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Pre-service teachers' preparedness for Fourth Industrial Revolution teaching and learning

By

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DECLARATION

I, Marinus Daniel van Wyk, declare that the contents of this thesis represent my unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed **Date**

ABSTRACT

In my experience of working at a Higher Education Institution, some pre-service teachers have been found to have a rudimentary understanding of the Fourth Industrial Revolution and its impact on education. Thus, the main aim of this study was to explore the preparedness of a sampled group of pre-service teachers at a HEI to teach adequately in the 4iR classroom. The study also looked at what knowledge these pre-service teachers had, and the extent of their knowledge, about the 4iR, what they perceived to be the foundational requirements to teach effectively in the 4iR classroom, and what their perceptions were of what constitutes comprehensive preparedness to integrate ICT tools in the 4iR classroom. This research study used a qualitative research design to ascertain the level of preparedness of pre-service teachers to use ICT tools for 4iR teaching and learning. The researcher employed two data collection methods, namely, participant observations and focus group interviews. Ten micro-lessons were observed, and three focus group interviews were conducted with two groups of seven participants (n=14) and one group of eight participants (n=8) of this study. The Technological Pedagogical and Content Knowledge (TPACK) framework was used to guide the research study in a process of creating themes and analysing the data collected. Participants reported on various aspects that they found hindered the successful implementation of ICT tools in the 4iR classroom. These included ICT school culture, inadequate computer infrastructure, and the need for the teacher education curriculum to be attuned to the 4iR for teaching and learning. It was clear from the findings that these pre-service teachers participating in this study had a rudimentary understanding of the 4iR and its impact on education. The findings also indicated that, while these pre-service teachers possessed a theoretical understanding of ICT tools, they lacked the practical skills to implement them for teaching purposes. This conceptualisation was found to directly impact the pre-service teacher study participants' TPACK knowledge domains. The findings thus indicated the need for the teacher education curriculum to address pre-service teachers' TPACK knowledge domains.

Key words: Fourth Industrial Revolution, Technological Pedagogical Content Knowledge, pre-service teachers, Information and Communication Technology, Teaching and learning, higher education

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DEDICATION

I dedicate this thesis to my children. It is not easy being a first generation academic, and thus I would encourage you not to let your circumstances derail you from attaining your goals.

ABBREVIATIONS

4iR: Fourth Industrial Revolution

3D: Three dimensional

AI: Artificial Intelligence

AR: Augmented Reality

BEd: Baccalaureus Educationis

CAT: Computer Applications Technology

DHET: Department of Higher Education and Training

HI: Human Interaction

ICT: Information and Communication Technology

IT: Information Technology

IoT: Internet of Things

LAN: Local Area Network

MRTEQ: The Minimum Requirements for Teacher Education Qualifications

PGWC: Provincial Government Western Cape

VR: Virtual Reality

WAN: Wide Area Network

WCED: Western Cape Education Department

TPACK: Technological Pedagogical and Content Knowledge

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CHAPTER 1: INTRODUCTION

1.1 Background and motivation

My involvement in teaching for the past nine years at both secondary and higher education levels has inspired this study. Seven of those years were at a high school in Cape Town and two years at a higher education institution in the same city in the Western Cape. My encounter with e-Learning in my teaching has attracted me to this educational technology study, and to the use of this medium in the classroom. My experience as an in-service high school teacher, in particular, provided me with the opportunity to acquire first-hand experience in using Information and Communication Technology (ICT) in teaching in a school context. This experience showed me new ways of adapting my and other teachers' practice to meet 21st-century ICT demands. It also revealed a generally high degree of learners' receptivity to ICT being implemented and used as a learning tool in the classroom.

Furthermore, I was the only Information Technology (IT) teacher at the local high school in Cape Town where I taught, and was thus regularly called upon to solve other teachers' IT-related and computer troubleshooting problems, as well as to assist my colleagues with the implementation and use of specific e-Learning tools in their classrooms. Based on this wealth of experience acquired in the process of assisting both colleagues and learners, and on my observations and subject curriculum requirements, my appointment as a lecturer in the Faculty of Education at a Higher Education Institution (HEI) both afforded me the opportunity, and encouraged me, to expose pre-service teachers to various e-Learning tools. It also enabled me to motivate them to make these part of their practice at the schools where they would teach, both during their teaching practices, and as future in-service teachers. By way of background and history, I situate this study regarding the emergence of ICT use in the 'Fourth Industrial Revolution' (4iR) classroom.

In South Africa there has been a recent and significant increase in interest in pedagogical activities aligned with the 4iR. According to Soni (2019), the 4iR is predicted to shape the future of South Africa through its impact on government,

industry, and on the economy. Soni (2019) explains this probability in terms of the dynamic nature of the 4iR and its role in creating opportunities for humans to live improved and more secure lives. Soni (2019) cites other scholars in the field who see the 4iR as creating the conditions for, and encouraging, economic growth. Hwang (2016) considers the 4iR to be creating enhanced platforms for online collaboration using cloud technology and the 'Internet of things' (IoT), and foresees it as continuing to foster real-time human interaction (HI) to maximise value creation. This prediction suggests that teaching pedagogies in the 21st-century should be aware of, and attuned to, the 4iR to ensure that students become global citizens in an ever more complex and dynamic society. A preliminary literature review reveals a paucity of research on the kind of impact the 4iR has already had, and is likely to have, on education contexts in developing countries, specifically in the South African education context (Butler-Adam, 2018). Butler-Adam (2018) argues that, particularly in the South African context, to succeed as a productive and competitive member of society in the era of the 4iR, high levels of numeracy and literacy, together with a thorough understanding of how the world operates, are essential. As a result of these and other claims and advocacy, the Minister of Basic Education announced that three new school subjects (Robotics, Coding, and Kiswahili) would be introduced and piloted across 1 000 schools in five different provinces as of 2020 (Business Tech, 2019).

One cannot deny that over the last two decades the South African government has been intent on transforming universities as structures of change attuned to the use and integration of Information and Communication Technology (ICT). This is corroborated in the 2004 White Paper's stated aims for e-Education regarding integrating ICT in classrooms. These aims include: to enhance teaching and learning, to apply ICTs to blend teaching and learning, and to manage administrative tasks more speedily and effectively (Department of Education [DoE], 2004). Furthermore, the Policy on the Minimum Requirements for Teacher Education Qualifications (MRTEQ), issued by the Department of Higher Education and Training (DHET, 2015) stipulates that a newly appointed teacher should be able to use ICTs competently and innovatively to enhance teaching and learning (DHET, 2015). In addition, the MRTEQ policy conceptualises teaching as a complex activity, thus acknowledging

the necessity for the qualified/in-service teacher to be pedagogically prepared to create and present lessons to learners, using ICT (DHET, 2015).

Guided by the 2004 White paper on e-Education, to date, the Western Cape Provincial Government (PGWC) has advocated for transforming and improving teaching and learning in Western Cape schools through implementing educational technologies through its ICT initiatives. One example was the early Khanya project in 2001, which is no longer in existence. More recently, there is the PGWC's current e-Learning program known as the Game Changer Programme and Broadband Initiative (Western Cape Government [WCG], 2018). Historically, the Khanya project was started in the Western Cape to capacitate teachers to use various e-Learning tools to maximise teaching and learning, and curriculum delivery (WCG, 2018). The Khanya project was implemented in two phases. In phase 1, personal computers were installed at schools, and phase 2 was geared to the training of teachers in ICT and its use in teaching and learning (Mooketsi & Chigona, 2016). In reality, many in-service teachers have claimed, and continue to claim, that they have not been adequately trained to integrate and use technology in their teaching (Abbitt, 2011).

In the South African context, as highlighted in a study conducted by Chigona and Chigona (2013), many pre-service teachers at the time of their study considered themselves to be under-prepared and under-equipped to teach in South African schools using ICT. This leads one to question how schools can transition towards the 4iR, despite many in-service teachers lacking the capacity to effectively implement even the most basic ICTs in schools. There can be no doubt that the lack of preparedness and training of pre-service teachers to adopt e-Learning tools in their practice widens the digital divide between affluent and historically disadvantaged schools as Gudmundsdottir (2010) found in a study conducted more than ten years ago. Thus it can be argued that the lack of training and preparedness of many pre-service teachers to utilise e-Learning tools in their practice emerges from limitations in the teacher training curriculum (Aslan & Zhu, 2016).

According to Tallvid (2016), who conducted a study in Sweden, ongoing training is needed to keep abreast of the rapid technological development. Based on his and other studies, I consider the current study to contribute to the recent and current discourse on effective ICT integration in the field of teacher education amongst Third-year BEd students. I argue in this study that an exploration of new pedagogical ways of enhancing pre-service teachers' capacities, together with substantial continued support and improvements to their existing ICT usage, may open up new avenues for schools where these prospective teachers might soon be teaching towards effectively integrating the ICTs necessary for the transition of both schools and learners towards becoming skilled and productive participants in the 4iR.

1.2 Statement of the problem

Despite the government's stated intent to transition schools towards the 4iR, it has been my perception and experience that most pre-service teachers seem to be underprepared for the integration of the most basic forms of ICT in their teaching and learning. The need to explore pedagogical means to advance pre-service teachers' ICT competencies is highlighted in the 2004 White Paper's stated aims on e-Education and in the MRTEQ of 2015. More specifically, both the literature and my own experience indicate a need for a comprehensive exploration of the ways in which various ICTs can transform and enhance pre-service teachers' teaching and learning in the schools where they intend to teach in the future.

1.3 Research question

The study's main aim is to establish in what specific ways a sampled group of pre-service teachers' are or are not prepared for 4iR teaching and learning.

The sub-questions of the study are:

1. What is the nature and extent of the knowledge and understanding of these pre-service teachers about 4iR?

2. What, according to these pre-service teachers, are the foundational requirements necessary to teach effectively in a 4iR classroom?
3. What are these pre-service teacher's perceptions of what constitutes comprehensive preparedness to integrate ICTs effectively in a 4iR classroom?

1.4 Research aims/objectives

The main aim of this study was to establish how prepared a group of pre-service teachers at a University of Technology are to teach in the 4iR classroom. The following sub-aims which guided the study are:

(i) To ascertain the extent of the knowledge and understanding of the participating pre-service teachers with respect to the 4iR.

(ii) To explore these pre-service teachers' desired and necessary foundational requirements to teach in the 4iR classroom.

(iii) To explore these pre-service perceptions and experience regarding the integration of ICTs in the 4iR classroom.

1.5 Brief description of Theoretical Framework

In this study the researcher used the Technological Pedagogical and Content Knowledge (TPACK) framework to attribute meaning to the participating pre-service teachers' use of Information and Communication Technology tools in the classroom. The TPACK framework was developed by Mishra and Koehler (2006), and is based on Shulman's (1986) construct of Pedagogical Content Knowledge (PCK). Shulman's (1986) PCK encompasses the fundamentals of teaching, learning, and the curriculum, creating links between assessment and pedagogy within the curriculum (Mishra & Koehler, 2006). Drawing on Shulman's PCK, content knowledge (CK) refers to links to the teacher's knowledge about the subject content being taught, while pedagogical knowledge (PK) is concerned with the processes and methods of teaching and learning.

According to Mishra and Koehler (2006), in several ways the TPACK framework serves as the underlying foundation of effective teaching which uses technology as a teaching resource and strategy. Firstly, it necessitates an illustration of the basic underlying concepts necessary for effective teaching using technology (Mishra & Koehler, 2006). Secondly, it offers teachers pedagogical methods that use technology in constructive ways to deliver content efficaciously (Mishra & Koehler, 2006). Thirdly, integrating pedagogy and content knowledge, using technology, offers effective pedagogical practices for subject content teaching where subject specific concepts may be deemed too difficult for students to understand using traditional text book, teacher centred methods. Fourthly, it provides teachers with the means to gauge and ascertain the extent of students' prior knowledge. Lastly, it offers teachers an understanding of how educational technology can be used by them to build on their own and their learners' existing knowledge in ways which can result in positive changing and dynamic classroom environments.

The TPACK framework focuses specifically on assisting teachers in improving content delivery and in their finding the most effective ways for doing this (Mishra, 2012). Such an approach creates an opportunity for pre-service teachers to be flexible and creative in the classroom environment (Mishra, 2012). The TPACK framework assisted the researcher in this study in evaluating the ICT knowledge of the participating pre-service teachers, and helped me to investigate the extent and nature of their technology integration during their micro-lessons on campus. The framework further provided an opportunity for the researcher to gain valuable insights concerning the specific TPACK skills the participants needed for them to be able to effectively integrate an e-Learning management system in a 21st-century classroom.

1.6 Research design and methodology

1.6.1 Design

A qualitative approach and case study research design was used in this study. Strydom and Bezuidenhout (2014) describe the case study research design as a

detailed description of a phenomenon that exists within a real-world context. According to Mouton (2001), a case study's strengths include high construct validity, in-depth insights, and a strong rapport with the research participants. Using a case study as a research design for this study enabled the researcher to produce an in-depth understanding of the research participants' use of an e-learning management system, as well as of their knowledge, understanding, experiences and perceptions regarding the use of this system. The case study research design further enabled the researcher to employ focus group interviews and participant observations, data collection tools commonly used with such a research design (Strydom & Bezuidenhout, 2014). The use of focus group interviews and participant observations provided the researcher with the opportunity to acquire rich primary data for interpretation and analysis.

1.6.2 Site and participant selection

This research study was conducted in the Faculty of Education at a University of Technology (UoT) in South Africa. The site was selected because this particular UoT is the largest provider of teachers in the Western Cape. The participants in this study were selected using a purposive sampling technique. Babbie (2014), Pascoe (2014), and Maree and Pietersen (2016) posit that the purposive sampling technique is used when the participants of a representative group or research population meet a list of characteristics that are derived from the research question. For this research project, some of the characteristics of the participants that the researcher identified were the participants' using ICTs, the participants' possession of some knowledge of e-Learning tools, and the schools (affluent and historically disadvantaged) where they have conducted their practice teaching during their second year and first semester of their third-year. Purposive sampling is a non-probability sampling method, according to which the research participants are selected based on the researcher's judgement (Babbie, 2014). This sampling method used as a form of qualitative research generally does not require researchers to approach the research with assumptions or predictions, but rather is used to assist researchers in gaining an in-depth understanding of the participants' activity during an event. Since this study used purposive sampling, it was imperative to ensure consistency amongst the group

(Greef, 2011). The researcher considered the selected participants to be crucial role players in adopting ICTs in the 21st-century classroom.

1.6.3 Data analysis

This research project used the qualitative data analysis method. This method allowed for non-numerical interpretation of observations in a process of discovering underlying meanings and patterns (Babbie, 2014). According to Nieuwenhuis (2016a), qualitative data analysis is not seen as a number of successive or sequential steps, but rather as an interlinked process where the researcher follows a cyclical approach by going back to the field notes to verify conclusions. Thus, the case study research approach allowed the researcher to use more than one data collection method and analysis technique in a process that positioned the researcher to triangulate data to strengthen the research findings and conclusions (Nieuwenhuis, 2016a). The data collected from the focus group interviews were recorded using Otter.ai, an artificial intelligence software application that allowed audio recordings to be transcribed. After the recordings were transcribed using the Otter.ai software, the data was manually transcribed to pick up human cues that computer software would not necessarily pick up. Lastly, after transcribing the data, the researcher put the data through a three-step coding process known as open coding, axial coding, and selective coding (Babbie, 2014).

1.7 Ethical considerations

Ethics is the cornerstone of research, and without it, the delicate and complex interweaving of research can fall apart in undesirable ways (Louw, 2014). Strydom (2011a) underscores that ethics is a set of accepted moral principles that offer behavioural expectations. Before this research could commence, ethical clearance was obtained from the Faculty of Education Ethics Committee at the UoT. An ethics certificate which highlighted the ethical implications of this study was provided by the Faculty of Education's Ethics Committee on receipt of the researcher's application. Maree (2016) argues that it is essential to highlight ethical considerations concerning research. Hence, all participants in this study were formally invited by the researcher to participate in this research, and the invitation sought to acquire the participants'

permission to form part of this research study voluntarily. The letter requesting permission informed the participants of every aspect of the research and assured the anonymity of participants in order to protect their identity. They were also informed that they could withdraw from the research at any stage, should they wish to do so, and without prejudice.

1.8 Contribution of the study

This study builds on those studies, theories, and models found in the existing literature (Pamuk, 2012; Aslan & Zhu, 2016; Bartolo, 2017; Pilten, Pilten & Sahinkaya, 2017) and is considered to contribute to the discourse concerning effective teaching-learning in pre-service teachers' education in several ways through the informed use of educational technology. First, it is hoped that the study will help create a platform for further discussion around the implementation and adaptation of e-Learning tools in the 21st-century classroom. Second, this study is intended to reflect on the various ways in which 21st-century teaching practices are moving ever more swiftly toward taking their place in, or being an integral part of, the 4iR, and thus how e-Learning can assist students in becoming competitive and productive global citizens. Third, it is hoped that this study may further inform teachers, researchers, and policymakers about the effective use, and the pedagogic potential, of ICTs in increasing real-time collaborative learning with students in the classroom. Fourth, this study has the potential to contribute locally to the future e-Learning and primary ICT literacy integration initiatives for undergraduate students at the higher education institution which is the site of this study. It is hoped that the study will speak to the Department of Basic Education's need for well prepared and equipped pre-service teachers (DoE, 2004). Fifth, this study can be said to contribute to pre-service teachers' professional development in terms of their own technological pedagogical and content knowledge. Sixth, it is hoped that the study will potentially allow pre-service teachers to evaluate their TPACK to successfully integrate ICT in the 21st-century classroom. Hence, the pre-service teachers in this study would hopefully develop sufficient competencies, character qualities, and foundational literacies, all of which have been described and discussed in the literature reviewed as 21st-century qualities and skills.

1.9 Structure of the study

Chapter 1: Orientation

Chapter one provides the study's background and the problem statement, and indicates the aims and objectives of the study. A brief overview of the theoretical framework that underpins this study is provided. The methods of the research are outlined, indicating the research methodology, the design, and the data analysis used.

Chapter 2: Review of Literature

Chapter two presents an in-depth literature review related to the use of Information and Communication Technology in the 21st-century educational context. The chapter focuses on literature which deals with studies done on pre-service teachers' preparedness to teach with ICTs in South Africa specifically, and on the country's Department of Basic Education initiatives to date in promoting the integration of ICT in schools. The chapter investigates the various different 21st-century skills, foundational literacies, competencies, and character qualities set out by the World Economic Forum, and how these skills can better prepare and equip pre-service teachers' teaching and learning. The chapter also presents an in-depth literature review on the 4iR and industry Education 4.0. Lastly, the chapter focuses on the theoretical framework – and the literature related to this framework - that guided the research process.

Chapter 3: Research design and methodologies

In Chapter three, a thorough account of the research methods implemented in this study is provided, together with a rationale for the choice of these. The chapter offers an interpretation of the sampling of the research participants, and of the qualitative data analysis. The chapter also explains the issues regarding the trustworthiness of the study, as well as the challenges experienced during the research process. The chapter further highlights the ethical considerations and the research processes followed in this study.

Chapter 4: Detailed discussion of research findings

Chapter four provides a summary of the findings, analysis, and discussion. The chapter discusses the process involved in the gathering of the qualitative data from the research participants. As mentioned, this involved the use of focus group interviews and participant observations. From the data collected, themes were identified related to the research questions. The findings are also linked to the literature review and to the theoretical framework applied in this research project.

Chapter 5: Conclusion and recommendations

Chapter five concludes the study by providing recommendations for future research studies

CHAPTER 2: LITERATURE REVIEW

Introduction

Chapter 1 described the focus and aim of this study as being an investigation of the extent to which a sampled group of pre-service teachers are prepared for 4iR teaching and learning. Essential to this investigation is a search and review of previous studies which have looked at the knowledge of, and use of ICTs by, pre-service teachers, and the adoption and implementation of ICTs by these teachers at undergraduate level in pre-service training colleges, and as part of their in-service training. This review is undertaken in order to broaden the researcher's understanding of the challenges surrounding the integration of ICT tools in curriculum delivery both at a training college and in the school classroom. The previous chapter mentioned ICTs in the South African classroom having become compulsory, with the aim of school learners being able to be globally competitive as well as to prepare our students for 4iR teaching and learning. In this context, Rahayu (2017) argues, that it is expected of students at both secondary and tertiary levels to master 21st-century skills to be competitive global citizens. This chapter presents a review of that literature which describes and explains the challenges confronting pre-service teachers both in earning how to use ICTs themselves, and in implementing these in their classrooms for teaching and learning.

The literature chapter is divided into subsections, each dealing with a topic related to the aim of the study:

2.1 The role of ICT in the 21st-century

2.2 ICTs in teacher education in South Africa

2.3 21st-century skills

2.3.1 Foundational literacies

2.3.2 Competencies

2.3.3 Character qualities

2.4 Education and the Fourth Industrial Revolution

2.1 The role of ICT in the 21st-Century

The rapid global changes in information and communication technology (ICT) both impact the availability of technology and make it ubiquitous, and have prompted measurable economic changes (Valtonen, Sointu, Kukkonen, Kontkanen, Lambert & Mäkitalo-Siegl, 2017b). Thus, the implementation of technology in society and in the workplace has forced changes in the nature and trends of employment and of education (Siddiq, Gochyyev & Wilson, 2017). Given that ICT systems are now taken for granted, and are widely used in organisations and educational institutions globally (Korpelainen, 2011), it follows that ICTs should be collectively used as a tool to assist teachers in meeting the educational needs of students for them to be able to enter the job market and succeed in their careers (Farah, Tarmizee, Rahman & Zuraida, 2018). According to these authors, teaching and learning methods should be adapted and developed in line with the advancement of ICT and internet access.

ICT has been broadly defined as constituting those technologies used to convey, manipulate, and store data electronically (Perron, Taylor, Glass & Margerum-Leys, 2010; Khan, Hasan & Clement, 2012). Globally, ICT has been taken on in various teaching and learning practices in the 21st-century classroom. These include asynchronous learning, blended learning, and the flipped classroom. Because technology is more prevalent and more accessible (Neiss, 2011), teachers and learners are required to develop the appropriate technological skillsets to function and operate effectively and competitively in the digital world (Heggart & Yoo, 2018). Valtonen, Sointu, Mäkitalo-Siegl and Kukkonen (2015) argue that these skillsets prepare both learners and teachers to work with ill-defined problems in multidisciplinary teams.

Currently, the digital world is increasingly and significantly impacted by technological reform. Technology is growing exponentially, with the potential to impact education in the form of artificial intelligence (AI), augmented reality (AR) and virtual reality (VR) (Department of Science and Technology, 2019). However, many third-world countries continue to experience inadequate infrastructure, and a lack of proper internet connectivity (Adesote & Fatoki, 2013).

