EXPLORING THE EFFECTIVENESS OF THE TEACHING STRATEGIES THAT TECHNOLOGY TEACHERS APPLY TO TEACH THE DESIGN PROCESS

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SEPHOTO SIBONGILE ANNAH KHETHIWE

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SUPERVISOR: **DR. M. KOLA**

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DECLARATION OF ORIGINALITY

Full names of student: **Sibongile Annah Khethiwe Sephoto**

Student number: [redacted]

I hereby declare that "Exploring the effectiveness of the teaching strategies technology teachers apply to teach the design process", is my own work and all sources used were acknowledged by means of references.

Signature of student: ---

Signature of supervisor: ---

ETHICAL CLEARANCE CERTIFICATE

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2212, Fax: (015) 268 2306, Email:noko.monene@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

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Researchers: Ms SAK Sephoto
Supervisor: Dr M Kola
Co-Supervisor: N/A
School: Education
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PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

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ABSTRACT

Technology education was introduced in the South African curriculum by the Department of Basic Education with the intention of developing learners' design skills while using the design process. Since the introduction of technology education, the South African curriculum has undergone a series of curriculum changes. Teachers were introduced to Outcomes-Based Education (OBE), the Revised National Curriculum Statement (RNCS), the National Curriculum Statement (NCS) and now the Curriculum and Assessment Policy Statement (CAPS). These changes compelled South African teachers to shift from a teacher-centred approach to that of a learner-centred approach. In the RNCS, the design process was presented as a linear process, whereas in the CAPS document, the design process has been represented as non-linear. This change has led to uncertainties amongst technology teachers on how to teach the design process.

The purpose of this study was to explore the effectiveness of the teaching strategies that technology teachers apply when teaching the design process. The CAPS document for technology stipulates that technology should give learners an opportunity to develop and apply specific design skills to solve technological problems in real situations. To solve such problems, learners should be exposed to a problem and then engage in a systematic process that allows them to develop solutions to the problem.

The theoretical framework used in this study was based on social constructivism. This theory was used based on the fact that it describes how learning occurs and puts emphasis on how learners construct their own understanding in a social context. This social constructivism was linked to the design process skills required to demonstrate the way in which the teaching and learning of the design process could be directed.

The design process is seen as the backbone of technology and should be used to teach technology, it seems that teachers are struggling to use the design process in teaching technology. The literature revealed that teachers' lack of knowledge in technology has an effect on how they use various teaching strategies to teach the design process. This is challenging and a reason for unease, therefore this study needed to explore this problem.

The study engaged in qualitative research using a case study design. Purposive sampling was used to select the participants, who comprised technology teachers who obtained an

Advanced Certificate in Education majoring in technology with at least six years of experience in teaching technology.

Data were collected using semi-structured interviews and observations, and were analysed using Shulman's Pedagogical Content Knowledge. The study revealed that only in exceptional cases were technology teachers using problem-solving to teach the design process. It was also revealed that technology teachers have difficulties with regard to PCK. The sampled teachers were also unable to support learners to acquire design skills such as investigation, designing, making, evaluation and communication. The observations indicated that the participants did not engage with the design process as set out in the CAPS document for technology.

The implication of this study is that understanding the content and how to teach it is essential in teaching and learning situations. There should be ongoing professional development programmes to assist technology teachers.

This study recommends that there should be repeated in-service training of technology teachers to address the issue of concern in teaching the design process. Teachers should be encouraged to attend such in-service training. The in-service training should also focus on teaching technology using the design process. Furthermore, technology teachers should encourage effective group-work in problem solving so that every member of the group has a role to play.

Key words: Design process; Social Constructivism; Investigation; Problem-solving; Discovery.

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LIST OF ABBREVIATIONS

CAPS	Curriculum Assessment and Policy Statement
DBE	Department of Basic Education
NCS	National Curriculum Statement
OBE	Outcomes-Based Education
PCK	Pedagogical Content Knowledge
RNCS	Revised National Curriculum Statement

CHAPTER 1 ORIENTATION OF THE STUDY

1.1 OVERVIEW OF THE CHAPTER

The purpose of this study was to explore the teaching strategies that technology teachers apply when teaching the design process in the classroom. It is hoped that the findings from this study will inform curriculum implementers on the way in which teachers teach the design process and how they support learners to develop design process skills in solving technological problems.

This chapter commences with an introduction and the background of technology in South Africa, and highlights the importance of the design process in solving technological problems. This is followed by the rationale of the study; the problem statement; the research questions; and a clarification of the key concepts that are used in this study. This chapter ends with the outline and organisation of this dissertation.

1.2 INTRODUCTION AND BACKGROUND

This study focuses on teaching strategies that South African technology education teachers employ to teach the design process in the technology classroom. In 1998, the Department of Basic Education introduced technology education as a subject in the curriculum after recognising that there was a need to produce engineers, technicians, artisans and technologically literate citizens that are needed in the modern world (Department of Basic Education (DBE), 2011:8).

The aims of technology education are to contribute to learners' technological literacy by giving them the opportunity to (a) Develop and apply specific design skills to solve technological problems, (b) Understand the concepts and knowledge used in technology education and use them responsibly and purposefully, and (c) Appreciate the interaction between people's values and attitudes, technology, society, and the environment. In addition, technology education stimulates learners to be innovative and develops their creative and critical thinking skills (DBE, 2011:8).

According to the policy, the intention of technology education is to introduce learners to the basics needed in civil engineering, mechanical engineering and graphics design. Additionally, learners will gain knowledge of the way that engineers apply scientific principles to practical problems. Elshof (2003:174) asserts that technology education teachers can provide excellent learning opportunities for young citizens to explore value judgement of an economic, moral aesthetic, social and technical nature in the design process and in evaluating the technological products that they encounter in the world.

The design process in the South African education curriculum is seen as the backbone of technology education, and all teaching of technology education should be structured using the design process as the methodology (DBE, 2011:10). The design process (investigates, design, make, evaluate, communicate) is used to deliver the learning aims of technology education. Learners should be exposed to a problem as the starting point, and should then engage in a systematic process to develop solutions to the problem. The design process empowers learners to function effectively in society and in a technological situation to the benefit of individuals and the natural environment (Potgieter, 2004:207).

Kananoja (2006:347) states that the design process in technology education improves the quality of life in most societies, and is important as it attempts to make learners innovative, knowledgeable, skilful, adaptable and enterprising. In the technology education classroom, learners learn to work together in teams or groups while solving the identified problem. Activities are authentic and have a connection with the real world. This means that the subject stimulates learners to be innovative, and develops creative thinking skills, while teaching learners to manage time and resources effectively.

In the technology education classroom, learning utilises a range of sense making-capabilities and assumes physical actions as well as knowledge acquisition as essential components for understanding. Learners have the chance to develop practical wisdom. Unfortunately, their success in achieving this wisdom is tempered by the teaching strategies used by their teacher in teaching technology (Hansen, 2008:11).

Technology education was implemented for the first time as part of the new National Curriculum in 1998, and because of the limited time frame for implementation, there was very little time to adequately train teachers. Teachers were expected to implement technology education in schools without being thoroughly trained on how to teach the subject (Engelbrecht, Ankiewicz & Swardt, 2007:579). The implementation of technology education in the South African curriculum caused many debates and initiated much research based on the problems that teachers encountered at the time. Problems such as a lack of qualified teachers in technology education, a lack of resources to use in the classroom, and not understanding the content or the learning outcomes were encountered by many teachers (Gumbo, 2003:131).

Heymans (2008:48) reveals that there were problems experienced with the implementation of technology education in schools. Teachers did not know exactly what to do and how to teach the design process as the backbone of technology education. Most technology education teachers previously taught technical subjects that focused on one discipline, whereas technology education requires teachers to be well-versed in various disciplines. Thus, teachers' lack of knowledge in all other disciplines may have an effect on how they use various teaching strategies to teach the design process (Engelbrecht, 2007:145).

Teachers were supplied with the new policy documents for technology education and expected to work using these without any training. The documents were confusing for most of the teachers and the syllabus very unfamiliar. The aims of technology education are to give learners the opportunity to develop and apply specific skills in solving technological problems, and to create learners that are innovative, creative and critical thinkers. Since the introduction of technology education in 1998, it has been observed in the literature that the types of classroom teachings do not resemble the intended aims of the education policy (Howie, 2002:153).

Some schools use the direct teaching approach, which is teacher-centred, where learners are passive recipients of information. However, this approach does not do justice to the proposed aims of technology education. McCormic (2004:6) points out that teachers often treat the design process as a series of steps and the teaching strategies that they use are insufficient and sometimes incorrect. The successful implementation of technology education is dependent on teachers having a firm, reputable personal construct of technology equivalent to that of the curriculum (Tholo, Monobe & Lumadi, 2011: 462). Ever since the introduction of technology education, teachers have been grappling with its instructional strategies. According to Lovington (2009), teachers teaching technology have had little or no qualification to teach the subject before 2010.

Teachers were asked to volunteer to teach technology during the year 1998. According to Reitsma and Mentz (2009), workshops held by the DBE did not offer teachers the opportunity to study and reflect on the new information. Mapotse (2012) conducted research with 18 technology teachers from secondary schools in the Limpopo Province. He discovered that some teachers in those schools could not teach technology, and found that 11 teachers had less than six years' experience teaching technology, 11 teachers had no qualification in technology education, and eight teachers could not plan a technology lesson. This implies that the teachers neither had an idea of the design process, which is the fundamental building block of teaching technology, nor did they use it to structure their technology lessons.

1.3 RATIONALE OF THE STUDY

The design process in technology education is regarded as the backbone of the subject, but there is little empirical evidence that enables and instructs teachers on how to teach the design process. For technology education to take off, this would require a wider understanding among teachers of the way in which learners approach and carry out activities of the design process and also the teaching strategies used to foster these practices. The traditional focus on models of the design process has been based on fundamental misunderstandings of how teachers actually teach, and has been driven by assessment needs. It is suggested that the current emphasis on models of the design process should be downplayed and more attention be given to providing learners with the necessary design skills and technological practices (Mawson, 2003:125). The research projects conducted in South Africa indicate that the type of teaching strategies dominating the technology education classroom does not resemble the intended aims as stipulated in the policy document (Potgieter, 2004:44). Recent publications have focused on teaching strategies used to teach sciences and mathematics, and has identified areas for curricular reforms. However, there are very few studies on teaching strategies for the design process in the technology education classroom (Miri, David & Uri, 2007:354).

It is ironic that at a time when there is a high demand for technicians, artisans and engineers in the work place, research shows that teachers are still struggling to teach technology, specifically the design process. Technology education should develop innovative learners, risk-takers and reflective problem solvers. This aim is not being achieved with the teaching strategies being based on current models of the design process (Williams & Williams, 2004:146).

In light of the above, it is important to investigate teaching strategies that technology teachers can employ in order to teach the design process in their classrooms, especially since the

Curriculum and Assessment Policy Statement (CAPS) for technology education articulates that the design process is the backbone of the subject and must be treated as such (DBE, 2011:9). Although the CAPS document clearly states this, it fails to assist teachers in the teaching of the design process.

1.4 PROBLEM STATEMENT

The aim of technology education, as outlined in the Curriculum Assessment Policy Statement (CAPS), is to develop learners who are technologically literate, creative, innovative and gives learners opportunities to develop and apply specific design skills to solve technological problems (CAPS, 2011:3). However, based on the observations made and the discussions held at workshops, there is evidence that many learners who passed Grade 12 have followed careers like medicine, teaching and nursing. It is assumed that this situation is promulgated because teachers do not know exactly what to teach and how to teach technology in the classroom. Specifically, teachers do not know how to teach the design process and which teaching strategies to use in order to teach the design process. It furthermore seems that there is dearth of information in the literature on teaching strategies that technology teachers can employ to teach the design process in the classroom. The learners' interest in pursuing technology as a career is not triggered in the classroom. Heymans (2008:48) found that there were problems experienced with the implementation of technology and that there are still existing problems in teaching technology in schools today. From the above information, it seemed that there was a need to investigate whether teachers' teaching strategies sufficiently and successfully allow them to teach the design process as it should be taught.

1.5 PURPOSE OF THE STUDY

The aim of this study is to explore the teaching strategies South African technology education teachers employ to teach the design process in solving technological problems.

1.6 RESEARCH QUESTION

The following main research question was asked:

> What are the teaching strategies that technology teachers apply in order to teach the design process when solving technological problems?

The following sub-research question were developed to address the main question:

(i) To what extent do technology teachers support learners to follow the design process methodically?

(ii) How effective are the instructional strategies that technology teachers apply in teaching the design process?

(iii) What are technology teachers' experiences in teaching technology?

1.7 CLARIFICATION OF KEY CONCEPTS

1.7.1 Technology

Technology encompasses all artefacts used by people to advance their lives. The definition of technology that is widely accepted is that it is the know-how and creative processes that may help people to use tools, resources and systems to solve problems in order to improve the human condition. The Department of Basic Education ((DBE) 2011:11) defines technology as the use of knowledge, skills, values and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environment factors into consideration.

1.7.2 Technological literacy

Technological literacy refers to being familiar with the technology process. The essence of technological literacy is the skill to analyse information and simplify multifaceted ideas in solving exceptional problems (DBE, 2011:58).

1.7.3 Technology education

Technology education is concerned with 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, 2009:1).

1.7.4 Artefacts

Artefacts are man-made objects such as buildings, computers, cell phones, cars, and chairs. Artefacts are produced by means of technology (DBE, 2003:63).

1.7.5 Artisan

This word is derived from French, meaning craftsman. In addition, it refers to skilled manual workers who make items that may be functional items, decorative clothing, jewellery, household items and tools, and even machines (DBE, 2011:8).

1.7.6 Engineering

Engineering combines the fields of science and mathematics to solve real world problems that improve the world around us (De Vries, 2005:11).

1.7.7 Graphic design

Graphic design is a creative process involving a client and a designer, and is traditionally completed in conjunction with producers of form (printers, sign makers). It also refers to a number of artistic and professional disciplines that focus on visual communication and presentation (Lewis, 2005:16).

1.7.8 Conceptual knowledge

According to McCormick (2004:24), conceptual knowledge deals with concepts that are manifested in a particular context. Conceptual knowledge includes knowledge of facts (Turnbull, 2002:32). He further states that in technology education, conceptual knowledge depends on what problem needs to be solved and what skills would be used to solve the given problem. Custer (1995:230) assets that technological knowledge is the knowledge that is used for technological purposes. According to Shield (1996:3), technology is concerned with implementing ideas, while according to DeVries (2003:84), the learner should know the physical characteristics of an artefact; the functional nature of the conceptual knowledge, which deals with how the artefact performs; and understanding of what characteristics of an artefact will enable it to do an activity; and the process that should be followed in using specific artefacts.

1.7.9 Procedural knowledge

According to McCormick (2004:24) procedural knowledge is about planning, problem solving, modelling, design, system analysis, optimisation, and creative thinking. However, McCormick (1994:144) alluded to the fact that procedural knowledge in technology refers to the thinking process and skills. Ankiewicz and DeSwardt (2005:16) agree that there is a link between problem solving and the design process, and also that the thinking processes form part of the design process. It is clearly stated by Ankiewicz and DeSwardt (2003:76) that technology encompasses procedural knowledge as an essential feature, and further, procedural knowledge deals with the design process stages and serves as a sequential guideline to assist in gathering solutions to a technological problem. This means that when teaching the design process, teachers have to consider what relevant knowledge and skills to teach. From the discussion above, the researcher is of the opinion that design is the process of devising a component to meet a need.

