The role of TPACK in enhancing students' knowledge of the design process: A case study of Grade 9 Technology Educators

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Abstract

The department of basic education is making efforts to transform educator pedagogy by introducing the use of digital technology in South African classrooms. Thus, the utilisation of digital tools in the technology classroom is likely to improve the students' comprehension of the design process. Educators need a well-developed Technological pedagogical content knowledge to meaningfully integrate Technology in their classrooms. The core purpose of this research is to investigate the role of the TPACK body of knowledge in enhancing grade 9 student understanding of the design process to improve learner achievement and to allow learners to design models that are fit-for-purpose and usable beyond the classroom. This is a qualitative research study aimed at capturing rich-data to answer the main research questions of the study. The TPACK framework was used in this study to determine the role of TPACK in enhancing the knowledge of students when they learn the design process. The data collection method used was interviews, where five grade 9 educators were purposively sampled from Sedibeng east to establish the role of TPACK in the Technology classroom. The study is underpinned by constructivism and social constructivism learning theory that follows a learner-centred approach to teaching the design process. The finding of the study reveal that educators are interested in using digital tools in their classroom, however they are constrained by the lack of technological support, limited access to digital tools and the lack of Technological pedagogical content knowledge. The findings further reveal that educators are attempting the integration of technology in the classroom but they do not appropriately articulate the affordances of digital tools that will enhance the learners understanding of the design process. To answer the research question, the role TPACK cannot be meaningfully measured as the educators showed a lack of Technological pedagogical content knowledge. According to the educators' point of view, students became interested in the lesson when they used digital tools therefore, if they can be trained in using digital tools, they will be able to enhance the understanding of students in the design process. This would allow learners to design and make models that fit-for-purpose and come up with solutions that show a deeper understanding of the problem they had to investigate. The finding further shows that if the TPACK can be used meaningfully, it will play an important role in learning of the design process. In future Pre-service and in-service educators must be equipped with TPACK body of knowledge and more digital tools must be available in the Technology classroom for the learners to meet the learning outcomes of the design process.

Key words: Design process, Technology pedagogical content knowledge, Technology education, Digital tools.

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- Above all, I would like to give my gratitude for God almighty for giving me the strength to complete my master's degree.

Declaration Of Original Work

I **REFILWE MODISE** certify that this research report titled *the role of TPACK in enhancing students' knowledge of the design process:* A case study of Grade 9 Technology Educators is my original work except where citations and acknowledgements indicate otherwise *is my original work and has never been submitted before*

REFILWE MODISE **Date: February 2023**

Dedication

I dedicate this study to my precious mother for always believing in me and supporting my dreams.

I dedicate this study to my late father Morrison Moses Modise; he sacrificed so much for my education.

Definitions of the key concepts/terms

The following list of the concepts and terms are included to give clarity to the connotation of the terms used in the context of this study. The terms will be beneficial to the readers to provide meaning clarity on the origin of the definition and how the terms are interpreted and conceptualised in the study.

Educator: a person (such as a teacher or someone who imparts knowledge to students) who has a job/occupation in the field of education. This word is used interchangeably with teachers in the study

Teacher: A teacher is a someone who guides others to acquire knowledge, competences, skills, or values. This word is used interchangeably with educators in the study

Digital tools: Laptops, smartphones, smart boards, tablets, the Internet, Google Classroom, videos, and other devices used to share and save knowledge are just a few examples of technology that can be used in education**.** (Mahiri, 2011)

Information Communication Technology (ICT). ICT includes all technologies that provides and presents access to information through telecommunication e.g. any hardware, software or any communication media. (Evoh, 2007)

Capability Task: Capability tasks encompasses of the designing and making a product that is functional (Barlex, 2000).These tasks are conducted over a longer time frame using the design process, i.e. investigating, designing, making, evaluating and communicating as prescribed by the (Department of Education, 2003).

Mini-PAT: "A short Practical Assessment Task which makes up the main formal assessment of a learner's skills and knowledge application during each term". (DoE, 2011).It can be an assignment covering aspects of the design process or it can be a full-featured assignment covering all aspects of the design process (IDMEC) in a form of capability tasks. A Mini-PAT focuses primarily on one of the knowledge Technology (structures, mechanical systems and control, electrical/electronic systems and control and processing), but may be integrated and may target more than one knowledge focus.

Problem-solving: Problem-solving in Technology education must be taken as a process used to come up with solutions in the design process. It is a formal instructional method in which learners in small groups gain knowledge through engagement with authentic and challenging real-life problems.

Technology education: focuses on the use of skills and resources in the identification of the needs of people and activities to satisfy those needs by applying science and the use of materials. It is further concerned with problem solving (Wicklein, Smith, & Kim, 2009)

Technology challenges: It is the challenges with the use digital tools including the access to the internet and all the resources required to make learning and teaching meaningful in the Technology classroom.

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Chapter 1: Background And Overview Of The Study

1.1 Introduction

The proliferation of digital technology is compelling teachers to rethink their teaching methods. Thus, several teachers are caught unaware on how to embed technology in their classrooms. To cope with the needs of the 21st century, both the pre-and in-service educators must be trained to use digital tools to enhance instruction and learning of Technology as a subject in school. The teaching and understanding of the design process remains a challenge in many Schools in the Sedibeng East region of Gauteng province in Republic of South Africa (RSA) as most of the learners in this region are not performing well in technology and are also failing to produce quality models in their termly mini-practical tasks. For the students to perform better in the design process which constitute seventy percent (70%) of the term mark, they need to understand the design process. To achieve the latter, it is necessary to get highly competent educators in the integration of technological tools in the classroom; Technology educators must possess TPACK knowledge body. (Mishra & Koehler, 2006) developed a TPACK framework which highlights how the relation between teacher's understanding of Pedagogy, Content, and Technology interrelate to produce effective teaching. The authors assert that TPACK is a theoretical framework that allows for "the thoughtful integration of technology into education". This framework meaningfully influenced and is still influencing theory and practice in teacher professional development in the integration of digital tools in education. The added value of TPACK framework is manifested through educator's successful integration of technology in their instruction as well as the development of student's conceptual and procedural qualities.

1.2 Background of the study

The advent of Technology as a school subject in South Africa came with major challenges as majority of the teachers lacked formal training and qualifications to teach the subject; as a result the DBE conducted professional development workshops to equip teachers with the pedagogical content knowledge of the subject. These training also included the integration of Information Communication Technology (ICT) in the classroom. However, the implementation and the teaching of the subject remains a challenge after it is introduced for sixteen (16) years. Technology education was introduced with the purpose of introducing learners to engineering and problem-solving skills. These skills are acquired through the design process, which is meant to enable students to engage in problem solving tasks.

Historically in South Africa and internationally, the understanding and learner performance in Technology as a subject, specifically the design process has been problematic, where a well-

developed understanding of the design process is essential in Technology education (TE) but lacking (Makgato & Gumbo, 2008). The primary cause of this issue is that the majority of technology educators are not formally qualified to teach technology; as a result, they lack the methodological and content understanding necessary to instruct the topic. The recommended approach to teach the design process by the DBE is to expose the students to a problem, need or opportunity. In the process, they rectify design issues and satisfy the needs by designing functional models. (Ankiewicz, De Swardt, & Engelbrecht, 2005) . It is argued that there is no common understanding of the design process as some educators still perceives it as a linear process, which then exacerbates the problem that educators are facing in understanding and teaching the design process.Students in senior phase produce poorly designed models/artefacts that are not usable beyond the classroom. Engineering has the distinct feature of design, which includes a sophisticated cognitive process. As a result, it is critical to make complex aspects of the design process explicit from the beginning. TPACK knowledge has interesting ideas on how to teach design process to equip learners to deal with design concept complexity. Having followed that, this study aimed to uncover how Technology educators may apply the TPACK framework to enhance grade 9 learners' knowledge of the design process.

1.3 Problem statement

The deficiency in educator's knowledge and understanding of the design process results in the educator's inability to teach the design process. (Mentz, Pool, & Reitsma, 2011) argue that technology teachers in South Africa lack the appropriate subject specific pedagogical content knowledge and Technological pedagogical knowledge (PCK) to teach technology and the design process which happens to be the backbone of technology education. In addition, educators seem to be having challenges in teaching effectively using ICT. Despite having the pedagogical and content knowledge of the design process, technology educators lack the technological body of knowledge (Sung & Kelley, 2019) to successfully teach the design process for the benefit of learners. Technology teachers are still uncomfortable with structuring the problem when teaching the design process, resulting in obstacles in the solving phases and eventually robbing learners of understanding the concept (Mettas & Norman, 2011).

(De Jager, 2011) affirms that insufficient pedagogical content knowledge (PCK), high learner ratios, and the transition from traditional methods of teaching to learner-centered approaches are amongst major challenges when teaching the design process. Learner-centered teaching is an important educational technique in the design process as it supports the theory of social

constructivism. To support view (Makgotho, 2012) identified three challenges when teaching the design process namely, personal understanding, context specificity and the sequence of the design process. Context specificity refers to the fact that when learners learn the design process, the problem they need to solve must be within their context to make it easier for them to grasp the problem they need to solve. Thus, lacking mentioned challenges may results in educators not being able to teach the subject meaningfully. There is limited research that support the use of TPACK in teaching the design process in Technology as a subject together with the impact it may have thereof. Thus, there is an urgent need for Technology educators to effectively teach students the design process to build functional models/artefacts that are used outside of the classroom utilizing the TPACK framework.

1.4 Purpose of the study

The study seeks to determine the role of the TPACK framework in enhancing grade 9 students' knowledge of the design process. The study field of technology education places a high value on design. (White, 2014) avers that engineering design is placed at the centre of science and technology education. Thus, it is critical to master and understand the design process in technology education so that it may be applied to other subjects such as science, woodworking, mechanical technology, and so on. When teachers apply the TPACK body of knowledge, they can unpack the complexity connected with the design process and scaffold students to easily grasp the taught concept. As a result, students will have a better understanding of the complex knowledge required while engaging in the design process, and they will be able to create well-designed models that meet a specific purpose.

1.5 Research question

How can TPACK body of knowledge improve Grade 9 Technology educators in the teaching of the design process to enhance students understanding of the design process?

1.6 Sub Questions

- How do Grade 9 Technology educators teach the design process incorporating TPACK knowledge base?
- What technological pedagogical challenges do teachers face in the teaching of the design process?
- In what way does the TPACK body of knowledge help Grade 9 Technology educators teach the design process, enhancing student knowledge?

1.7 Significance of study

The study will be beneficial to all Grade 9 Technology educators in the senior phase because it will motivate the educators to be developed in the TPACK knowledge base to enhance their understanding of the design process as well as their ability to teach it meaningfully using digital tools. The integration of TPACK knowledge base into teaching can assist in simulating the design process using various digital tools which may assist students to capture the rather abstract concepts. Teaching using technology is envisioned to encourage students' engagement in the design process and design functional models that can be used outside the classroom boundaries. Furthermore the TPACK knowledge base can assist curriculum developers to develop much-needed pedagogical guidelines to ensure that educators are able to facilitate the design process. The findings of this study may contribute to the scientific body of knowledge in that it may add value to an underexplored field of research in Technology education and change the attitude and beliefs of educators in the integration of Technology in their practice. Moreover, the study is significant to all educators who teach Technology National curriculum assessment statement (CAPS) in the senior phase, as most of them experience the similar challenges, even though they teach in different context and socio-economic backgrounds. The future impact of this study is that it can contribute to scientific body of knowledge in that it may add value in illuminating an underexplored field of research in Technology education and educational technology.TPACK knowledge base would assist curriculum developers and teachers to create learning environments which are conducive to complex thinking processes that reflects professional designers (Haupt, 2018).The study can offer solution on how to create meaningful learning environment that will allow learners to access deeper knowledge in technology education which can improve learner achievement in Technology as a subject.