2.2 ICTs in teacher education in South Africa

The use of ICTs in education has remained an important area of interest to education policymakers, researchers, and practitioners globally (Uluyol & Şahin, 2016). For Pérez-Sanagustín et al. (2017), pre-service teachers are the future of ICT use in schools in terms of their potential and acquired ability to use ICTs as tools to stimulate higher-order thinking skills amongst their learners (Ndlovu & Lawrence, 2012). This is corroborated by Reyes, Reading, Doyle and Gregory (2017), who see the ideal 21st-century teacher as one who becomes the expert teacher who possesses the necessary competencies for efficaciously using those ICTs required to support and enhance teaching and learning. To achieve this ideal of the teacher being the 21st-century expert in the implementation and use of ICT in the classroom, Liu, Toki and Pange (2014), and Raman and Yamat (2014) argue and advocate strongly for teacher training in ICT use.

Some literature has shown that integrating ICT in the classroom depends solely on the teacher (Vasant & Mehta, 2015; Heggart & Yoo, 2018). A study conducted in the United Kingdom by Moseley et al. (1999) found that ICT in the classroom could only become helpful and valuable to both teachers and learners once pre-service and in-service teachers had developed a positive attitude towards using ICT in the school. Building on the findings of Moseley et al. (1999) 20 years ago, according to Reyes et al. (2017), Bartolo (2017), and Gil-Flores, Rodriguez-Santero and Torres-Gordillo (2017) see initial technology courses as crucial in building the ICT competency of teachers. Given the rapid development of technology over the last few decades, it is widely recognised that educators in training need to be prepared to incorporate information and communication technology into their educational practices in

thorough and comprehensive ways (Valtonen, Sointu, Kukkonen, Häkkinen, Ahonen, Pöysä-Taronen, Järvelä, Näykki & Mäkitalo, 2017a). According to this argument, teacher training institutions are expected to provide teachers with the skills to teach using ICT (Tondeur, Aesaert, Pynoo, Van Braak, Fraeyman & Erstad, 2015). According to Palomino (2017), the pre-service teachers in her study conducted in Spain acknowledged a need to undertake specific training in ICT and to receive guidance in the appropriate and effective use ICT tools. Thus, from such studies as Palomino's (2017), and that of Kilinç, Kilinç, Kaya, Başer, Türküresin and Kersten (2016), through the nurturing of pre-service teachers and providing them with more technology-related in-service training, the use of technology in the classroom can become ubiquitous.

In terms of policy implementation in South Africa, the Department of Higher Education (DHET) promulgated the Minimum Requirements for Teacher Education Qualifications (MRTEQ) policy to evaluate teacher education programmes (DHET, 2015). This policy document encapsulates broad standards that a wide range of education stakeholders developed in a consultative process. These included the Council of Higher Education, Department of Basic Education, Department of Higher Education and Training, South African Council of Educators, the Education Training and Development Practices Sector Education and Training Authority, public universities and private higher education providers offering teacher education qualification, and teacher unions (DHET, 2015).

Furthermore, MRTEQ informs teacher education institutions on appropriate ways to develop their programmes and curricula, and offers guidelines for setting minimum standards for different qualification types for specific purposes in Higher Education (HE) (DHET, 2015). The guidelines stipulated by MRTEQ specify that pedagogical learning includes knowledge of the curriculum, of learners, of their learning, general instructional and assessment strategies, and specialised pedagogical content knowledge (DHET, 2015). Furthermore, these guidelines require teachers to know how to present the concepts, methods, and rules of a specific subject to develop

appropriate learning opportunities for diverse learners, and to evaluate the learner's progress (DHET, 2015).

In this context of what should constitute effective teaching and learning, and with reference to the use of ICT, MRTEQ specifies that a teacher's ability to utilise ICT for innovation in teaching and learning is fundamental to their teaching, and thus all teachers should in theory be competent in the use of ICT (DHET, 2015). However, according to MRTEQ, should a teacher be entering her/his preferred program of study without being ICT competent, the necessary steps should be put in place by the Higher Education Institution to develop the trainee teacher's confidence and skills in ICT (DHET, 2015). Earlier, in 2004 the DET had clearly indicated an expectation that pre-service teachers undergo ongoing ICT professional development throughout their in-service years (DoE, 2004). This is stipulation was further corroborated in the 2004 White Paper on e-Education which specifically states that ICTs play an essential role in education transformation (DoE, 2004). The White Paper on e-Education further states that, during pre-service training, pre-service teachers should be capacitated to integrate ICTs as flexible pedagogic tools to enhance teaching and learning (DoE, 2004).

2.3 21st-century skills: Foundational literacies, Competencies and Character qualities in teacher education

The 21st-century has been characterised by educationists such as Rahayu (2017) as the era of technology, and technologies have become part of every facet of life (Mishra & Henriksen, 2018). This has led to the promotion of identified digital technologies for success in the 21st-century (Ally, 2019). Pineida (2011) expands on this idea, arguing that, to develop and ensure quality learning using ICT, students and teachers should develop certain technological and learning competencies. A report published by the World Economic Forum (WEF, 2015), *New Vision for Education,* based on a detailed analysis of the research literature and on a study of almost 100 countries, identified and defined what the compilers considered to be the 16 most critical “21st-century skills”. They argued that:

> …to thrive in a rapidly evolving, technology-mediated world, students must not only possess strong skills in areas such as language arts, mathematics and science, but they must also be adept at skills, such as foundational literacies, competencies and character qualities (WEF, 2015:1).

2.3.1 Foundational literacies

Foundational literacy represents how core skills are used and applied by students to solve everyday tasks (WEF, 2015). The World Economic Forum (WEF, 2015) *New Vision for Education* report referred to above, lists six foundational literacies which, it argues, students need to acquire for the 21st-century:

(i) Literacy;
(ii) Numeracy;
(iii) Scientific literacy;
(iv) Information and Communication Technology literacy;
(v) Financial literacy, and;
(vi) Cultural and civic literacy.

These skills serve as the basis for students "to thrive in a rapidly evolving , technology-mediated [21st-century] world" (WEF, 2015:1). According to the WEF 2015 report, one of the core skills listed above, Information and Communication Technology (ICT) represents the starting point on the path towards mastering the cluster of 21st-century skills identified in the report. Nordin and Norman (2018) predict that integrating 4iR technologies in teaching and learning will make students aware of the potential of such technologies. This view on the possibilities for education in the context of the 4iR is corroborated by Hussin (2018), who argues that students are likely to become more independent in their learning, a development which would propel teachers to assume new roles as facilitators who will guide students through their learning process, rather than instruct them.

Literacy: The Organisation for Economic Co-Operation and Development (OECD) defines literacy broadly as a particular capacity and mode of behaviour incorporating

the ability to understand and use printed information for day-to-day tasks in a community to develop one's knowledge and potential (OECD, 2000). The above mentioned WEF (2015) report adds the ability to read, understand, and use written language to this definition of literacy (WEF, 2015). Within the context of the 21st-century, and the concept of multimodal literacy, the definition has come to include the understanding and interpretation of digital media (Towndrow & Pereira, 2018).

Numeracy: Numeracy literacy has become an important skill in the 21st-century (Borgonovi, Choi & Paccagnella, 2018). The WEF (2015) report describes numeracy as the ability to use numbers and other symbols to understand and express quantitative relationships. In addition Aishalya, Nandiyanto, Kurniawan and Bilad (2022), in a study done with secondary school students learning Economics, found that numeracy literacy could be taught to improve learner's ability to solve problems related to numbers, and, in the case of their study, learning Economics in this way can improve students' numeracy literacy skills. Garcia-Retamero, Sobkow, Petrova, Garrido and Traczyk (2019) argue that numeracy helps students to assess risks and to make informed decisions, which in turn assists them in making better real-life decisions.

Scientific literacy: Dragoș and Mih (2015) describe scientific literacy as the ability to evaluate information and arguments based on evidence and data collected. This view is corroborated by the WEF 2015 report, whose compilers found in their research that a person can use scientific knowledge and principles to understand their environment and to test hypotheses. This, in turn can result in a person being able to understand scientific laws, theories, and phenomena (Dragoș & Mih, 2015).

Information and Communication Technology literacy: ICT literacy is defined by the WEF 2015 report as the ability to use and create technology-based content, including finding and sharing information, answering questions, interacting with other people and computer programming (WEF, 2015). Fraillon, Ainley, Friedman and Gebhardt (2014) add to this definition, seeing ICT literacy as being required when a

user is set to know how a computer operates. If the user is ICT literate s/he is able to access and evaluate information, as well as manage, transform, create, and share information, to use information safely and securely.

Financial literacy: Financial literacy is the ability to understand and apply conceptual and numerical aspects of finance in practice (WEF, 2015). In addition. The Program for International Student Assessment (PISA) (OECD, 2013) describes financial literacy as the possession of knowledge and understanding of financial concepts and risks, and the skills, motivation and confidence to apply such knowledge and understanding in order to make effective decisions across a range of financial contexts. The acquisition of such knowledge and skills is claimed to improve an individual's and society's financial well-being, and to enable her/his full participation in economic life.

Cultural and civic literacy: Cultural and civic literacy together constitute the ability to understand, appreciate, analyse, and apply knowledge of the humanities (WEF, 2015). This kind of literacy includes the various ways in which an individual manages to achieve effective communication, collaboration, and the valuing of the emotions of others; cultural and civic literacy is seen by Kereluik, Mishra, Fahnoe and Terry (2013) as an essential component of economic success in the 21st-century.

2.3.2 Competencies

To succeed in an evolving, technology-mediated world, students should not only possess and acquire vital skills in areas such as language, arts, mathematics and science; they need also to be proficient in cognitive abilities such as critical thinking and problem-solving, and to possess curiosity (WEF, 2015). These competencies describe how students approach complex challenges (WEF, 2015). Thus, according to this directive, pre-service teachers entering the teaching profession need to be adequately trained to prepare their learners for changing work contexts (WEF, 2015). These competencies, including critical thinking/problem-solving, creativity, communication, and collaboration, are each discussed below.

2.3.2.1 Critical thinking/problem-solving

According to Kereluik et al. 2013), critical thinking/problem-solving is an everyday activity, and the ability to solve problems is instinctual; it involves the ability to interpret information and make informed decisions based on the interpretation . When faced with a particular concern, we analyse it from various vantage points. We draw conclusions based on what we perceive, and create understandings based on existing knowledge. As this process advances, we decide on a way forward based on 'critical internal reasoning', and predictions. Given what Kereluik et al. (2013) see as this innate human ability, essential critical thinking/problem-solving using ICT in the classroom provides learners with the opportunity to engage with each other socially/collaboratively, as well as allowing individual learners to observe or reflect on critical thinking/problem-solving procedures while they report on a particular problem-solving topic (Ilie & Pavel, 2016; Worch, Li & Herman, 2012). This process can lead to the teacher towards obtaining helpful knowledge about ways in which ICT can support and enhance pedagogical strategies or goals in the classroom (Jimoyiannis, 2010).

Häkkinen, Järvelä, Mäkitalo-Siegl, Ahonen, Näykki and Valtonen (2017) assert that critical thinking/problem solving requires approaching a problem collaboratively by working together in a process involving the exchanging of ideas, and managing conflicts. This collaborative engagement encourages (i) advancing the capability to take others' vantage points into account; (ii) eagerness and willingness to share information and verbalise thoughts; (iii) being mindful of the strengths and weaknesses of group members; (iv) planning and monitoring skills for developing strategies for problem-solving and shared problem exemplification, and (v) the ability to learn and scaffold knowledge through group interaction.

According to Kubrickÿ and Částková (2015), and Uluyol and Şahin (2016), ICT has the potential to create and promote environments that can stimulate critical thinking/problem-solving and increase learner motivation. Furthermore, Mishra and

Koehler (2006) theorise that integrating technology to encourage critical thinking/problem-solving is an effective way for teachers to further develop their Technological Pedagogical Content Knowledge (TPACK).

The DoE (2003) posited that appropriate ICT tools and skills should foster research, analysing, evaluating, and soft skills amongst learners and teachers. This would enable both learner and teacher to operate effectively and successfully in society. The development of these skills in both teachers and learners provide the opportunity for the classroom environment to be effectively changed in ways which can foster and instil higher-order thinking skills amongst learners (DoE, 2003). Through this process critical thinking/problem-solving propensity would be increased significantly (DoE, 2004).

2.3.2.2 Creativity

Creativity is described as the ability to imagine and devise innovative ways of addressing problems (WEF, 2015). Earlier, and based on a similar concept of creativity, Kereluik et al., 2013) were of the view that creativity was a necessary quality for people in the 21st-century, and one that should be fostered. Creativity takes a long time to evolve and action, together with any kind of obsession, or single-minded focus (Piirto, 2011). It also needs to be seen as a continuous process and not simply about thinking creatively: it also involves working creatively with others and implementing innovation (Piirto, 2011).

According to Piirto (2011), for any person to be creative, they need to understand the domain in which they are working or functioning. In the case of ICT, the domain uses technology to enhance teaching and learning and to achieve educational goals using e-Learning tools (DoE, 2004). According to Guo and Woulfin (2016), ICT plays a prominent role in a process of teaching creatively. This idea had been set out earlier by the DBE in the 2004 White Paper which stipulated that ICT creates a learning environment that advances creativity (DoE, 2004). Mishra (2012:14) argues, "the

TPACK framework emphasises the importance of teacher creativity in repurposing technology tools to make them fit pedagogical and disciplinary-learning goals".

The use of ICTs in the classroom can be seen to help create a unique learning environment, one that creates the space for teachers to incorporate the seven 'Is' developed by Piitro (2011): (i) inspiration; (ii) imagery; (iii) imagination; (iv) intuition; (v) insight; (vi) incubation and; (vii) improvisation, all of which, together with other practices, she sees as enabling creativity to emerge as a reciprocal process in the classroom (Piirto, 2011), and one particularly appropriate to the 21st-century. Thus, it can be argued, if a teacher uses ICTs Piirto's creativity approach, a 21st-century classroom learning environment can be created which provides opportunities for the teacher to inspire creativity amongst her or his learners and, equally, for her/him to learn from, and be inspired by, the learners, and for learners to learn from each other, thus moving away from the traditional teacher-centred learning to learner-centred learning.

2.3.2.3 Communication

Communication requires articulating oneself through verbal, written, non-verbal, and digital communication media, and being a positive and respectful listener for a diverse audience. According to Kereluik et al. (2013), both communication and collaboration are essential to the success of 21st-century teaching and learning, as collaboration with diverse groups is paramount in an increasingly diverse global culture and economy.

Information and Communication Technology has created new forms of communication together with a paradigm shift in human cognition and communication (Sturm & Carter, 2015). Donovan, Green and Mason (2014) see clear and effective communication as playing a critical role in 21st-century school structures. The use of digital communication tools has in the 21st-century become an expectation and a given in education, particularly at secondary and tertiary levels. Hence, the effective

use of ICT carries the potential of substantial and wide-spread access to information, resulting in new forms of communication within education (Sarkar, 2012).

The integration and utilisation of ICT in teaching and learning has now begun to provide an opportunity for a blended learning approach. Blended learning is an approach that allows for a combination of face-to-face classroom practices with e-Learning solutions and online modes of instruction (Mikre, 2011; Livingstone, 2021). In recent years blended learning has become a sought-after approach by both teachers and students as it augments face-to-face teaching and learning (Tynan & Barnes, 2014; Bagarukayo & Kalema, 2015). The United Kingdom alone has seen exponential growth in ICT use (Sarkar, 2012). Blended learning has also been found to have the potential to increase learner motivation and engagement (Tynan & Barnes, 2014). Blended learning may thus be seen as enhancing transparent and inclusive engagements without the threat of any form of contempt for the views of others (Waghid, 2017). It also creates new opportunities for students who are enabled by e-Learning technologies (Krasnova & Ananjev, 2015).

Pineida (2011) posits educational technology to be a robust 21st-century tool, one that enables teachers and learners to communicate with a high degree of effectiveness when used correctly: it supports bidirectional communication as the students and teachers are in the same virtual space (Duţă & Martínez-Rivera, 2015). In this context, Pineida (2011), Bagarukayo and Kalema (2015), and Gushchin and Divakova (2017) describe educational technologies as together constituting a valuable didactic resource to facilitate teaching in different ways. This is further corroborated by Ventayen, Estira, Guzman, Cabaluna and Espinosa (2018) who argue that education technology fosters seamless communication, making teaching more productive and meaningful, and eradicating time and space constraints (Zyad, 2016).Using blended learning, teachers can do an immediate intervention and focus solely on aspects that a learner has not mastered, instead of reteaching the content that a learner has already understood.

2.3.2.4 Collaboration

Digital technologies offer new progressive opportunities for learning and teaching in an increasingly connected society in which learning with others and collaboration have together become a crucial skill (Repiso, Pablos & Garcia, 2014). Moreover, 15 years ago, the Department of Education (2004) stipulated that using ICT as an integrated tool would redefine the classroom environment by creating learning experiences that leverage the power of technology, in turn allowing teaching and learning to become collaborative and new knowledge engaged with meaningfully amongst learners. For instance, when learners are actively involved in their learning, and collaborate with their peers, they may perceive situations and ideas in a number of different ways. Thus, collaboration as a pedagogic strategy, using ICT, enables learners to learn and practise social skills. These in turn can provide a satisfactory and valuable learning experience by practicing digital citizenship. As a result, with teaching and learning becoming a more engaged process, with learners engaging more actively, if virtually, with the teacher, and with each other, learners' psychological and social attributes are likely to develop in positive ways (Madoda, 2018). In addition, collaboration as a pedagogic strategy can be used to assist learners in acquiring new knowledge and skills. This process takes place when individual learners recognise themselves as an essential part of a collective group where individuals synergise to contribute during the teaching and learning process (Krasnova & Ananjev, 2015).

According to Vasant and Mehta (2015), traditional teaching pedagogies are being replaced by e-Learning tools, as ICTs increasingly create the potential for virtual learning environments (VLE) (Hunt, Huijser & Sankey, 2011), which are virtual spaces on the web. ICT has created platforms and opportunities for collaborative learning. According to Valtonen, Kukkonen, Mäkitalo-Siegl and Sointu (2018), ICT tools have shaped students and teachers' platforms to engage with each other using e-Educational tools actively. In this way, teaching and learning have become more interactive and engaged. This increased interactivity and engagement has impacted learner motivation, participation, and responsibility in positive ways (Madoda, 2018). The advancement of ICT has meant that computers have impacted whole societies and education systems in addition to learning and teaching in the classroom

(Mofokeng & Mji, 2010). The impact of this on education has been a transition from traditional 'chalk and talk' classrooms to a more 21st-century dialogic and collaborative approach.

In the 21st-century collaborative, rather than teacher centred, pedagogic practices have come to be seen as increasingly necessary for effective teaching and learning. These pedagogic practices have been found to stimulate different and multifaceted patterns of behaviour, and their impact on the transformation of pedagogical demands involves modes of learning different to those of the 20th-century (Chelliah & Clarke, 2011). In this context, 21st-century learning requires pre-service teachers to adapt to and learn those new technologies which create the potential for transformation to be triggered in schools. This arrives together with a call for the kinds of curriculum improvement and transformation which can prepare students to enter the 21st-century world equipped to cope with challenging and complex tasks. Ultimately the advantages of collaborative learning in terms of equipping students to function productively in a competitive world can be seen as threefold: (i) effective learning mechanisms being triggered in collaborative spaces; (ii) developing collaborative skills; and (iii) applying collaborative learning approaches (Valtonen et al., 2017a).

2.3.3 Character qualities

The compilers of the 2015 World Economic Forum report argue that numerous education innovations regarding technology in education are beginning to address and foster various valuable skills (WEF, 2015). According to the WEF (2015) report, these skills are necessary because of innovation within society and the economy. These technologies address learner experiences (literacy and computational), teacher productivity, teacher-student communication and collaboration (WEF, 2015). As has been mentioned, in order to awaken and stimulate ICT initiatives amongst pre-service and in-service teachers, the DBE promulgated an initiative to guide teachers in a process of transforming schools into centres of quality learning and teaching (DoE, 2004). One can therefore argue that this was done, not only to change the schooling/learning environment, but also to awaken teacher and learner

curiosity about ICTs and what ICTs can help them achieve in terms of modifying teaching and learning in South Africa.

The WEF has formulated three broad categories that speak to, and are seen as necessary for, developing students' and learners' 21st-century skills (WEF, 2015). One of the categories is 'character qualities'. The WEF, in its aforementioned *New Vision for Education* report (WEF, 2015), has categorised these six character qualities:

- Curiosity;
- Initiative;
- Persistence;
- Adaptability;
- Leadership, and
- Social and cultural awareness.

Curiosity. According to the WEF *New Vision for Education* report (WEF, 2015), curiosity amongst learners manifests when a learner demonstrates the ability and desire to ask questions and demonstrates an open-mindedness and curiosity. Faulkner and Latham (2016) underscore that curiosity amongst pre-service teachers must be a driving force to develop problem-solving skills amongst their learners. Faulkner and Latham (2016) further argue that teachers who possess this kind of curiosity are also resilient. Thus, Kaume-Mwinzi (2016) posit that curiosity is a starting point for investigating and discovering new concepts and ideas. Allowing and encouraging learners to be curious provides opportunities for them to pursue what interests them. Creating a Quick Response (QR) code, and displaying it on the board can spark learners' curiosity, as it provides the signal for the learners to take out their smartphones and scan the code, This is based on the assumption that humans have a natural curiosity for what cannot be seen (Burgess, 2012:185).

Initiative. The WEF report defines this as the ability and desire to proactively undertake a new task or goal (WEF, 2015). In a study conducted by Phang, Mohd-

Yusof, Aziz, Musa and Nawi (2017) in Malaysia, the authors found that taking the initiative to conduct new types of learning in the 21st-century can motivate teachers and learners to create new ways of learning. These new ways can help with the development of learner knowledge, awareness, thinking skills, and a positive attitude towards learning. Such studies can be said to indicate that teachers should persist with these sorts of initiatives. Based on a study done in Chemistry classrooms where these 21st-century skills were being developed, Hadinugrahaningsih, Rahmawati and Ridwan (2017) argue that students with a more significant learning initiative in the 21st-century could have a measurable advantage over their peers who are not motivated to take the initiative to undertake a new task, or to set a new goal.

Persistence. The 2015 WEF report defines this as the ability to sustain an interest, and to sustain the effort to persevere to accomplish any task or goal (WEF, 2015). Persistence is a much-needed quality in a learning situation as it keeps one striving in the face of, and the determination to overcome, adversity (Kaume-Mwinzi, 2016). According to the DBE White paper 7 (DoE, 2004), the ICT revolution has significantly impacted curriculum development and delivery. This revolution continues to pose new challenges for education and training systems around the world. Nevertheless, it is was expected by the DoE that the implementer/teacher should persist with implementing new thinking, creativity, problem-solving skills, and curiosity amongst learners, often in the face of adversity, and in schools trying to offer quality education in an unequal society such as that of South Africa.