1.8 OUTLINE AND ORGANISATION OF THE STUDY

Table 1.1 presents the outline and organisation of this study.

Table 1.1: Outline and organisation of this study

Chapter	Chapter heading	Chapter outcomes
1	Orientation of the study	Described the background and rationale of the study, and the problem statement. It also outlined the aim of the study, the research questions and an explanation of the key concepts.
2	Literature review	Presents a detailed review of the relevant literature on the design process. In this chapter, the theoretical framework of this study is also presented.
3	Research design and methodology	A detailed description of the methodology used in this study is described in this chapter. The research site and the data collection method employed in this study are also described. The data collection instruments and the sampling procedure used are described. This is followed by a description of the data collection procedure and the method of data analysis. Standards of rigour for research as well as ethical considerations are also explained.
4	Findings and results	This chapter discusses the findings and interprets the data. The interpretation of data stems from the questions and observations done, including interviews.

5	Summary of the findings, limitations, discussion, recommendations and conclusion	The final chapter gives a summary of the previous chapters. This chapter also discusses the recommendations relating to the findings and reflections. The limitations of the study together with suggested areas for further research are highlighted.

CHAPTER 2 LITERATURE REVIEW

2.1 2.1 INTRODUCTION

This chapter presents a review of the literature and the theoretical framework pertinent to the purpose of this study. The literature surveyed focuses on social constructivism; knowledge construction; situated cognition; learning environment; reality; socio-cultural learning; the role of the teacher in social constructivism; how learners learn; how knowledge is constructed in technology education; design as the organisation of design process; the design process and empirical studies concerning the design process; and the challenges already identified in this regard. Knowledge and understanding of the psychology of learning are basic to making decisions about and using the appropriate teaching strategies and techniques. Teaching is best described as directing and guiding the learning process such that the learners acquire new knowledge, skills or attitudes, increase their enthusiasm for learning, and further develop their skills as learners (Newcomb, McCracken & Warmbrod, 1986:20-21).

2.2 SOCIAL CONSTRUCTIVISM

This study is situated in the Social Constructivism Theory. Social constructivism comprises very different views of the process of constructing knowledge. According to Vygotsky (1978:58), social constructivism focuses on the interdependence of social and individual processes in the construction of knowledge. The centre of this theory is the notion that development takes place through social relationships (Vygotsky, 1978:58). According to Vygotsky (1978:58), from infancy onwards, learners are engaged in constructing shared meanings through their interactions with parents, peers, teachers and others in the social context. Learners progressively develop new or adapted meanings and knowledge by building up the space between what they currently understand and what confronts them in social interactions (Vygotsky, 1978:59).

Von Glasersfeld (1989:45) states that learners construct their own understanding, look for meaning, and try to find regularity and order in the events of the world, even in the absence of complete information. According to Piaget (1980:54), learners are actively engaged in an ongoing process of adaptation of the world in which they live. Furthermore, adaptation happens through a continuous process of organising and re-organising information and experience. He also states that learners are constantly confronted with new information from their environment and the social world around them (Piaget, 1980:54). Piaget (1980:54) supports Vygotsky's view of social constructivism, however, he adds that the construction of knowledge is based on assimilation, accommodation and equilibration.

The Social Constructivism Theory justifies one of the specific aims of technology in the South African Curriculum as the Curriculum and Assessment Policy Statement (CAPS) stipulates that "learners should appreciate the interaction between people's values and attitudes, technology, society and the environment" (DBE, 2011:8). The hallmark of constructivism is that learners are active in constructing their own knowledge and social interactions are important in knowledge construction. In other words, learning is a social activity through which learners are exposed to thinking processes and problem-solving techniques to arrive at their own solution. In the following section, a discussion of the construction of knowledge is presented.

2.2.1 Knowledge construction

Vygotsky (1978:57) describes the construction of knowledge as a human product that is socially and culturally constructed. Furthermore, learning is related to existing knowledge with the new knowledge being integrated into the existing knowledge (Vygotsky, 1978:57). Shunk (2012:165) affirms that knowledge exists as the outcome of mental contradictions that result from one's interactions with other people in the environment. Vygotsky (1978:57) argues that knowledge is based on real life adaptive problem solving, which takes place in a social manner through shared experience and discussion with others such that the new knowledge is matched with the existing knowledge.

According to Wertch (1985:38), social constructivism focuses on the learner as part of a social group, and learning as something that emerges from group interaction, where the meaning in social experience is emphasised. Vygotsky (1978: 58) states that learners interpret experiences and information in the light of their extant knowledge relating to their stage of cognitive development, cultural background and personal history. Learners use these factors to organise their experiences, select, and transform new knowledge (Vygotsky, 1978:58). Von Glasersfeld (1989:165) supports Vygotsky's (1978) view of knowledge construction and explains that individual development is dependent on the existing social environmental context. He further stresses that learners should learn from the world through continuous interaction with others.

The Social Constructivism Theory is in line with the general aims of the South African Curriculum (2011:5), which states that “the National Curriculum Statement aims to produce learners that are able to work effectively as individuals and with others as members of a team.” In this way, the knowledge gained will be mutually constructed and, by interacting with others, learners will be able to share their views (Vygotsky, 1978). According to social constructivism, knowledge is socially situated and is constructed through learners’ reflection on their thoughts and experiences, as well as other learners’ ideas (Vygotsky, 1978:90). Vygotsky (1978) explains that authentic learning occurs when instruction is designed to facilitate, stimulate and recreate real complexities and occurrences.

According to CAPS (2011:9), technology should provide learners with the opportunity to learn to use authentic contexts rooted in real situations outside the classroom so as to combine thinking and doing in a way that links abstracts concepts to concrete understanding. This emphasises the importance of the environment in the construction of knowledge. Jonassen (1994:34) believes that social constructivists’ learning environment provides multiple representations of reality and also emphasises that knowledge is constructed and meaningful learning that is rooted in authentic tasks. Jonassen’s belief confirms what Vygotsky (1978) alludes to in that context gives the child the cognitive tools needed for development. This is also stipulated in the unique features and scope for technology (DBE, 2011:9), “Technology will teach learners to use authentic context rooted in real situations.”

In light of the above, knowledge construction could encourage learners to be creative during the design process. The researcher is of the view that during the construction of knowledge, learners are able to interpret the concepts that are used in technology and problems related to their environment. The following section focuses on situated cognition as it is stated in social constructivism that learners should construct their own knowledge based on physical and social contexts. In technology, the construction of uniqueness within a community of practice requires being situated in a context that is meaningful and authentic to the learner. Therefore, the following section deals with situated cognition.

2.2.2 Situated cognition

According to Vygotsky (1978), situated cognition refers to the idea that thinking is located in social and physical contexts within individual’s mind, which means that knowledge is tied to the situation in which it is learned and it is thus sometimes difficult to apply in other situations. Thus, learning situations should be as close to real-life situations as possible (Vygotsky, 1978). Situated learning posits that learning is unintentional and situated within authentic activity, context and culture (Lave, 1998). He further argues that knowledge needs to be presented in authentic contexts, social interaction, and collaboration, which are essential components of situated learning. Brown, Collins and Duguld (1989:132) emphasise the idea of cognitive apprenticeship, which supports learning in a domain by enabling learners to acquire, develop and use cognitive tools in authentic activity.

Situated learning provides authentic contexts that reflect the way in which knowledge will be used in real-life, and provides access to expert performances and the modelling process. Situated learning supports collaboration in knowledge construction, and promotes the reflection on and evaluation of learning within tasks (Vygotsky, 1978). Subsequently, for learners to develop social cognitive skills, they should be able to work collaboratively with others (DBE, 2011:9). Lave and Wenger (1990:68) affirm that learning both outside and inside school advances through collaborative social interaction and social construction of knowledge. In situated learning, learning is structured to provoke the kinds of thoughtful engagement that helps learners develop effective thinking skills and attitudes that contribute to effective problem solving and critical thinking (Jordan, Carlile & Stack, 2008:186).

Situated cognition is concerned with how learners interpret the social world. According to the Unique Features and Scope documentation, technology should provide learners with the opportunity to learn and work collaboratively with other learners (DBE, 2011:9). This emphasises the importance of team work, which can be used in situated learning. In the technology classroom, learners are exposed to ill-structured problems where they search for information. Learners are then able to choose the most suitable solutions to solve the technological problem.

In light of the above, learners can learn easily by collaborating and working in groups. When learners work as a group, they find it easy to solve technological problems. Discussion can be promoted as learners investigate information and present their findings to the whole class. In technology, the use of authentic activities is relevant since learners should use a variety of life skills in authentic contexts such as decision making, critical and creative thinking, cooperation, problem solving, and the identification of needs (DBE, 2011:9). The next session presents literature regarding the learning environment.

2.2.3 Learning environment

Vygotsky (1978) proposed that the social environment influences cognition through its cultural objects and its social institutions. Adults teach learners in the course of their joint activity, the learners then internalise these tools, which function as mediators of the learners' more advanced learning processes. According to Schunk (2000:243), cognitive change results from using such cultural tools in social interactions and from internalising and mentally transforming these interactions. Vygotsky's most powerful claim was that all higher mental functions originated in the social environment (Vygotsky, 1978). Vygotsky describes the role of learners' self-directed talk in guiding and monitoring thinking and problem solving, and also emphasises the significant role played by adults and peers in learners' learning.

A social constructivist learning environment provides multiple representations of reality, which avoid simplification and represent the complexity of the real world (Jonassen, 1994:34). Therefore, a social constructivist learning environment emphasises knowledge construction. Vygotsky (1978) also highlighted the convergence of the social and practical elements in learning by finding that the most significant moment in the course of intellectual development occurs when in practical activity, completely independent lines of development converge. Through practical activity, the learner constructs meaning on an intra-personal level. One of the social constructivist notions is that of authentic situations, where learners takes part in activities directly relevant to the application of learning, which takes place within a culture similar to the applied setting.

The researcher is of the opinion that learning environment teaches the learners to develop cognitive skills as they find themselves in a context. As the learners construct their own knowledge, they also reflect on how others have solved similar technological problems. Learners who are familiar with learning environments develop skills to investigate, design, make, evaluate and communicate, and they are able to solve technological problems. The following section describes reality as part of social constructivism.

2.2.4 Reality

Reality is not something we can discover because it does not pre-exist to our social invention of it (Vygotsky, 1978:101). Kukla (2000) adds that reality is constructed by our own activities and that people, together as members of a society, invent the properties of the world. McMahon (1997:168) agrees with this view and emphasises that individuals make meaning through interaction with each other and with the environment in which they live. The process of sharing individual perspectives or collaboration results in learners constructing understanding together and also allows multiple realities (Meter & Stevens, 2000). According to this, the Theory of Social Constructivism's reality is constructed through human activity, as members of a society invent the properties of the world together. Learners create meaning through their interactions with each other and the objects in their environment. Also, learning is a social process and occurs when people are engaged in social activities (Vygotsky, 1978).

Vygotsky (1978:101) proposed the concept of a *zone of proximal development* in which learners in challenging situations can develop their own thinking abilities through appropriate guidance and support from teachers. The zone of proximal development is defined as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or peers" (101). Learners work within their zone of proximal development when they are engaged in tasks that they could not do alone but can do with the assistance of peers or the teacher (Vygotsky, 1978:101). When learners work together, each learner is likely to have a peer performing a given task at a slightly higher cognitive level. Vygotsky's work implies that learners should be given opportunities for co-operative learning and should be encouraged to organise their thinking (Schunk, 2000:243).

Based on the above, social constructivism comprises a social consensual interpretation of reality. The use of knowledge, skills and resources to solve real problems within a social context is a mutual thread. Technology offers authentic, real-life opportunities for learners to interact with their peers and their society to develop technological solutions. In the technology classroom, learners become aware of their responsibility in society.

2.2.5 Socio-cultural learning

Social constructivism encourages learners to arrive at their own version of truth, which is influenced by their background, language, logic and the mathematical systems that are inherited by the learner as a member of a particular culture (Vygotsky, 1978:50). According to this theory, humans develop in the context of a culture, and thus learners' learning is affected by the culture of their families. Culture provides the learner with the cognitive tools needed for development (Bruner, 1996:56). Vygotsky (1978:10) emphasises that culture has a major impact on an individual's learning. When learners have the opportunity to work in groups, they can contribute to a common understanding (Vygotsky, 1978:10). Learners are encouraged to effectively engage in learning to discuss, argue, negotiate ideas and collaboratively solve problems (Vygotsky, 1978:26).

By interacting with other learners in the same culture, learners get the opportunity to share their views and generate shared understanding related to the concept. These views confirm what is stipulated in CAPS (DBE, 2011:11), which is that learners should work collaboratively with others to investigate, design, make, evaluate and communicate. Bruner (1996:58) states that what people learn is framed by the surrounding culture and thus learning is the sharing of that culture. Furthermore, he explains that all learning is an induction into a culture, including all of the values of that culture. Brown (1989:33) affirms that learners working in groups with peers have been shown to create a culture that is open to learning. Social interaction with other learners is essential in developing a learner's thinking abilities. Learners are encouraged to arrive at their own version of the truth, as influenced by their culture (Brown, 1989:32-42).

Vygotsky (1978) states that learning must culminate in learner independence. He further believes that autonomous knowledge does not depend on a specific situation. Abstract knowledge is transformed and should not be limited by the context in which it was originally constructed (Vygotsky, 1978). He also asserts that in situated cognition, learners are dependent on the environment. From this view, we can deduce that real learning occurs only when the learners are the master of their own behaviour. However, learning needs to be facilitated and guided. Williams and Burden (1997:138) claim that socio-cultural learning advocates that education should be concerned with learning to learn, developing skills and strategies to continue to learn, and making learning experiences meaningful and relevant to the world.

According to Ellis (2000:193), learners who gain knowledge through socio-cultural learning first succeed in performing a new task with the help of another person and then internalise this task so that they can perform it on their own. Based on the views above, this study focused on the Social Constructivism Theory as it has a great impact on teaching and learning where, for example, learners are able to solve technological problems in technology education during classroom activities. In social constructivism, learners learn in collaboration with their peers where they have to hold discussions during the stages of the design process.

The design process requires problem solving to address needs and wants, and is likely to require social constructivism.

From the researcher's point of view, in social constructivism, learners have more control over their learning. Also, learners are grouped together to improve their discussion skills. During the learning process, the ability to learn is developed with tasks such as investigation, forming opinions, evaluating information and thinking critically. Bruner (1990) concurs with Vygotsky that learning must be a process of discovery through which learners build their own knowledge with active collaboration with peers and teachers, building on their existing knowledge Bruner (1990) further adds that in discovery learning, learners are placed in problem-solving contexts where they are required to draw on past experiences and existing knowledge to discover facts, relationships and new information.

In addition, learners who are familiar with social constructivism develop the skills to work collaboratively with the members of their groups and are able to arrive at a joint understanding. Furthermore, learners also develop skills to investigate, form opinions, evaluate information and be able to solve technological problems. During the design process, learners are required to investigate the problem in order to find out about the context and the needs described in the problem (DBE, 2011:12). This allows learners to develop opinions that will assist them in making valuable judgements. The following section discusses the role of the teacher as stipulated by Vygotsky (1978).

2.3 THE ROLE OF THE TEACHER IN SOCIAL CONSTRUCTIVISM

According to Vygotsky (1978), the teacher is a facilitator who helps the learner to come to their own understanding of the content. However, the learner plays an active role as well. He further reports that the teacher should align and design experiences for the learner so that authentic and relevant contexts can be experienced by learners. Moreover, the teaching strategies used should put emphasis on the identification of the context in which the skills will be learned and subsequently applied (Vygotsky, 1978:168). The teacher should understand that individuals bring different learning experiences to learning situations, which can impact experiences within the learning situation, and which can also impact the learning outcomes, determine the most effective manner in which to organise and structure new information to draw on learners' previously acquired knowledge, abilities, and experiences, and arrange practice with feedback so that the new information is effectively and efficiently assimilated within the learners' cognitive development (Vygotsky, 1978:168).