1.8 Limitations and the scope of the study

This study is conducted in the Sedibeng east region, where it only focuses on grade 9 Technology educators. This can be a limitation as the results are only based on the Sedibeng East region specifically. If the sample or population being studied was larger, the results would be generalised for all senior phase grade 9 educators. In this study it is also assumed that the Technology teachers possess TPACK knowledge base as they integrate ICT when teaching the design process. This can be a limitation because even though they integrate technology in their classroom, they might not be aware of the TPACK knowledge base as it was not measured.

This study focuses on the role of the TPACK knowledge base in enhancing the understanding of the design process by grade 9 students.

1.9 Conclusion

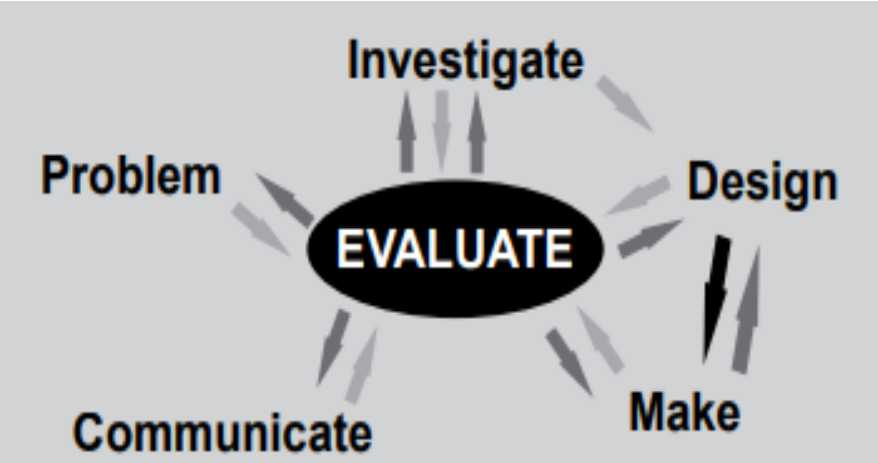
This chapter described the research problem in the context of evaluating the role TPACK knowledge base has on technology educators understanding of the design process. In the beginning of this chapter, the background of the study explained the history of the Technology as a subject; furthermore it described why the teaching and understanding the design process is such a major challenge. The chapter then outlined the research questions and the research objectives. Lastly the chapter outlines the limitations of the study. The next section of the study outlines the review of literature relevant to the main topic of this study.

Chapter 2: Literature Review

2.1 Introduction

This chapter provides a review of literature regarding the role of the TPACK body of knowledge to improve Grade 9 Technology educators in the teaching of the design process .The main question is to determine the role the TPACK knowledge base of teachers contributes to meaningful instruction and learning of the design process in the Technology classroom. This chapter will outline the design process and its presentation to provide a clear view of how TPACK knowledge can enhance the teaching and understanding of teachers. Furthermore this chapter will describe the elements that are required to successfully integrate digital tools in teaching the design process. Lastly this chapter will identify the gap in literature.

2.2 The design process and its representation



(Figure 1.1): (DBE, 2011, p. 10)

There are various perspectives among the researchers of what the design process entails; therefore for the context of this study it is important to review the differences to give a clear definition or explanation of the design process. The design process is represented as an ill-structured iterative process that is driven by evaluation. The representation of the design process illustrates that the design process is a back-and-forth process to enable the learners to evaluate their ideas at each stage. The design process's step-by-step order varies, making it impossible to declare that it is a logical order.

2.3 What is the design process?

The design process is the cornerstone of the Technology education. It is an open-ended and iterative method to generate solutions to known problems to satisfy human needs. (DBE, 2011).The design process is represented by an iterative process which offers multiple approaches to solve the problems as indicated on the CAPS document.

(Lawson, 2006) argues that the design process "is not a linear process", possible solutions can come from the intersection of the process which allows students to refine their ideas. The related skills of the design process include amongst others to investigate, design (to construct ideas), make, evaluate, and communicate. These are the steps students use when solving problems, collectively known as the design process (Ohemeng Appiah , 2014).In the context of this study the design process is an iterative process used to solve technological problems. In this study the design process is viewed as a problem-solving process as learners use procedural knowledge to solve real-life problems. In the context of this study problem-solving is an It is a formal instructional method in which learners in small groups gain knowledge through engagement with authentic and challenging real-life problems.

The Curriculum Assessment and Policy Statement (CAPS) of the Department of Basic Education of South Africa (DoE, 2011) Senior Phase Technology (Grades 7-9): avers that the design process permits learners to:

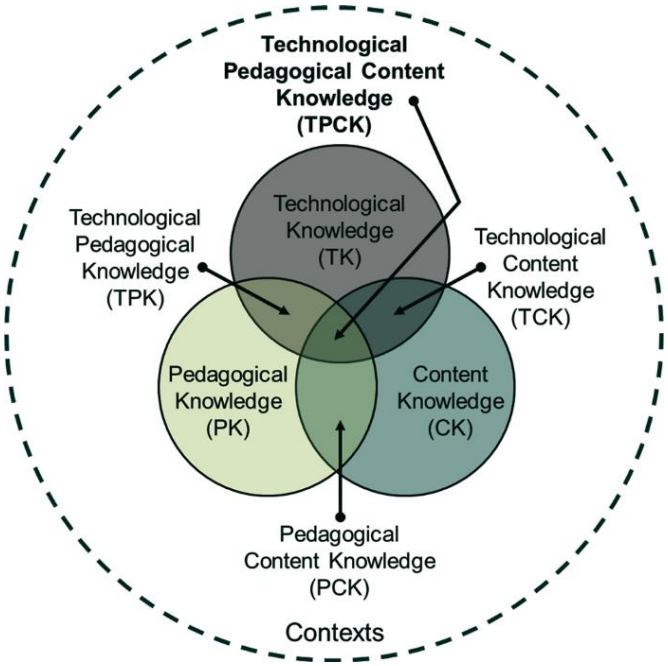
- To solve problems in creative and meaningful ways
- To merge critical thinking and doing Technology by combining conceptual ideas to real concrete understanding.
- To utilise a set of skills in authentic contexts.

The skills associated with the design process are investigation, design (development of initial ideas), make, evaluate, and communicate. In the investigation stage of the design process learners are discovering needs, existing products related to the design at hand and determining the product fit-for-purpose. It is important that the teachers know that investigation can happen at any stage of problem-solving. The design, making, and evaluation cannot be assessed separately, they need to be inter-related. Learners need to choose and evaluate the quality of their designs based on the pre-determined criteria by the teacher. When designing, learners are required to come up with the initial ideas by considering specifications of the project they need to design. Learners must consider whether the design is fit-for-purpose. To support this view,

designers elaborate on possible design ideas, and choose design ideas that could be further developed and detailed into a final design specification. (Dym, Orwin, & Little, 2014)

When making learners need to continue to reflect on their process and modify their designs or solutions base on the problem present to them. Communication must be seen as an integral part of the whole process .In this stage learners record and present their process, for beginning till the end. The communication stage must show the use of media and conventions, to allow learners to clearly communicate how they got to the final product they have designed.

2.4 History and background of TPACK framework



2.5 Figure 2.1: The technological pedagogical content knowledge (TPACK) framework, including context.

The Technological Pedagogical Content Knowledge framework, also called TPACK was originally introduced by Mishra and Koehler in 2006, which extended on Lee Shulman's (1986, 1987) concept of pedagogical content knowledge (PCK) to include technology knowledge. The TPACK framework is a knowledge trio of content, pedagogy and technology and the intersections of the framework are compulsory for teachers to enhance their teaching when integrating digital tools. The TPACK framework works as a conceptual lens that helps researchers examine how teachers are using technology in teaching. This framework promises to shape the way teachers are integrating technology in their classrooms. The main assumption

about this framework is that teachers are unable to meaningfully integrate technology in their classroom and if they have a deficiency in one or more of the knowledge domains the successful integration of digital tools will not be possible.

Technological Pedagogical Content Knowledge (TPACK) was introduced in the field of educational research as a theoretical framework for developing teacher knowledge and understanding required for successful technology integration in the classroom. The TPACK framework was developed because of the absence in theoretical guidance on the integration of Technology in education. In the context of this study, the TPACK will be used as a theoretical framework to determine the role it has on the Technology educators understanding and the teaching of the design process. In the context of this study, the TPACK is adopted as it is and is further used as a theoretical framework to understand the knowledge base required to determine the role of Technology educators understanding of the design process. The study will use TPACK framework to encourage Grade 9 Technology educators to realise the value it may have when incorporated during teaching and learning. TPACK is well-defined as interactions between content knowledge (content learning material to be learned in Technology), technological knowledge (computer hardware, digital tools, media) and pedagogical knowledge (processes, methods, and actions of teaching) to enhance student learning. (Mishra & Koehler, 2006)

Knowledge constructs are professional knowledge base teachers must acquire to be ready to facilitate learning in the knowledge society. This includes staying abreast with content and pedagogical knowledge of their subject matter or specialization (Tondeur, Scherer, Siddiq, & Baran, 2020)

2.6 The TPACK framework offers seven (7) knowledge constructs

2.6.1 Technology knowledge (TK)

Technology knowledge is referred to the fluency with Technology. This is the capability to use digital tools including hardware and software. It is argued that using Technology goes beyond computer literacy but requires the capacity to utilise Technology for productivity in teaching and learning. This is developed continuously knowledge and requires educators to be open minded when interacting with Technology as it evolves. Thus the technology grade 9 teachers must be able to use current digital tools enhance the teaching and learning of the design process.

2.6.2 Content knowledge (CK)

This is knowledge about the subject matter to be taught. It is referred to as the ideas, concepts and theories associated with the subject or the field of study. (Kereluik, Koehler, Mishra, & Shin

, 2014).In the perspective of this study the content knowledge is the procedural and conceptual knowledge of the design process. Teachers are expected to be fluent and conversant with their subject matter, once they have good foundation in their subject matter, they may have good skill to select appropriate digital tools to use teaching.

2.6.3 Pedagogical knowledge (PK)

This is the knowledge about the procedures and practices of teaching and learning, including among others the general educational aims, principles, and aims. A teacher ought to have a deep understanding of mental, social, transformation developmental theories and ideas of education and how they are applied meaningfully in the classroom. (Kereluik, Koehler, Mishra, & Shin , 2014)

2.6.4 Pedagogical content knowledge (PCK)

This knowledge of pedagogy is relevant to teaching content that must be understood by the teacher. PCK is knowledge that transforms subject matter into a meaningful teaching process. It is the knowledge of selecting a suitable teaching method for the topic to be taught. Thus, Pedagogical content knowledge permits the teacher to make conditions that encourages learning and minimises any possible misconception that students may encounter during the learning process. (Cain, Koehler, & Mishra, 2013)

2.6.5 Technological content knowledge (TCK)

This understands of the way technology and content affect each other. Educators must understand that certain technological tools will not be suitable for certain topics, therefore they are constraining rather than an affordance. TCK requires a deeper understanding of how to map digital tools with subject matter. The educator must have knowledge of identifying the affordances of technological tools (Khoehla & Mishra, 2009).The technology education teacher must identify information sources that learners can use in the earlier stage of the design process.