Adaptability. This is defined by the WEF (2015) in their report as a character quality to ensure resilience and success when faced with challenges. Thus, Information and Communication Technology has the potential to significantly transform the nature of education and aid when those involved are faced with challenges that can be solved using ICT. I such contexts, the use of educational technologies creates opportunities for students to engage with new knowledge and with each other and their teacher in classroom contexts (Bagarukayo & Kalema, 2015; Ghavifekr, Kunjappan, Ramasamy & Anthony, 2016; Erasmus, 2017; Waghid & Waghid, 2018) as well as the potential for learning outside of the classroom (Pineida, 2011). However, according to Waghid and Waghid (2018), educational technologies cannot replace students' actual

learning experiences. In this context, Pineida (2011), Maor (2017), and Ndlovu and Lawrence (2012) argue that, far from limiting or narrowing learning experiences, educational technologies have the potential to enhance and amplify the learning experiences of learners, and to extend the understanding of learners in ways which enable them to solve complex tasks. Educational technologies have the potential to transform teaching and learning by adding value to the learning experience of the learner. With the ever-changing world of educational technology, the kind of persistence and adaptability developed through the use of ICT ensure greater resilience and success (WEF, 2015).

Leadership. This is defined as the ability to effectively direct, guide, and inspire others to accomplish a common goal (WEF, 2015). Cultural factors can influence and develop an individual's quality of leadership.

Social and cultural awareness. This is the ability to engage with people in a social, cultural, and ethical manner (WEF, 2015). Blessinger and Wankel (2013:6) posit that the use of educational technologies in the 21st-century can break down learning, together barriers with certain social and technological pedagogical tools, thus providing a space for more inclusive learning to take place, while at the same time creating positive learning environments. Educational technologies also expand teaching capabilities, creating practical learning situations that are flexible and dynamic (Blessinger & Wankel, 2013). The advancement of ICT in e-Learning has brought prospects for personalised and innovative learning (Sanga, 2016). Thus, based on these studies, 21st-century learning has the potential for continuous engagement amongst learners and teachers, allowing them to draw links between instructional design and real-world experiences.

2.4 Education and the Fourth Industrial Revolution

Industrial revolutions, or profound social changes, have occurred throughout history. The history of social and technological revolutions in the Western, developed world spans the period from the First Industrial Revolution to the Fourth Industrial

Revolution (Schwab, 2016; Mpofu & Nicolaides, 2019). The First Industrial Revolution (17th-century), was succeeded by the Second Industrial Revolution, which saw a transition to mechanical power; the Second Industrial Revolution (18th-century – 19th-century), was followed by the Third Industrial, or digital Revolution (19th-century), which saw the dawn of the design and use of computers and the internet (Schwab, 2016). According to Schwab (2016), the Third Industrial/digital Revolution was a significant game-changer, one that saw the internet permeate the planet within a decade. Mpofu and Nicolaides (2019) are of the view that the world is already in the 4iR, and that at present, the 4iR is progressively altering how we live and work. This is view is corroborated by Banwari (2018), Lamprini and Bröchler (2018), as well as the Department of Science and Technology (2019) in South Africa, which predicts that the 4iR will significantly change how we live, work, and communicate with one another, and how we teach. Schwab (2016), like Mpofu and Nicolaides (2019), argues that we stand on the brink of a technological revolution that will fundamentally alter how we live, work, and relate to one another. Schwab (2016) argues that the 4iR transformation will be unlike anything humankind has experienced before in its scale, scope, and complexity. Although we do not yet know just how it will unfold, one thing is clear: the response must be integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academic and civil society (Schwab, 2016).

According to Schwab (2016), the 4iR uses a wide range of technologies. He describes the 4iR as being characterised by a fusion of these technologies, blurring the physical, digital and biological domains. This description is supported by Ślusarczyk (2018), who sees the 4iR as providing the means for exchanging information between objects and people and objects and objects. Cantemir (2016) points out certain new requirements that the 4iR imposes on education. These include future employees needing to be able to work within a 4iR environment (Mpofu & Nicolaides, 2019). In addition, preparedness of governments for the future is imperative for education systems to prosper in an era characterised by disruptive technologies (Sikhakhane, Govender & Maphalala, 2021).

The 4iR transforms the characteristics of the workplace from task-based to human-centred characteristics (Xing & Marwala, 2017). According to Banwari (2018), to adapt to the 4iR, people need the skills required to implement, manage, and work with the new technology and to work collaboratively. Hattingh (2018) describes these skills in terms of workforce readiness, soft skills, technical skills, and entrepreneurial skills. This prompts governments, educators, and parents to ask how they can prepare present and future generations to survive and to thrive in this rapidly transforming world (Brown-Martin, 2018). As a result, the Department of Science and Technology in South Africa seeks to improve innovation, technology-driven change, together with the necessary 21st-century skills for students at Higher Education and Training Institutions to ensure that this change does not hinder the future success of these students (Department of Science and Technology, 2019).

Technologies are seen collectively as a modern instrument to enhance and support new learning and teaching processes and contribute significantly to the 4iR (Razak, Alakrash & Sahboun, 2018). However, today most education systems continue to be based on century old models (Banwari, 2018). Since the early 20th century, not many pedagogical changes or innovations have taken place, resulting now in pressure placed on teachers to adapt and improve their modes of teaching in 21st-century schools (Msila, 2015). Thus, as has been mentioned, and the central assumption underpinning this study, given that technology has now been found to enhance students' learning, teachers now need to be prepared to use and to adopt technology as a teaching tool,. Thus teachers, and teacher training institutions are coming to realize that the 21st-century classroom must provide technology-supported teaching materials (Padmavathi, 2016).

According to Banwari (2018), fundamental education reform from early childhood to primary and secondary education, to vocational training and higher education will determine how the next generation of workers will find their place in the workplace across different scenarios. It is at this point, and in this area, that ICT and the preparation for the 4iR in education both play a pivotal role in implementing appropriate teaching strategies and organising work to foster learning (Xing &

Marwala, 2017). Thus, as these studies have indicated, the integration of ICT in the classroom has been predicted to be able to address inequalities and improve teaching and learning in schools. As a result of this, the number of low skilled workers is predicted to drop in the future as predictable tasks are replaced by machines or Artificial Intelligence (Xing & Marwala, 2017).

Much of the literature reviewed in this chapter has indicated that the use of technology for teaching has become an integral part of what is considered to be successful teaching and learning. However, the role and competencies of teachers needs to be included in the equation. While Lamprini and Bröchler (2018) argue that new and enhanced pedagogical practices and approaches and learning tools to assess innovation skills are critical in education, Razak et al. (2018) postulate that successful implementation and use of educational technologies in the classroom depends mainly on teachers' willingness to use these in their classrooms. Teachers are, according to this argument, the key component in the classroom, and it is they who ultimately decide whether to integrate these technologies and how they intend to use them in their classrooms. Nevertheless, regardless of the willingness, or unwillingness of teachers, the use of technology in the 21st-century, Lamprini and Bröchler (2018) argue, has the potential to help facilitate innovation by (a) bringing new ideas to educators, (b) documenting and sharing practices, and (c) connecting with other educational institutes and experts at the international level.

Adesote and Fatoki (2013) and Lamprini & Bröchler (2018) are of the view that education is one of the least innovative 'industries' globally, and one that is less influenced by ICT than other fields. Thus, the major challenge that South African education has is an historical approach to ICT training that might not always have been useful or innovative in enabling teachers to be competent in terms of their knowledge and use of ICT in their teaching. However, Sadeck and Cronjé (2017) concluded, from a study conducted with pre-service teachers whom they found to be on a continuum in terms of their use and willingness to use ICTs in their teaching, that teachers at an innovative apex should create and develop dynamic learning opportunities and environments for e-Learning. Consequently, Msila (2015), based

on a study of teachers in Gauteng which looked at their attitudes towards using ICTs in their classrooms, together with their competencies in using these, concluded that teachers need practical and meaningful ICT workshops to boost their computer competence.

One cannot look at the 4iR in isolation. It has to be in conjunction with Education 4.0. Education 4.0 is a response and align itself to the needs of 4iR (Hussin, 2018). Education 4.0 uses a combination of ICT tools to advance teaching and learning in the 21st-century. According to Puncreobutr (2016), Education 4.0 is catering to society's needs in the innovative era. Fisk (2017 cited in Hussin, 2018) stipulates nine trends relating to Education 4.0:

1. Learning will take place virtually anywhere if there is an internet connection. Learners will learn at their own pace allowing the teacher to give individual attention in the classroom.

2. Learning will be personalised. This will allow each learner to be challenged according to his or her capabilities. The one method fits-all approach will no longer be taken to effective.

3. Freedom of choice. Learners will be given the freedom to choose how they want to learn, which e-learning tool they would like to use, and which approach they want to follow, in what may be a blended or a ‘flipped-classroom’ approach.

4. Project and Problem-based learning. A project-based learning approach will be incorporated in the classroom which will create the opportunity for students to apply their skills to complete the projects. When students are actively involved during these project-based learning are practising essential skills such as time management, collaborative learning, all of which will be beneficial to them in their future careers.

5. Integrated learning experiences. Students will be at an advantage if they are using ICTs in the classroom to obtain the necessary field experience. This experience will be acquired without the student having to leave a room.

6. Data science, statistical analyses will be done by a computer. Computers are making the manual part of arithmetic obsolete. As a result, interpretation of these results by humans will become more critical and require human logic and reasoning.

7. Change in assessment methods and types will occur as the course material is changed and new material is developed. Students will be differently assessed, in ways which will create room for immediate feedback, and that indicate that they no longer have to cram their content knowledge for one test, but instead apply it gradually.

8. For responsible learning: students will take responsibility for their learning. They will become both independent, and involved in their learning as the curriculum is adapted to their needs and to the country's economic requirements.

9. Facilitating learning will play a pivotal role in the teaching and learning of students. Though students will gain much independence while learning, teachers will still form the central point of teaching and learning.

Education 4.0 has created a world where information is readily and ubiquitously available. Education 4.0 has also disrupted teaching and learning in positive ways (see Table 2.1), making it more dynamic (Halili, 2019). Hence, Hussin (2018) argues teachers need to repurpose their teaching approach to meet the need of the 21st-century teaching landscape. Based on such arguments, teaching with technology to support the learning process is the core concept of Education 4.0 (Hariharasudan & Kot, 2018). These authors predict that Education 4.0 will allow learners to learn at their own pace (see Table 2.1). Furthermore, Hariharasudan and Kot (2018)

stipulate that, to advance the education system, is to leverage advanced technologies such as:

- The use of 3D printing in the classroom to provide students with a better understanding of their subject matter. Using 3D printing in the classroom is seen as a means of bringing educational concepts to life (Waghid, Waghid & Waghid, 2019).
- Implementing Augmented Reality (AR) in the classroom to simulate a real-world environment
- The use of Virtual Reality (VR). This allows for far greater student engagement with prescribed textbooks than the conventional ways of engaging students. VR also simulates a physical presence in an immersive digital environment.
- The use of cloud computing, a technology process that will allow students access to their work from any place at any time if they have an internet connection.
- The use of hologram technology which offers visual and interactive learning experiences.
- Introducing the Internet of Things (IoT), a technology that allows for rapid communication and interaction amongst teachers and students as well as objects and objects.
- The use of Artificial Intelligence (AI) – a technology that can accelerate the teaching and learning process by giving immediate feedback, thus reducing the work that teachers have to do manually. With the help of AI, teachers will be able to focus on the meaningful task for a more engaging learning experience.

Thus, Education 4.0, technology-based teaching and learning, when utilised effectively, will provide for the needs of society in an innovative era (Hariharasudan and Kot, 2018). And when humans and technology are aligned, this will enable new possibilities (Hussin, 2018).

Table 2.1: Education profile (adapted from Demartini and Benussi (2017))

Role player	**Education1.0**	**Education 2.0**	**Education 3.0**	**Education 4.0**
Teacher	Source of knowledge	Facilitator	Leader of collaboration	Supported by AI, AR and VR
Content delivery mode	Textbook based	Open educational resources (OER)	OER and used by learner	Available various learning portals
Institution	Confined to the classroom	Collaboration amongst institutions	Teacher exchange, one-to-many affiliation between learners	Not confined to the classroom/institution, AI driven
Learning process	Lecturers, group work	Use of technology confined to classroom boundaries	Allowing student creativity, networking outside of classroom	Learning driven by AI, AR and VR
Learner	Mainly passive	Transition to active role, enhanced ownership	Ownership of own teaching and learning, collaborate	Autonomous – AI help to develop educational plans

Table 2.1 depicts how education has transitioned in the course of the four industrial revolutions. It is evident that, during Education 1.0, the teacher was the primary source of knowledge, and the learner was merely an absorber of the knowledge being transferred. As the education fraternity transitioned and evolved, lessons became more learner-centred, and the teacher's knowledge and pedagogy were broadened (Almeida & Simoes, 2019), while at the same time technology became more developed, prevalent, and relevant. Almeida and Simoes (2019), see Education 4.0 as an emerging paradigm where, ideally, learning models are adapted to the learner.

2.5 Theoretical framework: Technological Pedagogical and Content Knowledge

The Technological Pedagogical and Content Knowledge (TPACK) framework was first conceptualised and introduced by Mishra and Koehler (2006) to illustrate the types of knowledge teachers need to teach effectively with technology. Valtonen et al. (2017b), using a questionnaire, updated the framework, seeing it as a valuable tool for studying and supporting the development of pre-service teachers' 21st-century skills. The framework both builds upon, and branches out from, the Pedagogical Content Knowledge (PCK) of Shulman (1986). Shulman proposed that pedagogy knowledge and content knowledge should not be seen as separate domains, but that there should be a relationship between these domains (Mishra & Koehler, 2006). PCK was formulated to blend content and pedagogy in such an accessible way as to enable a grasp of how subject matter is structured, changed, and articulated for instruction (Mishra & Koehler, 2006:1021). These authors believed that the foundation of the TPACK framework is built using the idea of teachers being able to comprehend that teaching is a complex task that draws on a variety of knowledges. Thus, given this complexity, as Hofer and Harris (2012) point out, is it worth noting that not all subdomains of the TPACK framework may be present or emerge during teaching.

TPACK is also a framework for understanding the nature and extent of teachers' knowledge and how they would use TPACK in useful ways to implement and

integrate technology tools in their teaching and in the learning process (Neiss, 2011; Schmidt-Crawford, Tai, Wang & Yin, 2016). In addition, TPACK is viewed as a dynamic framework describing the knowledge that teachers need to rely on for them to design and implement curriculum and instruction while guiding their students' thinking and learning with digital technologies in various subjects (Neiss, 2011; Maor, 2017). Reyes et al. (2017) add that TPACK is useful for synthesising teachers' technological, pedagogical, and content knowledge. Based on the development and evaluation of TPACK, Mishra and Koehler (2006), and Tallvid (2016), argue for an interwoven relationship between the domains. Mishra and Koehler (2006) endorsed the following relational elements to be important in their suggested framework:

Technological knowledge (TK). This is knowledge of advanced technologies, such as the internet and digital video, and involves the skills required to exploit specific technologies. In the case of digital technology, TK includes knowledge of the operating system and computer hardware, together with the ability to use standard office suites and technology applications, including web browsers, e-mail programs, and word processors. TK covers the basics of applying various ongoing maintenance aspects to a computer device, such as installing and upgrading hardware and software, maintaining a data repository, and keeping up to date with the constant change of technologies. TK is seen as a crucial knowledge construct in the 4iR (Mpungose, 2020).

Pedagogical knowledge (PK). This is in-depth knowledge about the process and methods of teaching and learning and all that these embrace, as well as educational purposes, values and aims. In addition, PK includes knowledge of, and familiarity with, the techniques and methods used in the classroom. It is a knowledge strategy used to implement and apply different assessment techniques to assess student learning. Mishra and Koehler (2006) also argue that teachers with a deep PK can understand the various ways in which students build knowledge and acquire skills. Teachers with a deep PK can also foster effective thinking habits and positive attitudes towards learning amongst their students. Thus, PK requires on the part of

teachers, a thorough understanding of cognitive, social, and developmental learning theories, and their applications to students in the classroom (Mishra & Koehler, 2006).

Content knowledge (CK). This is knowledge about the actual subject matter that is learned or taught. Because CK differs from grade to grade, the teacher must have a thorough understanding of the subject matter being taught (Mishra & Koehler, 2006). In addition, the teacher needs to understand that CK is an essential domain for developing creativity. Hence, Mpungose (2020) argues that CK is a fundamental prerequisite for pre-service teachers.

Pedagogical content knowledge (PCK). This is knowledge about foundational areas of teaching and learning. PCK is the teacher's awareness of his or her subject matter and an ability to find multiple ways of teaching and of developing and adapting instructional resources to build onto students' prior knowledge (Mishra & Koehler, 2006). PCK is also the knowledge domain that seeks to improve teaching by creating connections across the different domains and improving the pedagogy to deliver the content (Mishra & Koehler, 2006).

Technological content knowledge (TCK). This is knowledge about how technology and content are commonly related. TCK is knowledge about the development of technology tools for teaching purposes and understanding the impact technology has in this process. Also, TCK requires an in-depth thought process in the use of the technology to convey and enliven the subject matter (Mishra & Koehler, 2006). This thought process is guided by the lesson objectives, which ultimately inform the choice of technology that can be most effectively used. TCK also affords the teacher the opportunity to demonstrate an understanding of how technology and content can complement or limit one another (Mishra & Koehler, 2006).

Technological pedagogical knowledge (TPK). This is knowledge of technologies' existence and capabilities as they are used in teaching and learning settings. TPK is acknowledging that the use of technology changes teaching and learning (Mishra & Koehler, 2006). TPK also requires a greater understanding of the existence and capabilities of technology within the subject matter in which they operate (Mishra & Koehler, 2006).

Technological pedagogical content knowledge (TPACK). This is an intersection and blend of all three knowledge domains (Figure 2.1). Understanding TPACK involves realising that pedagogy, technology and content cannot operate in silos (Mishra & Koehler, 2006). Instead, these function together as an emergent form, and a teacher needs to understand how these domains complement and interact with each other. Applying TPACK in every lesson in which a teacher utilises technology requires understanding the various ways in which subject matter can be represented using technology. In addition, TPACK includes an understanding of pedagogical methods that use technology advantageously to teach content — leveraging technology to teach complex concepts effectively and how technology can aid and facilitate students learning (Mishra & Koehler, 2006).

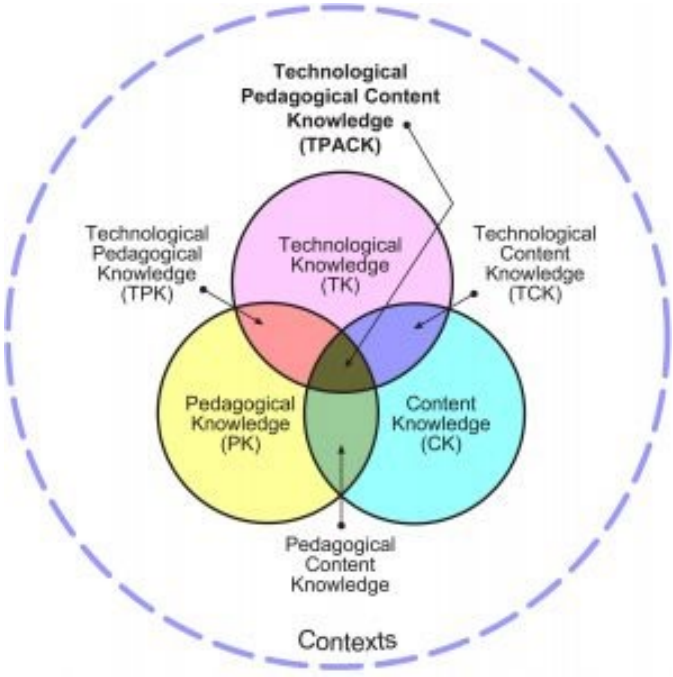

Figure 2.1 TPACK domains - Reproduced by permission of the publisher, © 2012 by tpack.org

Chai, Koh, Lim and Tsai (2014) argue that teachers need to be designed-oriented and creative professionals who can leverage technological knowledge and pedagogical knowledge for content learning. A creative and flexible relationship needs to exist between content, pedagogy, and technology (Bagarukayo & Kalema, 2015). However, as Harvey and Caro (2017) emphasise, teaching in the 21st-century which incorporates technology challenges pre-service and in-service teachers to execute teaching with a firm understanding of technology and its pedagogical uses.

Mishra and Koehler (2006) claim that the TPACK framework helps teachers to identify what is essential to the process of teaching a particular subject. Thus, TPACK is believed to help educators identify the nature of knowledge for digital technology in classrooms (Chigona, 2017). Harvey and Caro (2017) note that the purpose of this framework is to maintain the interconnection between three key context areas of teacher education – content, pedagogy, and technology – when researching technology integration practices. The value of the framework resides in its recognition that the three areas are not mutually exclusive. Thus, according to the framework, any measure of technology integration needs to consider that learning how to integrate technology is done in conjunction with studying the process and development of learning, how one teaches (pedagogy), and how one teaches the

particular subject or discipline (content). Furthermore, TPACK is in essence knowledge created by design. Therefore, rather than it being about the "truth", it is about creating satisfying pedagogical solutions for helping students learn for the twenty-first-century workplace and for their social and economic future (Chai et al., 2014). Thus, a case can be made for TPACK being central to teaching with digital technologies (Chigona, 2017). The TPACK framework is used in this study to examine how technology was used in the classrooms in which the participating pre-service teachers were teaching (Mishra & Koehler, 2006).

In conclusion, the TPACK framework is used in the current study as a theoretical framework to answer the research question and sub-questions. The framework is intended to provide a holistic overview of the abilities of the participating pre-service teachers to use technology effectively and creatively in the 21st-century classroom to prepare their students for the 4iR.

2.6 Chapter Summary

The studies and articles reviewed in this chapter have made it clear that the rapid and ongoing development of, and changes in, technology, both on a global scale and in South Africa, and its implementation in the workplace and in our daily lives, have forced changes in employment and education. Moreover, the literature has shown that, given this constant change and rapid development in technology implementation, it has become essential that teachers and learners develop the necessary skill set to use these technologies. It is also important to note that studies in the literature suggest that the implementation of technology in the classroom as a pedagogic tool is accompanied by various challenges. These include a lack of foundational literacies amongst learners, together with a lack of the ‘character qualities’ necessary for these changes amongst both teachers and learners. This chapter also highlighted the pivotal role these skill sets play, and are set to play, in the 21st-century classroom. Furthermore, the literature suggests that, should pre-

service teachers be adequately equipped with these skill sets, the implementation of technologies is likely to be a positive process in the 4iR classroom. Chapter 3 presents a description and discussion of the research design and methodology used to answer the research questions and sub-questions.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

Introduction

Chapter 1 provided a brief synopsis of the research methodology. In this chapter the research design and methodology applied in this study are described and discussed in detail. The research design is three-fold: exploration, description and explanatory (Babbie, 2014). The methods used to obtain, analyse and interpret the primary data collected are also described in detail and a detailed rationale offered vis-à-vis the selection of the most suitable research design and methodology to fulfil the aims of this research.

The rest of this chapter is organised as follows:

3.1 The research design and method

The research design is a blueprint plan for the research (Mouton, 2001). The blueprint guides the researcher's focus on, and steps taken in, the essential aspects relating to the collection of data, analysing the data and reporting on the data. The blueprint specifies all the significant components and indicates the ways in which they are interlinked to produce information adequate and appropriate to answering the research question (Yin, 2018). Babbie (2014) avers that the research design involves the creation and integration of all the research elements. Babbie (2014:120) adds that there exist a variety of ways to study a particular subject and a solid, reliable and appropriate research design needs to be established to ensure that the researcher maintains their focus on the purpose of examining the particular phenomena under study.