Kompf (1996:173) concurs that a constructivist teacher allows the learner to build their knowledge, controls the existence of learners during the learning process in the classroom, and also values learners' reflection and cognitive conflict and encourages peer interactions. To Ndon (2011:253), the teacher as a facilitator should provide rich environment experiences and activities for learning by incorporating opportunities for collaborative work, problem solving, and authentic tasks. According to Brownstein (2001:122), a facilitator needs to display a completely different set of skills, and design a learning environment that should support and challenge learners' thinking. Additionally, a facilitator provides guidelines and creates an appropriate environment for the learners to arrive at their own solutions and conclusions (Brownstein, 2001:122).

The researcher is of the opinion that in the technology classroom, teachers must be able to effectively facilitate the design process and provide circumstances that will enable the learners to be engaged with learning opportunities, and socially construct knowledge and understanding skills. Using the Social Constructivism Theory in the design process is necessary as it could lead to good results in design and could inspire unlimited creativity. The researcher is also of the opinion that the design process should engage learners in investigating and designing for specific need and environments, as in this way learners could explicitly express their thoughts during the design process.

2.4 HOW LEARNERS LEARN IN A SOCIAL CONSTRUCTIVIST CLASSROOM

Social constructivism views learning as an active process wherein learners should learn to discover principles, concepts and facts for themselves (Vygotsky, 1978:67) this means that learners should be actively involved in their learning process (Shunk, 2012). According to this theory, learners in the classroom are actively involved in their own learning. Knowledge is distributed between and within individuals and the collective, and this knowledge is transformed as individuals engage with others, which is an active process (McMahon, 1997). In a social constructivist educational setting, learning is the responsibility of the learner.

The learner is expected to engage with his peers and the teacher in a discussion of the topic, be exploratory and creative in self-directed research and development of new knowledge through innovative analysis, conceptualisations, and synthesis of prior knowledge to create new knowledge. Moreover, the learner should be able to look for meaning and try to find regularity and order in the events of the world, even in the absence of all the required information (Vygotsky, 1978:67). In the constructivist classroom, learners are provided with multiple representation of reality, and learning is emphasised through authentic tasks in a meaningful context; learners are also provided with case studies (Jonassen, 1994:87). The main activity in the social constructivist classroom is solving problems. Learners use inquiry-based knowledge to investigate a problem, and use a variety of resources to find solutions. As learners explore the problem, they draw conclusions, and as the exploration continues, they revisit those conclusions (Vygotsky, 1978).

Learners should be constantly challenged with tasks that refer to skills and knowledge just beyond their current level of understanding (Brownstein, 2001). Vygotsky (1978) further claims that instruction is good only when it precedes development. According to Jonassen (1992), the foundation of any subject can be taught to anybody at any stage in some form. This means that teachers should first introduce the basic ideas that give meaning to the topic and then revisit and build upon these repeatedly. The researcher is of the opinion that in a constructivist classroom, learners are given clear guidance and parameters within which to achieve the learning outcomes. Learning experiences are also open and allow learners to discover, interact and arrive at their own solutions. The next section deals with how learners learn in technology education.

2.5 HOW KNOWLEDGE IS CONSTRUCTED IN TECHNOLOGY EDUCATION

The table below represents the types of knowledge that are acquired during the design process, as adapted from Newell and Simon (1990:72).

Table 2.1: Knowledge acquired during the design process (adapted from Newell & Simon, 1990:72)

Types of knowledge	Explanation
General knowledge	Information that most people know and apply without regard to the specific field. It is gained through everyday experiences and basic schooling.
Domain-specific knowledge	Information in the form of individual objects. This knowledge comes from study and experience in a specific field. It is estimated that it takes about ten

	years to gain enough specific knowledge to be considered an expert in any field. Formal education sets the foundation for gaining this knowledge.
Procedural knowledge	The knowledge of what to do next. This knowledge is used in solving technological problems.

Knowledge in technology education comprises conceptual and procedural knowledge. According to McCormick (1997:147), conceptual and procedural knowledge cannot be separated because conceptual knowledge is used to understand procedural knowledge. Ankiewicz and De Swardt (2005:4) explain that conceptual knowledge is known as descriptive knowledge and has to do with the links between the knowledge items and procedural knowledge as implicit knowledge. According to De Swardt, Ankiewicz and Engelbrecht (2005:3), technology teachers are expected to have technological knowledge, which includes the conceptual and procedural knowledge required to be able to teach the design process.

According to McCormick (2004:24), conceptual knowledge deals with concepts that are manifested in a particular context. Conceptual knowledge includes knowledge of facts (Turnbull, 2002:32). He further finds that in technology education, conceptual knowledge depends on what problem needs to be solved and what skills should be used to solve the given problem. Custer (1995:230) asserts that technological knowledge is knowledge that is used for technological purposes. According to Shield (1996:3), technology is concerned with implementing ideas. According to DeVries (2003:84), the learner should know the physical characteristics of an artefact, while the functional nature of conceptual knowledge deals with how the artefact performs, an understanding of what characteristics of an artefact will enable it to do an activity, and the process that should be followed when using specific artefacts.

According to McCormick (2004:24) procedural knowledge is about planning; problem solving; modelling; design; system analysis; optimisation; and creative thinking. However, McCormick (1994:144) alludes to the fact that procedural knowledge in technology refers to the thinking process and skills required for this process. Ankiewicz and DeSwardt (2005:16) agree that there is a link between problem solving and the design process, and also the thinking processes that form part of the design process. It is clearly stated by Ankiewicz and DeSwardt (2003:76) that in technology, procedural knowledge is an essential feature, and furthermore deals with the design process stages. Procedural knowledge serves as a sequential guideline to assist in gathering solutions to a technological problem. This means that when teaching the design process, teachers have to consider what relevant knowledge and skills to teach. From the discussion above, the researcher is of the opinion that design is the process of devising a component to meet desired needs within a community or even society at large.

2.6 HOW LEARNERS LEARN IN TECHNOLOGY EDUCATION

Rowel (2004) argues that technology should be taught in a social context where learners generate knowledge through an interpretation of materials and tools, and the involvement of scaffolding in the learning process. He also adds that scaffolding will help learners to replace their existing knowledge with new knowledge (Rowel, 2004). According to Tok (2011), in the technology classroom, learners are allowed the independence to learn on their own. Mawson (2007) suggests that learners should be helped to discover their own abilities in reaching decisions and in building thoughts on their own existing knowledge. This view is supported by Lewis (2006), who believes that learners should be helped to achieve creativity. Jones (2002) recommends that teachers should occasionally interrupt learners during the generation of ideas to combine creative thoughts. Hartfield (2012) affirms that occasional interruption will foster the teacher-learner relationship, which plays an important role in building up the symbiosis that exists between teaching and learning.

In the technology classroom, the learning environment should reflect the real world and allow learners to explore and solve real-world problems as they develop investigative skills (DBE, 2011:9). Borko and Putnam (2000:236) state that learning is situated, distributed and authentic, which means that all learning should take place in a specific social context. According to Vygotsky (1978:68), learners should draw from their knowledge and previous experience if the task is on their existing level of development. Social constructivism emphasises the collaborative nature of learning and the importance of cultural and social contexts, which allow learners to engage in meaningful learning with others (Vygotsky, 1978:85). Collaborative learning requires learners to develop teamwork skills and to see individual learning as essentially related to the success of the group.

In the technology classroom, learners work in small groups, and are then required to investigate a technological problem. They are then held responsible for researching for information and presenting their findings in the classroom. Learners should be constantly challenged with tasks that require specific skills and knowledge (Norman, 1991:38). Learners in the technology classroom are challenged with tasks that refer to developing and applying specific design skills to solve a technological problem (DBE, 2011:8). This is in line with Vygotsky's zone of proximal development, which can be described as the distance between the actual development as determined by independent problem solving and the learners' level of potential development as determined through problem solving in collaboration with peers (Vygotsky, 1978:90).

Tam (2000:1-17) affirms that the teacher first has to establish at what stage of development the learners are to be able to provide learning activities that will build on learners' experience. Learners should also work face-to-face with each other when learning new concepts (Tam, 2000:1-17). According to CAPS (DBE, 2011:9), in the technology classroom teachers should develop an authentic problem to discover learners' previous knowledge, and learners should be stimulated to be innovative while solving the technological problems. According to Pool, Reitsman and Mentz (2013:465), teaching and learning approaches in technology are based on other fields of knowledge, and no previous teaching curriculum in South Africa exists for technology education. This is why technology teachers in South Africa lack the subject specific knowledge to teach the design process, which is the backbone of technology education.

A study by Potgieter (2012:964) shows the trends amongst the teaching strategies that are used to teach the design process. According to the findings of Potgieter (2012:964), the design process is taught in a rigid manner. He further establishes that many teachers create room for the design process to be interpreted differently, and believe that the steps in the design process should be followed in a particular order and that the prescription of the curriculum should be adhered to (Potgieter, 2012:964). Bailey's (2012) research shows that teachers do not really understand the nature of the activities involved in the design process.

It is most important to understand how learners best take in information. If the teaching strategy used is harmonised with how the learner learns, it improves the understanding of the learner in all levels of development. Teachers should help learners to become active participants in their own learning and to connect their learning situations with their societies. The following section presents a discussion of Pedagogic Content Knowledge (PCK).

2.7 PEDAGOGIC CONTENT KNOWLEDGE

The theoretical framework of this study was developed from social constructivism, Shulman's Pedagogical Content Knowledge model (1987), Argyris and Schon's (1974) notion of espoused theory and Theory in Use. This framework displays the most important aspects of teaching the design process. These aspects are: design process skills (investigate, design, make, evaluate and communicate), Pedagogical Content Knowledge, espoused theory and Theory in Use, and social constructivism.

The framework is intended to describe technology teaching with a focus on the design process. Ball, Hill and Bass (2005) suggest that what a teacher does in class depends on the teacher's knowledge and the classroom context. This framework was used in this study as it focuses on teaching, and the researcher considered it to be the most relevant. The framework was used to analyse and communicate the findings of this study.

The epistemology of constructivism will be discussed below to make sense of how learners learn in a particular context (Cobern, 1995). The assurance of constructivism is that learners are active in constructing their own knowledge and that social interaction is essential in knowledge construction. In other words, learning is a social activity in which learners are exposed to thinking processes and the fruitful problem solving of others in order to reach their own solutions. According to Vygotsky (1978), education is intended to develop an individual's personality and is also linked to the development of an individual's creative potential, therefore opportunities should be given for this creative development to take place.

The Zone of Proximal Development (ZPD) is the distance between a learner's ability to perform a task under the guidance of the teacher and the learner's ability to solve a problem independently (Vygotsky, 1978). The teacher has to first establish the stage of development of the learners before he or she can teach them (Vygostky, 1978). The process of scaffolding takes place when the task is given to learners on their level, as they will draw from their knowledge and previous experience. This means that in the technology classroom, teaching intervention from the teacher is needed to increase learners' cognitive development.

Mawson (2007) suggests that learners should be provided the opportunity to discover their own ability to make decisions, visualise their ideas during the design process, and engage in thoughts built on the recognition of their existing knowledge and ability. In this regard, Lewis (2006) contends that learners should be permitted to achieve creativity during the design process. This means that constructivism embraces the notion of learner creativity during the learning process (Bodner, 1986). The main aim of the teacher is to help learners to become active participants in their learning by helping them to make a meaningful connection between prior knowledge, new knowledge and the process involved in learning (Vygotsky 1989). In technology, the design process is seen as a higher cognitive task, therefore the teacher needs to understand the design process well to be able to assist learners when engaging with activities within the design process, which are investigation; designing; making; evaluation and communication.

In the social constructivist classroom, learners construct their own knowledge through social interaction. The classroom is set in a social context and learners work in collaboration with each other, learning new concepts in technology by giving meaning to them (Brooks & Brooks, 1993:123). By using the Social Constructivist Learning Theory in the technology classroom, the teacher changes from teaching a discipline as a body of knowledge to an exclusive emphasis on learning a discipline by experiencing the processes and procedures of the discipline (De Vries, 1997:24). The activities in technology are authentic and provide the experience of being personally relevant to the learners (Lewis, 1999:45).

The teacher guides development until learners can take responsibility for their own learning and utilise meta-cognitive skills (Lewis, 1999:43). Technology provides learners with an environment that fosters risk-taking. This risk-taking increases learners' self-confidence, motivation to learn, creative abilities, and self-esteem; and moves from a teacher-centred to a learner-centred approach (Wankat, 2002:3). Van Wyk (2007:3) argues that from a constructivist perspective, the primary responsibility of the teacher is to create and maintain a problem-solving environment in which learners are allowed to construct their own knowledge with the teacher acting as a facilitator and guide.

Teaching is a highly complex activity that draws from many kinds of knowledge. The types of knowledge that are drawn from are: knowledge of content, and knowledge of pedagogy (Shulman, 1986:9). According to Shulman (1986:9), knowledge of content and knowledge of pedagogy cannot be separated when teaching, but must be integrated as teachers are confronted with both while teaching. Shulman's (1987) framework was also used in this study as the researcher considered it detailed and a good fit as it allows for the achievement of creative skills during the learning process, unlike the other frameworks that were scrutinised.

According to Shulman (1987:8), Pedagogical Content Knowledge (PCK) is a special amalgamation of content and pedagogy that is uniquely the area of teachers, their own special form of professional understanding. This means that Pedagogical Content Knowledge distinguishes the teacher from a subject specialist. Shulman's definition of PCK refers to the conversion of content into a method that makes learning possible. Shulman (1987:8) lists seven fundamental knowledge domains in his professional knowledge base for teaching as follows:

1. Content knowledge;
2. General pedagogical knowledge with special reference to those broad principles and strategies of classroom management and organisation that appear to exceed subject matter;
3. Curriculum knowledge with particular grasp of the materials and programmes that serve as tools of the trade for teachers;
4. Knowledge of learners and their characteristics;
5. Pedagogical knowledge with a special amalgamation of content and pedagogy that is uniquely the territory of teachers, their own special form of professional understanding;
6. Knowledge of educational contexts, ranging from the working classroom, the governance and financing of school districts, to the character of communities and cultures; and
7. Knowledge of educational ends, purposes, and values, and their philosophical and historical grounds.

Bishop and Denly (2007:9) conceptualise the relationship between PCK and the other categories as a "spinning top" where all the categories in Shulman's knowledge merge into PCK as the teacher transforms the content being taught. Cochrane, De Ruiter, and King (1993) emphasise that knowledge of pedagogy, subject matter, learners and context plays an important role in the development of PCK. They use the term "knowing" to emphasise the active nature of PCK and also propose the synthesis and integration of the components of PCK. Gess-Newsome (1999) sees PCK as an intersection of subject matter knowledge, pedagogical knowledge and conceptual knowledge.

According to Grossman (1990:82), content knowledge, or pedagogy, on its own is not enough for quality teaching. Rather, sound knowledge of these is necessary, in addition, a transformation process is needed in order for effective teaching to take place. The implication is that when studying PCK, one cannot scrutinise subject matter knowledge, pedagogical knowledge and contextual knowledge on their own, and use these to make conclusions about the PCK of a particular teacher. PCK itself needs to be scrutinised to get an accurate reflection of the teacher's knowledge. Berry and Mulhall (2012) explain that PCK involves the teacher having the know-how to use alternative forms of representation and that some of these teaching strategies should be derived from research, whereas others should originate in the wisdom of practice.