2.6.6 Technological pedagogical knowledge (TPK)

TPK is the knowledge of how teaching and learning can be enhanced when technologies are used in meaningful ways. This is the understanding of how instruction can be enhanced or changes when Technological tools are used. TPK include teachers understanding of affordances and constraints of technological tools. To build TPK it is vital for teachers to understand how to fuse technology in the classroom, especially when trying to unpack abstract concepts in the design process. Educators will also need to be familiar with media forms

outlined by (Ndlovu, 2015) to understand the affordances of the digital Technology they are using in their classrooms. In the view of the researcher this can strengthen the Technology educators' Technological pedagogical knowledge.

2.6.7 Technological pedagogical content knowledge: (TPACK)

TPACK aims to support teachers' competence and development to acquire and explain how technology-related and subject-specific knowledge is applied during teaching and learning activities (Khoehla & Mishra, 2009).Technological pedagogical content knowledge (TPACK) is an understanding that emerges from interactions amongst content, technology, and pedagogical knowledge. In the context of this study TPACK knowledge base enables teachers to design and integrate relevant, context-specific design process activities for learners. (Divaharan & Koh, 2013).Technology teachers must use various digital tools such as drawing software, videos, simulations to explore and visualise interactive elements of the design process which promotes constructivist learning. The framework offers a clear direction to the education landscape on how to integrate technology in the classroom, however previous research done on the TPACK model suggest that the model be strengthened for its viability as a formal theory that informed integration of technology in the classroom. (Graham, Phelps, & Watts, 2011)

Educators with TPACK body of knowledge must have the following:

- Understand how to represent technological literacy concepts and knowledge.
- Pedagogical skills that utilise digital tools usefully to transfer technological content. Knowledge of how ICT and digital tools can assist learners in solving problems using the design process making learning possible. Knowledge of learners' existing knowledge their learning styles.
- Knowledge of how to utilise technology to construct new knowledge using learners' existing knowledge. (Mishra & Koehler, 2006)

2.7 Research done on TPACK

The framework offers a clear direction to the education landscape on how to integrate technology in the classroom, however previous research done on the TPACK model suggest that the model be strengthened for its viability as a formal theory that informed integration of technology in the classroom (Graham, 2012). Extensive research was conducted on the TPACK framework, where various scholars critiqued the effectiveness of the model in education. Firstly,

research conducted on exploring affordances and limitations of TPACK for researchers and teachers evaluate the framework according to its consistency, accuracy, and meaningfulness. (Kimmons , 2015).The finding of this paper indicates that the TPACK framework has limitations such as the fuzziness and techno centrality. It is concluded by the authors that the framework is not clear and focuses a lot on Technology as opposed to blending all the knowledge domains for a clear direction on how to use the framework for the successful integration of technology in the classroom. It is therefore vital for researchers and practitioners who adopt the TPACK framework to take into account the limitation and be reflective on how they will deal with issues of accuracy. (Mishra & Koehler, 2006).This study is intending to understand the role of technology teacher's knowledge base, to enhance the teaching of design process, therefore the TPACK knowledge base is considered as the anchor that Technology teachers should have to teach design processes successfully or to a level in which learners will grasp the concepts.

Secondly, studies were conducted on assessing the TPACK knowledge base of educators using TPACK-based rubric to assess pragmatic evidence of TPACK use during classroom instruction. (Hofer, Grandgenett, Harris, & Swan, 2011).The rubrics include criterion that covers all the knowledge domains and their interactions. The findings of the study indicated that the rubric be used in teacher development trainings to ensure that educators have the suitable knowledge base to integrate digital tools in their classroom. (Angeli & Valanides, 2009) developed rubrics to measure how teachers use TPACK knowledge to simplify complex and difficult concepts in ways that facilitate learner understanding in the classroom. The finding of this study indicates that the rubric should be was valid and could be used to assess educator TPACK knowledge in the integration of digital tools. Thus, this study uses a similar approach when interviewing the teachers to determine the role of their TPACK knowledge in enhancing the teaching and learning of the design process to ensure the students grasp the concept of the design process.

Research on the effectiveness of TPACK framework was conducted on English teachers in Saudi Arabia. The findings reveal that teachers do not necessarily possess all the knowledge domains though they are integrating technology in their classroom. The findings of the research indicated that teacher efficiency and effectiveness in addition to their skills and interaction of content knowledge could improve learner achievement. The findings of the study also reveal that TPACK is an effective tool to use for both students and educators if only it is used and implemented well. (Alhababi, 2017).The gap identified about teachers not having all the knowledge base will be used as a yardstick to redevelop teachers to a level that they can use TPACK knowledge base meaningfully to integrate Technology in their teaching.

According to (Windschitl & Sahl, 2002) it is also revealed that teachers in Singapore must develop pedagogical knowledge before they can successfully integrate Information Communication Technology (ICT) in their classroom. This shows that the TPACK framework can have an impact on teaching and learning if educators are well trained. If the educators are well trained, learning takes place and students can develop deeper learning of the concepts.

In addition, similar research was conducted by assessing ICT lesson activities designed by educators to determine the strengths and developmental areas of their TPACK knowledge base for excellent learning practices with ICT. The findings of this research revealed that the TPACK framework survey is a valid instrument can be used for measuring pre-service teacher knowledge base and for the development of in-service teachers intending to productively teach with Technology. (Schmidt, Baran, Thompson, Mishra , Shin , & Koehler, 2009).

The gap identified in the literature is the limited empirical research done on the role of TPACK or effects on the TPACK knowledge base in enhancing the understanding of the design process in Technology education. Most of the research conducted on the TPACK framework is developing and accessing the knowledge base of pre-service and in-service teachers in Mathematics and Science subjects. This study will fill the gap in the research and open a new field on research to assess the role of the TPACK knowledge base on enhancing the teaching and the understanding of the design process in Technology and engineering education.

Teacher TPACK knowledge base is the knowledge required for teachers to successfully integrate technology in their classrooms. The TPACK knowledge base is referred to as the Five domains that have an impact on the curriculum, pedagogy, and learners. These five domains are interacting with one another to shape the TPACK knowledge bases of teachers. (Al-bataineh, Anderson, Toledo, & Wellinski, 2008) .In this study the impact of the TPACK knowledge base is researched to determine whether this domain can allow educators to recognise the affordances, features of technological tools and the ability of the technological tools to shift learners thinking and to transform teacher's instructional approaches to that of meaningful learning.

The effectiveness of teaching with Technology is viewed as possessing content knowledge, pedagogical knowledge, and Technological content knowledge. Technology educators must possess the TPACK knowledge base to successfully teach the design process using technological tools. According to (Inan, Mims , Polly, & Shepherd, 2010) content knowledge of teachers' also impacts student learning and understanding, however the content is not

transmitted to the learners in the same way. This supposes that content knowledge alone cannot lead to deep learning. According to (Schulman , 1987) content knowledge is essential for teaching but far from being sufficient for providing meaningful teaching in the Technology classroom. The TPACK knowledge of educators in this study is viewed at the higher level of integration where teachers use technology to foster deep conception of the design process.

Technology educators must have good content knowledge because mapping technology with content has an impact on learning. To make visible the TPACK knowledge base the teachers must select appropriate tools and instructional methods that also match with the affordances of Technology tools. (Angeli & Valanides, 2009) .It is argued that if teachers understand the different knowledge bases and know how to apply them in unique learning context, teaching with technology will improve learning. To support this view cited in (Schmid, Brianza, & Petko, 2021, p. 1029) "there *is no single technological solution that applies for every teacher, teachers must understand the complex relationship among technology, content, and pedagogy"*

According to (Vandeyar, 2013) it is argued that teachers advance their TPACK knowledge base through "a constructive and iterative process" of carefully analysing, reflecting and modifying various methods for teaching with suitable technologies based on their views and knowledge. (Ohemeng Appiah , 2014) supports the notion that the understanding and the teaching of the design process remains a challenge for many grade 9 Technology educators in the senior phase. The study will be beneficial to all Grade 9 Technology educators in the senior phase because it will motivate the educators to be developed in the TPACK knowledge base to enhance their understanding of the design process thereby teaching it effective such that learners are able to grasp the concepts and design functional models. In addition, the findings will assist Technology educators to implement the design process successfully in their practice; furthermore it will assist them to design learning experiences that will bring change in students learning. To support this view, it is argued that TPACK is the base of meaningful and productive teaching because it enables the usage of pedagogical techniques that use technologies in constructive ways to teach content. (Mishra & Koehler, 2006) .Lastly the findings of the study may contribute to the scientific body of knowledge in the context of Technology education and educational Technology. The TPACK knowledge base may also add value to an underexplored field of research in the use of ICT in Technology education and change the attitude and beliefs of educators in the integration of Technology in their practice.

2.8 Relevance of ICT in education

The prevalence of ICT and various technological tools brings numerous benefits to the educational landscape. ICT allows meaningful learning experiences that support deeper conceptual change and a wide range of distribution of resources and learner centered approach to learning (Akkalwar, 2013). According to the author secondary schools use ICT compile resources for teaching and learners use ICT to compile assignment and to access learning resources. It is important to understand the meaning of ICT in education. ICT has several definitions; (Mayer, 2002) argues that ICT is defined as a tool for problem solving. Tezci (2011) defines ICT as "*computers, the Internet and electronic distribution systems such as radios, televisions, and projectors among others, and is widely used in today's education field*" (p.489). The researcher contends with the definition as it include technological tools that have pedagogical affordances for examples, projectors are mostly used at schools to display content and to engage learners in the learning process. The success of the lesson depends on how the teacher makes the cognitive process explicit and how they involve the learner in the cognitive process (Yoon, Choi, & Oh, 2015).

In the context of this study ICT is defined as digital tools including computer hardware, software, and media used to enhance teaching and learning in the classroom. The South African educational systems introduced the use of ICT to also equip students with the knowledge to use digital tools to allow them to participate in the global information society beyond the classroom.

The 21st century demands a radical transformation in the understanding of teaching and learning with ICT within a specific context. It is imperative to note that the use of ICT in education does not guarantee conceptual understanding, however if the teacher is equipped with the knowledge of teaching with ICT, learning can be enhanced which then results in conceptual change.

Digital tools used in education specifically in the design process is the computer aided software (CAD) used for producing real life prototypes to solve problems which are requirements for 21st century teaching, furthermore projectors, computers, YouTube videos, simulations, collaborative tools such as blogs, WhatsApp are suitable to use in teaching the design process. It is argued Yusuf , Afolabi , & Loto (2013) by that Technology affords learners and teachers the ability to complete complex tasks that are not possible in traditional classrooms. (Bell, 2013) argues that the use of digital tools is a prominent feature in contemporary education showing great effect in student achievement if used meaningfully by teachers. (Lowther , Inan , Strahl, & Ross, 2008)

argues that the crucial characteristics needed to develop quality teaching and learning is autonomy and creativity. They assert that autonomy means learners are taking control of their learning through the use of ICT; moreover they contends that creativity means employing instructional methods that support creative thinking, collaboration which allows the learners to construct their own knowledge. In teaching the design process, it is crucial for learners to apply critical and creative thinking.

