016. *Using IBM SPSS Statistics.* 2nd ed. Thousand Oaks: SAGE Publications, Inc.

Al-Zaidiyeen, N., Mei, L. & Fook, F. 2010. Teachers' attitudes and levels of technology use in classrooms: The case of Jordan schools. *International Education Studies,* 3(2):211-218.

Angeli, C. & Valanides, N., 2005. Preservice elementary teachers as information and communication technology designers: An instructional systems design model based on an expanded view of pedagogical content knowledge. *Journal of Computer Assisted Learning,* 21(4):292-302.

Angeli, C. & Valanides, N. 2009. Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers and Education,* 52(1):154-168.

Angeli, C. & Valanides, N., 2014. Technological pedagogical content knowledge: Exploring, developing, and assessing TPCK. New York: Springer.

Angeli, C., Valanides, N. & Christodoulou, A., 2016. Theoretical Considerations of Technological Pedagogical Content Knowledge. In: M. Herring, M. Koehler & P. Mishra, eds. *Handbook of Technological Pedagogical Content Knowledge (TPACK) for Educators.* New York: Routledge:11-32.

Araoye, M. 2013. Redressing students' motivation and academic achievement in biology education at the Federal College of Education (Special), Oyo Oyo State, Nigeria: *New Perspectives in Science Education,* https://conference.pixel-online.net/conferences/npse2013/common/download/Paper_pdf/071-ESM01-FP-Araoye-NPSE2013.pdf

Arokoyu, A. & Chukwu, J.C. 2017. Biology teachers' methods of teaching and academic performance of secondary school students in Abia State, Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS),* 8(4):228-231.

Ary, D., Jacobs, L.C. & Sorensen, C. 2006. *Introduction to research in education* .(7th ed.). Belmont, CA: Wadsworth.

Asamoah, M.K. & Oheneba-Sakyi, Y. 2017. Constructivist tenets applied in ICT-mediated teaching and learning: Higher education perspectives. *Africa Education Review*, 1753-5921.

Ayaz, M.F. & Şekerci, H. 2015. The effects of the constructivist learning approach on student's academic achievement: A meta-analysis study. *Turkish Online Journal of Educational Technology,* 14(4):143-156.

Bahufite, E. 2017. Application of the constructivist methods of teaching-learning through the use of ICTs in Zambia schools: A case of selected secondary schools in Lusaka. *International Journal of Scientific & Engineering Research,* 8(12):848-862.

Bakar, N. 2007. Factors that contribute to the effective use of computers in the classroom: the Malaysian context. *AsiaCall Online Journal,* 2(1):26-33.

Bangert, A. 2008. The influence of social presence and teaching presence on the quality of online critical inquiry. *Journal of Computing in Higher Education,* 20(1):34-61.

Beck, R.N. 1979. *Handbook in social philosophy.* New York: Macmillan.

Bhalla, J. 2013. Computer use by school teachers in teaching-learning process. *Journal of Education and Training Studies,* 1(2):174-185.

Bhattacherjee, A. 2012. *Social science research: Principles, methods, and practices.* (2nd ed.). Tampa, FL: University of South Florida. (USF Open Access Textbooks Collection. Book 3.)

Bingimlas, K.A. 2009. Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science and Technology Education,* 5(3):235-245.

Bransford, J.D., Brown, A.L. & Cocking, R. 2000. *How people learn: Brain, mind, experience, and school.* (Exp. ed.), Washington, DC: National Academies Press.

Brown, P., Friedrichsen, P. & Abell, S. 2013. The development of prospective secondary biology teachers PCK. *Journal of Science Teacher Education,* 24(1):133-155.

Buabeng-Andoh, C. 2012a. An exploration of teachers' skills, perceptions and practices of ICT in teaching and learning in the Ghanaian second-cycle schools. *Contemporary Educational Technology,* 3(1):36-49.

Buabeng-Andoh, C. 2012b. Factors influencing teachers' adoption and integration of information and communication technology into teaching: A review of the literature. *International Journal of Education and Development using Information and Communication Technology (IJEDICT),* 8(1):136-155.

Burda, D. & Teuteberg, F. 2014. The role of trust and risk perceptions in cloud archiving-Results from an empirical study. *The Journal of High Technology Management Research, 25*(2):172-187.

Cakir, R. 2012. Technology integration and technology leadership in schools as learning organizations. *Turkish Online Journal of Educational Technology,* 11(4):273-282.

Chand, B. 2017. A constructivism approach towards integration of ICT for collaborative learning. *Scholarly Research Journal for Interdisciplinary Studies,* 6(26):7213-7220.

ChanLin, L., Hong, J., Horng, J., Chang, S. & Chu, H. 2006. Factors influencing technology integration in teaching: A Taiwanese perspective. *Innovations in Education and Teaching International,* 43(1):57-68.

Chere-Masopha, M.J. 2011. *Integrating technology in classroom practices: The influence of teacher professional identities in secondary schools in Lesotho*. (Doctoral dissertation). Wollongong, NSW, Australia: University of Wollongong. https://ro.uow.edu.au/theses/3543/

Cimer, A. 2012. What makes biology learning difficult and effective: Students' views. *Educational Research and Reviews,* 7(3):61-71.

Cohen, L., Manion, L. & Morrison, K. 2007. *Research methods in education*. (6th ed.). New York: Routledge.

Cohen, L., Manion, L. & Morrison, K. 2018. *Research methods in education. (*8th ed.). New York: Routledge.

Collins, H. 2017. *Creative research: The theory and practice of research for the creative industries.* London: Bloomsbury Visual Arts.

Cooper, G. & Hausman, R. 2000. *The cell: A molecular approach (Vol. 10)*. (7th ed.). Washington, DC: ASM Press.

Cox, M. 2004. *Connecting teachers: Can there be models of effective practice for teachers with ICT?* Paper presented at the Becta Annual Research Conference. London. https://slideplayer.com/slide/7487717/

Cox, M., Preston, C. & Cox, K. 2000. *What factors support or prevent teachers from using ICT in their classrooms? Paper presented at the British Educational Research Association Annual Conference*. University of Sussex at Brighton, September 2-5 Brighton: University of Sussex.

Creswell, J.W. 2014. *Research design: Qualitative, quantitative, and mixed methods approaches.* (4th ed.). Los Angeles, CA: Sage.

Creswell, J.W. & Creswell, J.D. 2017. *Research design: Qualitative, quantitative, and mixed methods approaches*. (5th ed.). Thousand Oaks, CA: Sage.

Crowther, D. & Lancaster, G. 2012. *Research methods.* (2nd ed.). London: Routledge.

Cuban, L. 2001. *Oversold and underused: Computers in the classroom.* Cambridge, MA: Harvard University Press.