A qualitative research design was used for this research, with a case study approach. The case study was considered to be the preferred research approach for examining contemporary events and collecting data within a specific context (Yin, 2009; Zainal, 2007; Du Plooy-Cilliers, Davis & Bezuidenhout, 2014). I considered an additional advantage of a case study approach to be that it provides an opportunity for the researcher to see and experience a particular phenomenon through the eyes of the participants. According to research done using case study research, and through descriptions and reports of past case studies, a case study provides the opportunity for researchers to explore and understand complex issues and real-life phenomena (Yin, 2009; Zainal, 2007). Related to this, case study research affords researchers the means for "seeing something in its completeness". A case study using many angles and different vantage points, or perspectives, allows for a rich picture to be built by the researcher through his/her gaining analytical insights from such an image (Thomas, 2016). Hancock and Algozzine (2006) further see the case study research design as providing the researcher with the opportunity to capture multiple realities, which is not easily done when using a quantitative approach. In other words, the case study approach incorporates different vantage points from which the researcher is able to investigate and experience the lived experiences of the participants. Thus, given the complex nature and aim of this study, the case

study was considered the most appropriate research approach, and one which would assist the researcher in examining the complex, multi-faceted real-life phenomena of the sampled participants.

There are three dominant research traditions or paradigms, namely, positivism, interpretivism and critical realism (Du Plooi-Cilliers, 2014). Du Plooi-Cilliers (2014) posits that these research traditions have one commonality: research is seen as a systematic process whereby data are collected and analysed through appropriate data collection and analysis methods. The paradigm underpinning this study is interpretivism. The research questions guide the interpretive paradigm, and this paradigm foregrounds the meanings individuals assign to their experiences (Du Plooi-Cilliers, 2014). This paradigm allows the researcher to gain an in-depth understanding of the phenomena under study through the lens of the person or persons being studied (Kivunja & Kuyini, 2017). According to Du Plooi-Cilliers (2014), interpretivists seek to understand and describe meaningful social action and experience. Interpretivists believe that reality for individuals is, and is experienced, as fluid and subjective, and is created by human interaction. In addition, according to Du Plooi-Cilliers (2014), the interpretivist paradigm interprets a phenomenon or experience as knowledge when the researcher is aware that it “feels right” to those being studied Thus, the theory should describe and interpret the participants’ context to create an in-depth understanding of other people’s realities.

The epistemology of interpretivism allows the researcher to make meaning through the researcher’s own thinking and cognitive processes, which are informed by the interactions with the participants (Kivunja & Kuyini, 2017). Interpretivist researchers subscribe to the belief that reality is a social construction, and that it is dependent on, and/or ‘constructed’ from, the meanings that people ascribe to their interactions with others (Du Plooi-Cilliers, 2014:29). The methodological position of this study was that of using focus groups and observations as data collection methods to gain an in-depth understanding of multiple realities (Du Plooi-Cilliers, 2014; Kivunya & Kuyini, 2017).

3.1.1 Site selection

The research was conducted at a public Higher Education Institution (HEI), a University of Technology (UoT) in the Western Cape. The focus and site of this research was the Faculty of Education of the institution, which is sited on two campuses. The primary reason for the choice of this study site was that this HEI, and its Faculty of Education, is considered to be the largest provider of teachers in the Western Cape Education (CPUT, 2020). At the campus chosen for the site for this study the language of teaching and learning (LoLT) is Afrikaans. The campus is equipped with three computer labs for teaching and learning, and one computer lab for use by students. In addition to the three computer labs, there is a library where students have access to additional computers. These computers are available to all students after-hours, or in the event that the student computer lab is closed. The four computer labs are equipped with more than 45 personal computers installed with the latest software needed by the lecturers to deliver their curricula successfully. These computer labs also provide stable internet connectivity for students to conduct research and complete various assigned tasks assigned.

3.1.2 Participant selection

Research is a process during which knowledge is gathered by looking for answers to questions (Pascoe, 2014). In this study, the answers to the questions were gathered from the research participants who were purposefully selected (Fouché & Delport, 2011). When the research elements or participants are purposefully chosen, this sampling method is known as purposive sampling (Maree & Pietersen, 2016). Purposive sampling is non-random and does not require a set number of participants (Pascoe, 2014). Smaller samples than those used in quantitative research are used in qualitative research, as the general aim of sampling in qualitative research is to acquire information that is useful for understanding complexity, depth, variation, and/or the context surrounding a phenomenon (Gentles, Charles & Ploeg, 2015).

Pascoe (2014), and Etikan, Musa and Alkassim (2016), posit that the researcher in qualitative, interpretivist research deliberately chooses purposive sampling as this kind of research requires, or is based upon the assumption, that the sampled group of participants possess unique qualities or characteristics in common. The unique qualities which the 22 sampled participants possessed included:

(i) they were all BEd students
(ii) they were registered for Computer Applications Technology, an elective module
(iii) they had two years of pre-service teaching experience, in the course of which they obtained relevant ICT and computer literacy skills, and
(iv) they had experience of conducting their practice teaching at 'disadvantaged' and affluent schools throughout the Western Cape.

Furthermore, the participants were selected based on whether they had used, or encountered the use of, an e-Learning Platform from previous teaching experience at the schools where they had conducted their practice teaching. From my analysis of the students' applications prior to their enrolment at this campus, I found that 36% of the participants had not completed any form of computer literacy skills training during their schooling, while 64% of them reported having an in-depth knowledge of computer applications. These characteristics, together with their computer and information technology knowledge, experiences, and teaching practice experience, therefore, made them suitable for selection for the study sample.

3.1.3 Data collection

Fouché and Delport (2011) posit that the qualitative research paradigm refers to research that elicits participants' accounts of meaning and experience, thus making it difficult to measure and quantify the underlying qualities of subjective meanings of a phenomenon (Strydom & Bezuidenhout, 2014). The authors also advance that qualitative researchers are not interested in *how many*, but rather, how a participant experienced, perceived, and attached meaning to the phenomenon. While Mouton (2001) describes the a variety of data collection methods a researcher can use, the

research questions and sub-questions of this study guided the choice of data collection methods. These questions required that the data collection methods both underpinning, and appropriate for, this study would be the use of focus group interviews, together with participant observations of the participants' conducting their micro lessons.

Thomas (2017) identifies two forms of observation used in qualitative research, namely, structured and unstructured observations. For this study with the third year BEd students, the unstructured observation method was used these observations provided the researcher with the opportunity to become a participant during the observation process. Nieuwenhuis (2016a) posits participant observation to be an emic perspective. Strydom and Bezuidenhout (2014:180) list a number of key benefits accruing to the researcher and their study in the course of the observation(s):

(i) the researcher(s) become immersed in the reality of the participants education context social artefacts;
(ii) events are depicted within the actual real-life context where they occur;
(iii) participants may exhibit behaviour which they would usually try to conceal;
(iv) incongruities may be picked up between what was observed during practice teaching and what was said in the interview(s), and
(v) accurate findings are able to be triangulated (related to (iv)).

The observations conducted, during the micro-lessons where the sampled participants were using e-Learning as a pedagogical tool, provided opportunities for the researcher to gain a more in-depth insight into how participants were using a particular e-Learning tool(s). This process was assisted by the researcher taking notes, and observing the participants while they were actively using the e-Learning tool within the classroom. This created the opportunity for the researcher to fully comprehend the participant's world view regarding the implementation and use of technology, pedagogic approach, and decision-making process regarding the

research context, and to obtain an in-depth understanding thereof (Thomas, 2017; Queirós, Faria & Almeida, 2017).

In order to further explore the participants' experiences and understandings regarding the use of an e-Learning platform, together with their understandings of the 4iR, focus groups were conducted. Strydom and Bezuidenhout (2014) describe a focus group as a group interview in which various participant elements may be determined. The elements determined in the current study included the participants' understanding and experience regarding Google Suite for Education as an e-Learning system. In addition the participants' knowledge about the 4iR and its impact on the South African education system were explored through discussion. Strydom and Bezuidenhout (2014) also see the focus group interview as a useful strategy for the researcher/facilitator to determine the attitudes, behaviour, and preferences of the participants regarding the studied phenomenon. Greef (2011) and Nieuwenhuis (2016b) both see the focus group interview as being conducted based on the assumption that the group interaction is likely to be productive in eliciting a range of responses from the participants, activating forgotten details of experiences, and stimulating new ideas, in addition to releasing any inhibitions that may discourage participants from disclosing information or expressing opinions/feelings. Taking all of these advantages into consideration, Greef (2011:373) argues that the strength of focus groups as a data collection instrument resides in their ability to produce concentrated amounts of data related in a precise way to the phenomenon of interest.

During the focus group interviews, a set of questions was asked (see Appendix A) whose aim was to explore the participants' knowledge and understandings of ICTs, of the implementation of e-Learning tools, and their use and experience thereof (Strydom & Bezuidenhout, 2014; Thomas, 2017). What emerged from the focus group discussions was a sense of the participants' familiarity with the term '4iR', and, from this, their preparedness to embrace technological change in education was established. In addition, discussions were encouraged during the focus groups

regarding Google Suite for Education as an e-Learning platform. The focus of these discussions was an exploration of the different techniques used by the participants while they were implementing Google Suite for Education during their micro-lessons. They also expressed their acceptance of, and their readiness for, the 4iR shift in South African education. The focus groups each consisted of eight participants. This small number was to ensure that every participant would have the opportunity to participate equally in the discussions. During the focus group discussions the researcher remained watchful and attuned to the possibility that some research participants might feel inadequate, or intimidated by the dominance of other group members (Nieuwenhuis, 2016b). This possibility was addressed by encouraging contributions from each member of a group, and by maintaining focus amongst the participants as well as clarifying the questions to be discussed, when necessary. The discussions were recorded and were later transcribed for data analysis purposes.

3.2 Data analysis

According to Schurink, Fouché and de Vos (2011:397), the purpose of a qualitative study is to produce findings from raw information to identify significant. The focus groups and participant data observations used provided opportunities for the researcher to use various analysis techniques to triangulate the data for strengthening both the purposes and the accuracy of the findings and conclusions from the findings (Nieuwenhuis, 2016a). Mouton (2001:108) views the purpose and process of data analysis to be the breaking down of the mass of data into manageable themes, patterns, relationships, and trends. Therefore, in the analysis process, the data were grouped into the categories and sub-categories which emerged in the course of the analysis, in this way assisting the researcher to find coherence and to synthesise the results to achieve a useful and meaningful analysis on which to base the findings of the study (Thomas, 2016). Grouping the data into these categories was done employing coding (Du Plooy-Cilliers et al., 2014). Coding is the process whereby raw data are transformed into a standardised form (Babbie, 2014). Thus, Strydom (2011b:246) advances the argument that analysis of the data should be done in such a manner to ensure that qualitative themes emerge.

The following inductive coding steps, as set out by Du Plooy-Cilliers et al. (2014) and Schurink, Fouché & De Vos (2011) were followed to develop the themes and patterns embedded in the text:

- Step 1: Data preparation was done: raw data were transcribed derived from the focus groups;
- Step 2: The coding unit to be used was defined: phrases were used as coding units;
- Step 3: Categories and coding schemes were developed in which related coding units were grouped, and categories comprehensively described to identify differences between themes and categories;
- Step 4: Coding consistency was assessed, in the process of which the clarity and consistency of category definitions on sample data were tested;
- Step 5: Open coding was used to code, in the process of which relevant sections were highlighted.
- Step 6: The coding scheme was tested on the sample text, in the process of which a rechecking of the consistency of the coding was performed;
- Step 7: Interpreted data allowed me to create themes from data collected by looking for relationships. Results were then analysed and augmented using existing theories;
- Step 8: Methods and findings were reported or recorded: the software used to code the themes was ATLAS.ti. ATLAS.ti, a programme which allows for truthful reporting on the process applied in a digital format. To strengthen the findings, a voice recording software was used during the focus groups called Otter.ai. Otter.ai allowed for the instantaneous creation and developing of themes.

During the analysis phase, the researcher was able to triangulate the strengths and weaknesses of the pre-service teachers' Technological, Pedagogical and Content Knowledge capabilities; these were coded again by a researcher familiar with the

TPACK framework which underpins this study. This was done to maintain triangulation and to provide accurate data (Babbie, 2014).

3.2.1 Qualitative data analysis

According to Flick (2013), qualitative data analysis (QDA) involves the classification and interpretation of information to make statements about implicit and explicit dimensions and structures of meaning-making in the collected material, and what is represented in it. Babbie (2014) posits QDA to be a non-numerical examination and interpretation of observations, whose purpose is to discover underlying meanings and patterns of relationships. Nieuwenhuis (2016a:109) develops Babbie's (2014) argument by pointing out that QDA is a continuous non-linear process, implying that data collection, processing, analysis, and reporting are interlinked. Hence, Flick (2013) and Miles, Huberman and Saldaña (2014) see QDA as having three general aims:

(i) to describe the phenomenon being studied;
(ii) to give meaning to the differences of the phenomenon; and
(iii) to develop a possible theory.

These aims are intertwined as depicted in Figure 3.1 below:

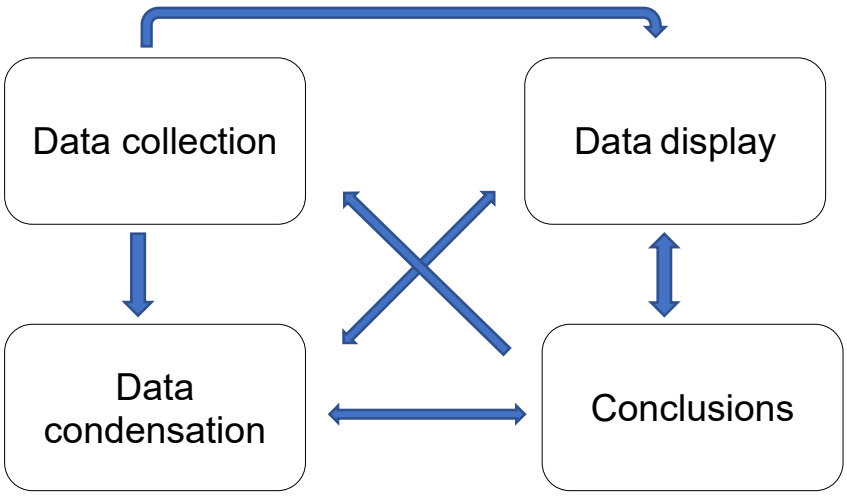

Figure 3.1 Adapted Miles, M. B., Huberman, A. M. & J Saldaña (2014). Qualitative data analysis An expanded sourcebook (3rd ed.). Thousand Oaks

As discussed in section 3.1.3, the data collection strategies for this study included focus groups and participant observations. The data condensation was done by coding the collected data. Nieuwenhuis (2016b) sees coding as a process of reading carefully through the transcripts, line by line, and dividing the transcribed material into meaningful analytical units According to Babbie (2014), and Bezuidenhout and Cronje (2014), the following stages of coding exist:

(i) Open coding;
(ii) Axial coding;
(iii) Selective coding and;
(iv) Thematic coding

The coding strategies underpinning this study included open coding, axial coding, and selective coding. Open coding is the process where the initial classification of concepts occurs (Babbie, 2014). Bezuidenhout and Cronje (2014) stipulate that, during the process of open coding, the researcher reads through the transcribed focus group interviews, and the notes made during the observation of the micro-lessons, to get an overall impression and understanding. In the current research,

once the researcher had read through the overall text, themes were developed with the help of the Otter.ai computer program used to record the focus group interviews. During open coding, the researcher was able to group and identify various concepts that emerged into more significant categories of concepts, to be able to conceptualise and compare these (Bezuidenhout & Cronje, 2014; Schurink, Fouché & De Vos, 2011). Once this was done, axial coding was used to reanalyse the results of the open coding, and to identify the core aspects of the current study (Babbie, 2014). This reanalysis stage assisted the researcher to identify the relationships and connections between the concepts and categories, and, in so doing, creating the opportunity to merge or re-categorises concepts (Bezuidenhout & Cronje, 2014).

Though the first round of analysis was done digitally, the succeeding rounds were done manually as, according to Bezuidenhout and Cronje (2014:243), it is not advisable to leave the analysis to a non-discriminatory method. Bezuidenhout and Cronje (2014) elaborate on this by arguing that computer-aided technology cannot assess the phrases and words in the transcript, nor pick up intonations and inferences as humans do. Thus, Nieuwenhuis (2016a) advises the researcher to revisit the original field notes or recordings to moderate and listen attentively for words such as “well… er… I suppose…", as these kinds of words are essential and telling elements of a conversation (Nieuwenhuis, 2016a). By following this advice, the researcher was able to verify various conclusions drawn from the recordings, transcripts, and observation notes.

3.3 Trustworthiness of the research

According to Koonin (2014), the term ‘trustworthiness’ is used in research to determine the validity and/or accuracy of the research findings in a qualitative study. Nieuwenhuis (2016b:23) postulates trustworthiness to be the critical test of the study’s data analysis, findings, and conclusions, and the process of establishing this trustworthiness is of the utmost importance in any qualitative research. Shenton (2004) and Koonin (2014) divide trustworthiness into four facets or domains:

(i) credibility;
(ii) transferability;
(iii) dependability and;
(iv) confirmability

Nieuwenhuis (2016b), Schurink, Fouché and Delport (2011) enumerate the following respective characteristics of credibility, transferability, dependability, and confirmability:

- credibility is the harmonisation between the findings and the reality, based on the data provided by the participants,
- transferability depends on the ability of the connections between elements of a study and research to be applied to a similar situation,
- dependability is a demonstration of the data collection instruments used through the research design and its implementation, and,
- confirmability is the result of the implementation of various strategies to strengthen triangulation and avoid bias. Its role and purpose is to inform and support the findings and interpretation of the research.

The credibility of this study was guaranteed as far as possible by interpreting the data provided by the participants during the participant observations and focus group interview process as accurately as possible, using triangulation to provide as accurate a report as possible of the findings (Babbie, 2014). In addition, the time spent with the proposed participants in the initial stages of this research study assisted in developing a rapport and gaining their trust, which in turn facilitated the collection of rich and honest data during the focus group interviews and participant observations (Strydom & Bezuidenhout, 2014).

Any process of consideration of the possibility of the transferability of the findings of the current study involves gauging whether this study can be applied to similar situations and yield the same or similar results (Shenton, 2004; Du Plooy-Cilliers et

al., 2014). Since this study used a purposive sample, it may be possible to replicate the findings of this study elsewhere with a different set of respondents using the same data collection instruments. Since this could prove problematic, the researcher continued to refer back to the theoretical framework of the current study to indicate how the data collection and analysis were guided by the TPACK domains (Schurink, Fouché & De Vos, 2011).

In the case of dependability, the researcher documented every aspect of the research to provide a detailed report of the research processes (Schurink, Fouché & De Vos, 2011). This was done due to the changing nature of what was being observed (Babbie, 2014). Besides, this documentation would inform any other researcher or person in the field of how the results came about (Nieuwenhuis, 2016b) if considering the possibly of having the process replicated in another study.

In any qualitative study, the researcher needs to admit their preconceptions regarding the phenomenon to be studied. The more the researcher becomes involved with the study, the higher the risk of bias creeping into the study (Nieuwenhuis, 2016b). Strategies such as triangulation were therefore used to increase conformability, and to reduce researcher bias (Nieuwenhuis, 2016b). Conformability can inform the degree to which the data collected is likely to support the findings and interpretations of this research project (Koonin, 2014).

The unstructured observations together constituted a reliable data collection instrument during this study. This data collection instrument helped the researcher to deduce and recognise various aspects not mentioned by participants in the focus group interviews, or of which the researcher was not aware during these interviews. The open-ended questions were designed by the researcher with a view to encouraging the willingness on the part of the participants to speak freely and to elaborate on their use of an e-Learning system and of ICT tools in their classrooms

and during their practice teaching services, as well as to comment on what other focus group members stated or thought during the focus group interview process. The purpose of the interview questions posed was to gain a deeper understanding of the participating pre-service teachers' TPACK knowledge, and to determine the nature and extent of these pre-service teachers' technological knowledge in relation to the research question and to the aims of this study. Although the pre-service teachers in this study demonstrated a relatively limited understanding of an e-Learning system, and of the use of Information and Communication Technology tools in the classroom during the focus groups, triangulation of the focus group interviews and participant observation data indicated that the pre-service teachers were in fact able to use an e-Learning tool in their lessons.

3.4 The challenges experienced while conducting the research

Every research study has its limitations and challenges, some of which can lead to potential problems, particularly in terms of the accuracy, reliability, and usefulness of the research findings (Du Plooy-Cilliers, 2014:291; Nieuwenhuis, 2016b:125). This is corroborated by Koonin (2014), who points out that there are always likely to be errors in research studies; it does not matter how meticulous the researcher was during the research process. Researchers should be cognisant that problems are never eliminated from any study (Fouché & Delport, 2011). Thus, Enslin (2014:276) posits that "clearly identified limitations guide us in the reporting of findings, and support the reliability and validity of research". Thus, it is imperative to anticipate and report on any possible limitations in a research project.

The challenges and limitations of this study concerning the research methodology were three-fold:

(i) crossing language barriers;
(ii) sample size; and
(iii) data collection

As already reported, this research study used two data collection methods: the focus group interview, and participant observation. The focus group approach allowed for group interactions and was productive in terms of widening the range of responses, activating forgotten details of experiences, such as those involving the use of ICTs, Learning Management Systems, e-Learning, and the use of 21st-century skills mentioned in Chapter 2, and releasing inhibitions that may have discouraged participants from disclosing or sharing valuable information (Nieuwenhuis, 2016b). However, some participants found it to be challenging to engage in discussion using their second language. As a result, those who experienced this difficulty, resorted to their mother tongue when answering questions. The researcher addressed this particular issue by translating into their mother tongue questions that the participants did not grasp, as well as answers that other participants were unable to fully understand, to provide maximum clarity, as well as maximum opportunities for discussion. This was done to ensure the answers of the respondents remained faithful to the research questions and sub-questions, and in turn to allow for accurate reporting and validated findings (Quintanilha, Mayan, Thompson & Bell, 2015).

The sample size of this research project was an essential aspect of this research study. Therefore it was important to the validity of the study for the researcher to involve all the participants during both data collections stages. However, not all sampled participants participated in the participant observations. This forced the researcher to persuade some participants to participate in the observations for the researcher to obtain enough data to be able to do a meaningful analysis to arrive at meaningful findings. Since the sample size was small, some participants observations had to be postponed due to the lack of availability from other participants.

The last anticipated challenge was that of the data collection process. The researcher had to adhere to the data collection schedule and timeline, thus making it imperative to communicate timeously with the participants as to the times when the scheduled focus group interviews and observations would be conducted. Also, the

researcher had to be mindful of the participants' class times as the data collection could not occur during these times. To overcome this problem, the researcher appointed a moderator to assist with the data collection schedule. The task of the moderator was to obtain each participant's class timetable. Based on the availability of the various participants, the moderator scheduled a specific time slot for conducting each focus group interview and participant observation.