The information and knowledge society demand high level skills and competencies in the successful use of Technology, thus the significance of ICT in education is to bring innovative teaching methods which enhance learning experiences for students (Akudolu, 2007). Integrating ICT in the teaching of the design process enables effective teaching methods such as project-based learning which places the student in the centre of learning. Even though ICT is beneficial in education, existing literature also identified barriers. The barriers include but are not limited to teachers lack knowledge in integrating ICT in their classroom. This shows that there is a need for educators to be trained in integrating ICT in their classrooms (Al-bataineh, Anderson, Toledo, & Wellinski, 2008).

2.9 Learning theories supporting the teaching of the design process

2.9.1 Constructivism

According to Elliott, Kratochwill., Littlefield, & Travers (2000) constructivism is defined “an approach to learning that argues that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner”. (Draper, 2002) concurs with Elliot et al that Constructivism “is the philosophy, or trust, that learners construct their own knowledge based on interactions with their environment including their interactions with other people”. In my understanding constructivism is based on the idea that to learn effectively, learners must construct and reconstruct knowledge. Certainly, constructionist theories assert that learning is a reconstruction rather than a transmission of knowledge.

Constructivism is the paradigm that underpins learning in the Technology classroom. It is crucial to note that all learning theories are useful in education; nevertheless, in the context of this research, constructivism is important in the teaching and understanding of the design process. In a classroom, constructivist view of learning is that learners must engage in active learning techniques to solve real-life problems, thus learners are able to reflect on their knowledge and how their understanding is changing in the learning process. This point of view preserves that learners vigorously construct new knowledge as they interact with their environment (Adesanya,

2009). Learners in the technology classroom engage in problem-solving during the design process, and the lesson is extremely learner-centered because the solutions they must devise are unique artefacts or models.Techonology teachers thus, need to have a sound understanding of what constructivism is, to use it knowledgeably and effectively in the classroom to enhance learning. (Tam , 2000)

When teaching the design process the primary responsibility of the teacher is to create and maintain a collaborative problem-solving environment, where learners are allowed to construct their own knowledge and meaning on the content. The teacher acts as a facilitator and guides the learning process. The selection of constructivism is relevant in this study because when learners engage in the design process through the mini-practical task in the technology class, teachers must facilitate the process and not directly instruct the learners using chalk and textbook.

The teachers can only be successful in doing this by designing a constructivist learning environment. The constructionist learning environment suggests that the effective learning and instructional methods includes selecting context-specific problems, collaborative tools, and cognitive tools. The latter shows that constructivist environments are highly collaborative, reflective, and active. Johassen (1991) constructivist learning environment supports the selection of constructivist theory as the learners are required to collaborate engage in activities that will eventually aid them to design a prototype of an artefact using the design process. Thus, in these environments teachers will be able to enhance learners understanding of the design process. To support this view Mapotse (2012) implies that learners should be allowed to discover their own ability in reaching decisions and conceptualise their ideas during the design process". In this study educators must support the constructivist environment with the use of digital tools. The educator can use videos to ignite the prior-knowledge of students. If the students do not have prior knowledge, the educator will then allow the students to construct the knowledge through activities. According to Ertmer (2005) by using collaborative technology, the constructivist learning environment encourages the development of collaborative work skills, long-term learning, and problem-solving abilities. These skills are essential to enhance the learning of the design process in the grade 9 classroom. The technology educator needs to integrate collaborative tools such as Wiki's, WhatsApp, have access to the internet to allow learners to co-construct knowledge.

2.9.2 Social constructivism

Social constructivism is a learning theory that considers learning to be a social process in which learners collaborate through group activities to achieve meaningful learning. Teachers provide instructional guidance to students by using teaching methods that allow them to discover and construct knowledge as they interact and collaborate in the learning process. Social constructivism shifts the learner's responsibility for knowledge acquisition from the teacher to the learner, transforming the learner from a passive listener to an active participant and co-constructor of knowledge. (Kanno, 2018)

According to Vygotsky (1986) language and culture are the frameworks through which humans experience, communicate, and comprehend reality. It is argued that language and culture plays an essential role in both human intellectual development and how they perceive the world. Social constructivism learning underpins this study as it views learning as a process done by means of language and culture. Thus, learning can happen when people interact and interpret concepts in a cultural context or setting. This theory explains that knowledge is co-constructed within a social context. When people share and construct knowledge, learning can take place**.**

The rationale for choosing this theory is that this theory supports the learning pathways of Technology education and the design process. This theory echoes with the belief that learners can collaboratively construct their own knowledge under the guidance of the teacher and with peers as well as in the absence of the teacher as a facilitator. Herrington & Oliver (2000) concurs that social constructivism of knowledge occurs outside the walls of the classroom in a variety of ways and places. The researcher chose the social constructivism theory as it supports collaborative learning, which is the pedagogical method needed to successfully integrate ICT in the teaching of the design process. This theory can assist in learning the design process as it allows the learners to work in groups and share knowledge on the project they need to work on.

2.10 The significance of this theory in learning and understanding the design process

When learners engage in the design process, they need to work collaboratively with each other to understand the problem they need to solve, thus the learners need to be in conversation with each other within their groups. The learning of the design process relies heavily on sharing knowledge.

(Kelly, 2012) suggests that social constructivism could be applied in the classroom using collaborative learning, guide discovery learning, and simulations among others. Thus, teachers teaching the design process must divide learners into co-operative learning groups and guide

students find concepts or gather learning experiences in accordance with the intended objectives through prompting, questioning, and direction. Kapur (2018) states that this method of teaching enhances learning by affording learners the opportunity to develop their communication and critical thinking skills. Furthermore, during the design process, students should be able to uncover their ability to make judgements and visualise their ideas, as well as recognise their own knowledge and potential.

When teachers facilitate the design process, they need apply problem-based teaching method which is supported by the theory of social constructivism. In the design process learners engage in authentic projects through their mini-practical task. The teacher need to create an environment that allows the learners to investigate, discover learning and to constantly evaluate their thinking. Blumenfled, Krajcik, Marx, Palincsar, & Ronald (2018) also recognise that project -based learning is a comprehensive approach to classroom teaching and learning designed to engage learners in the investigation of authentic problems. Learning theories are crucial to understand the lens used to understand how learning takes place. The two theories agree that learners need to collaboratively construct knowledge with their peers. It is important to note that in the design process learners need to work together to come up with innovative solutions, hence the two theories are relevant in this study.

2.11 The role of the TPACK knowledge on educators teaching the design process

When integrating digital tools in the classroom, there are benefits such as collaborative learning, active learning towards a greater change in conception of subject matter, and enhanced learning environment. However, it is reported that the role of technology integration on learning highly depends on how well educators manifest the TPACK knowledge base, ICT skills, and the ability to design authentic learning environments. According to Roblyer cited (Lim & Khine, 2006, p. 97) “how teachers understand ICT and the use of digital tools can influence how effectively they integrate ICT in their classrooms”. This shows that though there are benefits in integrating technology in the classroom, the readiness, knowledge, and teaching approaches plays a crucial role. Angeli & Valanides (2013) confirms that the goal of content mapping and teaching strategies is to provide improved teaching strategies. There are digital tools that are used in Technology education which include PowerPoint, interactive whiteboards, simulations, and animations; however there is still a great need for in-depth knowledge on how to select and use digital tools that promote meaningful pedagogy and content knowledge. It is therefore evident that the TPACK body of knowledge may enhance teaching and understanding of the design process (Nkula & Krauss, 2014).

2.12 Use of appropriate digital technology in the classroom

The selection of appropriate technology is part of developing and delivering effective teaching. This can be done by aligning learning objectives of the subject with digital tools that will make the lesson meaningful (Davidson-Shivers & Hulon, 2013). The choice of digital tools and the way they are integrated into the Technology lesson must also be associated with learning theory and learning objectives which can elucidate the benefits that may be obtained from using the digital tools. In this study the appropriate selection of digital tools is crucial to model the design process with scientific knowledge and to assist the learners to solve real-life problems. Furthermore, various ICT tools and software may be integrated into pedagogy with some tools being designed for specific purposes and many others for use of a general nature (Salehi & Salehi, 2012). ICT tools that are specifically meant to teach the design process are those that are more collaborative and interactive to allow the students to construct their own knowledge and be hand-on to the task.

2.13 Pedagogical value of digital technology in teaching the design process

According to Beetham & Sharpe (2013), pedagogy refers to “guidance-to-learn: learning in the context of teaching, and teaching that has learning as its goal” (p. 2). Pedagogy is viewed as subject-matter knowledge and strategies that lead to measurable outcomes in learner’s knowledge. Pedagogical values of ICT/digital tools are the benefits and affordances that various digital tools bring to enhance learning experiences. ICT can supplement, support, and facilitate the entire curriculum. However, merely using digital tools and ICT in the classroom is not sufficient; teachers must have TPACK body of knowledge to augment their knowledge of digital tools with content and meaningful pedagogy. In the teaching and learning of the design process, the use of digital tools and ICT is an example of how to deliver subject material or classroom pedagogy. Technological pedagogical content knowledge (TPCK) links the pedagogy, content, and knowledge and is fundamental to effective teaching and learning with ICT. In the context of this study pedagogical value means what make learning possible through recognition of affordances embedded in the digital tools. According to Lau & Sim (2008) the use of ICTs in pedagogy may promote "deep" learning and allow educators to better respond to the various needs of different learners.

The pedagogical value of digital tools in the design process is the ability of the tools to link the design process with reality, which allows a great deal of relevance in technology education. Moreover, the pedagogical value of digital tools includes collaboration, learner motivation to spark interest in the learning of the design process. These activities will not be possible if the

learners lack skills to use digital devices. It is the teacher's responsibility to teach learners how to use the devices simultaneously while teaching the knowledge and application of the design process. The design process must be taught using digital tools that support problem-based learning. Digital tools integrated must allow students to do research, share information and knowledge collaboratively. Educators must be aware of the media forms that are available for the integration of Technology in the classroom. Media forms are defined as tools that offer various combination of text, videos, simulations that allow channels of communication for instructional purposes.

2.14 Table 2.2 Media forms that can be used by educators to strengthen the teaching and learning of the design process.

Media forms	Affordances	Evidence	What pedagogical value does it add
Narrative	Non-linear	Multimodality	Apprehending structure/connections
Interactive	Immediacy	Immediate feedback	Exploration: Misconceptions amended
Communicative	Collaboration	Discussion: Class/group	Re-description of concepts
Adaptive	Diversity	Reproduction: Experimental/role play	Concretising theory: Practice knowledge construction
Productive	Articulation	Product: Animation/ model	Knowledge construction

Table 2.2 above describes the media forms that can be used by educators to strengthen the teaching of the design process. The media forms allows for the productive use of digital tools in the classroom. This study emphasises that good use of digital tools in the teaching of the design process is when educators can recognise and use the digital tools to support and enhance learning. According to Laurillard (2002) media forms are categorised as interactive, narrative, communicative, adaptive, and productive and are groups according to their affordances. The media forms are significant in this study because educators have to be knowledgeable about them. When teaching the design process communicative, adaptive and adaptive media forms may be used to enrich the learning environment. Communicative media forms may allow students to share information online. Teachers may introduce the use of wiki's for learners to share information or WhatsApp as a platform that learners have access to in different context of learning. This also allows the educators to provide immediate feedback. Though learning is placed on the learner, educators play an essential role in providing feedback for communicative media to influence learning. Moreover adaptive media forms are also considered in the context

of this study, adaptive media are media that will enable educators to create real-world situations in the classroom. In this case an educator can integrate videos, simulations to bring reality in the classroom that would otherwise not be possible without the use of digital tools (Conole & Dyke, 2004). It is essential in this study for teachers to be aware of the media forms when they integrate technology in the classroom. This may allow educators to identify pedagogical value of digital tools they use when facilitating learning of the design process.