Cubukcuoglu, B. 2013. Factors enabling the use of technology in subject teaching. *International Journal of Education and Development using Information and Communication Technology,* 9(3):50-60.

Das, S. C., 2015. Segmenting Work Life Balance Practices of Employees in Indian Insurance Industry: A Two-step Cluster Analysis. *PACIFIC BUSINESS REVIEW INTERNATIONAL,* 8(3), 12-23.

Dawson, K., Ritzhaupt, A., Liu, F., Rodriguez, P. & Frey, C. 2013. Using TPCK as a lens to study the practices of math and science teachers involved in a year-long technology integration initiative. *Journal of Computers in Mathematics and Science Teaching,* 32(4):395-422.

Dawson, V. 2008. Use of information communication technology by early career science teachers in Western Australia. *International Journal of Science Education,* 30(2):203-219.

De Vaus, D. & De Vaus, D. 2013. *Surveys in social research.* (6th ed.) London: Routledge.

Deaney, R. & Hennessy, S. 2007. Sustainability, evolution and dissemination of information and communication technology-supported classroom practice. *Research Papers in Education,* 22(1):65-94.

Dekkers, P. 2005. Teaching teachers NOS: Practical examples and classroom experiences. *Science Education International,* 18(30):193-210.

Ding, Q., Li, X., Liu, Y. & Shi, Z. 2012. Research on remote collaborative engineering practices for Master of Software Engineering based on cloud computing environment*. In 2012 IEEE 25th Conference on Software Engineering Education and Training*. Hefei China: IEEE.

Durmaz, B. 2007. The effects of the concept cartoons to the success of the students and sensory features in the constructivist science teaching (Muğla Provincial, Administrative District Sample), (Master's dissertation)*.* Muğla, Turkey: Muğla Sıtkı Kocman University.

Elliot, D., Wilson, D. & Boyle, S, 2014. Science learning via multimedia portal resources: The Scottish case. *British Journal of Educational Technology,* 45(4):571-58.

Ertmer, P. 1999. Addressing first-and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development,* 47(4):47-61.

Ertmer, P.A. 2005. Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development,* 53(4):25-39.

Ertmer, P. & Ottenbreit-Leftwich, A. 2010. Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education,* 42(3):255-284.

Ertmer, P., Ottenbreit-Leftwich, A., Sadik, O., Sendurur, E. & Sendurur, P. 2012. Teacher beliefs and technology integration practices: A critical relationship. *Computers and Education,* 59(2):423-435.

Forgasz, H. 2006. Factors that encourage or inhibit computer use for secondary mathematics teaching. *Journal of Computers in Mathematics and Science Teaching,* 25(1):77-93.

Francisca, A.D. & Samsudin, S. 2018. Are biology pre-service teachers ready to Implement 21st century skill in teaching and learning in Nigeria? *International Journal of Academic Research in Progressive Education and Development,* 7(3):414-423.

Franklin, C., 2004. Teacher preparation as a critical factor in elementary teachers: Use of computers. In *Society for Information Technology & Teacher Education International Conference* (pp. 4994-4999). Association for the Advancement of Computing in Education (AACE).

Gambari, A., Yaki, A., Gana, E. & Ughovwa, Q. 2014. Improving secondary school students' achievement and retention in biology through video-based multimedia instruction. *InSight: A Journal of Scholarly Teaching,* 9:78-91.

George, D. & Mallery, P. 2020. *IBM SPSS Statistics 26 step by step: A simple guide and reference.* (16th ed.). New York: Routledge.

George, F. & Ogunniyi, M. 2016. Teachers' perceptions on the use of ICT in a CAL anvironment to enhance the conception of science concepts. *Universal Journal of Educational Research,* 4(1):151-156.

Ghavifekr, S. & Rosdy, W. 2015. Teaching and learning with technology: Effectiveness of ICT integration in schools. *International Journal of Research in Education and Science,* 1(2):175-191.

Giddens, A. 1979. *Central problems in social theory.* London: Macmillan.

Gómez-Pablos, V., Del Pozo, M. & Muñoz-Repiso, A. 2017. Project-based learning (PBL) through the incorporation of digital technologies: An evaluation based on the experience of serving teachers. *Computers in Human Behavior,* 68:501-512.

Hadley, M. & Sheingold, K. 1993. Commonalities and distinctive patterns in teachers' integration of computers. *American Journal of Education,* 101(3):261-315.

Harrell, S. & Bynum, Y. 2018. Factors affecting technology integration in the classroom . *Alabama Journal of Educational Leadership,* 5:12-18.

Hennessy, S. Ruthven, K. & Brindley, S. 2005. Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution and change. *Journal of Curriculum Studies,* 37(2):155-192.

Hirsh-Pasek, K., Zosh, J., Golinkoff, R., Gray, J., Robb, M. & Kaufman, J. 2015. Putting education in “educational” apps: Lessons from the science of learning. *Psychological Science in the Public Interest,* 16(1):3-34.

Howard, T., Cornuel, E., Thomas, M. & Thomas, H. 2012. Using new social media and Web 2.0 technologies in business school teaching and learning. *Journal of Management Development,* 31(4):358-367.

Hughes, J. 2005. The role of teacher knowledge and learning experiences in forming technology-integrated pedagogy. *Journal of Technology and Teacher Education,* 13(2):277-302.

Irving, K.E., 2006. The impact of technology on the 21st century classroom. *Teaching science in the 21st century*, 3-20.

Jääskelä, P., Häkkinen, P. & Rasku-Puttonen, H. 2017. Teacher beliefs regarding learning, pedagogy, and the use of technology in higher education. *Journal of Research on Technology in Education,* 49(3-4):198-211.

Jansen, J. D., 2016. Introduction to the language of research. In: K. Maree, ed. *First Steps in Research.* Pretoria: Van Schaik Publishers, 15-24.

Jita, T. 2016. Pre-service teachers' competence to teach science through information and communication technologies in South Africa. *Perspectives in Education,* 34(3):15-26.

Jonassen, D.H., & Wang, S. 1999. Acquiring structural knowledge from semantically structured hypertext. *Journal of Computer-Based Instruction,* 20(1):1-8.

Jones, M. & Liu, M. 1997. Introducing interactive multimedia to young children: A case study of how two-year-olds interact with the technology. *Journal of Computing in Childhood Education,* 8(4):313-343.

Judson, E. 2006. How teachers integrate technology and their beliefs about learning: Is there a connection? *Journal of Technology and Teacher Education,* 14(3):581-597.

Kagan, D. 1992. Implication of research on teacher belief. *Educational Psychologist,* 27(1):65-90.

Kalanda, K.A. & De Villiers, R. 2013. E-learning in the science curriculum: A study in selected high schools in Lesotho. In J. Herrington, A. Couros & V. Irvine

(Eds.). Proceedings of EdMedia 2013–World Conference on Educational Media and Technology. Victoria, Canada: Association for the Advancement of Computing in Education (AACE). (pp. 1664-1673).