3.5 The researcher's role

The purpose of this research study was to answer the main research question and sub-questions and to present the findings of this study with the integrity required by the research process. To achieve these objectives, the researcher had to be transparent with all of stakeholders who participated during this study.

The particular nature of the role of the researcher dictated that the researcher clearly explain the purpose and process of the research, and enter into a collaboration agreement with the participants to collect and analyse the data with the purpose of creating understanding (Maree, 2016). This was achieved by being transparent with the participants throughout the research process in line with what Louw (2014) advocates: participants want and need to trust the researcher, and to feel safe during the process as they do not want to be misled or exploited.

During the research study, the researcher had to create and ensure conducive focus group interview environments, as well as ensuring access to a well-equipped computer laboratory to allow for useful observation to take place. In addition to the participant observation, the researcher needed to prepare the focus group facilities, and facilitate the focus group interviews with the help of a 'neutral' person who would be present in the interview room. Furthermore, the researcher was responsible for the data analysis process, and for validating the data that was collected using multiple methods of data collection to ensure triangulation (Maree, 2016).

3.6 Ethical considerations

There are always critical human elements that can influence the ethical implications in research. Strydom (2011a) lists five critical human elements: (i) mutual trust; (ii) acceptance; (iii) cooperation, and (iv) fulfilment of promises. Babbie (2014:63) posits ethics as strongly associated with morality, which addresses issues of right and wrong. Babbie (2014) and Louw (2014) argue for ethics being a fundamental and indispensable part of any research project.

The research participants in this study were approached with the necessary consent forms (see Appendix C) that each individual was asked to sign to participate in the research project. This was an important part of the research as the participants needed to know that they were participating in a research project, and what would be expected of them. The signing of the consent form was also a safeguard of the rights and safety of the participants. Before signing the form, the participants were informed of all aspects of the research project. The communique also outlined the necessary details concerning confidentiality and anonymity and provided reassurance of these.

The participants' anonymity was assured (Mouton, 2001; Maree, 2016). According to Louw (2014), anonymity means that a participant's name will not be recorded during the research process and that neither the participants nor other researchers in the field would be able to identify their responses. Thus, each participant received a pseudonym, for example, PS – A, PS – B, PS – C ,and so forth. However, although the researcher is able to match a responses to a particular research participant, this knowledge would be restricted to the researcher and would not be made public, according to the confidentiality paragraph in the consent form (Louw, 2014).

The communique outlined the participants' right to withdraw from the study at any time should they wish to do so, and without prejudice. During this study, the information volunteered by the participants, and the responses they offered, together with their views expressed during the focus groups and unstructured observations, would be kept confidential. Participants were thus considered to be safeguarded against any form of possible victimisation. In addition, the protection of the participants' responses and confidential information was guaranteed with the use of online data storage facilities. Participants were made aware that their physical and psychological comfort would be prioritised throughout the study. No anticipated uncomfortable questions relating to the research question would be asked during the focus group interviews, and nothing out of the ordinary such as teaching a lesson topic with which the participant was not familiar or about which they were not confident, or one that would make a participant uncomfortable, would be expected of participants during the observation process. This represented both an attempt and a promise by the researcher to create an atmosphere in which the participants and researcher could focus solely and uninterruptedly on the participants' TPACK abilities.

To gain access to the research participants, and to conduct the observations and focus group interviews, ethical clearance was obtained from the Faculty of Education Ethics Committee (Appendix B) of the HEI. This was done on the assumption that each institution has to maintain its reputation of integrity (Louw, 2014:263). The ethical clearance application was made within the time frame as set out by the Education Faculty Committee, after which permission was granted by the committee to conduct the research at the institution. The researcher then presented all the necessary documentation to the research participants before commencing with the data collection process.

3.7 Summary of the chapter

This chapter presented a description and a discussion of the research design and methodology used for the study. This included a description of the data analysis,

how the trustworthiness of the study was developed and ensured as far as possible, and the ethical considerations. A detailed delineation of the qualitative methods was given. The roles of participants and researcher were explained, and particular attention was given to the description of the essential ethics in the research. All of these descriptions and explanations are based on the belief held by the researcher that an overarching understanding of a range of research elements, and the ways in which they are interlinked, is rudimentary to conducting valid research.

In chapter 4 the research findings are presented and discussed, based on the research instruments used as data collection methods.

CHAPTER 4: FINDINGS OF THE STUDY

Introduction

This chapter presents the findings of the research from the analysis of the data collected through the focus group interviews with, and participant observations of, a sample of pre-service teachers at the University of Technology. The analysed data from the focus group interviews and participant observations were developed into themes that aligned with the TPACK framework underpinning this study. The study aimed to ascertain the nature and extent of the knowledge and preparedness of a sampled group of pre-service teachers for Fourth Industrial Revolution teaching and learning.

This chapter aims to respond to the three research questions:

- What is the nature and extent of the knowledge and understanding about 4iR of a group of pre-service teachers?
- What, according to these pre-service teachers, are the foundational requirements necessary to teach effectively in a 4iR classroom?
- What are the perceptions of these pre-service teachers regarding their preparedness to integrate ICTs effectively in a 4iR classroom?

The TPACK framework was used to answer the three subsidiary questions, in particular to ascertain the types of knowledge teachers need for them to be able to teach effectively using technology. The following themes that emerged from the analysis of the data using the TPACK framework have been used as subheadings for this chapter:

4.1 TPACK results

4.1.1 Sampled pre-service teachers' knowledge and understanding of the 4iR

4.1.2 Sampled pre-service teachers' perspectives of the foundational requirements to teach effectively in a 4iR classroom

4.1.3 Sampled pre-service teachers' preparedness to use ICTs in a 4iR classroom

4.2 Chapter summary

4.1 TPACK results

The data collected and analysed regarding the cognisance of TPACK domains amongst pre-service teachers constitute a response to the three sub-questions. Table 4.1 represents descriptive statistics based on the research participants' total responses per focus group to the question relating to the TPACK domains. This was to gain an overall idea of which domains were recorded as the highest. The full quotations (*n*=129) were coded in line with the TPACK domains across the focus groups (*n*=*3*). This was done to ascertain whether or not, and to what extent, during the focus group interviews, the pre-service teachers had a sense or knowledge of any TPACK domain, and how they integrated these domains during their micro-lessons (*n*=*10*) observed by the researcher.

It can be deduced from Table 4.1 that the research participants' responses to the focus group interview questions focused mainly on TK (Mean = 13.00), TPK (Mean = 8.33), and TPACK (Mean = 6.00). The domains, namely CK (Mean = 0.67), PK (Mean = 3.67), TCK (Mean = 3.00) were less frequently reported on during the focus group interviews, and with no reporting on PCK with (Mean = 0.00). Chai, Tan, Deng and Koh (2017) found a similar result from their study. The authors argued, from their study of that their group of sampled pre-service Chemistry teachers, that the teachers lacked the experience and capacity to integrate technology in their pedagogy effectively in their lessons. The focus group interviews in the present study were used to validate the participants' micro-lessons (*n*=10) observed by the researcher regarding their understanding of the TPACK domains and the implementation thereof during their lessons.

Table 4.1: Descriptive statistics of TPACK domains

	N	Mean	
	Statistic	Statistic	Std. Error
Content knowledge (CK)	3	.67	.667
Pedagogical content knowledge (PCK)	3	.00	.000
Pedagogical knowledge (PK)	3	3.67	.882
Technological pedagogical content knowledge (TPACK)	3	6.00	2.309
Technology content knowledge (TCK)	3	3.00	1.528
Technology knowledge (TK)	3	13.00	2.082
Technology pedagogical knowledge (TPK)	3	8.33	.882
Valid N (listwise)	3		

Sub-question 1: What is the extent of pre-service teachers knowledge and understandings about 4iR?

4.1.1 Pre-service teachers' knowledge and understandings of the 4iR

Table 4.2 presents the data primarily in response to focus group interview questions primarily related to the sub-question 1.

Table 4.2: Sub-question 1 – TPACK domains descriptive statistics

	N	Mean
Content knowledge (CK)	1	2.00
Pedagogical content knowledge (PCK)	1	.00
Pedagogical knowledge (PK)	1	5.00
Technological content knowledge (TCK)	1	2.00
Technological knowledge (TK)	1	13.00
Technological pedagogical content knowledge (TPACK	1	4.00
Technological pedagogical knowledge (TPK)	1	6.00
Valid N (listwise)	1	

The participating pre-service teachers were asked the following focus group interview question to determine their knowledge and understanding of the 4iR: “What do you know about the Fourth Industrial Revolution?”. Their varying responses to this question revealed that several of these pre-service teachers (*n*=4) understood the 4iR to be linked to technology. Pre-service teacher E in Focus Group 1, and participant M in Focus Group 2, and T in Focus Group 3 reported:

> “I think the fourth industrial revolution is about using technology to make life easier.” (PS – E)

> "The Fourth Industrial Revolution, it is a revolution, technology. Basically what it consists of is this era where technology improves and improved so quickly. Every day, new technology is coming out, new applications, new hardware, and new software. I would say the thing about the fourth industrial revolution is it is adapting so quickly that we as humans are starting to struggle; we as normal humans are starting to struggle to keep up with how the technology changes." (PS – M)

> “Fourth Industrial Revolution, in my opinion, is where artificial intelligence take over our work. For example, having a robot to deliver your food as we person with a smile can deliver it to you.” (PS – T)

These responses indicate that these pre-service teachers E, M, T and P had a general and rudimentary understanding of the 4iR. For instance, pre-service teachers E, M and T reported simply that 4iR would make life easier and that technology advances at a demanding pace. These comments are further linked to TK, the highest coded domain with a mean score of $\bar{X}$ =13.00 (Table 4.2).

Certain pre-service teachers commented that they did not understand what the 4iR is or entails:

> “I do not have any knowledge about the Fourth Industrial Revolution” (PS – D)

> “I also do not have knowledge about the fourth industrial revolution” (PS – A)

> “I do not know anything about this. But I do not think it's going to go all uphill from there. I think it is going to be a tough road. Looking forward easy and tough.” (PS – U)

Only one pre-service teacher (N) indicated some knowledge of the 4iR and its implications for the 21st-century, and was of the view that the 4iR has the potential to disrupt the traditional classroom, shifting from sole reliance on face-to-face teaching and learning to a more flexible teaching and learning environment premised on creativity:

> "Probably the first Industrial Revolution, the First Industrial Revolution introduced us to like education, formal education system because we had to educate people to work like in a factory. Right? However, today that is not the case anymore. The way they came from is a form and all that stuff, there are no

more formal offices, everything is on the internet. And I would argue that in today's world, your creativity and job abilities are more important than your literacy, even if you can have three degrees. But if you can fight your way out of a paper box, like if you only have book knowledge, but you can when someone gives you a problem, you can go around the problem cause you don't know beyond the books. So it would help if you had creativity. Furthermore, I think this is the fourth industrial revolution, even beyond the technology and all that stuff." (PS – N)

According to pre-service teacher N, the 4iR applied within the education context is vital for creating opportunities for creative problem-solving skills, a group of skills ranked high on the WEF (2015) critical skills list (See Section 2.3.2). Pre-service teacher N further contended that a teacher must engage theoretically with technology and technological practices. This finding is consistent with the theorising of Mishra and Koehler (2006) in terms of the various literacies, competencies, and character qualities both needed for, and generated by, engaging usefully with technology. As was explored in Chapter two, these authors believe the implementation of technology and integration has the potential to stimulate problem-solving, which can be an effective way for teachers to develop their TPACK (See Section 2.3.2.1).

Certain pre-service teachers (H, K and P) indicated mainly negative understandings and perceptions regarding the 4iR, seeing it as being likely to replace teachers and other workers:

> “…the bad thing about the technology it can replace teachers in the long run and there will be a high rate of people without work.” (PS – H)

> “I think that even though the Fourth Industrial Revolution improves e-Learning, I think it will take over the place of the teacher self. And then we would not have jobs anymore.” (PS – K)

> “I also think it is going to be a disadvantage for us human beings because that people are going to lose their jobs and stuff. So yeah, it is a positive thing. However, it is also a negative thing. If you think of work-wise income.” (PS – P)

These responses indicate that certain pre-service teachers possessed some fear of the 4iR relating to teaching and learning. One reason for this fear having developed in these students may be certain students having a relatively low TCK and TPACK which, according to Table 4.2, had mean scores of $\bar{X}$ = 2.00 and $\bar{X}$ = 4.00 respectively. Studies done by Hofer and Harris (2012), and by Maor (2017), revealed similar findings. Hofer and Harris (2012), reported that participants in their study had a low TCK but showed significant confidence in the other domains. Similarly, Maor (2017) reported that TPACK was low amongst the participants in her study. However, the responses of pre-service teachers K, H and P were in contrast to those from the respondents in Ślusarczyk’s (2018) study. Although her study was done in a business context, and based on secondary data (See Section 2.6), respondents responses could be said to support the argument that the 4iR will not replace teachers in the education workplace, but that, instead the phenomenon is likely to create, and is creating, opportunities for more efficient ways in which information is being exchanged amongst people and objects, and in the process could result in an “improvement in competitiveness” (Ślusarczyk, 2018:232).

Two pre-service teachers (S and N) acknowledged the importance of the 4iR in disrupting the traditional classroom. According to participant N, through the 4iR students would be able to choose the way in which they would want to learn, thus creating a space of independence. In their responses to the focus group interview question, “In what specific ways do you think the Fourth Industrial Revolution will impact teaching and learning?”, two pre-service teachers reported:

> “I know the Fourth Industrial Revolution that machines and robots only replace people who can't deliver something in person, for example, robots won't necessarily want to replace a teacher. Because, yes, online learning and everything, but you still need a physical person explaining something to you even if it's your friend; you will still need this person explaining something to you. So what I read a few years back is that it will not replace teachers and people who are doing work that requires the human mind? So it won't replace things like, I do not know, other things that robots can do, but it won’t to replace teachers, so we do not have to worry.” (PS – S)

> "If everything is digitalized, everything's online, then actually teachers and education would be a little bit better. Because, for instance, if you take everybody out of the classroom, And you say, but we're going to do everything online. So then you will allow the students to choose by what teacher he wants to learn by and what programmes he wants. Furthermore, that will cause educators to, like, compete to be better educators, because now they have to have students because they have to make money now to have to be better in the other teachers. So that would happen the opposite of that, in my opinion." (PS – N)

These focus group interview responses suggest that these two individual pre-service teachers were aware of the importance of TPK, which had a mean score of $\bar{X} = 6.00$ (Table 4.2), instead of merely being familiar with, and competent in, the technology. This finding is in alignment with that of Schmidt-Crawford et al. (2016), who had similar results in their case study which sought to understand the extent of teachers’ TPACK. The comments of these pre-service teachers in the current study are also consistent with the views of Hussin (2018), and Nordin and Norman (2018), who argue for the likelihood of students becoming more independent in their learning should 4iR technologies be integrated into the classroom (See Section 2.3.1). Furthermore, pre-service teacher N indicates that, when 4iR technologies are implemented in the classroom, it creates the opportunity for teachers to improve on their skill sets. The predictions of these pre-service teachers are consistent with findings from studies done by Xing and Marwala (2017), and by Banwari (2018),

which looked at how 4iR is transforming the kind of workplace in which people require the necessary skills to work with new technology.

Sub-question 2: What according to these pre-service teachers are the foundational requirements necessary to teach effectively in a 4iR classroom?

4.1.2 Pre-service teachers' perspectives of the foundational requirements to teach effectively in a 4iR classroom

Table 4.3 presents the data primarily in response to focus group interview questions primarily related to the sub-question 2.

Table 4.3: Sub-question 2 - TPACK domains descriptive statistics

	N	Mean
Content knowledge (CK)	1	.00
Pedagogical content knowledge (PCK)	1	.00
Pedagogical knowledge (PK)	1	3.00
Technological content knowledge (TCK)	1	4.00
Technological knowledge (TK)	1	13.00
Technological pedagogical content knowledge (TPACK)	1	8.00
Technological pedagogical knowledge (TPK)	1	11.00
Valid N (listwise)	1	

Regarding this sub-question, the participants were asked the following focus group question: "What do you consider to be the fundamental requirements for teaching effectively in a 4iR classroom?". Nine (*n*=9) participants' responses emerged which indicated these participants were in agreement that ICT literacy is an essential requirement for learners to engage, and teachers to teach, effectively in a 4iR classroom. Pre-service teachers L and J in focus group 1 reported:

"I think the basic requirements are students and teachers are need to know how to use the basic computer use, or how to use the Word, how to surf the internet, how to use the application for e-Learning they are about to use for the class; they need to know it inside and out. So it is easier for the students to understand. And so they can answer all the questions that the students have" (PS – L)

"I think that basic technical requirements for both teacher and learner is on computer literacy." (PS – J)

From the above responses, it is evident that, according to these two pre-service teachers in focus group 1, ICT literacy is a fundamental requirement for teachers and learners to possess in order for teachers to teach and learners to learn effectively in a 4iR classroom. This finding is consistent with the responses of pre-service teachers O and I in focus group 2:

"I would like to agree with pre-service teacher J. The teacher and the student both need to be the technology of need to be taught in, like, [a] crash course about the programme, which will be used in the classroom because, without the knowledge, the system will not work completely. I think the basic technical requirements for teaching effectively in a 4iR classroom is understanding how a computer works, understanding what the internet is, and how you will go about completing your learning through the e-Learning method." (PS – O)

"I would like to acknowledge Student O because what she said is more that you can use a lesson before you use e-Learning in your class to prepare the learners more so that you know that your lesson would go fluently." (PS – I)

These findings are consistent with those of Pineida (2011), who argues based on the authors findings, that, to develop and produce good quality learning using ICT,

students and teachers alike should develop technological and teaching competencies (See section 2.3). These findings are consistent with, or echo, one of the WEF's *New Vision for Education*, foundational literacies: ICT literacy. The finding also supports previous research by Heggart and Yoo (2018) (See section 2.1), who argue that teachers and learners need to develop the necessary technical skills to operate in the 21st-century.

These responses are a further indication of the importance of the context in which teachers find themselves. Some of the participants mentioned in their responses that computer infrastructure and technology knowledge (Table 4.3) play a critical role in teaching effectively in a 4iR classroom. Four participants (*n*=4) were cognizant of the importance of computer infrastructure, in particular internet connectivity, and technological knowledge. Pre-service teachers K and U in focus groups 2 and 3 suggested that, before one can make use of ICT tools in the classroom, it is essential that one establish the school's network infrastructure, including connectivity to the internet:

> "I think the basic requirements before you can make use of technology in the classroom is listening to what internet in your classroom firstly. And learners should know how to work on computers, otherwise, the email is not going to work in the class." (PS – K)

> "For me, the basic technical requirements in a 4iR classroom would be to have a network, to have internet access and then to have computers, laptops, or learners can have their cell phones or tablets and an OHP or data-projector a smartboard, yeah things like that." (PS – U)

These findings align with one of the nine trends relating to Education 4.0 outlined by Fisk (2017 cited in Hussin, 2018) (See section 2.6), who posits that learning which incorporates technology can occur anywhere as long as there is an internet connection. Furthermore, pre-service teachers H and F in focus group 1 in their

responses were of the view that TK is also a requirement for the successful implementation of e-Learning tools in the classroom:

> "I think the most important requirement for using e-Learning in the classroom is the teacher's knowledge of all the technology out there. So if you need to explain it to the learners who come for the first in contact with it, you must know it, at like the palm of your hand, so you need to explain everything so everyone understands." (PS – H)

> "I agree with (pre-service teacher H) that the teacher needs to know the ins and outs of these requirements; it's easier for them teach the learners." (PS – F)

This finding is consistent with those of Chai et al. (2014), and of Mishra and Koehler (2006), which indicated that teachers who leverage TK for content learning should be design-oriented and should possess knowledge about advanced internet and digital usage (See Section 2.5). While the findings suggest that the pre-service teachers in the current study were aware of the importance of the context, TK and TPK, which, according to Table 4.3 had mean scores of $\bar{X}$ = 13.00 and $\bar{X}$ = 11.00 respectively, few of these students acknowledged the significance of TCK $\bar{X}$ = 4.00.

Furthermore, pre-service teacher E in focus group 1, and pre-service teacher S in focus group 3 acknowledged that foundational requirements for effective teaching and learning in the 21st-century classroom need not be confined to the classroom or computer labs:

> "Learning occurs outside of the classroom using technology, anytime, anywhere you need to have network, or internet access." (PS – E)

> "You do not have to be in a classroom; it can be at home, you can be on the sidewalk, can be in anywhere; you only need internet and data. With such

learning that you do not have to be physically in the classroom with the teacher." (PS – S)

These two pre-service teachers (E and S) mentioned that one does not have to be in the physical classroom to use technology for teaching and learning. In this regard, one can use technology anywhere as long as one has internet access. This finding aligns with that of Fisk (2017 cited in Hussin, 2018) who, as has already been mentioned, outlines the nine trends relating to Education 4.0 (See section 2.4).

According to two pre-service teachers (*n*=4), A, G in focus group 1, and to I in focus group 2, and P in focus group 3, a further foundational requirement for effective teaching and learning in a 4iR is for it to be collaborative and inclusive:

"A teacher should be able to use the tools that you get online, on your computer, and in the classroom, to explain your work more efficiently and the children love technology. So if you use technology, you're going to get their attention." (PS – A)

"I think, I agree with pre-service teacher A, that, if used in class, e-Learning it draws the attention of the students easier. So they understand the work easier. And the knowledge of the e-Learning increases with the class." (PS – G)

"… I believe it's more that students are more technology inclined these days in the 21st- century; that is because they are more busy on their phones, more busy on their computers. So I think it is a better way to collaborate with the children and your lesson with them." (PS – I)

These findings are aligned to those of Krasnova and Ananjev (2015), who argue that collaboration assists learners in acquiring new knowledge and skills as well as creating the space for learners to recognise themselves as part of a collective to

contribute to the process of teaching and learning (See Section 2.3.2.3). From this it can also be deduced that e-Learning can offer progressive opportunities for learning and teaching in a connected society where collaboration has become an essential skill (García-Valcárcel et al., 2014) (See Section 2.3.2.3).

According to pre-service teachers M, N, and J in focus group 2, and R in focus group 3, a foundational requirement for teaching effectively in a 4iR classroom is for it to be learner-centred, breaking the authoritarian teacher-centred pedagogical barriers that once existed, and continue to exist, by making teaching and learning more inclusive. This resonates with the findings of Blessinger and Wankel (2013:6) (See Section 2.3.3.1). Pre-service teachers M, N, J and R further reported:

> "For me, a basic requirement is for there to be a learner-centred approach in which you can use technology in different ways to reach different students. In other words, if you have a student that struggles to get information, that is where technology adapts and gives the student new ways of learning information." (PS – M)
>
> "I would like to comment on PS – M's answer. I also consider a requirement for effective teaching and learning in the 21st-century to be more digitalised and more personalised to the student itself and it focused more on how the learner learns, and does not quite like well what current do focus more on content, but the way the learner learns everything for the very personalised to the student." (PS – N)

It is clear from pre-service teachers M and N's responses that they consider a learner-centred pedagogical approach in the 21st-century to be essential for learner personalisation and autonomous learning (see Table 2.1, section 2.4). By implication, these pre-service teachers were aware of the need to create an inclusive and enabling environment using educational technology effectively. This aligns with

the Department of Basic Education and Training (2007) approach, which stipulates that, when ICT is integrated into the classroom, it creates an environment that allows for engaged teaching and learning opportunities (See Section 2.3.2.3). Also, Jimoyiannis (2010) posits that when the teacher obtains valuable knowledge about ICT, this knowledge can enhance her/his pedagogical knowledge strategies (See Section 2.3.2.1).