2.15 Conclusion

A literature review was discussed and focused on the meaning of the design process and its representation to position the design process within the study. A detailed discussion of the TPACK framework was provided and the significance of this framework on this research. The TPACK framework is the conceptual framework used as a guide. The framework stressed how educators should be knowledgeable about technology, as well as the subject they teach and the instructional methods they use to teach in order to integrate digital tools effectively. The related chapter also reviewed literature on the significance of TPACK in education and the role of the TPACK in improving learning. The literature showed that TPACK has an essential role to play in education and if the TPACK is well developed, it can enhance learning in education. There is currently no research done on the integration of digital tools when teaching the design process. The constructivism and social constructivism were discussed to show how educators must teach to meet the learning objectives of the design process. Furthermore the chapter outlined appropriate digital tools to teach the design process and how educators can use the affordances to enhance students understanding of the design process. This supported by reviewing literature about media forms and how educators can use various categories of media forms to enhance learning and pedagogy in the classroom. In reviewing literature the chapter provided a synopsis of how the TPACK body of knowledge can be useful in the technology classroom to enhance the students understanding of the design process.

Chapter three outlines the research design and paradigms that underpins the study. The chapter further outlines the methodology used and phases taken to ensure validity and trustworthiness, including ethical considerations.

Chapter Three: Methodology

3.1 Introduction

In this chapter, the research method and design are presented. The chapter starts with an overview of the research design and paradigm, followed by the philosophical underpinning of the study. The sampling method used to obtain participants and information on selected participants is then provided. This is then followed by discussion of the research instruments used to gather data and research. The data analysis techniques are then explored. The chapter is concluded with a discussion of ethical procedures that were followed in this study.

3.2 Research design and paradigm

Glatthorn & Joyner (2005) defines the research design as a plan for investigating a research problem. In support of this definition Payne & Grey (2014) describes research design as the general plan for conducting the research study and how the research question is going to be answered. The researcher supports the definition by Mounton, (2001) which indicates that a research design is a “blueprint of how research is conducted” (p. 55). The research design thus provides clarity on what type of study is conducted.

An interpretive research paradigm guides this study's qualitative approach. Qualitative research provides multiple perspectives and allows for a more in-depth examination of the issue under empirical investigation (McLeod, 2017)

According to Nieuwenhuis (2017) interpretivists argue that reality is socially constructed; therefore, human experience can only be understood from people’s point of view. Manion, Morrison and Cohen (2011) concur that interpretivism aims to describe, understand, and interpret in detail the life experiences of participants in a study. In essence interpretivism allows people or participants to be studied in their own social context or natural setting, which provides a greater opportunity to understand the perception they have of their own activities

Hesse-Biber & Nagy Leavy (2011). Qualitative research approach is suitable for this study as it provides rich data in context or phenomenon or factor to be researched. This research strategy allows the researcher to explore the impact of TPACK knowledge base on Grade 9 Technology teachers in their social context and was therefore considered to be the most effective strategy for the purpose of this study. Alongside interpretivism paradigm, interpretivism ontology was adopted. The ontology supports the idea that intangible realities are constructed personally and socially.

This ontology is useful in this study as it gives a sense of how technology teachers interpret multiple realities in their unique context. The ontological position of the interpretive paradigm directs this research towards the development of a case study approach to explore the impact of TPACK knowledge base on Grade 9 Technology teachers understanding of the design process. (Crotty, 2003)

Table: 3.1 The following table summarizes the paradigm of the study.

Paradigm	Ontology	Epistemology	Methodology
Interpretivism	Multiple constructed realities exist	Subjective	Interaction Interpretive Qualitative
	Subjective experience influence by the context of the situation	Interactive communication between the researcher and participants is key to capture and describe the lived actual experience.	
	Interactive communication between the researcher and individual participant		
Overview Implications	Multiple realities are constructed and elaborated on through the subjective experiences of participants in their real context through interaction.	Interacted with all participants in their real context to capture their experiences through interviews and observations	Semi structured interviews, observations, and document analysis were used in order to understand the teacher's reality they came across in the classroom.

Table 3.1 above is included in the study to show the philosophical underpinning of this study. This study used interpretivism as a lens through which the research on will be done. The interpretive paradigm allowed the research to be done on multiple case studies of technology educators to show how they integrate digital tools to improve learner grasp of the design process. This study is a qualitative research study data was collected through interviews to capture the realities of the five participants.

3.3 Philosophical assumptions

Constructivism paradigm is part of interpretivism philosophy underpinning this study. In this study interpretivism remains the centre of the study in that it is crucial to understand how Technology teachers interpret their TPACK knowledge base. Thus, the teachers must be able to construct their own knowledge for them to understand and effectively teach the design process. Constructivism paradigm is also relevant to construct meaning from the results so that the data collected can reflect the phenomenon as it is. The advantage of using constructivism as a paradigm was that it assisted the researcher in building knowledge and understanding of the information gathered in the study. Constructivism is one of the best philosophical assumptions that aid researchers in comprehending the complexity of the phenomena, particularly in the twenty-first century where innovative ideas and inventions are actively sought through our research and education. (Kim, 2005)

3.4 A case study approach

According to Yin (2003), case study method is “an empirical investigation that studies a contemporary phenomenon in its real-life context; when the boundary between phenomenon and context is not clear; and in which multiple sources of evidence are used”. A case study can also be defined as “an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in a ‘real life’ “ (Simons, 2009, p. 189) .The case study method is thus selected because it is particularly good at providing an explanatory theory. This study focused on the cases of five senior phase Technology teachers, who were interviewed individually about how their TPACK knowledge base impacts their understanding of the design process.

3.5 Sampling

Sampling is used to narrow the scope of the study and for obtaining authentic results. In this study the researcher used purposive and convenient sampling method to select five Grade 9 Technology educators who are teaching Technology and integrating ICT in their classroom and were appropriately trained to use ICT. Purposive sampling is a method in which the researcher relies on his or her own judgement when selecting members of population to participate in the study (Creswell, 2014).Purposive sampling method is selected because the researcher specifically engaged educators who are Teaching Grade 9 Technology and who seem to be integrating Technology in their classroom.

The convenience sampling method is "*a set of techniques in which participants are selected by convenience due to their proximity, accessibility or other way that researcher decides*" (Abraham, 2010) .Convenience sampling method was therefore used to select participants in the Sedibeng East region because the researcher is teaching in this region and the participants will be within easy reach with the researcher.

3.6 Data collection methods

3.6.1 Interviews

Interviews are a communicating method to obtain information from a willing participant, often based on open-ended questions. Du Plooy & Cilliers (2014).The information obtained through interviews is likely to be more precise and correct compared to that secured through other techniques. The interviewer can avoid irrelevant answers by explaining the questions to the interviewee and by also asking probing questions to ensure clarity. Falsified information can easily be picked up and hence not used in the study.

In this study interviews are scheduled to get a sense of how TPACK knowledge base improves participants understand and teaching of the design process if any. The researcher selected interviews as a data collection method because the researcher wanted to establish the main decision teachers are taking when they plan their lessons.

The interview is also necessary because some of the terms are not familiar to the participants therefore; the researcher is able to explain the terms without influencing the participants answer. The researcher was able to gather in-depth information about their experiences, behaviour, and pedagogical decisions when teaching the design process.

The interview took place online at a convenient time for both the researcher and the teachers. The interviews were recorded in TEAMS and those that took place face to face were also recorded and transcripts were made available.

The interview schedule (appendices) the interview was structure in three sections.

- Section 1 focuses on teachers experience and their use of ICT in their classroom.
- Section 2 of the interview focuses on teachers and learners understanding the design process.
- Section 3 of the interview focuses on the impact of TPACK knowledge base of teachers in the understanding of the design process.

The interviews were used as the only source of data in this study. This conversational approach allowed the researcher to obtain first hand data.

Classroom observation was also the intended data collection method, however due to covid protocols the researcher had to settle for interviews as data collection method.

3.7 Data analysis methods

Qualitative data analysis is a process of describing, classifying, and interconnecting phenomena with the researcher's concepts. Furthermore, data analysis is a way of communicating finding of the study. The process of analysis includes organizing the data, coding, using the TPACK framework, and reducing the data, interpreting, and representing the data (Ary, Jacobs, & Sorensen, 2010). Braun & Clarke (2006) describe thematic analysis as a process of identifying themes or patterns with a sole purpose of generating meaning within raw qualitative data. Furthermore, this data analysis method is the most effective method for qualitative research strategies and allows more flexibility as opposed to other data analysis methods. The rationale for choosing thematic analysis is to enable the researcher to examine each participant's perspective, to identify similaries and differences in the responses and finally generating insight.

This is how data was analysed:

- The researcher transcribed the interview from the recordings
- The researcher then read and re-read the transcribed material to identify
  the data was then coded, and themes were identified. In the data collected a total of five themes were generated. The data was then analysed using the TPACK framework.

3.8 Methodological Norms

To enhance the standards of rigor in this study, the principles of validity, trustworthiness, transferability, dependability, and conformability will be adhered to. Participant's feedback was encouraged to ensure interpretative adequacy of the verbatim transcribes interviews.To increase trustworthiness of the data a thick description of the context of the study was provided so that potential researchers or readers could make necessary judgement of whether the findings can be transferred to another context. (Creswell, 2014) asserts that it is valuable to ask participants to read the transcripts and to verify the authenticity, as this helps to enhance the trustworthiness of the study.

In this study, conformability was achieved by sending the participants the transcription of the interview documentation for member checking and reaffirming that the information that they had

given was correctly recorded. Independent data verification was used to enhance conformability.To strengthen dependability in the researcher will monitor the quality of the recording and transcriptions.

3.9 Ethical Consideration

The researcher applied for the ethics clearance from the Wits Ethics committee (see appendix) before the commencement of the data collection. The application to the GDE will also be made to obtain clearance before going to interview educators. According to (Arifin, 2018) there are three main ethical issues associated with interviews, namely: confidentiality, informed consent, and consequences of the interviews.

Safety in participation

In this study, safety risks were very during the duration of the study. Teachers might have been uncomfortable, knowing that the researcher will know about their use of ICT in their classrooms. The issue was discussed with the participants and ensured that their identity was unknown, and they wouldn't be placed in any risk.

Privacy and Confidentiality

The information collected will be kept secure and confidential. Participants will be assured and guaranteed that the information they provided will never be disclosed to anyone but will only be used for this study.

Delimitations

The major delimitation to the study is that it is assumed that the participants can integrate ICT meaningfully in their classrooms, since they are trained in the Technology content knowledge and using ICT tools to teach technology.

3.10 Conclusion

In conclusion, this chapter outlined how this research study was conducted, illustrating the research design and paradigm underpinning the study. The study also outlines sampling methods used to select participants and the rationale for the researcher's choice. Lastly the chapter describes how data was analysed. This study seeks to determine whether there is any impact or value that the TPACK framework has on educators' ability to understand and teach the design process in a way that makes learning possible in the classroom. The data collected is used as a method to answer research questions. In chapter 4 the researcher will report the

findings of the research study. The chapter provides the presentation of transcribed information relative to the problem posited. The corresponding findings and interpretations are reported in the next section of the study.