Kalanda, K. & De Villiers, R. 2008. Toward ICT integration in the science classroom: A comparative study of cases in Lesotho and South Africa. In J. Herrington, A. Couros & V. Irvine (Eds.), Proceedings of EdMedia 2013–World Conference on Educational Media and Technology. Victoria, Canada: Association for the Advancement of Computing in Education (AACE). (pp. 1664-16730.

Kalpana, T. 2014. A constructivist perspective on teaching and learning: A conceptual framework. *International Research Journal of Social Sciences,* 3(1):27-29.

Kapting'ei, P. & Rutto, D. 2014. Challenges facing laboratory practical approach in physics instruction in Kenyan district secondary schools. *International Journal of Advancements in Research & Technology,* 3(8):13-17.

Karaseva, A., Siibak, A. & Pruulmann-Vengerfeldt, P. 2015. Relationships between teachers' pedagogical beliefs, subject cultures, and mediation practices of students' use of digital technology. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace,* 9(1). https://doi.org/10.5817/CP2015-1-6

Keating, T. & Evans, E., 2001. Three computers in the back of the classroom: Pre-service teachers' conceptions of technology integration. In: R. Carlsen, D, Willis, N. Davis. & J. Willis (Eds.). *Society for Information Technology and Teacher Education International Conference (*1671-1676*).* Norfolk, VA: Association for the Advancement of Computing in Education (AACE).

Kelleher, P. 2000. A review of recent developments in the use of information communication technologies (ICT) in science classrooms. *Australian Science Tecahers Journal ,* 46(1):33-38.

Kent, T. & McNergney, R. 1999. *Will technology really change education? From blackboard to web.* Thousand Oaks, CA: Corwin Press.

Khawaji, T.M. 2016. WEB 2.0 Technology: Social learning tools in higher education in Saudi Arabia. (Doctoral dissertation). Brisbane: Queensland University of Technology.

Koehler, M. & Mishra, P. 2015. *The SAGE encyclopedia of educational technology.* Thousand Oaks, CA: Sage.

Koehler, M. & Mishra, P. 2009. What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education,* 9(1):60-70.

Koehler, M., Mishra, P. & Cain, W. 2013. What is technological pedagogical content knowledge (TPACK)? *Journal of Education,* 193(3):13-19.

Koehler, M., Mishra, P. & Yahya, K. 2007. Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers and Education,* 49(3):740-762.

Koehler, M., Mishra, P., Akcaoglu, M. & Rosenberg, J. 2013. The technological pedagogical content knowledge framework for teachers and teacher educators. *ICT Integrated Teacher Education: A Resource Book*, 2-7. http://www.matt-koehler.com/publications/Koehler_et_al_2013.pdf.

Koehler, M., Mishra, P., Kereluik, K., Shin, T. & Graham, C. 2014. The technological pedagogical content knowledge framework. In: J.M Spector, M.D. Merrill, J.Elen & M.J.Bishop (Eds.). *Handbook of Research on Educational Communications and Technology.* New York: Springer Science+Business Media. (101-111).

Koh, J., Chai, C., Benjamin, W. & Hong, H. 2015. Technological Pedagogical Content Knowledge (TPACK) and design thinking: A framework to support ICT lesson design for 21st century learning. *The Asia-Pacific Education Researcher,* 24(3):535-543.

Koseoglu, P. & Efendioglu, A. 2015. Can a multimedia tool help students' learning performance in complex biology subjects? *South African Journal of Education,* 35(4):1-12.

Kothari, C. 2004. *Research methodology: Methods & techniques*. (2nd ed.). New Delhi: New Age International.

Kumar, R. 2019. *Research methodology: A step-by-step guide for beginners*. (5th ed.). New York: Sage.

Lai, H.-J. 2010. Secondary school teachers' perceptions of interactive whiteboard training workshops: A case study from Taiwan. *Australasian Journal of Educational Technology,* 26(4):511-522.

Lazarowitz, R. & Penso, S. 1992. High school students' difficulties in learning biology concepts. *Journal of Biological Education,* 26(3):215-223.

Lebata, M.C. & Mudau, A.V. 2014. Exploring factors affecting performance in biology 5090 at selected high schools in Lesotho. *Mediterranean Journal of Social Sciences,* 5(8):271-278.

Leech, N., Barrett, K. & Morgan, G. 2015. *IBM SPSS for intermediate statistics: Use and interpretation.* (5th ed.). New York: Routledge.

Lee, L. & Mautz Jr, R. 2012. Using cloud computing to manage costs. *Journal of Corporate Accounting & Finance,* 23(3):11-15.

Lekhetho, M. 2013. Stakeholder perceptions about factors that cause poor student performance in Cambridge Overseas School Certificate (COSC) examinations in Lesotho. *International Journal of Educational Sciences,* 5(4):385-395.

Lesotho Government. 2005. *ICT policy for Lesotho final*. Maseru: Government Printing.

Li, L., Worch, E., Zhou, Y. & Aguiton, R. 2015. How and why digital generation teachers use technology in the classroom: An exploratory sequential mixed methods study *International Journal for the Scholarship of Teaching and Learning, 9*(2): Article 9. https://files.eric.ed.gov/fulltext/EJ1134641.pdf .

Li, Y. 2011. On the cultivation of students' interests in biology teaching . *International Education Studies,* 4(2):141-143.

Lim, N., Grönlund, Å. & Andersson, A. 2015. Cloud computing: The beliefs and perceptions of Swedish school principals. *Computers & Education,* 84:90-100.

Lin, T., Tsai, C., Chai, C. & Lee, M. 2013. Identifying science teachers' perceptions of technological pedagogical and content knowledge (TPACK). *Journal of Science Education and Technology,* 22(3):325-336.

Lisene, L.N. 2017. The integration of information and communication technologies into teaching of physical science in Lesotho. (Master's dissertation). Bloemfontein: University of the Free State

Lisene, L.N. & Jita, T. 2018. Exploring the integration of modern technologies in the teaching of physical science in Lesotho. *Perspectives in Education,* 36(1):111-127.

Livingstone, S. 2012. Critical reflections on the benefits of ICT in education. *Oxford Review of Education,* 38(1):9-24.

MacCallum, K., Jeffrey, L. & Kinshuk. 2014. Factors impacting teachers' adoption of mobile learning. *Journal of Information Technology Education,* 13:141-162.

Mackenzie, N. & Knipe, S. 2006. Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research,* 16(2):193-205.

Maharaj-Sharma, R., Sharma, A. & Sharma, A. 2017. Using ICT-based instructional technologies to teach science: Perspectives from teachers in Trinidad and Tobago. *Australian Journal of Teacher Education,* 42(10):23-35.