These findings are consistent with those of Pineida (2011), Bagarukayo and Kalema (2015), and Gushchin and Divakova (2017), who conclude from their findings that educational technologies are a didactic resource that can be used to facilitate teaching in a variety of different ways (see Section 2.3.2.3). In addition, Fisk (2017 cited in Hussin, 2018) stipulates the nine trends relating to Education 4.0 that learners are likely to want to learn at their own pace, and to be able to choose how they want to learn (See Section 2.6). Consistent with the above views, in the lesson observation of pre-service teacher A, the pre-service teacher demonstrated how the use of Google Keep, Google Calendar, Google Docs, and Blogger, e-Learning technologies could be used, not only in the classroom by the teacher and learner, but also how these applications can make learning from a teacher's perspective more digitalised and create a space for learning to be personalised.

Certain pre-service teachers alluded mainly to TPK (Table 4.3), as confirmed by their comments:

> "I would just like to add that teaching in the 21st-century is basically like incorporating technology in the classroom for both teacher and learner." (PS – J)

> "My knowledge and understanding of teaching in the 21st-century is that it involves using the internet by using the electronic devices like your tablet or your smartphone." (PS – R)

"I would like to agree with PS – R that teaching in the 21st-century refers to having digital platforms to retrieve information and to submit like assignments or write tests on." (PS – U)

Similarly, in the micro lesson observation of pre-service teacher B, he shared a link of the slide deck application with the students, which created the opportunity for them to follow pre-service teacher B's lesson on their devices. This indicated a learner-centred approach observed in class. The above pre-service teachers' responses are consistent with one of Fisk's nine trends relating to Education 4.0, which speaks to the freedom of choice element – that is where learners will be able to choose how they want to learn (See Section 2.6). Pre-service teacher U's comment is also in line with the sentiments of Sarka (2012), who argues that the use of digital communication tools is crucial in the 21st-century, since the effective use thereof creates access to vital information (See Section 2.3.2.3). This finding also resonates with a finding of García-Valcárcel et al. (2007) who claim that digital technologies offer increased opportunities for teaching and learning (See Section 2.3.2.3).

Several pre-service teachers (*n*=3) alluded to the significance of an 'ICT culture' as a fundamental requirement for teaching effectively in a 4iR classroom. Certain pre-service teachers had a positive impression of how their mentor teacher used and implemented an e-Learning tool for teaching and learning in the classroom during teaching practice. The following were reported by pre-service teachers A and D in focus group 1:

"When I was at a school, they used Plickers a lot. Because their WiFi was slow. So all the children could not log onto the PCs and do like Kahoot! on the internet because it was a problem with the internet. So they used Plickers where they get cards. And the only thing you need as a teacher is your phone,

scan all the cards and then all the answers will come to you. So you would know who got the answers right who got the answers wrong. So that's because and children like it, they barely talk during class. They all participated in class. Yeah." (PS – A)

"During my time of teaching practice I experienced that the teacher I went to on my last teaching practice made a lot of use of e-Learning because she uses e-Learning to facilitate all the learning that happens in the classroom after each module of theory she does a Google Form and then they use that result that they [get] in the Google Form, and then she will ask herself the question, should she do the chapter over again or should she just call some students or some learners or explain them or ask them what they do not understand about that chapter, and then she will work on the Google Form results to go work further." (PS – D)

Pre-service teachers A and D from focus group 1 indicated that they experienced their mentor teacher using Plickers (TK) and Google Forms (TK) to facilitate teaching and learning. Pre-service teacher A reported that the mentor teacher did not rely solely on the school's internet infrastructure to use Plickers. This finding is supported by the DHET policy (DHET, 2015) (See Section 2.2), which stipulates that a teacher should be competent in using ICT tools. It can also be deduced that learner engagement took place when the mentor teacher used Plickers during the lesson (TPK). Pre-service teacher D indicated that her mentor exhibited flexibility in using ICT tools to enhance teaching and learning in the classroom, an aspect stated in the White Paper on e-Education (DoE, 2004) (See Section 2.2). According to the response of pre-service teacher D, it is evident that the mentor teacher exhibited TK, CK, TCK and PCK domains during the lesson. After every theory lesson, the teacher created a Google Form to establish what the audience or class of learners had learned. This guided the teacher's decision as to whether or not to reteach a particular module. It can thus be deduced, based on the pre-service teacher's observation of her mentor, that the mentor used different questioning techniques in the Google Form to guide the mentor to make informed decisions after the students had completed the Google Form. The following inference can be made, based on the

pre-service teacher's observation of her mentor teacher: that she was motivated to use technology in the classroom. The literature supports this finding with Mishra and Koelher (2006), and Tallvid (2016), postulating that there exists an interwoven relationship between the TPACK domains (See Section 2.5).

When teachers implement ICT tools during their lessons, this pedagogical practice goes beyond just chalk and talk. It demonstrates that the teacher is confident in building on the her or his TK to leveraging the kind of technology (TCK) that impacts the teacher's pedagogical usage of the technology (TPK). In addition, with the continuous use of technology in the classroom by the teacher, the teacher can continue to build incrementally on the transactional relationship of the teacher's TK, PK, CK, TCK, PCK, eventually broadening the teacher's use of TPACK (Mishra & Koehler, 2006) (See Section 2.5). A similar finding was reported by Moseley et al. (1999), who posited more than 20 years ago that ICT in the classroom can positively impact teaching and learning if the implementer and user has a positive attitude toward the use of ICT in the classroom (See Section 2.2).

In addition to the above findings, pre-service teacher M from focus group 2, and pre-service teachers R and S from focus group 3, reported similar experiences to those of pre-service teachers A and D in focus group 1. However, pre-service teacher M mentioned that he conducted his pre-service teaching at an affluent school where the technology ecosystem was fully integrated for teaching and learning and administrative tasks, and listed some of the advantages of this.

> "I was at a private school where it is basically the foundation that all the material that was used in the classroom was on tablets What it meant is, firstly, it saves the cost of using materials. And secondly, it's easily accessible, easier than using a book. So basically, you just go on your tablet; you search for what you need and find it quickly." (PS – M)

“I was at a school last year when I observed that the teacher doesn't make use of textbooks anymore; they make use of digital textbooks, like they go, uhm … every learner they make use of their tablet so they don’t have a hardcopy of the textbook in front of them; they make use of their tablets and smartphones.” (PS – R)

“I am agreeing with PS – R. The school that I did my practical … uhm … they are the first school … uhm … who digitised their learning material and loaded it onto the devices of the learners.” (PS – S)

A follow up question to the question ,“What was your impression of how your mentor teacher implemented ICT tools in the classroom” was posed, and the pre-service teachers reported the following:

“The students actually listened to the teacher; they communicate in class. It's not the teacher just sit there and talk material and they just sat there they're not taking in anything. They answered questions. They enjoyed what they were doing, Plickers. So every time a question end up everybody has questions . When someone gets something wrong, they debate why it's wrong. And so it wasn't like it just apply to us. Everybody was part of the class communicating with each other.” (PS – A)

“My impression was that the use [of] Google Forms is very great way to examine the learner stands in each chapter of theory so that you can know where you should focus on, or where that learner is a little weak and where’s that learner, what is that learners’ strong part of theory? And then you can work from that, and then you can help all the learners in each chapter that they need help with.” (PS – D)

“In some classes where the teacher was computer literate, the classes went fluently; the students knew how to collaborate on the tablets. But in classes where the teacher was not computer literate, and did not want to do effort to …

er … have his skills … uhm … maybe become better in computer literacy. When the teacher did not do any effort for that at all you can see the impact it had on the children. They also did not want to improve their skills." (PS – O)

"I was very impressed because it gave the learners like a new … uhm … mindset about how technology works. And they like for the CAT learners specifically made the stuff easier, and yeah it was a good impression. It was a good impression. It was the first time It was the first time I saw something like that. So I was impressed." (PS – R)

"I was also impressed because … uhm … the person who was in charge of getting the tablets to the school, he or she created an ICT group for learners. So they will learn how to set up a WiFi everything. So they can help the other learners, so it created an opportunity for normal learners as well to learn about whatever it is about WiFi because I was also involved. So I learned how to set up WiFi. I didn't even know how. And it was also impressive to know how the textbooks works online because I haven't experienced something like that. So I was… it was also impressive, and yeah, extraordinary." (PS – S)

"I also agree what I'm also impressed about what student R, T and S said because the learners .. uhm … learners develop computer literacy skills this is a good way to learn." (PS – P)

Based on the responses from these pre-service teachers, it can be deduced that the ICT culture in the classrooms where they were doing their practice teaching created a positive attitude, in both the learners and these pre-service teachers, toward the implementation of an e-Learning tool: the learners were more engaged in their learning, an observation on the part of these pre-service teachers, which supports the finding of a study done by Tynan and Barnes (2014) (See Section 2.3.2.3). These authors are of the view that the implementation of e-Learning tools through an influential ICT culture has the potential to improve learner engagement with learning. Pre-service teacher R also mentioned that this was the first time he observed a mentor teacher using an e-Learning tool in a situation where learning is more

learner-centred than teacher-centred. This was an opportunity for the student to witness that an e-Learning tool can enable dialogue between the teacher and the learner, as pointed out by pre-service teacher A in his response during the focus group interview. Pre-service teachers' A, D, O and P also emphasised that different learning spaces were created for the learners to take ownership of their learning. Interestingly, this process was evident during the observations of the micro-lessons and what students both observed and perceived during their practice teaching when they attempted to implement ICT in their lessons. For example, pre-service teachers A, B, I and E who attempted to create a learning atmosphere during their micro-lessons where the other pre-service students could be engaged, is an indication of the TPK (Mean = 11.00) in Table 4.3.

In contrast to these pre-service teachers' positive views and impressions of their mentor teachers in the context of an effective ICT culture, pre-service teachers H, C and G from focus group 1 had different opinions, and experiences to report, when the same focus group question was posed to them: "Can you recall a specific time during your teaching practice experience where a teacher made use of any e-Learning tools to facilitate teaching and learning? Describe this occasion." They reported:

> "During my time for the three years, not one of my mentors used eLearning tools. They only use the [print] textbooks and the writing boards in class." (PS – H)

> "During my time of teaching practice, I haven't experienced anything with eLearning or teachers that use eLearning in the classroom." (PS – C)

> "I haven't experienced mentors, or teachers using … uhm … using eLearning in class. Uhm … especially when it comes to theory; they usually want to rush the theory, but no one likes doing theory; the students don't like it, They usually talk during class. I think eLearning should be used mostly for theory, because it

attracts their attention. So they focus more on the theory and they do better in the test." (PS – G)

Pre-service teachers H, C and G from focus group 1 did not experience e-Learning tools or the use of them in their practice teaching training at schools. These pre-service teachers believed that their mentors relied on traditional teaching methods and failed to see the potential of implementing an e-Learning tool in the classroom. However, the literature has indicated that embedding ICT into the classroom carries a high potential for improving problem-solving, greater learner engagement, and creating the premise for learners to understand a particular topic (Satapathy, Govardhan, Raju & Manda, 2015) (See Section 2.3.2.3). It can also be argued that these in-service teachers did not have adequate network infrastructures or internet connectivity at their schools; hence they did not, or were not able to, implement or use ICT tools in their classrooms, as pre-service teachers E and G from focus group 1 mention in their response to the question posed:

"I think the internet is a big problem when it comes to e-Learning at schools or anything like that. Because the internet is way too slow, so, or they are no internet. Because [this is the case for] most government schools we are going out to. So in the government's internet speed at school is very slow that's why." (PS – E)

"So it restricts the teachers with using e-Learning like, There are lots of applications on the internet to use to make lessons more interesting. But they are restricted because the internet speeds are too slow. That's why Plickers is a good option because you do not need internet; only the teacher needs it. So you have the internet [and] no student needs internet." (PS – G)

From the above finding and responses the following inferences were made by the students in the follow up focus group question “What was your impression of, or what do you think the reasons were for, your mentor not using an e-Learning tool in the classroom:

> “My impression of using no e-Learning tools: most of the time the learners get bored because it’s every time, every day, it is the same story; you know what is going to happen in class so I think if the teachers use more, or make use of more e-Learning tools in the classroom, the children will become more participating in class and they would enjoy the learning and everything that happens in the classroom.” (PS – H)

> “What I encountered while doing my teaching practice was that I felt that senior teachers they ignored using e-Learning tools to facilitate teaching and learning, and it was more the younger teachers that tried to incorporate e-Learning methods into their teaching. And I think if you educate senior teachers more in using e-Learning as a tool to facilitate teaching and learning, you would better education.” (PS – L)

The statement made by pre-service teacher L was corroborated by pre-service teacher J :

> “I’ve encountered that the older generation of teachers how they preferred the old way of doing things cause, firstly, they don't want to learn how to use computers and refused to want to learn.” (PS – J)

This finding is a clear indication that not all in-service teachers implement and adhere to the departmental policy, which stipulates that all teachers should be

competent in using ICT (DHET, 2015) (See Section 2.2). However, from the literature, and from the responses of the participants who observed those in-service teachers who are implementing e-Learning tools in the classroom, they are creating different learning dynamics for the learners from those present in classrooms where e-Learning tools are not being used. These in-service teachers who are able to comply with the DHET (2015) policy continue to disrupt the traditional classroom spaces by implementing asynchronous, synchronous and flipped classroom learning practices. This is a finding that is consistent with that of Heggart and Yoo (2018). The authors strongly believe that teachers and learners need to develop the necessary technical skillset to function effectively in the digital world (see Section 2.1). These findings also strengthen the original stance of the (DoE, 2004) (See Section 2.2), which advocated at the time that the implementation of ICT played, and was set to play, a pivotal role in the transformation of education (DoE, 2004) (See Section 2.2).

Overall, these results indicate that the pre-service teachers were aware of the four essential requirements for teaching effectively in a 4iR classroom, namely having ICT literacy, having access to the technology through appropriate ICT infrastructure, the knowledge that teaching with technology is not limited to the confines of the classroom, and should be collaborative and inclusive, and the need for an influential ICT culture. Participants offered essential insights into the need for both pre-service and in-service teachers to be upskilled in the use of ICT tools in the classroom and to be exposed to creative ways of using them pedagogically in the classroom to enhance teaching and learning in the 21st-century. In addition to this, many participants indicated their willingness to learn more, and to stay up to date with the latest ICT tools, citing the reason that this ongoing process would provide them with a better understanding of the technology tool before its implementation in the classroom. In this regard, there were instances of TPK $\bar{X}$ = 11.00 (Table 4.3). However, the results suggest that there were fewer instances of TCK $\bar{X}$ = 4.00 (Table 4.3).

Sub-question 3: What are these pre-service teachers' perceptions regarding the nature and degree of preparedness needed to be able to integrate ICTs effectively in a 4iR classroom?

4.1.3 Pre-service teacher's perceptions of the nature and extent of preparedness needed to integrate ICTs effectively in a 4iR classroom

Table 4.4 below presents the data in response to focus group interview questions primarily related to the sub-question 3.

Table 4.4: Sub-question 3 - TPACK domains descriptive statistics

	N	Mean
Content knowledge (CK)	1	.00
Pedagogical content knowledge (PCK)	1	.00
Pedagogical knowledge (PK)	1	1.00
Technological content knowledge (TCK)	1	1.00
Technological knowledge (TK)	1	6.00
Technological pedagogical content knowledge (TPACK)	1	3.00
Technological pedagogical knowledge (TPK)	1	5.00
Valid N (listwise)	1	

Concerning the focus group interview question: "How do you feel about your preparedness to use ICT tools in a 4iR classroom?", six (*n*=6) participants responded, while, on the other hand, most participants (*n*=16) did not respond to this question. One reason may be that certain schools lack ICT infrastructure, thus preventing the integration of technology in their classrooms. This was confirmed by two students (*n*=2), namely pre-service teacher J in focus group 2, and pre-service teacher V in focus group 3:

"My preparedness to use ICT tools in a 4iR classroom. I think that you should not solely rely on computers. And you should always adapt to what the school has. So you must adapt to the school. If they do not have computers or projectors, you might need to be able to use posters and stuff. But If you do have computers, you must learn and educate yourself beforehand to use them successfully." (PS – J)

"It depends on some of the ICT tools, and we feel comfortable, like a Quizlet, and that [is] where the kids can just click on the link and then they have the questions with them. But in some cases, we still have to learn a lot. Do it in classes. Depending on the school's infrastructure." (PS – V)

The findings suggest that, despite the lack of ICT infrastructure in several South African schools, these pre-service teachers were cognizant of the need to advance their TPK $\bar{X}$ = 5.00 (Table 4.4). This finding is in line with that of Msila (2015) and Padmavathi (2016) (See Section 2.6), who argued that teachers need to be prepared to use ICT tools in the classroom. Teachers should understand that 21st-century classrooms need to provide technology-supported teaching materials. There was also a sense amongst the interviewees of needing comfort in teaching with ICT tools. They thought that they would resort to the ICT tools they are most comfortable with.

The results further confirm that three (*n=3*) participants felt adequately prepared to teach using ICT in a 4iR classroom. Pre-service teachers A and H in focus group 1, and M in focus group 2 expressed themselves generally prepared and confident to use ICT tools:

"I'm prepared to use the ICT tools in a 4iR classroom. And since we have been learning about some of the tools from our second year. We have [had] to learn

how to use certain tools, so I feel I am prepared to use some of the tools, but not all of them." (PS – A)

"I would say I would feel pretty prepared about using ICT tools in a 4iR classroom. Because it depends on the school. The subject I took was bad. And my teacher was willing to teach me more than was just given in the handbook. And that prepared me for using information communication tools in the classroom. So it is now something I can adapt and use forever as a teacher also." (PS – M)

"I think I am also prepared to use ICT tools in a 4iR classroom, but if you come in contact with the new ICT tool, it is easy to read stuff up on it, how to use it, what it does and the features of it. So you can use it the next day and make it part of a lesson. So we don't have to use the same ICT tools every time. You can do research and find more ICT tools to make your lessons more interesting. So I feel I am prepared to use ICT tools." (PS – H)

These participants appeared to be confident and sufficiently prepared to use ICT tools in a 4iR classroom. Pre-service teacher A pointed out that he had been exposed to ICT tools since his second year of tertiary studies, further acknowledging that, in this context, he considered self-discovery to be essential. Theis finding is e vindicated by a micro lesson that I observed presented by pre-service teacher A on campus. In his micro lesson, he used particular e-Learning tools, namely, Google Docs, Google Calendar, and Google Keep. I observed pre-service teacher A to be confident and prepared when he introduced these tools to the other students during the lesson. His body language indicated that he knew exactly what he was speaking about when using the application in the lesson. He demonstrated how Google Docs could create documents for teaching and learning, and how the explore tool in Google Docs can be used to search for images for reuse for education and commercial purposes. In addition, he demonstrated how Google Calendar could be used to set reminders to assist with the timeous submission of assignments. Pre-

service teacher A also introduced Google Keep to his fellow students as a note-taking application. This pre-service teacher explained that the notes created in Google Keep would be stored online for integration with Google Docs for detailed formatting, and would be accessible from anywhere at any time.

The tools used during this lesson were used by pre-service teacher A to demonstrate how ICT can be both relevant and useful in the teaching and learning of a particular subject. However, this lesson that I observed was more of a demonstration than a lesson : there was no engagement with, or responses from, the other students. While this 'demonstration' was an indication that pre-service teacher A was confident in using the technology tools, and this was consistent with what Mishra and Koehler (2006) posit, that TK is the teacher's ability to utilise technological tools (See Section 2.5), it became evident that pre-service teacher A appeared more focused on the technology being used to teach than the lesson objectives – TCK, which was recorded significantly low at $\bar{X}$=1.00 (Table 4.4). This was a limitation, as Reyes et al. (2017) argue: there should be a synthesis between the TK and CK domains (See Section 2.5).

Pre-service teacher H also stressed the importance of staying up to date with the latest 21st-century technological trends. What is significant about pre-service teacher H's response is his statement that reading up on new technology trends creates the opportunity for the teacher to apply and use different ICT tools for a specific lesson, a factor highlighted by Chai et al. (2014) (See section 2.6.) who made a similar finding, and argued that teachers need to be design-oriented creative professionals who can leverage technological knowledge and pedagogical knowledge for content learning. The statement by pre-service teacher H indicates how determined he was to strengthen his technological expertise by understanding the ICT tool first, then determining its purpose in the lesson, before implementing it. in this particular instance, this finding indicates the association between one teacher's understanding of when to use technology to assist teaching and learning, and either impeding or advancing teaching and learning in the classroom, a finding which resonates with the

work of Mishra and Koehler (2006) (See Section 2.5). However, in pre-service teacher H's lesson, the researcher observed that, in spite of setting out to use ICT tools in his lesson, he relied quite extensively on traditional teaching methods during the introduction phase of his lesson. This could be due to a lack of exposure to various ways of using ICT tools in the classroom, as reported by pre-service teacher L during the focus group:

> "I think more emphasis is placed on more traditional methods of teaching instead of focusing on teaching us how to use different technologies when teaching, for instance, Business Studies, or CAT even. And I think we should get more exposure to that, not only in schools but on campus as well, because [if] you do not teach a lot of lessons with technology, but you would rather go to the traditional method of standing in front of a class and explaining, rather than focusing on using technology throughout the lesson. And I think we should have more emphasis on that." (PS – L)

In pre-service teacher H's micro-lesson that I observed, there was no engagement with the other students during the introduction phase. During the body of the lesson, he used Google Docs to teach what he had planned. It was also notable that he had conducted sufficient research on the content, introduced (CK), and that the application tool was used (TK). Only during the latter stages of the lesson, did learner engagement become evident. This finding is in line with that of Satapathy et al. (2015), who argue that embedding ICT into classroom learning creates an environment for the learner – teacher engagement, in turn creating the opportunity for learners to understand a topic in more depth (See Section 2.3.2.3).