William and Lockley (2012:34) state that PCK is topic specific, unique to each teacher and can only be gained through teaching practice. They continue, explaining that teaching is a complex and problematic activity that goes beyond the transmission of concepts and skills from the teacher to the learner. Furthermore, teaching requires varied, on-the-spot decisions and responses to the ongoing learning needs of learners. PCK, as defined by Shulman (1986), tries to link what he describes as the gap between the content that teachers are required and expected to know and the tools that they should use to make that knowledge accessible to learners.

An enhanced teachers' PCK stimulates a positive attitude towards teaching and brings about interest in teaching technology (Rohaan, 2010). This also refers to the knowledge of teaching strategies that are particular to the content being taught in a particular context. This implies that content knowledge alone is not enough to bring about learning in learners. The transferal of concepts to learners is crucial, hence the use of constructivism, PCK and espoused theory, and Theory in Use to frame this study. According to Shulman (1986:7), PCK is the most useful way of representing and formulating the subject to make it comprehensible for others.

According to Shulman (1986), PCK involves knowledge of and about the subject, beliefs about it and how to teach it; knowledge of when and what to teach; knowledge of why, what and how to assess; knowledge of learners' understanding of the subject; and knowledge of teaching strategies. Therefore, the researcher decided to use this framework because it forms an intersection of content knowledge and pedagogical knowledge specific to the content area. Using Shulman's PCK framework was of advantage during the data analysis as Shulman (1986) looked to understand how teachers make decisions about how to teach a design process, how they choose to represent an idea and to address learner misconceptions, and where teachers' knowledge comes from.

The viewpoint of the teacher meaningfully influences the development of creativity and collaborative learning, and these viewpoints are influenced by Shulman (1986:177). According to Shulman (1986), there is a need to know the contents and theories of the learning and sense of the contextual needs of the learning context. It is therefore imperative to know the PCK of the teacher as such knowledge shapes his or her views regarding the design process and will subsequently influence their teaching strategies.

Argyris and Schon (1974) indicate that teachers hold mental maps about how to plan, implement, and review their actions. They also assert that few teachers are aware that the maps they use to take action are not necessarily the theories that they explicitly espouse. In addition, Argyris (1980) contends that even fewer teachers are aware of the theories or maps that they use. In other words, this is more than just a difference between what the teacher says and does. There is a theory consistent with what teachers say and consistent with what they do. Hence, the concepts of Espoused Theory and Theory in Use were used in this study. Espoused Theory explains the action to others, but is not necessarily applied when conducting the action, whereas Theory in Use is explicit. Theory in Use is embedded in the logic of the action; it is the theory that commands the thinking of the action as Theory in Use is tacit. Teacher action may or may not be consistent with a person's espoused theory; therefore, it is never accidental or theoretical (Argyris, 1980).

To achieve a comparison between Espoused theory and Theory in Use, the researcher has to engage in reflective practice during observation. According to Argyris and Schon (1974), the goal of reflective practice is to create a world that more faithfully reflects the values and beliefs of the people in it through the revision of people's action theories. Within the social constructivist framework, using Shulman's (1986) Pedagogical Content Knowledge and Argyris and Schone's (1974) notion of Espoused Theory and Theory in Use, this study explored the teaching strategies that technology teachers employ to teach the design process.

2.8 DESIGN: AS THE ORGANISATION OF THE DESIGN PROCESS

According to Steward (2011:516), design refers to a plan of action. Visser (2009:192) agrees with Steward and further explains that design is a cognitive act that involves ill-structured problems that need to be solved, and thus a procedure ought to be constructed to bring about a solution. Matcham (2001:9) states that design has been highly developed within contemporary engineering and technology since the late 16th century. He further explains that engineers design authentic structures using sophisticated systems and procedures. However, design in technology education outlines the process that must be followed to construct an artefact while considering design skills. According to Miodduser (2009:4), design is the strategy used to solve technological problems by considering the following series of steps: an intensive analysis of the problem; identifying the link between elements of the problem; seeking a solution; and combining components of the problem.

Norman (2009:91) defines design as a purposeful, problem-solving thought that does not necessarily have a single answer. Keirl (2002:247) concurs that design is working with faulty information from a certain initial point and without exact answers. According to Buchanan (1996:564), design is about creating change in the made world; understanding the processes of change; and engaging in it. Cross (1990:136) explains that design is an activity that requires aptitude, skills, creativity and innovation. He further finds that aptitude can be gained from proper experience, skills can be developed with time, and innovation is the extent to which the design is a success or failure and depends on the learners' ability, which is influenced by social environment (Cross, 1990:136). Lewis (2005:37) argues that design is the concept situated within the engineering, while Mioduser and Levi (2008:267) further state that design is the use of a highly structured and mindful process.

Mioduser and Levi (2008:267) stress that design is the heart of technology and that design skills are used in different occupations. The word 'design', as defined in the Longman Dictionary of Contemporary English as the following meaning: "*a drawing or pattern showing how something is to be made; the art of making such drawings; the arrangement of parts in any man-made product; a decorated pattern that is not repeated or a plan in the mind."* Based on the above definition, it is clear that design is a process used to deliberately create a product to meet a set of needs. Although many writers explain design in different ways, one thing they all agreed upon is that design has always been an integral and necessary part of the curriculum for the teaching of artisans, engineers, architects, industrial designers and clothing designers.

Lewis (2005:37) argues that design is extremely important as it is situated within engineering. Leahy and Gaughran (2007:382) maintain that design is something that can be taught and is necessary to understand the concept design. They further add that the majority of teachers and learners do not totally understand the activities of design in the present education system. According to CAPS (DBE, 2003:12-14), design is a creative, intellectual, problem-solving process involving problem identification, planning, research, innovation, conceptualisation, prototyping and critical reflection. This process results in systems, services and products that may be unique or intended for mass production, hand-crafted or produced by machine. Furthermore, design is concerned with the issues of purpose, functionality and aesthetics in determining the social, cultural and physical environment that is to the benefit of society. Design is also aimed to quip learners with knowledge, skills, and values and attitudes that will enable them to adapt, participate and succeed in an economically complex society. Moreover, design promotes productivity, social justice and environmental sustainability (DBE, 2003:12-14).

Rowell (2002:216) states that in the classroom setting of technology activity, teachers use design as a critical mediator of learning. As can be seen from the above discussion, design is not a single activity but part of a larger process. To gain understanding of how to teach design, we need to know about and understand the stages of the design process. Duran and Sendag (2012:243) assert that it is essential that learners are taught the skills of investigating, analysing, interpreting, and reflecting. People who participate in the design process play various roles in the design process and influence the design of different artefacts. Dasgupta (1989:67) points out that a real need forms the basis for the definition of the design; however, need acts as the initial motivational force that provides the basis for starting the design work.

Lawson (1980) explicitly expresses that the universal feature of design is simply the intentional devising of a plan to create something new. The need or intention forms the basic elements of all designs or the problem to be solved. Many designers believe that the product of a design is a symbolic representation of an artefact to be implemented. According to Dasgupta (1989:78), design simulates what we want to make before we make it as many times as may be necessary to feel confident in the final solution. Simon (2000:181) explains that design is the structuring of existing situations to achieve a favoured situation. He further regards design as an imaginative shoot from present facts to future possibilities. According to Willem (1991:132), design is a creative activity that involves bringing something new and useful to society that has not existed previously. He also prefers to use the term ‘development’ to describe the transformation that occurs during design.

Abstraction is used to make generalisations, while elaboration provides great detail on the specifications of a design. Design is seen as decision making in the face of uncertainty, with high penalties for errors (Simon, 2000:181). Design problems are often described as 'ill-structured problems' because of their complexity and difficulties in determining their associated constraints and requirements. In general, further constraints are often discovered during the design work itself. Mostow (1985:44-57) agrees, and states that design is an activity with the goal of creating an artefact description that satisfies the constraints derived from the functional and performance-related specifications of the artefact and process through which the artefact is produced. Many researchers agree that the major part of designing involves the discovery and satisfaction of constraints, which apply both to the designed artefacts and to the processes and participants involved in the design activity.

In my opinion, design empowers learners to take a task from the beginning through to the realisation of the solution. This helps learners think in a creative and critical way. In other words, learners are able to use the knowledge and skills acquired during design for continuous development. The next section presents a discussion of the design process as it forms the backbone of technology.

2.9 DESIGN PROCESS

Barlex (2005:6) states that the design process could be considered central to the curriculum of technology. He further states that using the design process can present firm teaching and learning in the technology education classroom. A common understanding of the design process continues to grow as there have been several attempts to illustrate the design process. As an educational skill, the design process is the realisation of a need, a problem activity, and the act of developing solutions that meet authentic needs and opportunities (Jonsey, 1995:201). The design process is innovative and comprises complex procedures that emphasise the construction of artefacts (Mioduser, 2009:3). The design process is a technological process that seeks to foster creative and critical thinking, effective group dynamics, management skills, research and information handling, communication, and the socio-environmental awareness of learners (Gauteng Department of Education, 2005:5).

Hill and Anning (2001:121) conducted a study to establish the skills gained when engaging in the design process among learners aged four and nine. Their findings were that the frequent features of learners who engaged in the design process included good observation skills; the capacity for idea generation and communication; the demonstration of curiosity and the ability to ask questions; and engagement with the iterative process of design. Williams (2000:53) acknowledges that the design process and problem solving are used interchangeably. However, the design process deals with an ill-defined problem that might not begin with a problem, while problem solving does. According to Benenson (2001:731), in the design process, reflection and evaluation become integral components as they link defined problems with solutions. One of the main intentions of technological literacy is to present learners with tools to solve technological problems.

The main tool used to implement intentions is the design process, as used by engineers who create solutions to solve human needs and to enhance the quality of life (Dagan, Mioduser & Israel, 2003:254). Corkery, Grant, Roche and Romero (2006:11) add that within the design and making process, learners' ability to reflect on and evaluate the whole process is key. They further state that such reflections integrate an iterative process where learners begin to visualise their human-made environment, cross-examine it, make decisions concerning unanswered questions, and engage in creative activities based on these decisions..

It is clear that learners' reflection in consultation with the teacher at each step brings continuity to the design solution. Barlex (2005:5) states that during the design process, learners speculate about what might be. These speculations are developed, modelled, evaluated for fitness of purpose, realised as a prototype, and evaluated further against intention and impact. He further suggests that the design problem interacts with the design solution, with elements of both the problem and the solution only becoming apparent as the solution is developed in response to the problem. Gruber and Wallance (1999:95) suggest that collaborative learning is the best method for solving problems. They add that learning from the design process will accumulate from the sharing of knowledge among team members. This statement is in line with social constructivism, as discussed in Section 2.2.

Hong, Yu and Chen (2008:286) explain that when people start with a new design project, they try to make sense of it, and at the same time they become involved with it, they review what they know and need to know about the project in order to complete it, and they make comparisons and associations with other experiences. Davis (2002:81) agrees that an important feature of any technology curriculum is that learners should be provided with opportunities for engagement in meaningful learning experiences. Learners draw upon their existing knowledge of materials, tools, machines and systems, and gather and use information from a variety of sources. For the Department of Education (DOE) (1996:13), the design process provides an opportunity for learners to achieve technological capability. DeLuca (1992:5) defines the design process as a process that breaks down the complexity of a problem and allows learners to focus on the task, which could lead to a technological solution.

Dorst and Cross (2001:425-437) agree with the above statement and explain that the design process normally starts with an investigation into and a breakdown of the problem, followed by an intentional linking of the various components of the problem. DeVries (2011) states that the design process forms the central part of the South African technology education curriculum. Mawson (2003:117-128) concurs with DeVries, and maintains that the design process is the concept that undergirds technology education. According to Pudi (2007), the design process describes all the activities that should take place from the inception of the problem up to the end, where a technological solution is implemented. Therefore, it is important to investigate the teaching strategies that technology teachers use to teach the design process.

According to the DOE (2002), the design process engages learners in identifying a need; investigating; designing; making; evaluating and communicating their solutions. Lawson (2006) states that the design process is a complex process and is cyclical and iterative in nature. He further reports that the process is not linear, as possible solutions come from interactions and the refinement of the technological problem, as well as the ever-changing nature of the design. As for Williams (2000), the design process is a series of steps that are outlined by teachers, while learners are expected to follow the steps successively in their solutions. Rowel (2004) argues that the rigid nature of the design process does not provide enough room for developing the creative skills of learners, and suggests that there is a need for an alternative teaching approach to teaching the design process.

In this view, Hill (1998:203) directs attention to the difference between the design process employed in problem solving in real life contexts and in the classroom. In a real-life context, the design problem is seen as creative, dynamic and iterative, explorative, requiring the use of conceptual and procedural knowledge, and encouraging human and environmental interactions (Hill, 1998:203). In the classroom, the design process is based on closed design scenarios that are assigned by teachers and not related to the learners' environment (Hill, 1998:203). Hartfeld (2012:133) contends that both the design problem in real-life contexts and the design problem in the classroom have five important points: the assumption that the design requires problem solving; designing far exceeds problem solving; design problems are inevitably problems for which a single or set of solutions are expected; the realisation that the design outcomes are obviously satisfying solutions; and that the designer sets the problem. Hill (1998:207) states that technological problem solving is open-ended and creative. In the creation of a solution, there are states of order and disorder. However, practices reveal that it is also a systematic, step-by-step, guided process.

2.10 DEPARTMENT OF BASIC EDUCATION (DBE, 2011) - THE DESIGN PROCESS

This study uses essential design skills and sub-skills, as identified by the DBE (2011). These skills are used to explore how technology teachers teach the design process in the technology classroom. Figure 2.1 gives a summary of these design skills and sub-skills.

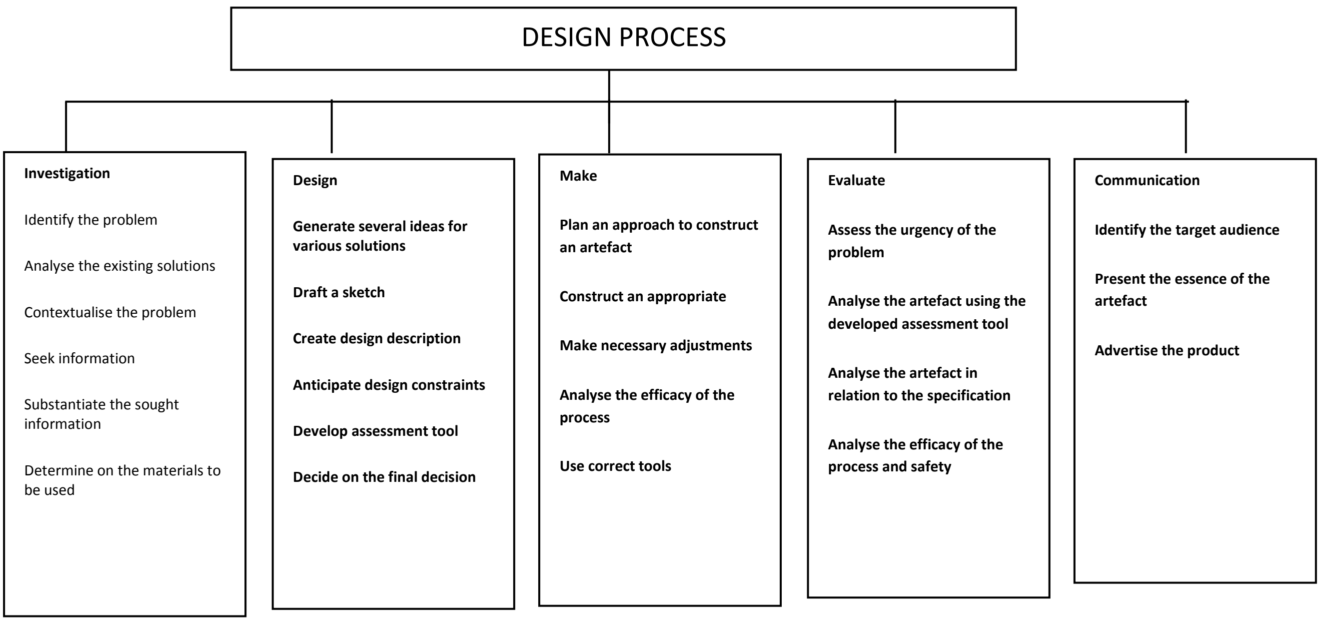

Figure 2.1: Essential design process skills, adapted from DBE (2011)

Investigation

Investigation requires learners to seek information, conduct research, grasp the concepts and gain insight, and determine new techniques. Before learners can engage with investigation, the teacher should set the scenario to describe the context in which the specific technological problem could meet a need (DBE: 2011). This activity allows learners to investigate the context in which the problem is located. According to CAPS, the unique features and scope of technology provides learners with the opportunity to use authentic contexts that are embedded in real-life situations (DBE, 2011:9).