Maree, K. (Ed.) 2016. *First steps in research. (*2nd ed.). Pretoria: Van Schalk.

Maree, K. & Pietersen, J. 2016. The quantitative research process. In: K. Maree (Ed.). *First steps in research*. (2nd ed.). Pretoria: Van Schaik. (pp. 161-172).

Marshall, C. & Rossman, G. 2014. *Designing qualitative research.* (6th ed.). Singapore: Sage.

Martin, S., Diaz, G., Sancristobal, E., Gil, R., Castro, M. & Peire, J. 2011. New technology trends in education: seven years of forecasts and convergence. *Computers and Education,* 57(3):1893-1906.

McMillan, J. & Schumacher, S. 2001. *Research in education: a conceptual introduction.* (5th ed.). New York: Addison-Wesley Longman.

Meleisea, E. 2007. *The UNESCO ICT in education program.* Bangkok, Thailand: United Nations Educational, Scientific and Cultural Organization (UNESCO).

Mertens, D. 2005. *Research methods in education and psychology: Integrating diversity with quantitative and qualitative approaches.* (2nd ed.). Thousand Oaks, CA: Sage.

Mikre, F. 2011. The roles of nformation Communication Technologies in education: Review article with emphasis to the computer and Internet. *Ethiopian Journal of Education and Sciences,* 6(2):109-126.

Ministry of Education and Training, 2019. ECCD, primary and secondary schools teachers' career structure. [Online] Available at: http://education.org.ls/assets/storage/TEACHERS-CAREER-STRUCTURE.pdf [Acessed 07 August 2020].

Mishra, P. 1998. *Flexible learning in the periodic system with multiple representations: The design of a hypertext for learning complex concepts in chemistry.* Urbana-Champaign, IL: University of Illinois.

Mishra, P. & Koehler, M. 2006. Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108:1017-1054.

Mishra, P. & Koehler, M.J. 2008. *Introducing technological pedagogical content knowledge. Paper presented at the Annual Meeting of the American Educational Research Association*. New York City, March 24-28,2008 .

Mooij, T. & Smeets, E. 2001. Modelling and supporting ICT implementation in secondary schools. *Computers and Education,* 36(3):265-281.

Morgan, G.A., Leech, N.L., Gloeckner, G.W. & Barrett, K.C. 2004. *SPSS for introductory statistics: Use and interpretation.* (2nd ed.). New Jersey: Lawrence Erlbaum.

Muleta, T. & Seid, M. 2016. Factors affecting implementation of practical activities in science education in some selected secondary and preparatory schools of afar region. *African Journal of Chemical Education,* 6(2):123-142.

Mulwa, A., Kyalo, N., Bowa, O. & Mboroki, G. 2012. Influence of ICT infrastructure on readiness to adopt e-learning in secondary schools in Kitui District, Kenya. *Journal of Continuing, Open and Distance Education,* 2(1):i-229.

Mumtaz, S. 2000. Factors affecting teachers' use of information and communications technology: a review of the literature. *Journal of Information Technology for Teacher Education,* 9(3):319-342.

Mustafa, A. 2008. *Case study method: Theory and practice: Research and management approaches.* New Delhi: Atlantic Publishers & Distributors.

Mwalongo, A. 2011. Teachers' perceptions about ICTs for teaching, professional development, administration and personal use. *International Journal of Education and Development using ICT,* 7(3):36-49.

Mwanda, G., Mwanda, S., Midigo, R. & Maundu. 2017. Integrating ICT into teaching and learning biology: A case for Rachuonyo South Sub-County, Kenya. *International Journal of Education, Culture and Society,* 2(6):165-171.

Mwangu, E. & Sibanda, L. 2017. Teaching biology: Practical lessons in secondary schools: A case study of five Mzilikazi District secondary schools in Bulawayo Metropolitan Province, Zimbabwe. *Academic Journal of Interdisciplinary Studies,* 6(3):47-55.

Naqvi, T. 2018. Integrating information and communication technology with pedagogy: perception and application. *Educational Quest: An International Journal of Education and Applied Social Sciences,* 9(1):31-37.

National Curriculum Development Centre & Examinations Council of Lesotho, 2014. *Lesotho General Certificate of Secondary Education Syllabus: Biology 0180*. Maseru: Ministry of Education and Training.

National University of Lesotho. 2018. *Undergraduate prospectus 2018.* [Online] Available at: http://www.nul.ls/download/undergraduate-prospectus-2018/ [Accessed 16 March 2019].

Ndibalema, P. 2014. Teachers' attitudes towards the use of information communication technology (ICT) as a pedagogical tool in secondary schools in Tanzania: The case of Kondoa District. *International Journal of Education and Research,* 2(2):1-16.

Nguyen, N., Williams, J. & Nguyen, T. 2012. The use of ICT in teaching tertiary physics: Technology and pedagogy. *Asia-Pacific Forum on Science Learning & Teaching,* 13(2):Article 6.

Nieuwenhuis, J. 2016. Introducing qualitative research. In: K. Maree (Ed.) *First steps in research.* (2nd ed.), Pretoria: Van Schaik. (49-70).

Olabintan, D.F. & Badru, A.K., 2018. Teachers’ competence, classroom organization and climate as predictors of students’ academic achievement in secondary school biology. *Journal in Humanities,* 7(2):25-32.

Olatokun, W. & Ntemana, T. 2013. Information and communication technology (ICT) use by lecturers at the National University of Lesotho. *Ghana Library Journal,* 25(1):73-95.

Olugbenga, O. & Adebayo, O. 2010. Enforcing ICT knowledge on students as a means of enhancing academic performance in a democratized society: counselling and management perspective. *South-West Journal of Teacher Education,* 3:376-400.

Olumide, D.-R. A., 2018. The Roles of Information Communication Technology (ICT) in Teaching and Learning of Mathematics for Educational Development in Nigeria. *International Journal of Research and Analytical Reviews, 5*(3), 133-138.

Oppenheim, A.N. 1992. *Questionnaire design, interviewing and attitude measurement.*. New York: Basic Books.

Ottenbreit-Leftwich, A., Glazewski, K., Newby, T. & Ertmer, P. 2010. Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers and Education,* 55(3):1321-1335.

Overbay, A., Patterson, A., Vasu, E. & Grable, L., 2010. Constructivism and technology use: Findings from the IMPACTing leadership project. *Educational Media International,* 47(2);103-120.

Ozerbas, M. & Erdogan, B. 2016. The effect of the digital classroom on academic success and online technologies self-efficacy. *Educational Technology and Society,* 19(4):203-212.

Öztap, H., Özay, E. & Öztap, F. 2003. Teaching cell division to secondary school students: An investigation of difficulties experienced by Turkish teachers: Case studies. *Journal of Biological Education,* 38(1):13-15.