Chapter Four: Data Analysis,Presentation and Interpretation of Findings

4.1 Introduction

This chapter attempts to answer the main research question, which is: How can TPACK knowledge base improve Grade 9 Technology educators in the teaching of the design process? Data was collected from five Grade 9 Technology educators from five different schools in Gauteng province of South Africa using the interviews. The common responses emanated from respondents were mixed thoughts about what design process is, method of teaching design process, lack of ICT resources, oblivious of TPACK knowledge base, pedagogical challenges (lack of training), and ICT affordances. The participants names were pseudo coded to hide their identity, so they were coded as follows: Responded 1, as R1 Responded 2 as R2… and responded 5 as R5. The schools were coded as School 1 as S1, School 2 as S2 and School 5 and S5.

Table 4.1 shows the information about the participants in the study. R1, S1 means the Respondent 1 is comes from school 1.

Table 4.1: Participant's demographics

Teacher	School	Gender	Position
R1	S1	Male	Senior Educator
R2	S2	Female	Educator
R3	S3	Female	Educator
R4	S4	Male	Educator
R5	S5	Male	Head of Department

4.2 Mixed understanding of the concept design process

The respondent provided different views of the concept of design process. In simplest term the design process, include identifying a problem, researching on the problem, generating possible solutions, selecting the optimum solution, creating a model, testing and maintaining the model and communicating the final product. Respondents provided mixed thoughts about this concept. Respondent R1 mentioned that the design process is,

> *In the design process, it is whole process of making things… identifying a problem, you go through finding a solution, making the solution, evaluating, investigating then communicating what you have made. It is a cyclic process,*

it is a repeating process whereby you do the investigation, you come up with a solution then you make or design and communicate. Then you continuously communicate. That is my understanding.

R1 seem to understand the process as he mentioned that it is about identifying the problem and provide the solution. The design process is cyclic in nature or is a repeating process. However, despite that he knows that the design process is cyclic in nature, he did not mention other critical steps within the process that should be followed in finding the problem up to coming up with the solution. The thought of R1 is a bit comprehensive compared to R2, who mentioned that,

The design process is where you must let the children understand what they are going to resolve the issues or the problem according to whatever need.

R2's definition of the design process is ambiguous in the sense that it does not show all the processes required in the design process. His definition includes what the children must understand but is not specific on what exactly the learners should understand.

Similarly, R3's response is vague, as she talks about the design process as,

The design process is when you make a model. It includes writing, the drawing and constrains until you do the project.

Her definition of the design process lacks clarity and deep understanding of the concept. There is nowhere in her definition that indicates the design process steps. She is talking about writing and drawing without elaborating what is being written (content) and drawn. In addition, the definition leaves a lot to be desired as these writings and drawings will solve the identified problem.

Contrary to R2 and R3, R4 seems to be closer to the definition of the design process as he defines the process as:

The design process is the backbone of how we approach technological problems, coming up with practical solutions. It is not linear. It has five steps or stages as IDMEC.

R4's gave the correct definition of what the design process is as he mentioned that the design process is not linear process. This means that if a stage fails, one cannot move to the next stage; rather, the previous phases must be studied and the problem recognized, allowing one to progress to the next stage until the desired outcome is obtained. Generally, the design process includes five steps (Investigating, Designing,

Making, evaluating, and communicating) that can be used as an approach to come up with practical solutions to technological problems.

R5 responded similarly to R2 and R3. His response shows a hazy understanding of what the definition of the design process is. He mentions,

> *the design process is to define and identify the problem by going to the different steps to find various possible solutions. The problem must be clearly identified, and the design brief should be short and complete. It must give all the information that is available about the problem*

R5 indicated that the design process includes defining and identifying the problem by going through different steps, but the steps done in the design process were not specified. His definition only talks to identifying the problem; the other important stages of the design process are not mentioned.

According to the information gathered, Information Technology Grade 9 educators have conflicting views on what the design process entails. They have personal understanding of what the design process. This has an impact on their class delivery because they will be unable to teach the idea fluently. Furthermore, this clearly indicates that their content knowledge is lacking, hence affecting their pedagogy.

4.3 Method of teaching design process

The concept of methodology of teaching the design process featured strongly during data collection. All five participants mentioned various ways of teaching the design process. There is no one size fits all when teaching the design process in Technology. Teaching methodology is about general strategies used to assist learners in achieving learning goals and mastering the idea of the content taught. R3 mentioned that she uses ICT tools to enhance learners to understand the design process. Her remarks,

> *…the use of ICT such as YouTube video help to show learners different Ideas on how they can build the model. However, I am still not conversant on how to choose to select best videos.*

R3 employs ICT in her classroom, but she does not explain how the video improves learners' grasp of the design process or how she engages learners in the learning process while they watch the video. The method described merely addresses how she teaches the making step and does not touch the on other phases. She is using the YouTube videos in helping the learners grasp the understanding of the making process, though not conversant in that space.

R4 stated that he uses ICT tools to help students comprehend the design process. He mentioned that,

> *I use pictures to model what I want them to design projected on the smart board. So that they can understand the problem they need to solve. However, I am lacking the skills on using the PowerPoint so that I can elaborate the concept being taught clearly.*

R4 is using ICT tools that are in line with the content of the design process. It shows that his technological knowledge and some Technological pedagogical content knowledge is somehow limited. It is however not clear how he uses PowerPoint to enhance learning of the design process. In addition, it is not clear how the pictures are used for teaching the design process.

R2 similarly mentions that she uses ICT tools to enhance learner understanding of the design process.

> *I use computers and projectors so to project images or diagrams prepared that they could see exactly what we are saying. It is better if you use a projector to show the learners the dimensions and views of the design, it will improve the way I explain it as an educator and help my learners to understand what I require of them when it comes to the design stage. Nevertheless, I still lack the skill of getting simulated or animated objects to enhance learner understanding.*

R2 did explain how she uses the ICT tools are used to enhance her teaching. Among the things she uses ICT tools during teaching are projecting images or diagrams and explaining dimensions and views in design. However her explanation does not show any technological simulation of the design process to enhance learner understanding.

R1's teaching method

> *… In the classroom, I do not have smart boards' .I use projectors. The learners are encouraged to use the internet to find information for the problem they are solving. We also use computers and printer's lesson plans and handout notes.*

R1 uses a projector in the classroom but did not provide what is being projected that facilitates the learning process to improve learner understanding of the design process. He does not seem to understand the technological value of the digital tools he is using.

Four out of five participants are aware of instructional media used in the classroom but lack the technological pedagogical content knowledge required to teach the design process. All five

educators lack meaningful technological teaching method to help students understand the design process. According to their responses, they use ICT tools to show the learners what to design, which only addresses the making stage of the design process. There is no evidence that they teach the overall design process effectively using digital technology meaningfully which may allow learners to eventually design models that are fit-for-purpose. Furthermore, the teaching methods they used demonstrate a lack of the modelling and simulation of the design process, which will impede learner understanding of the design process. They lack the TPACK knowledge base which is assumed to be essential for teachers to effectively teach the design process.

4.4 Limited access to ICT resources and other teaching resources

Most respondents stated that they had limited access to ICT resources. Access to ICT tools is critical for successful ICT integration in the classroom. This could have an adverse effect on the methods used to teach and learn the design process. R1 mentioned that though he has access to a projector and he experiences poor Wi-Fi connection. He indicated:

> *I minimally use videos when I teach and require to be downloaded in advance before the lesson. The issue is access to Wi-Fi connection. I find myself not even being able to play videos or make my lesson interactive due to the lack of Wi-Fi connections.*

R1 mentions that he has limited access to ICT tools due to poor Wi-Fi connectivity. He is only using the projector and during his classroom practice. The limited access to ICTs and the lack of proper Wi-Fi-connection make them seldom use the ICT for pedagogical integration.

R3 mentioned that:

> *I have a challenge with the limited knowledge of using the smartboard when I want to show my learners some videos. Most of the time I use print outs of pictures and I also use the textbook, however, the printer is always having technical glitches and power out outages affect the printing of the materials. I also do not have technology know-how to teach the design process to enhance learners learning.*

The lack of printer access has an impact on R3, who tends to adopt traditional methods of instruction. The school printer is always having problems, such as technical fault, and the experience of load shedding exacerbates the problem. She is using it to show the students what they should design. Instead of being giving suggestions for what to build, the design process

requires learners to be creative and construct their own knowledge. R5 mentioned that he has access to ICT tools, however,

> *...the projection screen that I use has an interactive pen which malfunctions sometimes and calibrating the interactive pen is also a challenge when I teach. The challenge is also getting ICT resources or tools I can use to differentiate my teaching methods.*

R5 states that he only has access to a subset of the interactive whiteboard's functions because many of them are malfunctioning. A lack of digital resources can have an impact on pedagogical instruction, particularly throughout the design process.

R4 Mentioned that he does not have access to ICT tools at his school.

> *I do not have access to any ICT tools at school. I teach my learners with a textbook and a whiteboard. I also improvise when I need to teach them the knowledge.*

R4 mentions that he does not have access to digital teaching materials in his class. Since he does not have access to ICT, technology is taught without the integration of ICT. R4, on the other hand, stated that he is aware of several ICT tools that he can employ when teaching the design process.

R2 and R1 face similar difficulties. R2 said that she is having trouble connecting to Wi-Fi, and that the students do not have smartphones or tablets. The biggest problem was that the school lacked technical ICT help because school-based coordinators are not technical support specialists. When ICT gadgets fail to function, there is no immediate assistance accessible.

4.5 Oblivious of TPACK knowledge base

To address the study's major goal, it is necessary to ask the teachers questions regarding their TPACK body of knowledge. The TPACK knowledge base is unknown to the responders. They all said it was their first-time hearing about the framework. Despite their lack of knowledge in the use of digital tools, teachers also demonstrated a lack of content knowledge, as they concentrated more on the making stage of the design process instead of holistically incorporating all the stages in their teaching. The teachers exhibited a lack of technological skill, which appeared to be exacerbated by severely restricted access to ICT tools for teaching the design process. Furthermore, there is a lack of significant integration of TPACK in the design process**.**

4.6 Technological Pedagogical challenges

There are technological pedagogical challenges educator's faces when teaching the design process. The educators confirmed this challenge when they were unable to explain how they create meaningful learning environments when teaching the design process.

R1 mentioned that …

> *At technological pedagogical level I struggle to engage my learners in the lesson. I use questions and group work to enhance scientific knowledge which learners can use in the design process, which is simply pedagogy that we trained at as teachers. E.g., example of the term 3 (Mini-practical Task) the learners need to engage the design process to design and make an alarm system. I assist them in understanding what they need to do using the traditional method. They are required to understand how simple circuits are constructed.*

R1's response shows limited technological pedagogical knowledge. R1 response indicates that teaching the design process with ICT is difficult and probably has no clue to go about it. He is comfortable in teaching using the traditional method. In other words he has fear of changing the teaching method in the event things go wrong.

R3 also commended on how she seldom integrates technology in teaching the design process.

> *Firstly, I ask my colleagues that are good in technology to download me some videos that I will use to show students. These videos grab the learner attention, which is the important part of teaching and learning. However, I still have a challenge in using technology pedagogy that will allow my learners to understand the design process. In fact, I need training on meaningful teaching strategies.*

R3's explanation reflects lack of knowledge of Technological pedagogical knowledge. She uses the videos to explain and grab learner's attention, thus enhancing learner understanding of the design process. But she does not explain the pedagogical value of the videos in the lesson. She also mentions that she needs more training on how to employ different teaching strategies.