Design

This activity requires learners to write the design brief after they have understood the problem. Learners should generate alternative solutions and write down their ideas. Design requires learners to be familiar with graphics such as two-dimensional and three-dimensional objects. Lastly, learners should choose the solution that best suits the specifications.

Make

This stage gives the designer the opportunity to choose and use suitable tools and materials to make the designed product with accuracy and control by measuring, marking, cutting or separating, shaping, joining and finishing a range of materials accurately and efficiently. The designer is also able to use measuring and checking procedures while making so as to monitor quality and changes, and adapt the design in response to practical difficulties encountered when making the product. The designer should demonstrate knowledge and understanding of safe working practices and the efficient use of materials and tools (DBE, 2011:50).

Evaluate

The learners, at this stage, evaluate the product based on self-generated objective criteria linked directly to the design brief, specifications and constraints using self-designed procedures for self-testing. They must then suggest sensible improvements or modifications that would clearly result in a more effective or higher-quality end product. The learners evaluate the efficiency of the plan of action followed, objectively demonstrate insight into the results of key decisions, and suggest improvements (DBE, 2011:50).

Communicate

In this aspect, the learners present ideas using formal drawing techniques, using two-dimensional or three-dimensional sketches, and circuits. They then choose and use the appropriate technology to combine and organise graphics and text effectively to produce a project portfolio, poster presentations, and case study reports that have a formal organised structure that is appropriate for the target audience. A record of the processes from the beginning up to the realisation of the solution should be carried out in the form of a project portfolio (DBE, 2011:50).

In the following different stages of the design process, Brown (2008:88) describes the design process as a system of three demarcated spaces, each with related activities, rather than as a sequence of arranged steps.

Table 2.2: The design process according to Brown (2008:88)

Inspiration	Ideation	Implementation
Information gathering and research.	Synthesis and discovery.	Execution of the vision.
Observations.	Exploring the problem.	Implementation.
Questions.	Design brief.	Final execution.
Discussion.	Development of conceptual ideas.	Testing.
Nature of the problem.	Evaluation.	Communicating.

Each of the activities of the design process listed in Table 2.2 will now be discussed. According to Brown (2008:88), inspiration refers to the way in which the problem is researched. This phase involves the exploration of information about the problem to be solved. In this phase, observations are made, questions are asked, and the discussion of ideas takes place. Ideas can be elaborated on or rejected (Brown, 2008:88). To deliver effective solutions to the identified problem, the learner has to understand the problem that needs to be solved (Brown, 2008:88-123). In the inspiration phase, more information is needed to refine the design (Brown, 2008:88). During this phase, an attempt is made to identify and understand the specific problem motivating the search for solutions and to determine and interpret the parameters of the design brief (Brown, 2008:88).

Based on Brown’s (2008) design process, the researcher has noticed differences after comparing this model with others. The said model emphasises aspects of inspiration, a feature that the prescribed design process for technology does not mention (DBE, 2011:68). The researcher is of the opinion that considering inspiration in design allows technology teachers and learners to gain deeper understanding of the criteria that the product needs to fulfil. Inspiration provides an opportunity for technology teachers and learners to explore the constraints of the design and be able to develop different conceptual ideas to ensure that the product meets the needs of the client. Exploring restrictions gives an opportunity for future technology scenarios since the constraints are outlined and designers are then able to improve their products by adjusting to and working around these restrictions.

Brown, (2008:8) states that delivering effective and sustainable design results that address the context, while considering the impact of the results on the system, requires designers to have a clear consideration and understanding of complex design problems, as well as the user's needs and expectations. According to Brown (2008:88), the starting point is the design brief, which comprises a set of constraints (Brown, 2008:88). The prescribed design process for technology should consider incorporating inspiration (research for design) (DBE, 2011:68). The researcher suggests that this feature will encourage learners to develop design thinking skills rather than just investigation-based skills. After the brief has been constructed, the designer should discover what people's needs are (Brown, 2008:88).

In CAPS (2011:12), the first stage is investigation, where learners find out about the need, and evaluate the existing products in relation to the key design. Research is performed at this stage and the skills of recording, identifying, predicting, comparing, classifying and interpreting are acquired. According to Brown (2008:88), investigation should take place after the learners have identified the problem and the design brief, with the learners stating how they intend to solve the problem, including the context. In this stage, learners are encouraged to work collaboratively with their peers and social learning thus takes place. Based on Brown's (2008:88) model, the most important stage is proposal writing because it comprises a statement showing what needs to be done in order to solve the problem. However, with regard to CAPS (2011:68), the design stage is where possible solutions are written, including any drawings made.

The process of synthesis is where the designer distils what she or he saw and heard into insight that can lead to solutions or opportunities to change. This is part of the second stage, ideation (Brown, 2008:88). This stage is about openness, curiosity, optimism, and a tendency towards learning through doing and experimentation (Brown, 2008:88). Designers are encouraged to come up with many ideas. In this stage, learners are assisted with the process of grouping and sorting out ideas (Brown, 2008:88).

The last stage of Brown's (2008:8) design process is implementation. This is when the best generated ideas during ideation are turned into a concrete, fully considered action plan (Brown, 2008:88). The essence of the implantation process is prototyping, turning ideas into actual products and facilities that are then tested, iterated and refined (Brown, 200888). Through prototyping, the design process seeks to discover unexpected implementation challenges and unintended results in order have more reliable success. Prototyping puts learners at ease and helps them to develop communication strategies to communicate the solution (Brown, 2008:88). The following section deals with empirical studies on design.

2.11 EMPIRICAL STUDIES

2.11.1 Asunda and Hill's research

Asunda and Hill (2007) studied the features of engineering design in technology education and noticed that the design process in engineering was an iterative, developmental process, as well as a complex activity that comprises a problem, product and process. Thus, they explain that the design process in engineering is a distinct activity that entails a systematic way of developing solutions through: defining a problem; identifying a problem; conceptualising possible solutions; conceiving a solution; developing; and production. This supports Lawson's (2006) claim that the design process is a complex process that has a cyclical and iterative nature in that solutions come from interactions between parallel refinement and the ever-changing nature of the design. For teachers to successfully teach learners the design process, it is essential that they should first identify with the design process and its practice (Wong & Siu, 2012).

The researcher is of the opinion that attention should be directed to the disparity between the design process applied in problem solving for real-life contexts and that which is found in the classroom. Asunda and Hill (2007) state that in problem solving for real-life contexts, the design process is seen as a creative, dynamic and iterative process that engages exploration; joint conceptual and procedural knowledge; action; and encourages considerations regarding technology, learner and environmental interactions. This opposes what is typically found in schools. The design process cycle is based on closed design briefs that are teacher assigned, which are not related to the learners' environment.

2.11.2 Makgato's study

Makgato (2011) conducted research that outlined the key technological process skills in teaching technology education. The study was focused on discovering if teachers understand the technological process skills required when teaching technology. His findings were that the teachers were able to identify technological process skills. The researcher realised that the findings were remarkable because identifying technological process skills could have an impact on teaching and learning in technology education. However, identifying technological skills does not mean that teachers can relate and implement these skills in the teaching and learning of the design process in technology education.

It is thus important for technology teachers to have an understanding of and expertise in the teaching of the design process. Learners are capable of applying the procedures given to them by their teachers as they make their own designs. This leads one to question the knowledge base of technology teachers in terms of the design process.

2.11.3 Potgieter's study

A study carried out by Potgieter (2012) shows the trends amongst the teaching strategies that are used to teach the design process. According to his findings, the design process is taught in a rigid manner. He further established that while many teachers create opportunity for the design process to be interpreted differently, most of the teachers believed that steps in the design process should be followed in a particular order and that the prescription of the curriculum should be adhered to. However, Rowel (2004) argues that the rigid nature of the design process does not provides learners with opportunities to develop creative skills, and also suggests that there is a need for an alternative teaching approach for the design process. Based on the above argument, the researcher finds it to be important to explore the teaching strategies that technology teachers apply when teaching the design process.

2.11.4 Kola's study

In his study, Kola (2015) disclosed that technology teachers were unproductive in supporting learners to evaluate each step of the design process. The study further revealed that technology teachers were unable to follow the design process when solving technological problems. According to this study, technology teachers should understand the design process to be able to enhance critical thinking skills during technology lessons.

I considered this study as an inspiring revelation, having an effect on the teaching of the design process. Conceptualisation of critical thinking was essential in teaching technology. The study added value to the literature review as critical thinking skills are part of the design process. It is influential to combine critical skills in teaching the design process such that learners are exposed to different teaching and learning strategies.

2.11.5 Mapotsa's study

Mapotsa (2012) conducted action research with 18 technology teachers form selected secondary schools in the Limpopo Province. His findings were that some teachers in those schools could not teach technology, and some were unable to plan a technology lesson. This is an indication that teachers are still struggling to teach technology and to structure technology lessons using the design process.

2.12 CONCLUSION

This chapter gave an overview of the literature on social constructivism, the theory in which this study is located. The Social Constructivism Theory embraces social learning, which encourages collaborative learning in the designing and making of artefacts that will solve a technological problem. In this theory, learners learn in groups and share knowledge. Learners also construct knowledge through interacting with each other in their environment. Social constructivism is considered to be appropriate in teaching technology since learners are required to work in groups when solving technological problems.

The design process is the backbone of teaching technology; while content knowledge and procedural knowledge play a vital role in teaching the design process. Technological problems are solved collaboratively, which makes social constructivism influential. However, the recommended design process does not emphasise the core of social-cultural learning. The CAPS document states clearly that technological problems are solved collaboratively, whereby learners collaboratively investigate technological problems in their environment, which makes social-cultural learning vital.

This chapter referred to different authors who define the design process, and it was concluded that emphasis is placed on the skills of investigation, designing, making, evaluating and communicating the whole process. Therefore, it is vital to explore the teaching strategies applied to encourage learners to acquire design process skills. The literature is silent about the specific teaching strategies that teachers should apply when teaching the design process.

It is the responsibility of the teacher to create a classroom environment where learners can creatively solve technological problems collaboratively. To achieve this, it is expected that teachers draw insight from understanding and procedural knowledge of the subject. Teachers need to understand the design process in order to help learners when engaged with activities related to design.

The literature highlighted some challenges that teachers experiences when teaching the design process. Based on the above statement, the researcher concludes that the understanding of the design process is crucial as learners have to understand the procedural and the conceptual aspects of a technological problem before they have to solve it. The theoretical framework that guided this study was also discussed. The following chapter explores the research design and methodology employed in this study.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

3.1 OVERVIEW OF THE CHAPTER

This chapter presents the research approach, research paradigm, and population and sampling used in this study, the choice of which was influenced by the purpose of this study. This is followed by a discussion of the data collection strategy, as well as the instruments that were used to collect data. Later, the data analysis and the quality criteria of the study are explained. Lastly, the ethical considerations of this study are clarified.

3.2 RESEARCH DESIGN

This study comprised a case study design. A case study is described as a strategy of enquiry in which the researcher explores in-depth events, activities, processes, one or more individuals in time during a certain activity (Creswell, 2009:13). Yin (2009:20) maintains that a case study is an empirical, inquiry-based approach that investigates a phenomenon within its real-life context. He further notes four applications where case studies can be used:

1. To explain the assumed fundamental links in real-life interventions that are too complex for the study;
2. To designate an intervention and the real-life context in which it occurs;
3. To clarify certain topics within an evaluation, again in a descriptive mode; and
4. To clarify those situations in which the intervention being evaluated has no clear, single set of outcomes (Yin, 2009:19-20).

A case study was used in this study to obtain an in-depth analysis of the topic under study. Four technology teachers were approached to describe their teaching of intervention in a real-life context. The case was purposefully selected to explore the effectiveness of the teaching strategies that technology teachers apply to teach the design process.

3.3 RESEARCH APPROACH

A qualitative approach was used in this study to explore the effectiveness of the teaching strategies that technology teachers apply when teaching the design process. This was done in schools, which is the context within which teaching and learning takes place (Yin, 1994:13). The reason for choosing a qualitative research approach was because it accepts the complex and dynamic quality of the context, and also describes the real-life context in which the interventions occur (Merriam, 2001:238). The qualitative data in this study was collected through interaction with the four technology teachers in their context, through interviews and observations to explore the effectiveness of the teaching strategies that they applied to teach the design process. The qualitative approach comprises the ability to establish persuasive opinions of how things work, and allows the creation of cross-contextual overviews (Yin, 2009:28). This is confirmed by Creswell (2005:515), who explains that the qualitative approach defines and investigates people's individual and collective social actions, beliefs, thoughts and perceptions.

3.4 RESEARCH PARADIGM

This study is located in the constructivist paradigm. The constructivist paradigm enables the researcher to reveal deeper sense and allows the researcher and the participants to jointly co-construct the findings from their interaction and interpretations (Ponterotto, 2005:129). A constructivist paradigm was followed to explore the effectiveness of the teaching strategies that technology teachers apply to teaching the design process. The ontological, epistemological and methodological implications of choosing the constructivist paradigm will now be discussed.

3.4.1 Ontology

According Ponterotto (2005:130), ontology involves the nature of reality and presence. In accordance with the constructivist paradigm, reality is subjective and influenced by experience and perspectives (Ponterotto, 2005:130). The implication here is that people construct multiple realities and interpret these multiple realities differently. Ponterotto (2005:130) advocates that in the constructivist paradigm, multiple realities are explored and constructed through human interaction. Therefore, the researcher either endeavours to reveal a specific reality as described by the participants, or tries to confirm certain fixed assumptions (Ponterotto, 2005:130). As a result, another researcher might arrive at a different conclusion while using the same data (Ponterotto, 2005:130).

Botha (2010:33) emphasises that ontologically, technological problems are solved in a social and physical environment where learners are grouped according to their diverse knowledge and skills. The experiences and the multiple settings of the technology teachers who participated in this study are vital. For this reason, the technology teachers were interviewed and observed in different schools (settings) to understand their environment.

3.4.2 Epistemology

Epistemology addresses the relationship between the inquiring and the inquired (Ponterotto, 2005:131). According to Ponterotto (2005:131), the constructivist paradigm supports a transactional and subjective standpoint, which emphasises that reality is socially constructed. The interaction between the researcher and the participants is significant when transcribing and describing the experience of the real life of the participants (Ponterotto, 2005:131).