Pajares, M.F. 1992. Teachers’ beliefs and educational research: cleaning up a messy construct. *Review of Educational Research,* 62(3):62, 307-332.

Palak, D. & Walls, R.T. 2009. Teachers’ beliefs and technology practices: A mixed-methods approach. *Journal of Research on Technology in Education,* 41(4):417-441.

Peeraer, J. & Van Petegem, P. 2011. ICT in teacher education in an emerging developing country: Vietnam’s baseline situation at the start of ‘The Year of ICT’. *Computers and Education,* 56(4):974-982.

Piaget, J. [1952]. *The origins of intelligence in children.* New York: International Universities Press.

Pierson, M. E., 1999. *Technology integration practice as a function of pedagogical expertise (Doctoral dissertation, Arizona State University).* Dissertation Abstracts International.

Pierson, M. E., 2001. Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education,* 33(4):413-429.

Pittman, T. & Gaines, T. 2015. Technology integration in third, fourth and fifth grade classrooms in a Florida school district. *Educational Technology Research and Development,* 63(4):539-554.

Rahman, A. & Rahman, F.M. 2015. Knowledge, attitude and practice of ICT use in teaching and learning in the context of Bangladeshi tertiary education. *International Journal of Science and Research (IJSR),* 4(12):755-760.

Rahman, M. & Akter, N. 2015. 'ICT-Periodism' in the classroom: Lessons learnt from English in action. *International Journal of Science and Research,* 4(2):2319-7064.

Ramalingam, S.T., Pereira, S & Pereira, C,T. 2010. *Modern biology for senior secondary school.* Ibadan: African FEP.

Rammala, M.S. 2009. Factors contributing towards poor performance of grade 12 learners at Manoshi and Mokwatedi High Schools (Doctoral dissertation). [Polokwane]: University of Limpopo.

Razavi, A., Ghanizadeh, A..& Akbari, O. 2015. Teachers' perceptions of the use of multimedia in teaching English in official and non-official language learning Settings. *International Journal of Research Studies in Educational Technology,* 5(1): 97-109.

Richardson, V. 1996. The role of attitudes and beliefs in learning to teach. In: J. Sikula, (Ed.). *Handbook of research on teacher education*. New York: Macmillan, 102-119.

Rolando, L.G., Salvador, D.F. & Luz, M.R. 2013. The use of internet tools for teaching and learning by in-service biology teachers: A survey in Brazil. *Teaching and Teacher Education,* 34:46-55.

Roschelle, J., Pea, R., Hoadley, C., Gordin, D. & Means, B. 2000. Changing how and what children learn in school with computer-based technologies. *The Future of Children*, 10(2):76-101.

Ruthven, K., Hennessy, S. & Brindley, S. 2004. Teacher representations of the successful use of computer-based tools and resources in secondary-school English, mathematics and science. *Teaching and Teacher Education,* 20(3):259-275.

Samikwo, D.C. 2013. Factors which influence academic perfomance in biology in Kenya: A perspective for global competitiveness. *International Journal of Current Research,* 5(12):4296-4300.

Sangrà, A. & González-Sanmamed, M. 2010. The role of information and communication technologies in improving teaching and learning processes in primary and secondary schools. *Australasian Journal of Educational Technology,* 18(3):201-220.

Schmidt, D., Baran, E., Thompson, A., Mishra, P., Koehler, M. & Shin, T. 2009. Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education,* 42(2):123-149.

Scott, D. & Morrison, M. 2006. *Key ideas in educational research.* London: A&C Black.

Scrimshaw, P. 2004. *Enabling teachers to make successful use of ICT.* Coventry: British Educational Communications and Technology Agency (BECTA).

Senthilkumar, R. Sivapragasam, C. & Senthamaraikannan, B. 2014. Role of ICT in teaching biology. *International Journal of Research (IJR),* 1(9):780-788.

Shu, X. 2016. An action research on TPACK's influence on teachers of National Open University: Exemplified with an English teacher of Zhejiang Radio and TV University. *Open Access Library Journal,* 3(1):1-6.

Shulman, L. 1986. Those who understand: Knowledge growth in teaching. *Educational Researcher,* 15(2):4-14.

Shulman, L. 1987. Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review,* 57(1):1-23.

Slough, S. and Connell, M., 2006, March. Defining technogogy and its natural corollary, Technogogical Content Knowledge (TCK). In *Society for Information Technology & Teacher Education International Conference* (1053-1059). Association for the Advancement of Computing in Education (AACE).

Smeets, E. & Mooij, T. 2001. Pupil-centred learning, ICT, and teacher behaviour: Observations in educational practice. *British Journal of Educational Technology,* 32(4):403-417.

Šorgo, A., Verčkovnik, T. & Kocijančič, S. 2010. Information and communication technologies (ICT) in biology teaching in Slovenian secondary schools. *Eurasia Journal of Mathematics, Science & Technology Education,* 6(1):37-46.

Starbek, P., Starčič Erjavec, M. & Peklaj, C. 2010. Teaching genetics with multimedia results in better acquisition of knowledge and improvement in comprehension. *Journal of Computer Assisted Learning,* 26(3):214-224.

Stith, B. 2004. Use of animation in teaching cell biology. *Cell Biology Education,* 3(3):181-188.

Tom, F.B., Coetzee, I. & Heyns, T. 2014. Factors influencing academic performance in biological sciences among students in a nursing education institution in the Eastern Cape Province: An appreciative inquiry approach. *African Journal for Physical, Health Education, Recreation and Dance*, suppl. 3:102-115. http://hdl.handle.net/2263/43092

Tüysüz, C. 2010. The effect of the virtual laboratory on students' achievement and attitude in chemistry. *International Online Journal of Educational Sciences,* 2(1):37-53.

University of the Free State. 2018. *Prospectus-UFS.* [Online] Available at: https://www.google.com/search?q=ufs+prospectus&rlz=1C1CHNQ_enLS578LS578&oq=ufs+pros&aqs=chrome.1.69i57j0j69i60l3j0.10536j0j7&sourceid=chrome&ie=UTF-8 [Accessed 16 March 2019].

Ukoh, E. & Adejimi, A. 2018. Analogy and guided inquiry instructional strategies and students’ achievement in basic science in Lagos Metropolis, Nigeria: Way forward for effective science teaching and learning. *Journal of Education, Society and Behavioural Science*, 26:1-12. https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.9734%2FJESBS%2F2018%2F41378

Valdez, G., McNabb, M., Foertsch, M., Anderson, M., Hawkes, M. & Raack, L. 1999. *Computer-based technology and learning: Evolving uses and expectations.* Oak Brook, IL: North Central Regional Educational Laboratory (NCREL).