R5 like R3 mentions that:

> *The learners are generally exposed to a problem, a need or opportunity as the starting point. They are then engaged in a systematic process using group work to develop solutions for the problem. I could get them to engage further if I was trained to use facilities such as smart board to demonstrate the concept.*

R5 noted that learners are frequently exposed to the design process problem. Learners then design and develop solutions based on the knowledge they have gained. His response demonstrates a hazy technological pedagogical understanding, specifically how to teach the design process utilizing smart boards.

The educators demonstrated adequate mastery of the subject matter. Their knowledge of technological pedagogy appears to be lacking. Without adopting inquiry-based learning as a modern pedagogical technique, the five teachers highlighted how they employ pedagogical illustrations and content representations in their lessons to guarantee students grasp the information. Essentially, teachers had challenges applying the TPACK structure in its entirety.

4.7 ICT affordances

Understanding ICT affordances can help educators choose technical tools that will improve the teaching of the design process. Educators discussed the ICT they use and how they use it to facilitate the design process and its use in various contexts. The study investigates the capabilities of TPACK in order to enhance teaching and learning. Four participants indicated that ICT is a useful tool in this contemporary education. This is what they said:

> *The tools I am using in the classroom are the projector, videos, WhatsApp. I also use a PowerPoint presentation that allows me to have features for differences in colour. If there was no connectivity problem, I would use more resources if I was familiar with the tools to teach the design process. [R4]*
>
> *I normally use the whiteboard, but I want to use digital technologies and various educational learning tools such as videos etc. … However, we experience problem in trying to use them and we are not yet efficient in integrating them into teaching and learning. But they play are bigger role in teaching today's learners [R2]*
>
> *The videos allow me to show the learners visually what I want them to see. However, I am still a newcomer in the use of technology. [R1]*
>
> *I do not have access to ICT tools, but I see the benefit that ICT tools have in teaching and learning. [R3]*
>
> *Teaching using ICT is ideal in today's education. It helps learner see the concept you are teaching fast. However, we need training on how to integrate these digital tools in the classrooms. [R5].*

All five participants agree that adopting digital technology for pedagogical instruction is a good thing. They are cognizant of the 21st century learner's contemporary needs, such as critical thinking, collaboration, and communication, among others. The only disadvantage is that they

are not yet proficient at integrating technological pedagogical tools. They are urging the government to implement training programs that will allow for the seamless integration of technology into teaching and learning.

4.8 Conclusion

The aim of this chapter was to interpret the data relating to the role of TPACK in enhancing grade 9 student knowledge of the design process. Five educators from five different schools in the Sedibeng east region were interviewed. In the interview, the focus was to determine how teachers TPACK knowledge was used to enhance student knowledge of the design process. The interview questions focused on educator's content knowledge (CK), pedagogical content knowledge (PCK) and Technological pedagogical knowledge (TPK). With the content knowledge I focused on whether the educators understand what the design process is. They came up with mixed understanding of what the design process is. This showed that the content knowledge might be lacking in some of them .The focus was also on the instructional methods the educators use when teaching the design process and how they integrate digital tools in the lesson. During the interview I examined how they use the TPACK knowledge base to make it easier for the learners to understand the design process. The next chapter presents discussions and analysis of the findings of this study.

Chapter 5: Discussion and Analysis of Findings

5.1 Introduction

The goal of chapter five is to discuss and analyse the findings based chapter four, keeping in mind that the primary goal of this research is to investigate the role of TPACK in improving students' knowledge of the design process. The research's findings, conclusions, recommendations, limitations and finally, ideas for future research.

5.2 Summary of findings

Thematic analysis was employed in the study to analyse qualitative data. It comprises searching through a data set to find, analyse, and report on repeating patterns. It is a data description approach, but it also requires interpretation in the processes of selecting codes and generating themes (Kiger & Varpio, 2020)

Thematic analysis is distinguished by its adaptability to a wide range of theoretical and epistemological contexts. The theme is a 'patterned response or meaning' obtained from the data that informs the study question (Braun & Clarke, 2006, p. 82). In contrast to a category, which provides definition and organisation to a data set's "manifest content," a theme is a more abstract object that requires a greater degree of interpretation and data integration. The research revealed three themes that came out strong from the participants, and these are:

- Lack of Technological Pedagogy knowledge to teach the design process
- School based technological support
- Digital technological affordances in the classroom.

Theme 1: Lack of Technological Pedagogy knowledge.

The research question: **How do you teach the design process incorporating digital tools?**

The participants were asked how they teach the design process incorporating digital tools in their classroom. R3 mentioned she has a challenge in using technology pedagogy that will allow her students to understand the design process. R5 amongst others had good pedagogical content knowledge, but he showed a lack of Technological pedagogical knowledge because he was unable to explain the pedagogical value of using the videos in his lesson. R1 indicated that he does not know how to teach the design process using technology. The findings reveal that the educators have challenges integrating technology in their classrooms. Furthermore, the results revealed

that educators rely on the textbooks to teach the design process, which makes it difficult to enhance student knowledge of the design process. They use more traditional methods of teaching because of the challenge they have with using Technology. According to traditional education is always passive, making it difficult to support today's students in developing complex thinking skills and collaborative abilities. Digital tools in the technology classroom must be used to enhance the understanding of the design process. In chapter 2 it was indicated that it is vital for educators to understand how to fuse digital technology in the classroom, especially when trying to unpack abstract concepts in the design process. Moreover technology students need to also develop skills of investigating a problem and coming up with solutions embedded in real-life experience. According to (Duran and Sendaĝ, 2012) Students must be taught skills such as inquiring, reflecting, and analysing information since they are necessary for the development of their critical thinking capacity in the design process.

The research findings reveal that Technological pedagogical knowledge is lacking. According to the research it shows that TPACK knowledge base of technology teachers must be developed in full paying particular attention to Technology pedagogy. As previously mentioned, there is a deficiency in Technological pedagogical knowledge of the design process amongst most of technology educators. Technology educators must be required to evaluate their subject matter content and the influence of technology has on the development of the design process.

It was interesting to discover that educators are familiar with different digital tools that they can use in their classroom to teach the design process, together with the fact that they have attempted to use the digital tools as noted in chapter four. However they did not use the digital tools to make the lesson meaningful because they do not have the required technological pedagogical knowledge. According (Niess, 2011) digital technologies are used by educators to create better learning environments that promote students' active construction of knowledge.

To answer the main research question, the educators only reflected a good content knowledge, which is the knowledge of the subject; however they lacked pedagogical and Technological pedagogical knowledge. According to chapter two for a Technology educator to have TPK, they need to understand the affordances of digital tools. Moreover, educators must be know the pedagogy of the subject, which include teaching methods, conversations, assessment and all educational goals of the subject.

Theme 2: School based technological support

The use of digital tools is shaping the educational landscape today. Many school districts show their support for increased levels of technology integration in the classroom by providing hardware such as computers and tablets, improving Wi-Fi connectivity, and implementing programmes aimed at improving computer literacy for both educators and students. According to (Buabeng-Andoh, 2012) Despite investment in ICT infrastructure and teacher professional development, technology adoption and integration in teaching and learning have remained inadequate in many nations. This results in teachers not integrating ICT in their classroom.

The challenge is now lying in the school based technological support. It was not pleasant to find out that educators in this study have limited access to digital tools and teaching resources. The other challenge that was indicated by the educators is that the digital tools they have are malfunctioning and the Wi-Fi connection is often down. R1 indicated that he minimally use videos because he is unable to play the videos due to poor Wi-Fi connection. This means that educators do not meaningfully integrate ICT in their classroom which hinders them from enhancing the students understanding of the design process. Furthermore, R3 indicated they he does not have access to digital tools. If he had access, he was going to explore more digital tools to use in the classroom. (Brantley-Dias & Ertmer, 2013).

In teaching the design process educators need to use all the TPACK knowledge base to improve classroom learning. According to the findings the role of TPACK knowledge base cannot be measured because educators are not fully integrating technology and they also lack skills of using digital tools for learning. There are more digital tools that are available to be used in the technology classroom that do not require any Wi-Fi connection. The results show that educators must be trained on the digital tools they can use as an alternative when the school has connectivity challenges.

Theme 3: Digital technological affordances in the classroom.

The design process is a complex process to teach, and it was revealed in chapter two that learners struggle to come up with creative solutions and models that are used beyond the classroom. Participants did not show sufficient understanding of the affordances the digital tools have to improve the learning experience. For educators to use digital tools to enhance learning, they need to articulate the affordances meaningfully to support learners. According to (Conole & Dyke, 2004) affordances are able to give students a simulated real world experience that would otherwise not be possible in the absence of digital tools. In the design process learners must be

exposed to artefacts/models that are available in real-life for them to invent and design enhanced design artefacts/models using the design process.

The research revealed that educators are not aware of the affordances of digital tools they use in their classrooms. E.g. in chapter 4, R4 mentioned that he uses the PowerPoint to allow him to have difference in colour when he is presenting his lesson. He further mentions that he uses the projector to show learners the videos. His responses show that he embraces digital tools in his classroom but there is still a gap in the knowledge to identify affordances of digital media that will help his students grasp the concept of the design process. The affordances of PowerPoint in the context of this study is for educators to use slides to structure the content of the lesson, integrating videos and pictures to show existing technological design to guide learners on what they are expected to design and make.

R2 indicated that she is using the whiteboard, but want to use digital technologies because they play a bigger role in today's education.R1 mentioned that he only uses videos for learners to view pictures.R1 is not aware of other more affordances that can be used to enhance the understanding of the design process such as interactive technology that can allow his learners to interact in the lesson such as simulations. The digital tools make explicit the distribution of cognition and will allow the learners to construct their own knowledge as they interact with the digital tool. (Conole & Dyke, 2004). However, (Cook & Boyle, 2004) argues that simply using the affordances of the digital device does not is guarantee that learning is taking place due to the affordances. It is therefore important that educators be equipped with the pedagogical content knowledge of the subject and then use digital tools to enhance their teaching.

Educators showed a positive attitude towards the integration of digital tools in the classroom. In the finding one educator mentioned that students become interested when she uses digital tools in her classroom. This shows that digital tools might benefits in the classroom and learning can take place as the result of the excitement that is ignited by technology.

5.3 Implications of the Findings

The emergence of digital technology has drastically altered habits and practices in almost every field of human endeavour. Advocates of educational technology frequently see comparable drastic breakthroughs in the teaching and learning processes. However, it has become evident that in education, reality has far fallen behind the ambition. Part of the problem has been a propensity to focus just on technology rather than how it is used. Simply incorporating technology into the teaching process is insufficient. The subject of what educators need to know

in order to effectively incorporate technology into their teaching has recently gained a lot of attention (Mishra & Koehler, 2006). However, the evidence from the study clearly shows that our major attention should be on researching how the technology is utilized. The impediment might be linked to a lack of theoretical underpinning for creating or comprehending this integration process. The study applied the technological pedagogical content knowledge (TPACK) paradigm to consider teacher knowledge and how it influences the argument over what teachers need to know (and how they might grow it). Furthermore, the framework demonstrated how the pedagogical approach of technology educators may lead to teaching technology using actual artefacts, which finally grounds the comprehension of the topic taught. The research presented examples of how this paradigm has informed process design teaching. Another goal of the research was to provide instances of combining the pragmatic and theoretical approaches to teaching the design process, hence minimizing teaching in abstract. How can educators learn about the intricate links between material, pedagogy, and technology? The conventional wisdom holds that educators merely need to be educated to use technology. This approach is based on a vision of technology as a generally applicable ability; unlocking the power and potential of technology may be accomplished by obtaining basic proficiency with hardware and software packages. Technology has the potential to empower educators as content engineers, experience designers, leaders, guides, and transform experiences with students in new learning and deeper investigation of subject (Thomas, 2016). Best practices-based educational reform efforts emphasise student-centered teacher facilitation using information and communication technology (ICT) as the most effective approach of educating modern learners (Ertmer & Ottenbreit-Leftwich, 2013). Educators found it difficult to teach using unfamiliar methods. To make matters worse, when educators attempt to incorporate technology, they are met with little technological assistance. The department of education is failing to deploy school-based technicians to assist educators when they encounter technological difficulties. These technological issues are what cause teachers to resort to conventional teaching methods, which must be addressed in this modern digital context.