The participants were interviewed to give them the opportunity to discuss their experiences and to explain how they taught design process skills in their technology classrooms. Their experiences were transcribed and described. Observations were conducted to confirm what was said during the interviews. However, the researcher has noted that the participants were struggling to teach the design process.

3.4.3 Methodology

According to Ponterotto (2005:132), methodology refers to the process and the procedures involved in conducting the research. Constructivists hold a naturalistic research design through which co-operation between the researcher and the participants is promoted. Naturalistic research often calls for qualitative researchers to use direct contact interviews and observations of the participants, which was the evidence collected in this study.

The literature provided Shulman's (1986) theory, as well as that of Argyris and Schon (1974) within the social constructivist conceptual framework, which was used to formulate the interview questions and the observation schedule, and then used to analyse the data in this study. The sampled technology teachers expressed their experiences verbally and were also observed in their classrooms while teaching technology. Considerable data was collected in order to understand and interpret the multiple realities of these participants.

3.5 POPULATION AND SAMPLING

Technology teachers in the Rakwadu circuit in the Mopani district of the Limpopo Province were considered to be the population for this study. The Rakwadu circuit is situated in the southern part of the Mopani district. Most of the schools in this circuit are categorised under Quintile 1, which is an indication that they are in a deep rural area. The Rakwadu circuit was selected as the population of this study because the researcher teaches in this circuit.

Purposeful sampling was used in this study. According to Creswell (2012), purposeful sampling is when researchers select individuals and sites to understand a central phenomenon. The phenomenon in this study was the effectiveness of the teaching strategies that technology teachers apply to teach the design process in the classroom. Patton (2008:233) states that purposeful sampling is a non-random method of sampling where the researcher selects "rich information" cases for in-depth study.

The researcher purposefully selected four teachers who were teaching Grade 8 technology in in a deep rural area. The purpose of selecting technology teachers was based on the findings that teachers who teach technology are struggling to teach the subject in South Africa (Potgieter, 2012; Mapotse, 2012; Kola, 2015; Makgato, 2011). Design process skills include investigation, design, make, evaluate and communicate (DBE, 2011:12); these are the design skills that Grade 8 teachers should support learners to develop.

According to Merriam (1998), purposeful sampling takes place when the researcher selects a sample from which the greatest amount of information can be learned. Patton (2008:235) affirms that the advantage of purposeful sampling is that any common patterns that emerge from great variation are of particular interest and value in capturing the core experience and central shared dimension of a setting. To achieve the purpose of this study, teachers with suitable qualifications and experience in teaching technology were selected.

The researchers' assumption was that teachers who are qualified and have experienced in teaching technology would be able to apply different teaching strategies when teaching the design process. Technology teachers who obtained the Advanced Certificate in Education (ACE) were considered as experienced and those who had taught the subject for six years were considered as novice teachers in this study. In qualitative research, saturation refers to a sense of closure that transpires during data collection once new information is no longer forthcoming (Powers & Knapp, 2011:115-116). A minimum of four schools around the Rakwadu Circuit in the Mopani district were visited in order to identify Grade 8 technology teacher participants and these were interviewed to determine their experience in teaching technology.

3.6 DATA COLLECTION

The interview questions were used to obtain information relevant to this study. Patton (1980) considers that during interviews, the researcher finds out things that cannot be directly observed, such as thoughts, feelings and intentions. Interviews allow the interviewer to see things from the participant's perspective (Merriam, 1998). Semi-structured interviews were conducted with the selected technology teachers. In a semi-structured interview, certain information is desired from all participants, while the interview is guided by a list of questions to be explored. The interviews questions were developed from the stages of the design process (DBE, 2011:68) to allow the researcher to respond to the situation at hand (Merriam, 1998).

Observations (Appendix C) were used to verify what was said during the interviews. An observation schedule was developed from the DBE's design process (DBE, 2011:68). According to Bennet (2005:50), interviews and observation are complementary and offer a comprehensiveness that would otherwise not be offered in this study with only one of the two methods. The two methods were used together to enhance the quality and richness of data. Interview questions and the observation schedule were established from the essential design process skills discussed in Section 2.7 and Figure 2.1 (see Appendix C for an example of the observation schedule).

3.6.1 Interviews

In this study, the researcher used semi-structured interviews (Appendix B). The purpose was to obtain information of a qualitative nature from the participants regarding their perspectives on the design process. Semi-structured interviews are defined as an informal conversation, and entails being open to hearing what people have to say, being non-judgmental, and creating a comfortable environment for the participants to share (Longhurst, 2010:56). The semi-structured interviews were used to probe for information regarding the participants' views on the design process; the teaching strategies used to teach the design process; reasons for using the mentioned teaching strategies; and activities given to learners during technology lessons.

Open-ended questions a were used, which give the participant an opportunity to give his or her own answers to the question (Reaves, 1992:106). The open-ended questions were used to gain biological information from the participants, and to establish how they taught the design process. Six open-ended questions were designed in a way that the researcher could achieve an understanding an some insight into the knowledge and skills of the participants with regard to the teaching of the design process in their Grade 8 classes.

The first question required the demographic information of the participants, for example, their name, age, qualifications, gender, teaching experience and number of years teaching technology. This information helped the researcher to build a profile of the participants. The last questions dealt with the stages of the design process. The aim of these questions was to give the researcher insight into whether the participants saw the design process as the backbone of teaching technology, and to compare their answers with what the literature advocates. The rest of the questions were asked as to what they did when teaching each step of the design process. This provided the researcher the opportunity to establish whether the participants understood and were able to teach the design process.

The focus of the interviews was on the way in which the teachers applied teaching strategies to teach the design process. The interviews were recorded and transcribed verbatim. The researcher used the transcribed records to gain answers to the research questions. The researcher also took notes during the interviews to capture important aspects.

3.6.2 Observations

Observations afford the researcher the opportunity to gather live data from live situations (Cohen, Manion & Morrison, 2002:305). Observations enable the researcher to verify the information obtained during the interviews. According to Yin (1994:80), there are two types of observations, direct observations and participant observations. Direct observations concern the reality of events in their contextual form. In this study, direct observations were chosen as the researcher limited discussions to the teacher only, and there was no interaction with the learners. Lancy (1993:242) highlights that observations should include critical details of a person, place and activity, date and time. Moreover, the notes from the observations should be broken into capable blocks and the researcher should decide when sufficient data have been collected.

An observation schedule (Appendix C) was designed with the assistance of the design process stages to observe the teaching of technology. The observation schedule focused on the following aspects: how the lesson was introduced; teaching strategies applied to teach the design process; how learners participated in the learning activities; and all the activities in which the learners were engaged. The purpose of the observations was to gain insight into the participants' practice (Theory in Use) and to capture the transformation of the participants' espoused views of the design process, if any.

Observations in this study were conducted during the third term when the topic of mechanical systems and control was addressed. The observations were conducted in the technology classroom and four teachers were observed while teaching. Field notes were taken during the observations while the participants presented their lessons. The observations were analysed using the Rogan and Grayson (2009) construct of profile of implementation scheme. The reason for this was that its levels fits well within the context of the study.

The researcher observed lessons lasting for 30-45 minutes in the teaching schedule without disrupting the school timetable. The observations allowed the researcher to confirm the information that was prominent during the interviews. The observations contributed to the realisation of the purpose of the study (see Appendix C for the observation schedule).

3.7 DATA ANALYSIS

The data was analysed using social constructivism and the design process, and was presented in a narrative form. An inductive approach was also followed, which primarily involved detailed reading of the raw data in order to derive concepts, themes or a model as the researcher drew interpretations from the raw data (Thomas, 2006). The aim of the data analysis of qualitative research is to discover patterns, concepts, themes, and meanings (Patton, 1990:109). According to Hatch (2002:148), data analysis is a systematic search for meaning, and is a way to process qualitative data so that what has been learned can be communicated to others.

Observations were used to verify the findings obtained from the interviews. Firstly, the context of each observation was provided, secondly, the lesson presentation, and then a discussion. Afterwards, the findings were discussed in detail. Using the interviews and observations to gather data allowed the researcher to ensure trustworthiness by employing triangulation. Triangulation refers to understanding a situation by combining different ways of looking at a situation (Silverman, 2010:277).

Nieuwenhuis (2007) states that the researcher should follow a specific type of analysis to analyse information, and use a narration guided by certain procedures. This study engaged a multi-case study approach. The interviews and observations were used to collect the data, which was analysed using a cross-case analysis. The three research questions posed in this study were used for organising the analysis. In this approach, all relevant data from the interviews and observations were collated to provide a collective answer to each research question. This was in line with the explanation given by Cohen, Manion and Morrison (2011) that qualitative data involves organising, accounting for and explaining the data in terms of the participants' conceptualisation of the phenomenon being explored, noting patterns, themes and categories, and regularities.

3.8 STANDARD OF RIGOUR FOR RESEARCH

According to Guba and Lincoln (1981), the trustworthiness of qualitative research can be established by using four strategies: credibility, transferability, dependability and conformability. The above procedures were followed to ensure that the data collected meant what it was thought to mean. The four strategies are discussed briefly in the following sections.

3.8.1 Credibility

To ensure the credibility of this study, a detailed description of the context, participants and themes is provided (Creswell & Miller, 2000:128). To enhance the credibility of the data, the researcher engaged in the triangulation of data, as well as member checking. This means that the data collected via interviews and observations were triangulated. Triangulation aided in categorising and classifying the contradictions encountered during data collection.

Four cases were studied using multiple data sources in the form of interviews and observations, and patterns were identified and coded. Member checking is a research procedure used to ensure the credibility of the study. Member checking involves taking the interview transcript or observation transcripts back to the participants so that they can check its accuracy (Carlson, 2010). In this process, participants are provided with an opportunity to elaborate, clarify or confirm aspects of the interview in order to ensure that their views, experience and perceptions were captured accurately during the interview. Thus, in this study, member checking was adopted to guarantee credibility. The same research questions were applied to all participants to avoid bias, which could influence the interpretation of the data.

3.8.2 Transferability

Transferability refers to the degree to which the results can be applied to other situations. With a case study, the findings cannot be generalised to the rest of the population, but might shed some light on similar contexts (Trochim, 2000). This study provided a detailed description of the context to allow the reader to make decisions regarding the differences and similarities attained from the cases studied. Complete descriptions were provided through transcripts during the interviews and observations.

3.8.3 Dependability

Dependability is the degree to which one's findings can be replicated and if the study were to be repeated, if the same results would emerge (Cohen, Manion & Morrison, 2007). This study employed an audit trial, which enables the reader to understand the context of the research, which influenced the conclusions that were drawn from this study. The researcher used the framework to develop the interview questions and observation schedule. This added to the trustworthiness of this study. The research results and findings are presented and multiple cases were studied during the interviews and observations for triangulation purposes to establish the dependability of the study's findings.

3.8.4 Confirmability

Member checking was applied in this study to confirm the findings of the study (Ary et al., 2010:499). The participants were provided an opportunity to verify the accuracy of the verbatim transcripts extracted from the interviews, and to comment on the field notes taken during the observations.

3.9 ETHICAL CONSIDERATIONS

In this study, certain ethical considerations were maintained. To conform to the appropriate ethical considerations, the postgraduate research policy of the University of Limpopo (Faculty of Education) was consulted. The research policy clearly outlines the procedures and regulations, and also the application forms that provide guidance in terms of ethical considerations.

The researcher applied for ethical clearance at the Faculty of Education, and permission was granted to collect data for this study. It was emphasised that upon completion of the research, the declaration should be submitted to confirm that the conditions were adhered to. The clearance certificate shows that the research was approved by the Faculty of Education's ethics committee. The participants were treated fairly, permission to conduct the research was requested from all relevant authorities, the principle of confidentiality was adhered to, and the participants were treated with respect.

Academic research is about creating a community of scholars that is sustained by trust and scepticism (Potter, 2002:156). Permission was requested from the Circuit Manager (see Appendix G) and Appendix G confirms that permission that was granted. The principals of the four schools were consulted and the purpose of the study was explained, and permission was also sought to approach the technology teachers. Therefore, letters of informed consent from the principal and technology teachers are attached (see Appendix E and F). The technology teachers were given consent forms that outlined the purpose of the study. It was further emphasised that participation was voluntary and that the participants had the right to discontinue their participation in the research at any time without any consequences.

Informed consent forms were sent to the parents of the Grade 8 classes of the sampled schools due to the fact that learners were present in the classroom during the observations. The focus of this study, however, was on technology teachers. It was emphasised that the researcher would not disturb the lesson, and that the findings obtained from this study would be used for the purpose of this study only.

Pseudonyms were used to protect the names of the schools and the participants during the observations and interviews (see Appendix A & B). The researcher strived for academic rigour in analysing and reporting the data. According to Leedy and Ormrod (2005:101), researchers should report their findings in a complete and honest way without misrepresenting what they have done. This has been adhered to in this study.

3.10 SUMMARY OF THE CHAPTER

This chapter has outlined the research approach of this study, which was qualitative. This was used to explore the effectiveness of the teaching strategies that the technology teachers applied to teach the design process. The reasons were given as to why this study adopted a qualitative approach and also the use of a case study within the social constructivist paradigm. The constructivist paradigm was justified by looking at the characteristics and the assumptions thereof, as related to this study.

The population and sampling were explained in detail. An explanation was also given as to why purposeful sampling was used. This chapter also gave a detailed description of the methods used for data collection, which were interviews and observations. This chapter gave a description of the methods of data analysis and the chapter ended with a discussion of the aspects of credibility, transferability, dependability, confirmability and the ethical considerations adhered to in this study. The subsequent chapter present the findings of the study.

CHAPTER 4 FINDINGS

4.1 INTRODUCTION

The purpose of this study was to explore the effectiveness of the teaching strategies that technology teachers apply to teaching the design process. The following objectives were addressed: determining the teaching strategies that technology teachers apply to teach the design process; evaluating the effectiveness of the selected teaching strategies; and understanding the experiences of technology teachers in teaching the design process. This chapter presents the results and findings of the study. The results and findings were based on the data obtained from the interviews and observations. The chapter starts with an outline of the demographic information of the teacher respondents to show their age, gender, qualifications, teaching experience and number of years teaching technology education. the demographical information helps to create the context for Grade 8 technology within the Mopani district. This is followed by a discussion of the participants' responses as obtained from the interviews. These are presented in a narrative style and conclusions are drawn in agreement with the teachers' responses. A discussion of the observations will then be presented whereby the context will be provided and followed by a summary of each observation.

4.2 DEMOGRAPHIC PROFILE OF THE PARTICIPANTS

The data acquired from the demographic profiles of the participants was used to create a context for the Grade 8 technology teachers. Table 4.1 summarises the demographic profiles of the participants, focusing on age, gender, qualifications, teaching experience and years teaching technology.

Table 4.1: The demographic profile of the participants

Name	**Age**	**Gender**	**Qualifications**	**Teaching experience**	**Years teaching technology**
Thulani	50-55	Male	SPTD	20-25	9
James	40-46	Male	BA & ACE tech	10-20	4
John	32-39	Male	STD & ACE tech	15-20	6

Thandi	44-50	Female	STD & ACE tech	22-30	8

In terms of the teachers' qualifications and experience in teaching technology, three of the four teachers met the requirements as stipulated in the sampling in Chapter 3. Teachers who held an Advanced Certificate in Education (ACE) as their highest qualifications were considered as experienced and those who only attended the workshop were considered as novices. In school A, it was discovered that the respondent (Thulane) did not have any qualification in technology, but attended the workshops offered by the Limpopo DBE to support the implementation of technology education, and had also taught the subject for a period of nine years.