Van Rooy, W. 2012. Using information and communication technology (ICT) to the maximum: learning and teaching biology with limited digital technologies. *Research in Science & Technological Education,* 30(1):65-80.

VanderStoep, S.W. & Johnston, D.D. 2009. *Research methods for everyday life: Blending qualitative and quantitative approaches.* San Francisco: John Wiley & Sons.

Veen, W. 1993. How teachers use computers in instructional practice: Four case studies in a Dutch secondary school. *Computers and Education,* 21(1-2):1-8.

Vozikis, A., Ypofanti, M. & Papadopoulos, I. 2010. Attitudes towards the use of information and communication technologies (ICT) at work: Findings from the health care sector in Greece. *SPOUDAI-Journal of Economics and Business,* 60(1-2):82-96.

Vygotsky, L.S. 1978. *Mind in society: The development of higher psychological processes.* Cambridge: Harvard University Press.

Wallace, R.M. 2000. *Teaching with the internet: A conceptual framework for understanding the teacher's work and an empirical study of the work of three high school science teachers.* (Master's dissertation). Ann Arbor, MI: University of Michigan.

Webb, M. 2005. Affordances of ICT in science learning: Implications for an integrated pedagogy. *International Journal of Science Education,* 27(6):705- 735.

Wellington, J. 2005. Has ICT come of age? Recurring debates on the role of ICT in education, 1982–2004. *Research in Science and Technological Education,* 23(1):25-39.

Wu, Y., Pan, C. & Yuan, C. 2017. Attitudes towards the use of information and communication technology in management education. *Behaviour and Information Technology,* 36(3):243-254.

Zhao, Y. (Ed.). 2003. *What teachers should know about technology: Perspectives and practices.* Greenwich, CT: Information Age.

Zimbabwe School Examinations Council (ZIMSEC). 2014. *Biology examination report*. Harare: Government Printers.

Zosh, J., Lytle, S., Golinkoff, R. & Hirsh-Pasek, K. 2017. Putting the education back in educational apps: How content and context interact to promote learning. In: R. Barr & L.D. Linebarger (Eds). *Media exposure during infancy and early childhood.* Cham: Springer International. ( 259-282).

## APPENDICES

### Appendix 1: Ethical clearance letter

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

**GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)**

21-Jan-2020

Dear Mr Makuru, Bobojane BE

**Application Approved**

Research Project Title:
**Teachers' perceptions on the use of information and communication technology for teaching Biology in Lesotho**

Ethical Clearance number:
**UFS-HSD2019/1854/2101**

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

**Prof Derek Litthauer**
**Chairperson: General/Human Research Ethics Committee**

Digitally signed by Derek Litthauer
Date: 2020.01.22 21:34:50 +02'00'

205 Nelson Mandela Drive
Park West
Bloemfontein 9301
South Africa

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Bloemfontein 9300
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## Appendix 2: Permission to conduct research in schools

THE KINGDOM OF LESOTHO
MINISTRY OF EDUCATION AND TRAINING

15th /October/2019

The Ethics Committee
University of the Free State
Bloemfontein

Dear Madam/ Sir

**Re: PERMISSION TO CONDUCT RESEARCH**

I, 'Mabakubung Seutloali, attest to have granted Mr Bobojane Makuru permission to conduct research in Lesotho high schools that offer Biology as a teaching subject. He is a student at the University of the Free State and he is conducting research on the topic:

*"Teachers' perceptions on the use of information and communication technologies for teaching Biology in Lesotho"*

The Biology teachers participating in the study will be required to fill a questionnaire that may take up to forty (40) minutes. Their participation is absolutely voluntary and they are free to decline or withdraw at any point if there is a need. He pledges that they will not be exposed to any harm, and the information shared will remain confidential and will not be used for any purposes outside the study.

Yours faithfully

B. M. Seutloali (Mrs)
**Chief Education Officer - Secondary**

## Appendix 3: Letter to the Ministry of Education and Training

P.O Box 1635

Maseru 100

The Senior Education Officer
Ministry of Education and Training

Dear Madam/ Sir

Re: REQUEST FOR CONSENT TO CONDUCT RESEARCH

I kindly request consent to conduct research in some of the high schools that offer Biology as one of the teaching subjects in the country.
My name is Bobojane Makuru, a master's degree student at the University of the Free State. As part of my master's programme, I am required to conduct research on the following topic:

*Teachers' perceptions on the use of information and communication technologies for teaching Biology in Lesotho*

The purpose of the research is to describe the teachers' perceptions on the use of information and communication technologies (ICTs) for teaching in Lesotho high schools. I intend to investigate the ICT tools that the teachers commonly use in teaching and learning activities, describe the practices that characterize the patterns of use, and then determine the correlation between teachers' perceptions and their use of ICTs for teaching.

The study will reveal the current status of the use of ICTs for teaching, open the stakeholders' eyes to critical issues regarding ICT integration, and thus inform formulation and execution of ICT policies by the relevant authorities in education. Thus, the necessary interventions could be made to improve the quality of educational practices in schools. Furthermore, with teachers' perceptions in mind, school administrators would make better choices when procuring ICT-resources.

The teachers participating in the study will be required to fill a questionnaire that may take up to 30 minutes. Their participation is absolutely voluntary and they are free to decline or withdraw at any point if there is a need. I pledge that they will not be exposed to any harm, and the information shared will remain confidential and will not be used for any purposes outside the study.

For any comments and further clarification, please contact me or my supervisor, Dr Thuthukile Jita at JitaT@ufs.ac.za or +2751 401 7441.
Thanking you in advance for considering my request.

Yours faithfully,

Bobojane Makuru (**Cell:** 62314521, **e-mail:** bobojanemakuru@gmail.com)

## Appendix 4: Letter to the Principal

P.O Box 1635

Maseru 100

The Principal

............................................................ School

Dear Madam/ Sir

Re: REQUEST FOR CONSENT TO CONDUCT RESEARCH

I kindly request consent to conduct research in selected high schools in your school.
My name is Bobojane Makuru, a master's degree student at the University of the Free State.
As part of my master's programme, I am required to conduct research on the following topic:

*Teachers' perceptions on the use of information and communication technologies for teaching Biology in Lesotho*

The purpose of the research is to describe the teachers' perceptions on the use of information and communication technologies (ICTs) for teaching in Lesotho high schools. I intend to investigate the ICT tools that the teachers commonly use in teaching and learning activities, describe the practices that characterize the patterns of use, and then determine the correlation between teachers' perceptions and their use of ICTs for teaching.
The study will reveal the current status of the use of ICTs for teaching, open the stakeholders' eyes to critical issues regarding ICT integration, and thus inform formulation and execution of ICT policies by the relevant authorities in education. Thus, the necessary interventions could be made to improve the quality of educational practices in schools. Furthermore, with teachers' perceptions in mind, school administrators would make better choices when procuring ICT-resources.
The teachers participating in the study will be required to fill a questionnaire that may take about 15 minutes. Their participation is absolutely voluntary and they are free to decline or withdraw at any point if there is a need. I pledge that they will not be exposed to any harm, and the information shared will remain confidential and will not be used for any purposes outside the study.
For any comments and further clarification, please contact me or my supervisor, Dr Thuthukile Jita at JitaT@ufs.ac.za or +2751 401 7441.
Thanking you in advance for considering my request.