5.4 Teaching affordance and agency are mutually related

Affordances not only contain numerous behavioural opportunities, but also invite specific actions based on the relationships between the environment and agents. For example, the digital globalization of the twenty-first century has seen the proliferation of online learning platforms, but local restrictions on Internet infrastructure and teachers' technological capabilities make some platforms more likely to be used than others. The actionable features of affordances, on

the other hand, are triggered by instructors' exercise of their agency to notice, choose, and assess possible actions in relation to behaviour situations. The persistence of teachers' reflection on their teaching reveals the ecological nature of affordances and educator agency. Reflective teaching is a constructivist approach to classroom education that stresses the investigation of teaching performance and its underlying logic, as well as the investigation of student learning. (Chen, 2020). As a result, it can capture the emergent processes of teaching behaviours and perceptions that occur as a result of interactions between instructors and their surroundings.

5.5 Limitations of the Study

- The first limitation I encountered was the data collection method, during covid I could not have access to the school where I did research. I had to conduct virtual interviews with the educators without observing them in practice. Data collected was only limited to what educators were saying. Future studies must use observations and focus group interviews.
- The second limitation was that educators were unaware of the TPACK knowledge base and the fact that they did not have access to digital tools in their classroom. This limitation might have compromised that richness of the data that was collected in this study.
- The third underlying limitation was the sample selection, future research must focus purposive sampling, and however they must select schools that have ICT tools where educators receive training and also be subject specialist.

5.6 Recommendations for Further Research

- Pre-service and in-service teachers TPACK knowledge base must be developed in a robust and impactful training.
- A quantitative study to measure the TPACK knowledge base of educators in the Sedibeng east region.
- A mixed method study must be conducted to measure the impact of TPACK knowledge on student achievement in technology.
- A study has to be conducted on the progress of the rolling out if ICT tools and the level of use in the classroom.
- It will develop the knowledge necessary to identify appropriate teaching methods when using technology to teach the relevant subject matter and to apply skills to encourage active participation by students.

5.7 Conclusion

The main purpose of this study was to understand the role of TPACK in enhancing students' knowledge of the design process. Based on the findings of the study, it can be concluded that technology teachers do not have the TPACK knowledge to teach the design process meaningfully to enhance student knowledge. The findings indicate that the TPACK knowledge base may have an influence on student understanding of the design process if educators TPACK knowledge base is developed.

The TPACK framework in this study was used to determine how the knowledge base must be used by the educator to meaningfully integrate digital tools in the classroom. Though the study expected that educators possessed TPACK knowledge base, it appears that educators only have subject knowledge, implying that technology teachers require a well-developed TPACK knowledge base to improve their grasp of the design process. To effectively teach the design process, educators must understand the ill-structured nature of the design process and adapt instructional methods that will allow learners to develop high levels of understanding of the design process as well as critical thinking skills to understand the design process and come up with creative solutions in their work. Moreover the research show that technology educators need training to use digital tools with affordances that can over quality learning in the Technology classroom. Failure to develop educator TPACK knowledge base can inhibit the development of proficient design skills and the understanding of the design process as prescribed by the CAPS document.

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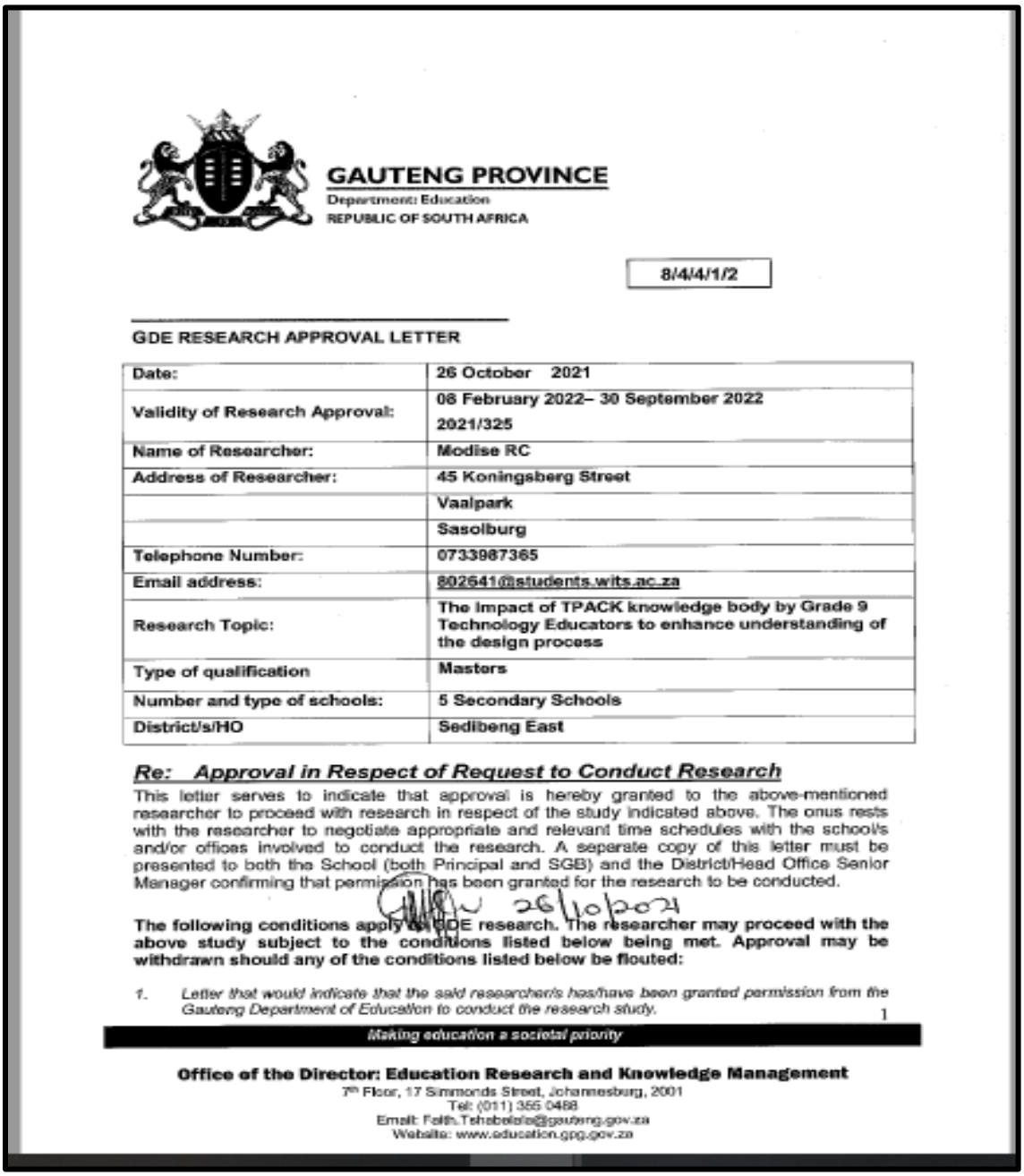
Appendices

2.16 GDE Research Approval Letter



GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**26 October 2021**
Validity of Research Approval:	**08 February 2022– 30 September 2022** **2021/325**
Name of Researcher:	**Modise RC**
Address of Researcher:	**45 Koningsberg Street**
	Vaalpark
	Sasolburg
Telephone Number:	**0733987365**
Email address:	**802641@students.wits.ac.za**
Research Topic:	**The Impact of TPACK knowledge body by Grade 9 Technology Educators to enhance understanding of the design process**
Type of qualification	**Masters**
Number and type of schools:	**5 Secondary Schools**
District/s/HO	**Sedibeng East**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

26/10/2021

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of COVID 19 pandemic researchers can ONLY collect data online, telephonically or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate. The approval letter will then indicate the type of arrangements that have been made with the school.***
4. ***The Researchers are advised to make arrangements with the schools via Fax, email or telephonically with the Principal.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
14. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

.....

Mr Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 26/10/2021

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2.17 Ethical Clearance

GRADE 9 TECHNOLOGY TEACHER'S CONSENT FORM

Dear Participant

Please fill in and return the reply slip below indicating your willingness to be a participant in my research study called: **The role of TPACK in enhancing students' knowledge of the design process: A case study of Grade 9 Technology Educators**

I, _____ give my consent for the following:

Permission to be interviewed.

I would like to be interviewed for this study.	YES/NO
I know that I can stop the interview at any time and don't have to answer all the questions asked.	YES/NO

Permission to be audiotaped

I agree to be audiotaped during the semi-structured interview	YES/NO
I know that the audiotapes will be used for this project only	YES/NO

Informed Consent

I understand that:

- my name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped, photographed and/or videotape
- all the data collected during this study will be destroyed after the successful completion of my research study.

Sign_____ Date_____

Thank you for your participation

NAME Refilwe Modise
ADDRESS 45 Koningsberg street.
Vaalpark
Sasolburg
EMAIL 802641@students.wits.ac.za
TELEPHONE NUMBERS 0733987365

2.18 Interview Schedule

REFILWE MODISE 802641

Date…… Venue…….

Interviewer: ……Interviewee…….……...

Entirely individual information provided by the participants will remain confidential. Pseudonyms will be used in the findings of the study where needed to refer to the individual participants, identity will remain private. All information received will only be used for the purpose of the research.

The role of TPACK in enhancing students' knowledge of the design process: A case study of Grade 9 Technology Educators

INTERVIEW QUESTIONS

DESIGN PROCESS: CONTENT KNOWLEDGE:

1. What is your understanding of the design process?
2. Do your learners understand the design process in such a way that they are able to design models that are fit for purpose? Elaborate
3. What components of design process need the use of ICT elaboration and why?

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

4. *Do you know the model called* TPACK? If you do, what is your understanding of the model? How can a design process teacher in Technology?
   If you do not know TPACK, which technology do you integrate in your teaching?
   (Researcher will explain the concept of TPACK if the participant does not have a clue what it is)
5. How do you use ICT in teaching design process to enhance learner understanding of the concept?
6. How effective is your teaching method with or without ICT in your classroom?
7. Describe any challenges you experiences in teaching design process using Technological tools.
8. Does the integration of ICT tools enhance learners understanding of the design process? Please explain and elaborate.
9. Describe your typical lesson of the design process with the integration of ICT

10. Does the TPACK knowledge base/knowledge in ICT used in teaching have an impact on your understanding of the design process? Explain
11. Do you think ICT integration the classroom enables meaningful learning of the design process?
12. Would you recommend educators to use ICT the teaching of the design process and why? Please specify the ICT tool that can be used in teaching the design process in technology
13. In what way can TPACK knowledge base help Grade 9 Technology educators to teach the design process effectively?

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