Upon establishing the level of preparedness amongst the participants, and how they felt about their use of ICT tools in the classroom, the following focus group question was asked: "What do you think should have been done differently during your

undergraduate studies to prepare you adequately for the 21st-century and for teaching using ICT?". Several concerns were raised among certain pre-service teachers (*n*=7). Two of the participants, pre-service teachers C and G in focus group 1, mentioned the lack of adequate exposure to ICT tools in their undergraduate studies concerning particular subjects, and that this may have influenced their TCK:

> "I think they should spend more time on using ICT tools in the classroom. I know some of us still don't know how to use some of the tools." (PS – C)

> "We didn't do any ICT, basically. When we second year, and now we have to jump into ICT or the ICT work, and it was first from the second year on. And we didn't do the basics. Some of us are fine; we had the subject in high school, but some of us did not. They do not know anything about ICT. And now they struggling with the subject, their marks aren't as well as some of the students who have had it, and some of the students who have had it don't remember stuff from that year who [did it] in high school. So if it were not for first year, I think ICT would be much easier for some of us because they had a background of ICT. But circumstances were unfortunately so that we only started really having the subject in second year." (PS – G)

Pre-service teacher C in the same focus group echoed the sentiments of pre-service teacher G. Pre-service C added that it is essential to have subject-specific teachers teaching a particular subject. These findings align with those of Mishra and Khoeler (2006) and with what they concluded regarding CK (See section 2.5). The authors argue that the teacher should have a thorough understanding of the subject matter being taught. Pre-service teacher C reported:

> "To add on to pre-service teacher G, that is where, like she said, some of us and some stuff about it mainly because we do not have a background in ICT. Because we did not in first year have any ICT work; we got tasked, and we got

tested because we had so many teachers. So what they could do differently is have a certain teacher if they … if there is trouble with teachers that they are not coming to class, not moving jobs or whatever, have someone else to do at least one part of the work so you have a basic background. So they can get someone who has a formal background in the subject to come and give at least, say ICT or Excel or Word or whatever the subject needs, the most difficult or the most important part of the subject." (PS – C)

Pre-service teachers L and O, in another focus group, reported that, from their experience and perceptions, more emphasis continues to be laid on traditional teaching and learning pedagogies, than teaching using technologies, a situation which may significantly influence their TPK and TCK:

"I think more emphasis is placed on more traditional methods of teaching instead of focusing on teaching us how to use different technologies when teaching say, for instance, Business Studies or CAT even. And I think we should get more exposure to that, not only in schools but on campus as well, because you do not teach a lot of lessons with technology. But you would rather go to the traditional method of standing in front of a class and explaining rather than focusing on using technology throughout the lesson. And I think we should [put] more emphasis on that." (PS – L)

"I agree with PS – L; I think only in major subjects like Computer Applications Technology and Information Technology, this emphasis on using ICT tools in the classroom. But in other major subject areas there is no focus on it at all." (PS – O)

The above findings are corroborated by two other pre-service teachers (*n*=2), S and P in another focus group:

"I think in every class that we have, they should have, exposed us not just in our CAT class because in CAT we learn a lot about ICT tools, yes, but we forget when we get home so I would prefer that I be exposed to this ICT tools mostly three days a week and in different subjects so that I can know how to use it and get familiar and get comfortable. So I will prefer more exposure to ICT tools or any other whiteboards, anything I would prefer more exposure." (PS – S)

"I agree with PS – S because, with the CAT learners who have … uhm … CAT as a subject, it is easier, but for learners who don't have CAT, it is difficult, so I think I also agree with student two that more needs to be done." (PS – P)

It is clear from the above responses that, regarding the participants' preparedness to adequately implement ICT tools for pedagogy in a 4iR classroom, many participants had similar, albeit negative, experiences during their undergraduate studies, and a high likelihood exists that this limited their TCK and TPK which, according to Table 4.4, had mean scores of $\bar{X}$ = 1.00 and $\bar{X}$ = 5.00 respectively. It can be inferred from their responses that these pre-service teachers would have appreciated observing, and would have gained from, the lecturer using a specific ICT tool for teaching. This would have encouraged and guided them to utilise the ICT tool in their own teaching more effectively and confidently. This finding aligns with what Department of Higher Education and Training (2015) outlines: that a teacher should use ICT for innovation in teaching and learning (See Section 2.2). The findings of the current study also suggest that the implementation of ICTs in certain classes is not in alignment with the MRTEQ (2015). Together these results provide important insights into initial teacher training and suggest that initial teacher training plays a pivotal role in the pre-service teacher's preparedness and confidence to teach with ICT. In addition, the responses from participants in this, and in other studies conducted in South Africa, indicate that many pre-service teachers consider themselves under-prepared and under-equipped to teach in South African schools using ICT (Chigona & Chigona, 2013) (See Section 1.1).

4.2 Chapter Summary

This chapter presented the findings from the analysis of the data collected. From this analysis the researcher identified specific challenges that the participating pre-service teachers had experienced during their contact time at university and when they were out on in-service training. The researcher further identified from the analysis the extent and nature of the sampled pre-service teachers' understanding and implementation of the TPACK framework. The TK, TPK and TPACK (Table 4.1) domains of several of the pre-service teachers were relatively high compared to the remaining domains. This was evident from their responses to the questions posed during the focus group interviews, and confirmed during their micro-lessons. Some pre-service teachers found it challenging to intersect the knowledge domains at any given time.

Moreover, their responses indicated that these pre-service teachers had a basic understanding of the 4iR. Many indicated that, for teachers and learners – and their schools - to thrive in the 4iR classroom, both teachers and learners need to be ICT literate. ICT literacy was one of the prevalent foundational literacies most often mentioned by the pre-service teachers. These pre-service teachers further indicated the need for adequate subject-specific didactical training during class time, as well as more exposure to ICT during their in-service training. The data analysis revealed that, should the sampled pre-service teachers be more regularly, and in an ongoing way, exposed to ICT use and implementation, they would be willing to implement it on a regular basis. Against this background, the participating pre-service teachers' perceived their preparedness for this to be hindered in terms of their successful implementation of ICT tools for 4iR teaching and learning. The next chapter provides conclusions and recommendations based on the findings presented in this chapter.

CHAPTER 5: DISCUSSION, RECOMMENDATIONS AND LIMITATIONS

Introduction

As outlined in chapter 1, section 1.3, this study set out to establish how prepared a sampled group of pre-service teachers study participants at a University of Technology were, and perceived themselves to be, to teach in the 4iR classroom.

In response to the main question: in what specific ways are the pre-service teachers who participated in this study prepared for 4iR teaching and learning?, this study found that these pre-service teachers were either not adequately prepared for the 4iR classroom or lacked significant exposure to TPACK training in the course of their undergraduate studies. The rest of this chapter is organised under the following sub-headings:

5.1 Discussion

In this chapter, the researchers' insights concerning the implications of this research for both policy and practice are offered. Several implications emerged from this study. These are:

- Students' limited knowledge of 4iR as a result of an inadequate educational schooling background
- The need for the existing teacher education curriculum to develop students' PCK and TCK
- The lack of reliable ICT infrastructure and internet connectivity in some schools during teaching practice, and the necessity for this.
- The significance and value of a developed and sustained ICT culture in schools
- The need to expose pre-service teachers in subject-didactics to content specific ICT tools.

The first two implications are discussed concerning sub-question 1: What is the nature and extent of the knowledge and understanding about 4iR of a sampled group of pre-service teachers? The subsequent two implications are discussed in relation to sub-question 2: What, according to these pre-service teachers, are the foundational requirements for teaching effectively in a 4iR classroom? The remaining implication is discussed in relation to sub-question 3: What is the nature and extent of these pre-service teachers' preparedness to integrate ICTs effectively in a 4iR classroom, as perceived by them? The findings discussed in this chapter are consistent with the theoretical framework (TPACK), and are supported by the literature review presented in chapter 2. The study's main aim was to establish the specific ways in which a sampled group of pre-service teachers' were prepared for 4iR teaching and learning? Based on the findings discussed in Chapter 4, the majority of the participating third year pre-service teachers felt that they were not prepared, or were insufficiently prepared, to teach in the 4iR.

Sub-question 1: What is the nature and extent of the knowledge and understanding about 4iR of a sampled group of pre-service teachers?

5.1.1 The necessity for existing university curricula to develop students' PCK and TCK

The description of the findings from the data analysis in Chapter 4 showed that several of the members of the participating group of pre-service teachers (*n=4*) understood 4iR primarily in terms of their theoretical understanding of technology (see Section 4.1.1). The literature indicates a need to consider various factors to fully understand the rationale for these pre-service teachers' beliefs and perceptions around 4iR. According to Schwab (2016), the world was on the brink of a technological revolution six years ago. At this time, a revised policy was published for South African teacher education institutions which led to the creation and implementation of their respective teacher education curricula. As outlined previously (See section 2.2), the revised policy on the MRTEQ (2015) stipulates that the entry-level teacher should have a high level of ICT skills, and specialised PCK, and that teacher education curricula must contain integrated and applied knowledge mixes (Table 2.1). This indicates that the teacher education curriculum should be designed to advance pre-service teachers' ICT skills commensurate with invoking their capacities to implement and effectively utilise technological pedagogical practices in the classroom. As mentioned in the literature review (See section 2.2), according to the MRTEQ policy, teacher training should embrace the use of ICT in order for prospective teachers to implement it successfully in their teaching. Based on my inferences, some pre-service teachers in this study were not able to meaningfully conceptualise their understanding of the 4iR. This I contend, is an indication of the inadequate existing school and teacher education curricula, and their failure to expose these pre-service teachers to understandings concerning the history of past industrial revolutions and, more recently, the benefits to education and a country's economy of the current industrial revolution, namely, the 4iR. In addition it indicates the failure of education departments to offer both pre- and in-service teachers ongoing practical training and support in the use of ICT. I submit that the teacher's risk as the primary source of knowledge continues to have a significant influence on school students' passively absorbing knowledge, with learning remaining confined to the classroom, and learning material being primarily textbook-based in (secondary) education contexts (Table 2.1). This, I believe, does not bode well for effective 4iR teaching and learning in both universities and schools. This in fact indicates that many pre-service teachers are not accustomed to, or minimally knowledgeable about, teaching philosophies and pedagogy underpinning various industrial revolutions, as they are not exposed to such. While I acknowledge that ICT use

cannot be considered as the panacea for disrupting the status quo around asymmetrical power relations that may exist between educators and their students, I would argue that, by not exposing pre-service teachers to the potential benefits of the 4iR in the classroom, the likelihood exists that they will continue to resort to traditional 'chalk and talk' teaching styles in their own classrooms. This, I believe may stifle student/learner creativity and innovation, and equally inhibit the richness of the process of establishing meaningful relationships between educators and their students in the classroom. As educators, we have witnessed the overwhelming negative impact the current pandemic has had, and continues to have, on teaching and learning in universities and schools. Thus, if education is not adequately aligned to the conditions and possibilities of the 4iR, it is likely to continue to place universities and schools in a precarious situation when it comes to adequately addressing a potential education crisis post-COVID-19.

Furthermore, and encouragingly, the results presented in Chapter 4 confirmed that certain members of the group of pre-service teachers study participants (*n=3*) could relate the 4iR to more than technology alone. These pre-service teachers mentioned that, due to their mentor teachers' utilisation of technology in their classrooms for content delivery, and to enhance teaching and learning, they witnessed, and were able to imagine, the possibilities of using technology. These pre-service teachers reported applying what they had observed from their mentor teachers during their lessons. An implication of this that effective, responsible, and developmental mentorship is necessary for building trust and confidence so that pre-service teachers can implement and utilise what they have observed from their mentor teachers (pre-Service teacher's A and D: see Section 4.1.2). This finding suggests the possibility that pre-service teachers in general may in turn be confident to implement an e-Learning tool, or tools, during their lessons in the same way that pre-service teacher A implemented an e-Learning tool during his micro-lesson (see Section 4.1.3). This finding is an indication that school culture can play an integral role in the successful implementation of ICTs in the classroom, a finding which is consistent with that of Mishra and Koehler (2006) and with what they advocated based on their finding (See section 2.3.2.1). It can also be deduced that these pre-service teachers' exposure to ICT in the classroom developed in them a keen

interest in keeping abreast with the latest education technological implementation An illustration of this would be pre-service teacher H strongly advocating for researching a technology tool with which one is newly acquainted before implementing it in the classroom. Thus, I argue that the implication of an ICT culture would be a measurable strengthening of pre-service teachers' attitudes and their willingness to successfully implement ICTs in their school classrooms.

The results from the analysed data in Chapter 4 indicate that some of the participating pre-service teachers' (*n=3*) held misapprehensions about the 4iR (See section 4.1.1). These pre-service teachers were under the impression that the 4iR would replace teachers. While scholars such as Ślusarczyk (2018) predict that the 4iR is likely to create opportunities for teaching and learning to enter into new spheres (See section 2.4), these pre-service teachers' failed to see or imagine any likely opportunity that would accompany the 4iR. This misapprehension could either be a result of their rudimentary understanding of the 4iR, or simply due to their lack of exposure to the 4iR during their undergraduate studies. This would be due in turn to the above-mentioned existing inadequate teacher education curriculum. This finding identifies a pressing need to revise the MRTEQ policy concerning the skills necessary for 4iR teaching and learning. These skills are expanded on later in this chapter. A further inference from the findings is linked to the participating pre-service teachers' fear of technology due to the current economic climate in South Africa, with a current high unemployment rate of 34.9% (Statistics South Africa [Stats SA], 2021), and existing poor economic growth of 1.2% (Stats SA, 2021). While a discussion of this particular implication for teaching in the 4IR goes beyond the scope of this study, it is essential to acknowledge the impact of the socio-economic conditions of a developing country such as South Africa on the attitudes of individuals towards technology, and their willingness to learn about and engage with, it.

The data analysed in Chapter 4, section 4.1.3, revealed several concerns amongst individual pre-service teachers participating in this study (*n=7*). These were regarding their institution's existing teacher education curriculum. They indicated that

a lack of technology integration during their undergraduate studies lectures, together with a strong focus on traditional teaching methods in some subjects, served to create something of a negative experience in their learning. Three of the pre-service teachers (PS — L, C and G) expressly indicated that they would have preferred their lecturers to expose them more on how to use and practise with technology in their teaching. These pre-service teachers reasoned that, had they been exposed to ICT during their teaching and learning, they would have implemented technology to a greater extent in their lessons during teaching practice. This finding was an indication that these pre-service teachers, while lacking in confidence, had a desire to improve their PCK and TCK. This argument is worth noting, as it emerged and developed as a discussion during the micro-lesson observations, where many of the participating pre-service teachers felt that they had not implemented technology successfully in their classrooms. As a result of this failure, they would revert to traditional 'chalk and talk' teaching styles. Therefore, this indicates that the absence of effective technology integration during the teaching and learning of subject-specific content in their undergraduate studies had had a direct impact on these pre-service teachers' PCK and TCK.

Furthermore, the findings from the data analysis show certain pre-service teachers indicating the desire to learn when to use technology effectively in teaching specific course content. This was an interesting finding as it suggests that certain of the participating pre-service teachers did not fully understand the importance of subject didactics concerning when and how to use technology appropriately and successfully in the classroom. Although lesson plans can be considerably time-consuming, the perceived benefits to pre-service teachers of planning a lesson include the development of their PCK and TCK. In addition, the process of the planning of a lesson creates the opportunity for the pre-service teacher to reflect on the implementation of e-Learning tools, thus serving to improve the PCK and TCK of these pre-service teachers (see Section 2.5). I see the benefits of lesson planning as being significant for teacher education, considering the changing landscape of teacher education. This observation is consistent with that of Pamuk (2012), who argues that the lack of training and preparedness of many pre-service teachers in the utilisation of e-Learning tools in their practice is a direct result of the short-

comings of the teacher training curriculum. This finding of Pamuk (2012), together with an observation from this current study could be said to be an indication of the necessity for university curricula reform. This finding also points to the possible implementation of a bridging course whose focus would be on pre-service teachers' technological content knowledge and their pedagogical content knowledge domains to select appropriate ICT tools for effective curriculum delivery.

Moreover, a learner-centred pedagogical approach in the 21st-century is essential for learner personalisation and autonomous learning. In my observations of the pre-service teachers' micro-lessons, I found that certain pre-service teachers were able to successfully implement ICTs in line with the TPACK domains but would fail to allow the TPACK domains to traverse at any given time during lessons. In addition, where these domains may have intersected, there was no real connection between what the pre-service teachers envisaged teaching and the lesson objectives. This finding is consistent with the those of Mishra and Koehler (2006), and of Tallvid (2016), who posit an interwoven relationship between the TPACK domains (See Section 2.5). The literature reviewed, and my observations, suggest that, when these individual strands are adequately aligned, this can be said to create a lesson and a classroom for the 21st-century learner.

From my own experience the proper instructional use of the TPACK framework is essential for a community of practice among students in digital and face-to-face contexts. Should pre-service teachers be suitably exposed to the utilisation and successful implementation of technology in the classroom, this would prepare them to navigate teaching and learning effectively in response to any education crisis. Pre-service teachers would appropriately observe the content to be taught, and the way technological tools could be used accordingly. Thus, from the findings of the present study, and from those in the literature, I argue for the need for teacher education curricula not to be one dimensional, in other words, curricula which focus narrowly either on primarily subject-specific content or on specific ICT tools rather than creatively integrating the two. Secondly, there is a need for existing education policy to stipulate that teachers and lecturers alike should innovate with the purpose of

constantly improving both their pedagogical content knowledge and their technological content knowledge.

Sub-question 2: What according to these pre-service teachers are the foundational requirements necessary to teach effectively in a 4iR classroom?

5.1.2 The consequence of inadequate ICT infrastructure and internet connectivity in schools

The findings (See section 4.1.2) confirmed that certain of the participating pre-service teachers reported ICT literacy most frequently as a foundational requirement for 4iR teaching and learning. It was somewhat surprising that these pre-service teachers did not mention some of the other foundational competencies listed in the 2015 WEF report, namely, literacy (command of language skills), numeracy, scientific literacy, financial literacy and culture, and civic literacy. Pineida (2011) argues that students and teachers should develop technological and learning competencies as outlined by the WEF (2015) report, in order to develop the kind of high-quality learning using ICT, which was mentioned in the literature review. Pineida (2011) is of the view that, with sufficient training, the classroom will become 21st-century centred with technology-supported materials. The implication of this finding in section 4.1.2 suggests a need for existing teacher education curricula at the undergraduate level to be critically scrutinised in line with the aforementioned foundational competencies. I submit that these competencies, albeit essentially listed individually, are interrelated. In this regard, while ICT literacy is fundamental for effective ICT integration in teaching and learning, how students apply a core skill, such as literacy, to construct meaning from their everyday tasks is equally important when assisting students with their approach to complex problems. The latter, of course, is further dependent on students' competencies (See section 2.3.2), in addition to their foundational competencies, namely, critical thinking capacities, creativity, communication, and the ability to collaborate (WEF, 2015) (See section 2.3.2). These competencies have a direct influence on the positive ways in which students approach changing environments. More specifically, these competencies are seen to influence and trigger students' curiosity to ask questions and help create conditions for them to be autonomous and open-minded learners. They act as

catalysts for students to proactively undertake a new task, and for them to sustain their interest and effort to persevere to accomplish common goals. The possession of these competencies helps students to direct how their learning will take place, and encourages them to inspire others. They have the potential to ensure continuous engagement amongst students, allowing links to be drawn between instructional design and real-world experiences (See section 2.3.3). Therefore, I submit these as important qualities for teachers to instil in a classroom to advance 21st-century learning and to prepare their students to thrive in a transforming world. Given these findings, together with what is advocated in the literature, I submit that it is imperative for teacher education curricula and MRTEQ to expand and prioritise these qualities in order for them to have a more direct and sustained impact on teaching and learning.

The findings revealed several participating pre-service teachers outlining the importance of access to technology through ICT infrastructure in schools during their teaching practice. While the current study's data analysis indicated a theoretical understanding of technological tools on the part of the participating pre-service teachers, due to poor ICT infrastructure and inadequate internet connectivity at particular schools, most often historically disadvantaged schools, a number of individual pre-service teachers reported being unable to practically implement and utilise technology successfully during their teaching practice. Thus, it is reasonable to argue from this finding that, should pre-service teachers not be exposed to school environments with adequate ICT infrastructure and reliable internet connectivity during their teaching practice, they are likely to develop a level of frustration, and become discouraged regarding the implementation of e-Learning tools in general, and particularly at such schools, and subsequently tend to be demotivated and neglect to expand on their theoretical knowledge of technology. This is an indication that schools should adopt and implement a policy that governs the sustainability of adequate ICT infrastructure and reliable internet connectivity at these schools This responsibility should of course, be shared with the DoE whose task it is to support schools in providing and sustaining these resources. The limited access to ICT infrastructure and reliable internet connectivity in historically disadvantaged schools hinders teachers in these schools from adequately integrating ICTs in the classroom.

Those schools with adequate resources and appropriate and reliable computer infrastructure continue to make strides in leveraging technology to create 21st-century learning environments. These are learning environments that have a high potential to introduce students to all of the foundational literacies, competencies, and character qualities in education outlined in Chapter 2, section 2.3. The results from the current study are obviously not an accurate representation of all schools and of the varying levels of ICT infrastructure and internet connectivity in schools in the Western Cape. According to the Western Cape Education Department (WCED, 2015) broadband and game-changer initiative, by the end of 2018, 1 273 schools out of 1 470 plus schools should have had internet connectivity, and 356 schools should have been connected to a LAN (See section 1.1). However, from my own experience, and based on the literature, I would argue that, while some schools may to date have adequate ICT infrastructure and reliable internet connectivity, ICT support remains limited. As a result some teachers do not have a positive or confident attitude towards implementing ICT tools during their lessons, particularly in ways which have the potential to hone 21st-century teaching and learning skills.

Based on the findings, of the current study, one could argue that, while some of the participating pre-service teachers had a rudimentary understanding of the 4iR, they were not fully aware of the foundational requirements for teaching in the 4iR classroom. Consequently, there needs to be a greater emphasis on developing urgency among pre-service teachers in general to gain greater exposure to the full range of 21st-century skills needed for them to teach successfully in the 4iR classroom.

5.1.3 The significance of an ICT culture in schools

In the report on the findings in Chapter 4, section 4.1.2, one specific pre-service teacher M reported that during the time that he was conducting his teaching practice at an affluent school, a technology ecosystem was integrated for teaching and learning and to perform administrative tasks. This finding identified the endless possibilities for teaching and learning when a school leverages technology to its advantage, and has the financial resources to do so. Pre-service teacher M elaborated on this development, describing the ICT culture at the affluent school as

being of such a nature that all learning materials were available in digital format to students. This created an ease of access to a range of learning material for the students, and also ensured that the school was thriving financially by not habitually printing activities and lesson material or purchasing printed textbooks. In contrast to the experience of pre-service teacher M, several pre-service teachers (H, C and G) in this study indicated that their mentor teachers relied on traditional teaching methods and neglected to see the full potential of implementing an e-Learning tool in the classroom. This, I argue, negatively influenced these pre-service teachers in successfully integrating an e-Learning tool in their classrooms, either during practice teaching in schools, or during their micro teaching. What this indicates is that reality works against the MRTEQ specification that pre-service teachers should undergo practical learning, which is one of the applications of knowledge for teaching (See Table 1, section 2.2). Practical learning makes provision for pre-service teachers to observe their mentor teachers and to be exposed to and practise various pedagogical strategies. Subsequently, when a mentor teacher uses an e-Learning tool they incidentally and seamlessly allow the pre-service teacher to do the same. This was deduced during the focus group interviews, where some interviewees reported feeling comfortable enough to resort to the ICT tools they were most comfortable with and were exposed to during their micro-lessons or teaching practice.