At a glance, an assumption could be made that these respondents should be au fait with the design process as they have studied and attended technology workshops on the design process. However, there was a disparity between the number of years of teaching technology amongst these teachers. This disparity indicates that more teachers need to be trained to teach technology due to multiple factors, such as teachers resigning and the re-deployment of teachers due to a drop in learner enrolment. Another finding from the demographic information was that technology education remains a male dominant territory. Ninety percent of this sample of technology teachers were males.

The data were collected by means of semi-structured interviews and classroom observations. The interviews were conducted first, and the following section provides a discussion on the interview process.

4.3 DATA FROM THE INTERVIEWS WITH THE RESPONDENTS

Eight questions, resulting from the design process framework, were used which focused on the skills of the design process. These questions were used to conduct the interviews (see Appendix A). The first question explored the teachers' understanding of teaching strategies and how they applied these teaching strategies to teach the design process in the classroom. The rest of the questions were on the design process stages.

The findings will be presented as follows: the question asked will be stated, followed by a discussion of the respondents' answers. The discussion will be related to Shulman's PCK and Argyris and Schon's Espoused Theory and Theory in Use, and this will be done in a narrative form. The utterances of the respondents will be provided to support the discussion.

Subsequently, conclusions will be drawn based on the teachers' responses. In the following section, Question 1 is presented. The researcher used the design process (CAPS) as the framework to develop these questions.

Question:1 How do you support learners to gather data when investigating?

The aim of this question was to give participants the opportunity to clarify and explain the ways in which they supported learners to identify a problem and gather information related to the problem. Investigation is a fundamental skill used in the design process. The skills involved in investigation are: recording; identifying; comparing; classifying; and interpreting (DBE, 2011:12). In this stage, learners have to investigate what other designers have already done in relation to their design.

The participants highlighted that learners should gather information independently. Learners are given technological problems that encourage them to gather data, record findings, identify the most important information, and then compare and interpret the information. The following are the quotes from the participants on how they supported learners to gather information.

> *Thulane: Learners should gather information on their own as this will help them to be creative.*
>
> *James: For learners to collect the information needed to solve the problem I usually give the homework to seek for information.*
>
> *John: In design process learners investigate the problem and gather information. I give them the problem and let them gather necessary information.*
>
> *Thandi: Learners in technology should be creative and critical thinkers. I give them the problem and allow them gather data.*

The participants indicated that they encouraged learners to gather information on their own in diverse and creative ways as far as design-related problems are concerned. Furthermore, the learners were put in control of their learning. This finding concurs with Vygotsky (1978), who refers to this as autonomous knowledge. Vygotsky (1978) maintains that learning must culminate in learner independence, and that autonomous knowledge depends on a specific situation. One can conclude that the participants' years of experience in teaching technology has impacted how they view the teaching of the design process.

These respondents indicated that they encouraged problem-solving in diverse and creative ways as far as seeking information was concerned. Furthermore, they allow learners to take control of their learning during the design process (*they gather information on their own).* This particular finding concurs with what Vygotsky (1978) refers to as the zone of proximal development, in which learners develop their own learning skills. Therefore, it can be deduced that these four respondents had a learner-centred classroom.

Question 3: How do you support learners to understand technological concepts?

The question was asked to determine the instructional strategies that the participants used to help learners understand technological concepts. According to CAPS (2011:8), understanding technological concepts enables learners to use those concepts responsibly and purposefully. Understanding concepts refers to the ability to articulate the meaning of the word in different contexts.

The respondents revealed that they provided learners with the opportunity to explore and share their understanding. The respondents further indicated that the concepts used in technology education are difficult to explain to the learners. Learners were grouped and instructed to search and discuss the meaning of each given concept. After a discussion on the concept and gaining an understanding of it, learners were supposed to determine how the particular concept could help them in solving a technological problem.

The following are the statements of the participants on how they supported the learners to understand technological concepts:

> *Thulane: I give learners opportunity to search for the meaning of the concept in the dictionary.*
>
> *James: I sometimes allow them to search for the meaning of the concept in the glossary at the end of the textbook I use.*
>
> *John: I write the definition on the chalkboard and ask them to use the concept in their own sentences*
>
> *Thandi: I give them an opportunity to explore and share knowledge especial in finding the meaning of the concept.*

The respondents found it difficult to help learners to understand concepts. Once a concept is presented, learners should be given opportunity to clarify that concept, because in clarifying the concept, learners attempt to understand and contextualise it. However, it seems that the respondents were unable to teach learners to understand technological concepts. Technology teachers should teach learners to combine thinking and do so in a way that links abstract concepts to concrete understanding (DBE, 2011:9).

Question 4: Are learners able to develop new techniques to solve a technological problem?

The respondents interpreted the design process as the way of developing learners to be critical and creative thinkers. In other words, for these teachers, there are several solutions in the design process to any given problem, and various ways of working towards the solution to the identified problem. The suggestions made were that learners should be free to develop new techniques in solving a technological problem, as reflected in the quotes below:

Thulane: To show creativity they must have new techniques.

James: Sometimes learners may have better solution than what I thought of.

John: Yes, as they have to create their own design.

Thandi: It depends, usually I follow the design process step by step.

CAPS stipulates that during the design process, learners are expected to generate a possible solution and choose the best solution. They are also expected to develop new techniques to solve a technological problem (DBE, 2011:68).

The respondents' views on developing new techniques indicate that learners were able to develop new techniques (*to show creativity).* Furthermore, the learners were allowed to create their own designs. This means that the learners applied their minds to the task. However, it appears that the respondents did not create sufficient time for the learners to develop their new techniques. The researcher is of the opinion that learners could develop new techniques in solving technological problems if they are provided the opportunity to do so.

Question 5: Are learners able to write a design brief, generate alternative solutions and use 2D and 3D drawings?

The aim of this question was to find out from the respondents if the learners could write a design brief, generate alternative solutions, and use 2D and 3D drawings while solving technological problems. According to CAPS (DBE, 2011:68), learners need to design after the problem is fully understood. Design involves writing a design brief; generating possible solutions; drawing these ideas, which requires graphic skills; selecting the best solution; and preparing a working drawing. The respondents indicated that the learners were able to write a design brief to explain the problem and how they intended to solve it. The following are the utterances of the respondents in this regard:

> *Thulane:* *Yes! They write as they have to state the problem and the procedures they use to solve the particular problem.*
>
> *James:* *When you design an artefact you have to write all the procedures you followed to reach the solution. I encourage them to write a design brief.*
>
> *John:* *I am having a challenge on 2D and 3D drawings, so I usually ask for assistance from mathematics teacher.*
>
> *Thandi:* *They write and draw so many solutions.*

The respondents only mentioned two aspects that needed to be followed during the stage of writing a design brief. According to CAPS (DBE, 2011:68), during the design process, learners have to demonstrate competence in writing a clear design brief, a list of specifications and constraints, and generate possible solutions using graphic or modelling techniques. In the respondents not mentioning all of the requirements for compiling a design brief, this may show a lack of understanding of all the skills needed for a design brief. Therefore, it is essential to know how the design process is represented if it is to be used to solve technological problems.

It appears that the respondents found it difficult to support learners in generating alternative solutions and using 2D and 3D drawings. None of the respondents mentioned how they taught learners to use 2D and 3D and express alternative solutions to the problem. Learners should be taught to recognise and describe the context of a technological problem, and to identify possible constraints. The respondents were unable to articulate how they encouraged their learners to use two- and three-dimensional drawings in solving a technological problem.

Question 6: How do you support learners to use tools, build, test and modify technological solutions?

The question was asked to find out how the participants facilitated the making process of the product. The researcher explained the making stage according to CAPS, which is that making provides opportunities for learners to use tools, equipment and materials to develop a solution to the identified problem. Skills such as cutting, joining, shaping, and measuring, among others, are developed. Importantly, making should happen in a safe environment (DBE, 2011:68). The respondents disclosed that it was difficult to help learners to use tools as they did not have tools in their schools. However, the respondents used a pairs of scissors as found in their stationary, as well as some materials from home. The utterances of the respondents on how to support learners to use tools to build, test and modify a product are presented below:

Thulane: *Mam, you see, in my situation these learners are taught theory practical part is a problem as you see we do not have even a classroom. But I try my best.*

James: *Mm - I can say this stage is difficult to teach as there is no tools. For leaners to design and make a product, I bring empty boxes to use.*

John: *Technology is interesting subject, learners have to design and make product but in this school, is very difficult to teach this subject as there are no tools, even the space to store our products*

Thandi: *I collect old newspapers and glue to design the solution.*

Crucial skills are associated with making, skills such as planning an approach to construct a product, observing safety precautions, analysing the efficacy of the process, and using the correct tools. None of these were mentioned by the participants as they only taught the theory on the making process and not the development of skills. In the literature, Rowel (2004:89) argues that technology should be taught in a social context where learners generate knowledge through an interpretation of materials and the use of tools in the design process. Mawson (2003:119) urges teachers not to focus too much on the end product, but to see the design process as the process of developing skills. It appears that the respondents found it difficult to help learners to use tools.

It seems that the respondents did not attempt to support learners to use tools, build and modify their solutions. According to CAPS (DBE, 2011:13), it is the responsibility of the school to provide each learner with the tools and materials to meet the needs of the subject, and to develop the teacher' appropriate knowledge and skills. It appears that the learners used inappropriate materials and tools to solve technological problems in these classrooms. Failing to make practical solutions suggests that technology teachers are unable to properly teach learners about the design process.

Question 7: How do learners evaluate their decision-making and problem-solving methods?

The question attempted to gain insight into the ways in which learners evaluated their decisions regarding a particular problem, and which methods they used to solve technological problems. Learners need to evaluate actions, decisions and results throughout the design process (DBE, 2011:10). The respondents alluded to the fact that the time allocated to teach technology is limited. The subject consisted of two hours per week, which meant that the learners did not have the time to evaluate their work, as reflected in the excerpts below:

Thulane: Usually the time for evaluation of the design process is limited given the two hour periods per week.

James: I have a challenge on time for evaluation. The periods for technology are only two; one on Tuesday and the other one on Friday. I only teach one period per week so the time do not allow for evaluation.

John: Time allocated for the subject is a challenge when coming to evaluation.

Thandi: I give learners rubric to evaluate their decision.

According to CAPS, learners are expected to evaluate their learning activities, conclusions and the results of the whole design process. Learners did evaluate the technological problem to some extent, although, when the researcher compares this to how the DBE (2011) and Ankiewicz et al. (2000:128) depict evaluation, it is clear that evaluation involves self-regulated objectives. This is linked to evaluating the design brief, specifications and constraints using self-designed methods.

Although the respondents mentioned that evaluation must take place against specifications, only one respondent suggested the use of a rubric. However, no one mentioned the need to suggest the improvement of the product. Three of the respondents did not give details on how their learners evaluated their own decisions and methods. All of them saw time as a challenge. CAPS (DBE, 2011:70) emphasises that a record of the process from inception to the realisation of the technological solution should be in the learners' portfolio. None of the respondents mentioned that their learners had developed a project portfolio. This implies that the respondents did not support learners to engage in the design process as prescribed by CAPS.

Question 8: How do you support learners to provide evidence of the process after following the design process?

This question concerned how the respondents supported learners to communicate the results of the whole process. In the design process, communication is the last stage and is described in CAPS (2011:68-69) as evidence of the preceding process. All stages of the design should be recorded in the portfolio file of the learner. CAPS states that during the design process, communication requires learners to provide a record of the processes from the beginning of the problem to the realisation of the solution (DBE, 2011:68). Communication can be done orally, in a written, graphic or electronic form.

The respondents responded that learners could present a clear description of the results produced when solving technological problems. How learners were helped to provide evidence of the process after following the design process is reflected in the excerpts below:

Thulane: I ask learners to give clear evidence on the procedures followed to reach the solution.

James: Learners are allowed to present their evidence by giving all procedures followed.

John: Learners are given an opportunity to present their work in groups.

Thandi: I give them an opportunity to present the evidence of the process followed in arriving at the solution. they present it in project portfolio.

CAPS stipulates that communication in the design process involves the ability to investigate, analyse and evaluate the process followed while learners develop a solution to the problem (DBE, 2011:68-69). It is evident that the respondents did attempt to teach learners what communication entails in the design process. Therefore, an assumption can be made that these respondents understood the design process. What is interesting about their views in teaching the design process is that when I traced their demographic information, these participants had been teaching technology for more than six years. One can conclude that their years of experience in teaching technology had an impact on how they taught the design process.

The following section presents a discussion of the classroom observations to confirm what transpired during the interviews. The respondents were asked about the teaching strategies they applied to teach the design process in their classrooms. The respondents mentioned that they applied the problem-solving and discovery teaching strategies. Learners were encouraged to seek information independently. The researcher assumed that these teachers' classrooms were learner-centred. The classroom observations were a confirmation of what was said by the respondents during the interviews.

4.4 THE OBSERVATIONS

This section will be structured as follows: the context will be discussed first, followed by a summary of each observation. Lastly, the results will be discussed in detailed. Four respondents were observed and pseudonyms were used to protect them (Thulane, James, John &Thandi). The observation schedule (Appendix B) was copied from the CAPS design process (DBE, 2011:68). The observation schedule was prepared in a way that the design process and the related skills were parallel to the design process stages. In this way, the researcher was able to observe how the respondents used teaching strategies to teach the design process. During the observations, field notes were taken to enhance the rigour of the study. Each case will be dealt with separately. As the lesson proceeded, insufficient or sufficient was written on the design process stage if there was or was not adherence by the respondents to the correct teaching strategies.

The observations took place during the third term and the focus was on mechanical systems and control. According to CAPS (DBE, 2011:25-27) and the textbook used by the respondents, at the end of the section on mechanical systems and control, learners should be able to work out the mechanical advantage in levers using ratio, calculate using load and effort, and present the information graphically. Petroski (2002:287) asserts that the ability to perform calculations will help learners to predict the performance of the design before it is built and tested.

At the end of the section on mechanical systems and control, learners are expected to write a design brief of the product that will use the combination of gears, draw gear systems, represent the product in two dimension (2D). Moreover, in groups, learners have to decide on a final solution, build the product, and compile the records of the whole design process.

As mentioned earlier, the following indicators of procedural knowledge, use of teaching strategies, knowledge of the design process, and knowledge of technology were used to cross examine the data. Due to the examination schedule, I was only able to observe one lesson for the three respondents regarding the design process.

4.4.1 Observation of school A

Context

Thulane taught at school A, which was situated in the Rakwadu Circuit. At the time of this study, the school had a learner enrolment of 350 and was classified under Quantile 1 (a no-fee school). The school was situated in a deep rural area where most of the community members were unemployed. It had only three blocks. On arrival, some of the learners were loitering around the school, there was also a lot of noise and littering. The respondent took me to the office of the principal to report my presence. I was surprised to realise that there are still schools without classrooms. The respondent took me to his classroom, which was under a tree.

Introduction phase

An examination of Thulane's technology master file revealed that each year, he made use of a different lesson plan. The file was indexed and it contained the CAPS document for technology education, and the work schedule for the year for Grade 8. It was interesting to note that analytics were done for the first test written during the second term. An analysis of the lesson plan for the lesson to be observed indicated that the specific aim was to calculate mechanical advantage in levers. The resources to be used to teach the calculation of mechanical advantage in levers included a textbook and a chart. This was a follow-up lesson to the introduction to levers. Thulane introduced the lesson by going back to the learners' relevant previous knowledge on levers using a question and answer technique.