Yours faithfully,

Bobojane Makuru (**Cell:** 62314521, **e-mail:** bobojanemakuru@gmail.com)

## Appendix 5: Invitation for biology teacher participation

P.O Box 1635

Maseru 100

The Biology Teacher

Dear Madam/ Sir

Re: INVITATION TO PARTICIPATE IN A RESEARCH STUDY

I hereby invite you to participate in a research study. My name is Bobojane Makuru, a master's degree student at the University of the Free State. As part of my master's programme, I am conducting a research project titled:

*Teachers' perceptions on the use of information and communication technologies for teaching Biology in Lesotho*

The purpose of the research is to examine the perceptions of Biology teachers on the use of information and communication technologies (ICTs) for teaching in junior and senior secondary schools known.

You have been identified as one of the teachers implementing the Biology curriculum and hence your contribution would be significant in this research project. The study is likely to benefit you and other teachers who are implementing the said curriculum as it will expose their perceptions on the use of modern technologies, the commonly used ones and the patterns of use in and probably outside the classrooms.

If you agree to participate, you will be required to complete a questionnaire. You are free to participate, decline or withdraw at any point during the study if there is a need. While responses to all questions are important for the study, you may not respond to those that you are uncomfortable to answer.

I pledge that you will not be exposed to any harm, and the information shared will remain confidential, in that your identity or that of your institution will not be disclosed. This information will not be used for any purposes outside the study and only the researcher and his supervisor(s) will have access to all the material used.

If you agree to participate, please complete the attached consent form.

Yours faithfully,

Bobojane Makuru

(**Cell:** 62314521, **e-mail:** bobojanemakuru@gmail.com)

**Appendix 6: Consent form**

*Teachers' perceptions on the use of information and communication technology for teaching Biology in Lesotho*

I.......................................................................................... (name and surname),

• *Hereby give free and informed consent to participate in the above-mentioned research study;*

• *Understand what the study is about and why I have been approached to participate;*

• *Understand what the potential benefits and risks that may originate from the study are; and*

• *Give the researcher permission to use the information collected from my participation for research purposes only.*

Email address: ..........................................................................................................

Cell number: ..............................................................................................................

Participant's signature: .....................................................Date: .................................

Researcher's signature: ...................................................Date: .................................

## Appendix 7: Turnitin Digital Receipt

turnitin

# Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the re
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Appendix 8: Letter from the language editor

**8 September 2020**

**TO WHOM IT MAY CONCERN**

I, Ernéne Roalda Verster, hereby confirm that I edited Mr B Makuru's M.Ed thesis to the best of my ability, during August 2020, completing on August 31, 2020 .

I always strive to consistently maintain the highest quality in respect of document editing and translation. However, as I have no way of ensuring that source documents are indeed replaced with my edited version, and also have no control over changes subsequently made to documents, the final responsibility for documents always rests with the commissioning author.

**Title of thesis / Titel van verhandeling**

Teachers' perceptions on the use of Information and Communication Technology for teaching biology in Lesotho

## ER Verster

B.Bibl (Hons)
BA (Hons) (Language practice/Taalpraktyk) Cum laude

Member no 1002779: The South African Translators' Institute (SATI)
Lid nr. 1002779: Die Suid-Afrikaanse Vertalersinstituut (SAVI)
Member no/Lid nr. 123: Library and Information Association of South Africa (LIASA)

## Appendix 9 : Questionnaire

UNIVERSITY OF THE FREE STATE
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YUNIVESITHI YA FREISTATA

UFS·UV EDUCATION OPVOEDKUNDE

**QUESTIONNAIRE FOR BIOLOGY TEACHERS**

Thank you for taking time to complete this questionnaire. Please answer each question to the best of your knowledge. Your thoughtfulness and honest responses will be greatly appreciated. Your individual name or identification number will not at any time be associated with your responses. Your responses will be kept completely confidential and will not influence your work.

Information and Communication Technologies (ICTs) is a broad concept that can mean a lot of different things. For the purpose of this questionnaire, ICTs refer to digital technology/technologies. That is, the digital tools we use such as computers, laptops, iPods, handhelds, interactive whiteboards, software programs, online tools, etc. Please answer all the questions and if you are uncertain of your response you may ask the researcher for assistance or select "Neutral".

**A. DEMOGRAPHIC INFORMATION:** Please circle the letter of the correct response.

**1.** Gender

a. Female
b. Male
c. Other

**2.** Teaching experience (years)

a. 0- 5
b. 6-15
c. 16-25
d. Above 25

**3.** Highest Qualification

a. Bachelor of Science Education (BSc.Ed)
b. Postgraduate Certificate in Education (PGCE)
c. Bachelor of Education (B. Ed) Honours
d. Postgraduate Diploma in Education (PGDip)
e. Master of Education (M. Ed)
f. Other, please indicate

.......................................................................................



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YUNIVESITHI YA FREISTATA

**B.** This section intends to determine and measure the general perceptions of the teachers regarding use of ICTs to teach Biology.
Please tick in the appropriate box to rate your perception.

Scale: **SD**=Strongly Disagree **D**=Disagree **N**=Neutral **A**=Agree **SA**=Strongly Agree

| **Perceptions on the use of technology** | **SD** | **D** | **N** | **A** | **SA** |
|---|---|---|---|---|---|
| **4.** Creative and lively use of technology tools can enhance the teaching and learning activities/processes and thus understanding of Biology. | | | | | |
| **5.** Technology makes teaching Biology a faster, easier and enjoyable experience. | | | | | |
| **6.** Technology makes learning Biology faster, easier and enjoyable for me and my learners. | | | | | |
| **7.** ICTs can be used to enhance learners' grasp of difficult Biology content | | | | | |
| **8.** ICT can enhance learners' critical thinking skills. | | | | | |
| **9.** Technology allows me to modify resources so as to present more organized lessons that concentrate on the relevant Biology content. | | | | | |
| **10.** ICTs are impressive instruments that can visually illustrate Biology concepts that would otherwise remain abstract, thus promoting learners understanding. | | | | | |
| **11.** Technology increases learners' interest and concentration in the learning process | | | | | |
| **12.** Technology accommodates and encourages modern educational approaches such as cooperative learning, inquiry learning | | | | | |
| **13.** ICTs offer opportunities for me to address my professional development needs e.g collaboration with peers, searching for new ideas and educational resources for use in classroom | | | | | |
| **14.** Social media platforms e.g. whats-App, facebook, twitter etc are helpful for discussions and sharing information with peers to both learners and teachers. | | | | | |
| **15.** ICT can enhance learners' participation, and feedback to teachers | | | | | |
| **16.** ICT can enhance teacher and learner interaction, and collaboration among learners | | | | | |
| **17.** ICT can enhance learners' scientific and practical skills (e.g. observational, experimental, data handling etc) | | | | | |