For teachers to buy into the use of technology at the school, there should be a clear and holistic ICT strategy that outlines different phases of ICT integration and usage in the classroom. An influential ICT school culture is of paramount importance for the following reasons: firstly, it creates continuous growth opportunities. Secondly, it provides a space for students to become active 21st-century agents. Thirdly, it enables teachers to innovate and share ideas confidently with other teachers in a collegial way. In this context, Adesote and Fatoki (2013) argue that appropriate use of ICT can influence and change traditional teaching methods. Based on studies, such as that of Adesote and Fatoki (2013), and on the findings of the current study , I contend that ways should be devised to assist teachers to come to see the significance of the use of ICT in the classroom in promoting digital equity. This, I believe, would have the potential to lessen the impact of the digital divide between affluent schools and historically disadvantaged schools, and help create a situation

where every member of society has not only full access to technology, but also the capacity to use the technology. When teachers who serve as mentors, either formally or informally, at schools where pre-service teachers conduct their practice teaching, themselves use ICTs to promote and advance the 21st-century classroom, they create the opportunity and model for the pre-service teacher to do the same. This finding is in line with the gist of the 2004 White Paper on e-Education, which stated at the time that, during pre-service training, pre-service teachers should be capacitated in integrating ICTs as flexible tools to enhance teaching and learning (DoE, 2004). This capacitating also creates the opportunity for all stakeholders to collaborate in ICT initiatives that advance a teacher education curriculum; it creates the opportunity to lay the foundations for collaborations between universities and schools for effective ICT implementation in the teaching and learning process.

Sub-question 3: What is the extent of these pre-service teachers' perceived preparedness for them to be able to integrate ICTs effectively in a 4iR classroom?

5.1.4 The need to capacitate pre-service teachers with fundamental ICT literacy skills

The findings of this study indicated the relatively level of preparedness for 4iR teaching and learning of a participating group of pre-service teacher to be a source of concern. During my observations of their micro-lessons, what became evident was that these pre-service teachers were underprepared for the use of technology for teaching purposes in effective and useful ways. The data analysed in Chapter 4 indicated that all the participating pre-service teachers had a theoretical understanding of the implementation of ICT tools (TK) in the 4iR Classroom (See section 4.1.3 Table 4.1), but lacked the capacity to practically implement an ICT tool (TPK) in ways which would integrate it effectively with the lesson objectives. They also failed to find the point of intersection between CK, PK and TK (See section 2.5) to demonstrate their ability to conceptualise how their stated lesson objectives during their micro-lessons were to be achieved using an ICT tool (PCK) (See section 4.1.3 Table 4.1). In this context, Chai et al. (2014) advocate the need for teachers to be design-oriented to leverage TK and PK for content learning (See section 2.5).

Sikhakhane et al. (2021) argue that teachers and students learn by doing. In this regard, the under-preparedness of pre-service teachers requires a pragmatic approach towards mitigating several challenges faced by those pre-service teachers who do not have access to technology. This under-preparedness presents significant challenges to industry 4.0, one of which is an inefficient workforce incapable of using technology for the benefit of the industry. Another contributing factor to the pre-service teacher's under-preparedness, as indicated by the findings of the present study as well as the literature and policy documents, is the lack of creativity within curricula. The Computer Applications Technology (CAT) curriculum remains outdated and in need of a curriculum review that would consider and address the complexities of the 4iR, and would be redesigned based on the idea of fostering meaningful learning using technology. In addition, gaps should be identified in the curriculum, and remedied in ways which would ensure that students are ready for employment in industry 4.0. Also, in many instances, the subject CAT remains exclusive to those who have access to adequate computer resources. In this regard, students from historically disadvantaged communities who do not have access to such resources remain marginalised from participating effectively in practical assessments.

The findings further indicated a need to advance pre-service teachers' TPACK domains for successful ICT integration in the 4iR classroom. This suggests pre-service teachers striving to follow a basic substitution and implementation model to transition from traditional teaching pedagogy to a more 21st-century pedagogy. This approach would strengthen the pre-service teachers' utilisation of ICT tools and build their confidence. It would also create the opportunity for such pre-service teachers to critically scrutinise a particular ICT tool before its implementation during the lesson, while at the same time the pre-service teacher would strengthen his/her TPACK domains. Pre-service teachers should also deepen their knowledge of the subject matter (CK) to be taught, as this forms an integral part of the successful implementation of ICT tools in the classroom. Shulman (1986) argued 25 years ago that mere content knowledge in teaching is likely to be impractical without any

pedagogical skill. Thus, when a pre-service teacher improves his/her CK, and has a firm PK foundation, the likelihood exists that they will be able to make informed decisions in the process of successfully implementing ICT tools in the classroom y. Also, it is my contention, for pre-service teachers to be better prepared to teach in the 4iR classroom, collaborative relationships between historically disadvantaged schools and public areas/resource facilities (libraries) and/or the private sector (internet cafes) need to be explored. When relationships between schools and these stakeholders are adopted, it is envisaged that several of these schools would then be able to access the internet, thus creating online assessments for students. Hence, Schwab (2016) argues that all stakeholders have a responsibility to collaborate, be better informed, and make the effort to understand emerging trends (See section 2.4). Should stakeholders not form relationships in a project to build a better digital school society, and should parents continue to neglect their children's need for internet connectivity, students are less likely to be inspired to integrate technology into their lives and their learning.

Given that most millennials have a desire to explore technology, the public and private sectors could utilise this eagerness to collaborate in the introduction and induction of young students to new ICT tools, such as the tablet, VR or robotic devices. These devices can be used for various teaching and learning approaches, such as the introduction of block-based programming on these devices using the devices' web browser, given that critical thinking is an everyday occurrence and develops the ability to solve problems (Mishra et al., 2011) (See section 2.3.2.1). Block-based programming can be utilised to further develop critical thinking amongst students for them to make informed decisions. In addition, the use of an LMS (Moodle, Google Classroom) in which course content can be stored online may assist both pre-service and in-service teachers in maintaining a high standard for lessons with relevant teaching and learning resources. This would further assist learners with access to such materials. In this regard, a blended learning approach may assist students with being exposed, at least to some extent, to basic ICTs (chrome books).

Based on the analysis of the data in chapter 4, section 4.1.3, the participating pre-service teachers had a mean score of 0 for CK and PCK, and a mean score of 1 for PK and TCK (See Table 4.3).This suggests a need for significant investment in teaching, research, and the retraining of teachers and students within the context of digital transformation. In addition to the need for this investment, there is a need for the current curriculum to be attuned to the needs of the digital society in ways that can contribute to capacitating pre-service teachers' fundamental ICT needs.

Though the digital world is growing exponentially, and has already had a significant impact on education (Department of Science and Technology, 2019) (See section 2.1), the implications of theft of ICTs from many schools will continue to have devasting effects on students' and teachers' willingness to use ICTs. Ongoing theft is likely to hinder the impact the digital world may have on education in such schools. In this regard, the likelihood exists that prospective pre-service teachers will not be allowed to observe in-service teachers using ICTs during teaching and learning. Unless stopped, or reduced, ongoing theft is also likely to result in historically disadvantaged schools not being able to compete with affluent schools in equipping their classrooms with the latest technological tools for teaching and learning, as is stipulated as a requirement in various DoE documents . These hindrances to the securing and the use of technology in schools are likely to oblige teachers to continue to use traditional teaching and learning methods, or require them to innovate and to use cost-effective alternatives, such as Plickers, which only requires the teacher to have a mobile device and paper on which to print the unique codes of every learner to allow for their engagement during the lessons, and is not based on the assumption that learners possess their own devices.

Pre- and in-service teachers being adequately prepared and capacitated to embrace ICT tools in the classroom allows for collaborative learning. A collaborative approach encourages students to take ownership of their learning, for example, teachers being able to create diverse group learning activities where learners are engaged with each other and with learning in a collaborative learning process. In this context ICT tools create the opportunity for teachers to reflect on the lesson, for example, on the

use of Plickers and Google Forms, both of which allow for results to be returned immediately. Upon reflecting on the results, in this learning situation, teachers can either improve on what was/is being taught or adapt the lesson in a manner that responds to individual learners' needs. When a teacher uses ICT tools, and allows her or his learners to be actively engaged during the lessons, the teacher creates an environment for the learner to connect what they are currently doing to their own milieu and life experiences, and this has been shown to result in the student easily being able to apply what she/he is being taught. Collaborative learning approaches also create room for problem-based learning. More specifically, problem-based learning creates an opportunity for students to critically engage with the learning material, facilitating knowledge building and understanding.

5.2 Recommendations

The following recommendations are based on the findings from this research, and on the literature review. It is hoped that these recommendations may positively impact the ICT usage of ICT by all pre-service teachers during their undergraduate studies, including both practical and work-integrated learning, and may also improve their TPACK domains for 21st-century teaching and learning in the 4iR.

5.2.1 The role of in-service teachers in providing effective mentorship of pre-service teachers

This research has indicated that the role of in-service teachers' in providing mentorship to pre-service teachers is critical during the pre-service teacher's practical and work-integrated learning periods. It can be argued that the quality of the mentorship provided to pre-service teachers directly impacts their career development. More specifically related to this study is how pre-service teachers are likely to implement ICT tools during their teaching. In addition, as has been suggested, should pre-service teachers observe their mentor teacher displaying a positive attitude towards implementing and using ICT tools effectively in the classroom, a strong likelihood exists that the pre-service teacher will develop the same attitude towards using these tools in their classroom.

When an in-service teacher mentors a pre-service teacher, this experience provides an opportunity to the pre-service teacher to practically observe an in-service teacher's Technological Pedagogical and Content Knowledge domains during lessons, in turn providing the opportunity for the pre-service teacher to theoretically engage during lesson reflections with the mentor teacher on how the pre-service teacher can improve his/her TPACK domains. Thus, based on this argument, I advocate for research to be conducted to explore the state and quality of mentorship in South African public schools, and to develop an appropriate and agreed-upon intervention approach. I specifically propose that professional development courses be developed in line with such research towards ascertaining the effectiveness of existing mentorship programmes in order to advance the mentoring capacities of existing mentor teachers. This may require an adequate budget for a collaborative agreement between universities and the WCED and/or the DBE and DHE. In addition to this, and to consolidate this programme, I further suggest the need for schools to be part of a community of practice to collaborate and explore a viable and sustainable method for developing a mentorship programme in the absence of adequate financial resources.

5.2.2 ICT school culture

The current study found that ICT school culture is pivotal to the successful integration of ICT tools in the classroom. The participating pre-service teachers saw this culture, or lack of it, to directly impact their attitude towards the successful utilisation and implementation of an ICT tool in teaching and learning. I propose that, when pre-service teachers are exposed to a positive and influential ICT culture in schools, their likelihood of expanding on their existing ICT knowledge to successfully implement an ICT tool in their teaching would be high. The findings from the study's data analysis also indicate that schools with successful ICT cultures follow a comprehensive ICT policy that extends beyond the minimum requirements of classroom teaching and learning. More specifically, these schools routinely

implement ICT tools for teaching and learning, and utilise ICT tools for administrative tasks.

As an enthusiast and advocate of technology reform within teaching, I would argue that ICT culture is not simply about using any ICT tool for teaching and learning; it is about using the most appropriate ICT tool for curriculum delivery. Furthermore, to navigate and to continue to foster a positive ICT culture at any institution, there needs to be buy-in from all teachers, together with an environment where teachers can freely share and learn from each other. Not only should they learn from each other and share best practices, but both in-service teachers and pre-service teachers should constantly be well-informed of the latest technological changes, and adapt their practice accordingly. Lastly, pre-service teachers and in-service teachers should acquire various e-Learning badges or certifications, such as becoming certified Microsoft Educators, Google certified educators, certified Flipgrid Educators. This would provide teachers with opportunities to demonstrate deep learning and understanding regarding a specific e-Learning tool when it is implemented in the classroom.

5.2.3 The realignment of teacher education curriculum

I would argue for the teacher education curriculum to be redesigned in ways which would expand the knowledge of pre-service teachers of past and current industrial revolutions. This historical contextualising of the 4iR would go some way to ensure that prospective and current pre-service teachers make informed and sound TPACK decisions during their teaching, and in ways which would directly impact pre-service teachers' ICT capacities. Chapter 4, section 4.3.1 describes and assesses the extent of participating pre-service teachers' knowledge and understanding of the 4iR. Some of the participating pre-service teachers believed that the 4iR would replace teachers in the future However, should teacher education address the educational benefits of 4iR, pre-service teachers would no longer have a rudimentary understanding of the 4iR and would steer away from the self-limiting belief that the 4iR will replace teachers.

Based on the findings, I recommend a possible bridging course in the first year of the Bachelor of Education degree whose the focus would be on the pre-service teachers' technological content knowledge and pedagogical content knowledge domains to select appropriate ICT tools for practical use in curriculum delivery. This recommendation is consistent with that which emerged from a prior study conducted by Palomino (2017), who noted the importance of specific training in ICT for appropriate and effective classroom implementation (See section 2.2.). Such a bridging course would enable pre-service teachers exposed to technology use during their schooling career to expand on what they have learned, and for pre-service teachers who were not exposed to technology use during their schooling to gain the confidence to use technology in their teaching. In addition, and to complement this course, as has been mentioned, there is a need for teacher education to include the fostering of foundational literacies, certain specific competencies, and character qualities in these programmes, as outlined in chapter 2 (See section 2.3). This would be guided by a revised MTEQ policy document.

5.2.4 Lesson planning using 21st-century ICT tools

Lesson planning is an essential skill that requires constant shaping, reflection, and reforming to assist and guide the teacher in successful teaching and learning. In the 21st-century, various ICT tools can assist with such lesson planning. These include word processing tools like Microsoft Word (365) and Google Docs. When using this kind of word processing tool, lesson plans can easily be shared with colleagues for their input and critical evaluation, and with learners to allow for asynchronous learning. Teachers can also use this kind of word processing tool to create interactive lesson plans by transforming them into HyperDocs. This transformation of lesson plans into HyperDocs facilitates the autonomy of learners in their engagement with the lesson in their own time. To achieve these outcomes using these various ICT tools in lesson planning, I would argue, strong emphasis should be placed on the role of TPACK domains during subject didactics when students are learning about the setting up lesson plans. Both pre- and in-service teachers need to have the knowledge and skill to gauge when to apply a specific TPACK knowledge

domain, and when knowledge domains intersect during a lesson. Creating well-designed lesson plans using these ICT tools would enable pre-service teachers to critically evaluate these teaching and learning resources in alignment with the proposed lesson objectives.

5.3 Limitations of the study

According to Du Plooy-Cilliers (2014), every research study has its limitations and challenges. Thus, several limitations need to be noted regarding the present study. The anticipated limitations of this study were:

- the use of a small sample size,
- not exploring current in-service teachers and university educators' approaches to 4iR in the classroom, and
- a lack of critical scrutiny of the existing high school Computer Application Technology curriculum.

5.3.1 Sample size

A qualitative research design was used in this research project with a case study approach. As was mentioned in Chapters 1 and 3, according to Yin (2009), the case study is the preferred research approach when examining contemporary events and collecting data within a specific context. The main aim of this research study was to establish how, and to what extent, a group of pre-service teachers were prepared for 4iR teaching and learning. The size of the sample of CAT third year pre-service teachers the study used was not ideal as the results from a small sample size cannot be applied elsewhere to studies using a larger sample size. In addition, this small group of pre-service teachers could not be considered as accurately representing all pre-service teachers, although Gentles et al. (2015) advance that smaller samples are used in qualitative research whose purpose is to acquire information to understand the complexity surrounding a phenomenon.

5.3.2 In-service teachers' and university educators' pedagogical approaches to 4iR in the classroom

The current research study only looked at the nature and extent of the preparation of a small sampled group of pre-service teachers for 4iR teaching and learning. It did not explore what pedagogical approaches current in-service teachers in public and private high schools align with Education 4.0. If in-service teachers' approaches had been included in this study, the results of the study would likely have been different. In addition, the present study did not explore or compare what other university educators, in other subject areas or disciplines, at this institution where the data was collected, are or were doing and implementing at the time of this study to ensure their pre-service teachers are prepared for 4iR teaching and learning.

5.3.3 Lack of critical scrutiny of the CAT school curriculum

This research study failed to critically scrutinise the CAPS for CAT. As a teacher of many years' experience, I had sufficient background knowledge of the contents of the CAT CAPS document. However, being a novice researcher, I neglected to see what possible impact critically and systematically scrutinising the CAT CAPS document would have had on the results of this study.

5.4 Recommendations for future research

This study aimed to establish how and to what extent a small group of pre-service teachers were prepared for 4iR teaching and learning at the time of the study. However, given the small sample size used, and the use of two types of data collection methods, several questions to do with the preparation of pre-service teachers for teaching in the context of the 4iR remain unanswered. This omission can be said to create an opportunity for future studies to be undertaken with larger sample sizes and at more than one teacher education institution. Such studies would establish a more in-depth and varied understanding of pre-service teachers' TPACK knowledge domains and their preparedness for teaching in the 4iR. Future research could also be conducted which looks at in-service teachers' 4iR teaching and

learning capabilities, as well as at what university educators and education departments are or are not doing concerning 4iR teaching and learning. Exploring the nature of other university educators 4iR implementations could result in establishing a better picture of what hinders and what promotes pre-service teachers' utilisation of ICT tool for teaching and learning, thus creating a better understanding of the pre-service teachers' TPACK domains.

5.5 Summary

This chapter has described and discussed the findings outlined in chapter 4 in line with the three subsidiary research questions: What is the nature and extent of the knowledge and understanding about the 4iR of these pre-service teachers? What, according to these pre-service teachers, are the foundational requirements necessary to teach effectively in a 4iR classroom? What are these pre-service teacher's perceptions regarding their preparedness to integrate ICTs effectively in a 4iR classroom? Based on the insights that the findings provided, and based in turn on the subsidiary questions, recommendations could be made in line with the main research question and the three subsidiary questions. What emerged from the findings was that the pre-service teachers in this study were not adequately prepared for teaching in the 4iR classroom. The findings also indicated room for improvement regarding the research participants' Technological Pedagogical and Content Knowledge domains. In addition, the findings suggested that these pre-service teachers should also strive to gain access to schools for practice teaching and/or visits where a healthy ICT culture exists in order for them to learn how to, and be inspired to, use and implement ICT tools in their classrooms. Lastly, it was recommended that pre-service teachers also be exposed to various ways of integrating ICT tools in their subject didactics lectures when they are in the process of planning their lessons.

As we advance into the 21st-century, and confront an increasingly technology reliant and competitive job market, it is the responsibility, not only of teacher training institutions, but of schools and education departments to develop and improve teachers' Technological Pedagogical and Content Knowledge domains. This includes providing regular hands-on practical training and support for teachers in

their use of ICT tools in their classrooms. In this context it is also, as the current study has indicated, the responsibility of WCED to improve the quality, updating, security, and infrastructure of ICTs at schools in order to narrow the gap between historically disadvantaged poorly-resourced schools and affluent, well-resourced schools.

Thus HEIs, schools, and education departments, both individually and collaboratively, need to find ways of inducting both pre- and in-service teachers into teaching and learning in the 4iR.

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APPENDICES

Appendix A: Focus group schedule

1. What is your knowledge and understanding of e-Learning in the 21st-century?
2. What do you consider to be the basic technical requirements for using e-Learning tools in a classroom?
3. Can you recall a specific time during your teaching practice experience where a teacher made use of any e-Learning tools to facilitate teaching and learning? Describe this.
4. What was your impression of that?
5. What is your preferred e-Learning management system in your own teaching and learning? What are your reasons for your choice?
6. How do you intend using your preferred e-Learning management system for teaching and learning? Give reasons.
7. How do you intend using your preferred e-Learning management system to improve your own teaching and learning?
8. How do you feel about your preparedness to use ICT tools in your classroom? If so, what would be your reasons?
9. What do you think should have been done differently during your undergraduate studies to prepare you adequately for the 21st-century and for teaching using ICT?
10. What is your opinion of Google Suite for Education as an e-Learning platform?
11. In what specific ways do you think Google Suite for Education as an e-Learning platform can improve your content delivery and ICT pedagogy use in the classroom?
12. The Fourth Industrial Revolution (4IR) is upon us.
    - 12.1. What do you know about the 4IR?
    - 12.2. In what specific ways do you think the 4IR will impact teaching and learning?
    - 12.2.1. In what specific ways do you think the 4IR will impact on and be important in Higher Education?

Appendix B: Research ethics certificate

Cape Peninsula University of Technology

***For office use only	
Date submitted	
Meeting date	28th August 2019
Approval	P/Y/N
Ethical Clearance number	EFEC 3-8/2019

FACULTY OF EDUCATION

RESEARCH ETHICS CLEARANCE CERTIFICATE

This certificate is issued by the Education Faculty Ethics Committee (EFEC) at Cape Peninsula University of Technology to the applicant/s whose details appear below.

1. **Applicant and project details (Applicant to complete this section of the certificate and submit with application as a Word document)**

Name(s) of applicant(s):	Marinus van Wyk		
Project/study Title:	The use of an e-learning pedagogy in preparing pre-service teachers for Fourth Industrial Revolution teaching and learning No		
Is this a staff research project, i.e. not for degree purposes?	N/A		
If for degree purposes the degree is indicated:	M.Ed		
If for degree purposes, the proposal has been approved by the FRC	Yes		
Funding sources:	None		

2. **Remarks by Education Faculty Ethics Committee:**

Ethics clearance granted from 1/9/2019 – 30/12/2023		
ApprovedX:	**Referred back:**	**Approved subject to adaptations:**
Chairperson Name: Dr Candice Livingston **Chairperson Signature:** Livingston		**Date: 29 August 2019**
Approval Certificate/Reference: EFEC 3-8/2019		

Appendix C: Participant consent form

01 May 2019

Title of Research project:

Investigating pre-service teachers' preparedness for Fourth Industrial Revolution teaching and learning

Researcher: Marinus Daniel van Wyk

I am Marinus Daniel van Wyk, and I am a student at the Cape Peninsula University of Technology, currently doing my Master's degree in Education, specialising in Computer Application Technology and Information and Communication Technology.

The research I wish to conduct explores the use of an e-Learning Platform in the classroom. This research could help improve your ICT self-efficacy as a third year BEd student, and that of other students as well as your future school learners.

I will be conducting focus group meetings and unstructured observations. The focus group meetings will take place over a two-month period from May 2019 to June 2019.

Your participation in this research will be entirely voluntary. If you choose not to participate, no questions will be asked and you will not be observed or judged for withdrawing from the study.

I undertake not to share any personal information I receive from anyone, and the information collected from you for my research project will be kept private. Any information you volunteer or contribute during our focus group and observations will have a pseudo name instead of your real name. After my write-up, all information that I have collected will be kept electronically in the cloud.

- I have been given, and have understood, a description and an explanation of this research project.
- I have had an opportunity to ask questions of the researcher and he has answered them to my satisfaction.
- I understand that any information I provide will be done do anonymously, and I will not be identified in any of the analyses or reports resulting from data collection.
- I agree to take part in this research.

Signed : _____

Print name : _____

Date : _____

Appendix D: Observation schedule

Computer Applications Technology 3	**Observed by: MD van Wyk**
Date of observation:	**Activity observed:** the use of GSuite as an e-Learning pedagogy
Purpose of observation: how are the GSuite applications being implemented to enhance the pre-service teacher's Technological, Pedagogical and Content Knowledge.	

Time	**Observation**	**Student actions**