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This part is intended to establish the teachers' perceived ICT skills (competency) by rating them on a four-point Likert scale ranging from "cannot use" to "very competent"

Scale: **CU** = cannot use, **SC**= slightly competent, **MC** = moderately competent, **VC** = very competent

| **Teachers' perceptions of their ICT competencies** | **CU** | **SC** | **MC** | **VC** |
|---|---|---|---|---|
| **18.** Word processor (e.g. Microsoft word) | | | | |
| **19.** Presentation of information/ lessons (e.g. Microsoft PowerPoint) | | | | |
| **20.** I can use spreadsheet (e.g. Microsoft Excel) to process data and report results. | | | | |
| **21.** I can use technology resources to facilitate higher order and complex thinking skills, including problem solving, critical thinking, informed decision-making, knowledge construction, and creativity. | | | | |
| **22.** I can use content-specific tools (e.g., Internet, software, simulation) to support learning and research. | | | | |
| **23.** I can use technology tools (e.g. e-mail, whatsapp messenger) and resources (e.g. computers, mobile phones) for managing and communicating information. | | | | |
| **24.** I can evaluate and select new information resources and technological innovations based on their appropriateness to specific tasks | | | | |
| **25.** I can troubleshoot common computer problems. | | | | |
| **26.** I am proficient in the use of common input and output devices; I can solve routine hardware and software problems; I can make informed choices about technology systems, resources, and services. | | | | |
| **27.** I can use technology to locate, evaluate, and collect information from a variety of sources. | | | | |
| **28.** I can use technology tools and information resources to increase productivity, promote creativity, and facilitate academic learning. | | | | |
| **29.** I can choose learning and technology resources. | | | | |
| **30.** I can use a variety of media and formats, including telecommunications, to collaborate, publish, and interact with peers, experts, and other audiences. | | | | |



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**C.** The purpose of this section is to determine ICTs that are commonly used and practices that characterise the patterns of use.

(i) ICTs that are commonly used.
The following table lists some ICTs.
In the second and third columns please circle yes (**Y**) if the ICT is available for your use in your school or home or no (**N**) if not.

In the fourth column, please circle **T** if you use the ICT for purposes related to teaching, **NT** for non-teaching purposes.

In the fifth column, please circle the correct number to indicate how often you use the ICT: **1**= never, **2**= very infrequently (about once in a term), **3**= infrequently (a few times a month), **4**= frequently (almost every week), **5**= very frequently (almost daily).

| **31. ICT tool** | **32. Available in school?** | | **33. Available at home?** | | **34. Purpose of use?** | | **35. Frequency of use** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Computer / laptop | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| Electronic mail | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| Flash drive | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| Internet | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| Mobile phone | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| Videos and simulations | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| Printer | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| Projector | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |

Please specify if there are any other technologies that you use.

| **ICT tool** | **Available in school?** | | **Available at home?** | | **Purpose of use?** | | **Frequency of use** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |
| | Y | N | Y | N | T | NT | 1 | 2 | 3 | 4 | 5 |



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(ii) Practices that characterise the patterns of use

Please circle the appropriate number to indicate the extent of your ICT related practices as measured on the scale; 'very irregularly' (at least once a term), 'irregularly' (at least once a month), 'regularly' (at least once a week) or 'very regularly' (almost daily).

Scale: **1**= not at all **2**= very irregularly 3=irregularly **4**= Regularly **5**= Very regularly

| **Practices (activities) that characterise patterns of use** | **measure of use** | | | | |
|---|---|---|---|---|---|
| **36.** Searching for information on internet, hard disk and compact discs (CD ROMs) to prepare for lessons. | 1 | 2 | 3 | 4 | 5 |
| **37.** Using computer programs such as Microsoft picture it, paint, and movie maker to create pictures, posters, diagrams, or animations for use in teaching. | 1 | 2 | 3 | 4 | 5 |
| **38.** Using spreadsheets to for recording test scores and other learners' information | 1 | 2 | 3 | 4 | 5 |
| **39.** Using Microsoft PowerPoint to present lesson content, show pictures, diagrams, videos, and simulations to teach or facilitate discussions | 1 | 2 | 3 | 4 | 5 |
| **40.** Using Microsoft office word for writing notes for learners | 1 | 2 | 3 | 4 | 5 |
| **41.** Using educational software to learn how certain Biology topics can be approached | 1 | 2 | 3 | 4 | 5 |
| **42.** Designing things like programmes for functions, invitation cards etc. | 1 | 2 | 3 | 4 | 5 |
| **43.** Organizing computer settings such as files, memory, system etc. | 1 | 2 | 3 | 4 | 5 |
| **44.** Using internet for fun, downloading and/or watching or listening to music, and other personal purposes such as shopping. | 1 | 2 | 3 | 4 | 5 |
| **45.** Playing games on computers. | 1 | 2 | 3 | 4 | 5 |
| **46.** Using printers and scanners to produce handouts showing different representations (textual, graphical, diagrammatic etc) of biology content for learners | 1 | 2 | 3 | 4 | 5 |
| **47.** Using mobile applications such as whatsapp messenger, facebook for non educational purposes such as chatting or socialising with other people. | 1 | 2 | 3 | 4 | 5 |
| **48.** Using mobile applications such as whatsapp messenger, facebook, shareit, wifi-direct etc for teaching purposes, information exchange, and discussion forums with and for learners. | 1 | 2 | 3 | 4 | 5 |
| **49.** Using computers for drill-and-practice and tutorial software packages. | 1 | 2 | 3 | 4 | 5 |
| **50.** Issuing class instructions and/or communicating with learners | 1 | 2 | 3 | 4 | 5 |
| **51.** Organizing class discussion, demonstrations and presentations | 1 | 2 | 3 | 4 | 5 |
| **52.** Assessing learners' learning through tests/quizzes | 1 | 2 | 3 | 4 | 5 |
| **53.** conveying feedback to learners | 1 | 2 | 3 | 4 | 5 |
| **54.** Supporting collaboration among learners | 1 | 2 | 3 | 4 | 5 |



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Please specify if there are any other technologies that you use.

| Practices (activities) that characterise patterns of use | measure of use | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| | 1 | 2 | 3 | 4 | 5 |
| | 1 | 2 | 3 | 4 | 5 |



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