The learners were asked to look at pictures of a pair of scissors, a bottle opener, and an arm. They were then given the opportunity to classify these pictures according to the class of levers. Thulane allowed the learners to answer the questions verbally. This was done as a revision of the learners' previous knowledge.

Learners were given the following activity from the textbook:

Look at the pictures of paired levers below and answer the questions that follow

1. *Which paired levers are examples of:*

    (a) Third-class levers?

    (b) Second-class levers?

    (c) First-class levers?

The learners were given five minutes to write the answers in their classwork books. They were then instructed to put their books in their bags in order to pay attention to the lesson for the day.

Lesson presentation

Thulane explained that levers are simple machines that are divided into classes. He also gave an example of how to calculate mechanical advantage in levers. Thulane also gave a definition of the concepts ‘effort’ and ‘load’. Learners were granted the opportunity to practise writing the formula and calculating mechanical advantage in their groups. The lesson lasted for an hour. The teaching strategies used were instruction and collaborative learning. He also allowed learners to work in collaboration with each other in practising formula writing. This is in line with CAPS as by interacting with others, learners get the opportunity to share their views and generate shared understanding of the formula (DBE, 2011:11). The learners were given an activity to calculate mechanical advantage.

The lesson observation revealed that Thulane used the following teaching strategies: question and answer, discovery, and problem-solving. When using the question and answer technique, the participant showed learners a picture of different classes of levers and asked the learners questions pertaining to the levers. As part of his discovery learning, the learners were given an opportunity to practise writing a formula and to discover another way of calculating mechanical advantage in levers. The learners were given a task to solve a problem related to mechanical advantage in levers and to apply their knowledge of mechanical advantage to a specific case highlighted in the textbook.

The researcher noticed that the respondent used the scenario that was in the textbook. His teaching was in accordance with CAPS. According to CAPS (DBE, 2011:26), in teaching the design process, the teacher should set a scenario and describe where mechanical advantage in levers can meet a technological need. Setting a scenario enables learners to investigate the appropriate levers that can be used to solve a problem. This was evident when the teacher was asked *how he supported learners to gather data.* Thulane responded, “*By coming out with the scenario and ask them questions what is the problem and ways can they use to solve the problem.”* It appears that Thulane was knowledgeable about the teaching of the design process. From the foregoing, it is evident that Thulane was guided by the CAPS document in his teachings.

According to CAPS, teachers should set a scenario so that learners will be able to investigate, design, make, evaluate and communicate. To facilitate investigation, the learners were given a scenario from their textbook and they were then required to investigate the problem. Thulane allowed the learners to write the identified problem on the chalkboard, as well as the procedures they would use to solve the problem.

It was interesting to note that during the interviews, Thulane was categorised as a novice as he did not have the qualifications to teach technology, but the way in which he taught his lesson shows that his experience in teaching technology had an impact in teaching the design process. In learning the concepts *load and effort,* a group of learners were given an opportunity to search for the meaning of those concepts in the dictionary, while the other group was searching for the concepts in the glossary at the back of the book they used because there was only one dictionary in the class. In other words, Thulane allowed learners to construct their own understanding and look for meaning, as embraced by Von Glasersfeld (1989:45).

Learners were given an opportunity to write a design brief to state the problem, give specifications, and generate alternatives solutions. There were only two groups in the class and they wrote the design brief according to these groups. Thulane was well informed about how to teach the design process, irrespective of the challenges he faced in teaching under a tree. His teaching experience enabled him to change between teaching strategies and use a learner-centred approach. From the above discussions, it is evident that Thulane's understanding of technology education influenced him in choosing the appropriate teaching strategies to teach the design process. He taught under a tree every day - he understood the situation, which is the reason why he was able to teach in it. He also had a good relationship with his learners.

The key findings here regarding the teaching strategies applied to teach the design process emerging from the case of Thulane were discovery learning, collaborative learning and problem-solving. Therefore, it is affirmed by this observation that discovery learning, problem-solving and collaboration are important teaching strategies that can be used to teach the design process as the learners are encouraged to think critically and be creative. These teaching strategies also provide a logical flow of knowledge and progress. An understanding of the design process is essential in teaching technology education.

From the observation of the lesson, it was visible that the atmosphere in Thulane's class was nurturing and learners were free to answer the questions posed, and were willing to participate in solving technological problems on the chalkboard. Learners were confident in their learning and in dealing with problem solving. He also encouraged learner engagement (*come write the problem you identified and the procedures to solve that problem)*

His orientation towards social-constructivism, the use of pictures, had a direct bearing on his Pedagogical Content Knowledge (PCK) in terms of the design process. His PCK of the design process, in this case levers, served as a concept map that guided his teaching strategies. Thulane's concept map for the teaching of the design process (mechanical advantage in levers in this case) was guided by his understanding of the design process as the methodology used to teach technology.

However, Thulane missed a point as he only addressed two stages of the design process: investigation and the writing of a design brief. While his lesson provided two stages of the design process, more opportunities were available that could have been utilised to encourage learners to make, evaluate and communicate, but he failed to do so. This confirms what Thulane alluded to when answering Question 6 as he indicated that learners were taught theory only as the time allocated to the subject was limited.

4.4.2 Observation of school B

Context

James taught at school B; which was a secondary school within the Rakwadu Circuit. At the time of this study, School B had a population of more than 250 students, and was categorised under Quintile 1 (a no-fee school). It was situated in a deep rural area where most families were working in the farms nearby. The school consisted of six classrooms, and multi-graded classroom teaching was practised. The school was neat and free of littering. I was greeted by quietness and discipline. On arrival to James' school, I was given a visitor's book to sign.

James took me to his classroom, and as I entered the classroom, I realised that the classroom was divided into two. While I was moving around the classroom to observe the setting, James made me aware of the division. The group on the right-hand side represented Grade 8 learners, while the left-hand side group represented Grade 9 learners. Teaching was thus multi-graded. The respondent had to present the same lesson to both Grade 8 and Grade 9 learners, although I had to observe the Grade 8 lesson.

Introduction phase

The researcher examined the technology teacher's file and it was revealed that the respondent kept a copy of the CAPS document for technology and the textbook that he used, the work schedule for both classes, a common assessment plan, question papers, and memorandums. It was stated in the lesson plan that the specific aim of the lesson was: to investigate how gears work and calculate gear ratios in solving technological problems. The resources to be used were textbook and chalkboard.

To introduce his lesson, he asked the learners the following questions: What is a gear? What are the uses of gears in the structure? The question and answer method was used to obtain the attention of the learners. Learners were actively involved to the lesson as they answered the questions. The content that James taught was guided by the CAPS document and the textbook used.

Lesson presentation

During the observation of the lesson, it was revealed that James used three teaching strategies to teach the gear ratios: instructional; demonstration; discovery learning. In answering the question: what teaching strategies do you apply to teach the design process? He stated that he used problem solving and discovery. Then, he introduced the lesson for the day (*remember that when a small gear is used to drive a large gear, the large gear turns more slowly than the small gear. Depending on the size of the driver gear…)* this was done to facilitate the concept of calculating a gear ratio.

James presented his lesson by showing the learners a model of a gear train with a 3D drawing from the picture in the textbook. As part of his demonstration, James explained to the learners how gear trains work. Then James asked the learners to calculate the number of cogs in each gear. This allowed learners to gather information before they were introduced to calculating the gear ratio formula. Learners were given an activity to calculate the gear ratio using the formula given to them. From the foregoing, it is evident that James was completely familiar with the CAPS technology policy, and his teaching was guided by the policy. James' classroom environment was learner-centred, which is mirrored in the quote below:

> *"Look at the photographs of different gear trains alongside. Calculate the gear ratio for each gear train. Remember show your formulae and calculations" ...choose one from your group to work the answer on the chalkboard."*

It was visible that the atmosphere in James' classroom encouraged learners to construct their own knowledge. This implies that learners had to develop critical and creative thinking in dealing with these calculations. The learners were actively involved in their learning.

In understanding technological concepts, and through the use of instructional teaching, concepts such as *driver gear*, *driven gear, gear ratio, gear train and idler gear* were explained. James used practical examples to scaffold learners' understanding of the concepts. Learners were given the opportunity to use the concepts in sentences to show how these can be used in solving technological problems. During the interviews, James alluded to the fact that technology education has many concepts that need to be explained so that learners can use them in solving problems, as seen in his quote ("*I just explained the concepts and give learners chance to search the meaning in the dictionary")*. This is confirmed by Jonassen (1994:34), who finds that in social constructivism, the classroom learning environment provides multiple representations of reality and knowledge is thus constructed.

Rowel (2004) states that technology should be taught in a social context where learners generate knowledge through the interpretation of materials and tools, and the involvement of scaffolding of knowledge. James' lesson supported learners to understand the concepts related to gears and gear ratios. He had an ACE certificate in technology education. There were no tools or materials in the school, but James brought some bottle tops and empty boxes to show examples of the gears and also to use them to design a solution. This confirms what he said during the interviews, "*I bring empty boxes".* The lesson ended and the researcher noticed that James did not followed the prescribed design process when planning his lesson.

The CAPS document for technology states that the appropriate design skills must be achieved (DBE, 2011:33). To develop investigative skills, learners should investigate the situation and the nature of the problem so that the appropriate gears ratio can be chosen to solve the technological problem given in the scenario. However, James did not set a scenario. In accordance with the design process, technology teachers should set a scenario and, in this case, describe where a gear ratio can be used to solve a technological problem or need (DBE, 2011:35).

During the interviews, James was asked if the learners were able to write a design brief. James responded, "*I encourage them to write the design brief".* James missed an opportunity to encourage learners to write a design brief in this lesson. In the first place, James taught learners about the concepts of gears and the formula used to calculate the gear ratio without providing the learners with a scenario in order for them to state what the problem or need was, and how to solve that problem. In writing a design brief, learners need to understand what the specifications are, and alternatives must also be drawn in the design brief. According to CAPS (DBE, 2011:68), learners need to understand the problem before writing a design brief.

In essence, James should have set a scenario to encourage learners to investigate the problem and to write a design brief. James did little to support learners in understanding and developing design process skills. The CAPS document stipulates that technology teachers should set a scenario in order to describe a situation where gear ratio could be used to solve a technological problem or need (DBE, 2011:35). However, James gave learners an activity without setting a scenario. As a result, the learners calculated the gear ratio without knowing the context of the activity.

James' lesson was restricted to the investigation stage of the design process. The lesson did not represent the other design process stages such as designing, making, evaluating and communicating. It is evident that James prepared his lesson without adhering to the CAPS document for technology education, which stipulates what technology teachers must teach in order to achieve the purpose of this subject (DBE, 2011:25-27). As learners progress through a task, they must be taught the associated knowledge and skills needed to design and create a solution (DBE, 2011:12). This indicates that the teaching of the design process was a challenge for James.

As James was teaching Grade 8 and grade 9 at the same time, the same topic of calculating gear ratios was also taught in Grade 9. CAPS emphasises that it is compulsory to cover a given scope according to the grade. In Grade 9, he was supposed to teach electrical systems and control. Due to the multi-grade class, it was difficult for him to teach another topic to the other group. Technology education was thus not taught as required by CAPS. According to CAPS (DBE, 2011:4-5), the minimum standard of knowledge and skills to be achieved at each grade are specified, and the content and context of each grade shows progression. In James' classroom, there was a lot of interference as he had to move from Grade 8 to Grade 9 learners.

James was knowledgeable about the subject of technology and what was required to teach the subject. He had access to the CAPS document and technology textbooks. He was also passionate about teaching technology, as can be gleaned from his comments during the interviews (*teaching technology is interesting but also challenging as we do not have resources).* From the observation of the lesson, learners were confident in answering questions. He encouraged learner engagement (*come show your groups how to the formula).*

He used practical examples to teach concepts such as driver gear, driven gear, gear ratio, gear train and idler gear. The teaching of concepts on gears was influenced by the teacher's content knowledge, as well as his PCK (*remember when a small gear is used to drive a large gear, the large gear turns more slowly than the small gear).* In his teaching, he made sure that the learners understood the concepts, and allowed them to use these concepts in a sentence.

James espoused dual views of teaching strategies during the interviews. On the one hand, he viewed problem-solving as the best teaching strategy, whilst on the other hand, he considered discovery learning as the strategy that best allows learners to investigate and discover the technological problem. James did not directly link the lesson to either a problem solving strategy or discovery learning. The learners were not given a scenario or a problem to be solved. The lesson was solely based on explanations and the question and answer technique.

The interview conducted with James confirmed that, in principle, he embraced the idea of problem solving and discovery, as can be seen in the excerpt below:

> *"In the design process, learners are dealing with problems, the teaching strategy that I can use is problem-solving and discovery."*

It is significant to note that James' espoused view of the teaching strategies used to teach the design process was problem-solving and discovery – yet this had no bearing on his teaching of the design process. In other words, there was a vast mismatch between his advocated theory and Theory in Use. Even though James demonstrated that he was knowledgeable about the content in technology, the teaching strategies used to teach the content, which was calculating gear ratios, was not aligned with the specific aims of technology education. This made it impossible for learners to be involved in critical or creative thinking. The learning activities in which the learners were involved did not promote active learning. His teaching strategies were different from what he had indicated in the interview. None of the mentioned teaching strategies were observed in his lesson. James' lesson had no direct bearing on his PCK regarding the design process. Although the lesson was intended to be social constructivist in nature, the learners did not have enough opportunity to engage in the lesson as the lesson was teacher-centred with no interaction between learners. This hampered the development of learner creativity. The evaluation observed in the lesson was the responses of the learners to questions as the teacher was giving examples.

4.4.3 Third observation: John

Context

John taught in School C, which was a secondary school in the Rakwadu circuit in the Mopani district. School C was categorised as Quintile 1. The classrooms did not have doors or windows, and learners had to share a table and chair, while some had to stand during the lesson. The physical structure of the school was not well maintained and the resources at this school were not beneficial to learning.

Introduction

John's lesson was on calculating mechanical advantage in levers. John did not have a lesson plan for the lesson that was going to be presented. Unlike Thulane, who had no formal qualifications to teach technology and who had a lesson plan stating the aims and the objectives, John with his technology qualification was supposed to have a lesson plan, but did not have one. A lesson plan is an instrument that is used as a guide that outlines the outcomes to be achieved, the resources to be used, and the time allocated for the lesson (Jensen, 2005:403). As a qualified and experienced technology education teacher, he was supposed to have a lesson plan. To introduce his lesson, he told the learners to open their textbooks, and he read the aim of the lesson, which was to calculate mechanical advantage in levers. The teaching strategy used was direct-telling teaching strategy.

Presentation

Firstly, the learners read the word bank, which gives the definition of mechanical advantage, input force, and output force. John told the learners that levers are simple machines that are divided into classes. The learners were passive during his lesson. Without giving examples of the levers he was talking about and the classes of levers, he simply proceeded to the calculation of mechanical advantage in levers. Anbessa (2012) states that the direct-telling method is used to achieve the aims of lower-cognition when dealing with facts and principles than to achieve higher-cognitive aims related to the design process. This means that direct-telling does not give learners an opportunity to develop critical thinking and creative skills. In the design process, learners are expected to work collaboratively with their peers in solving technological problems.

The lesson presentation was limited to being teacher-centred; the learners were not engaged in the lesson. John did not follow the progressive development of knowledge, as prescribed in the CAPS document (DBE, 2011). As a qualified teacher, John should have set a scenario and supported the learners to understand the concepts related to levers. His teaching strategies were different from what he indicated during the interview, which is mirrored in the quote below:

> "*In the design process, learners are expected to solve problems by investigating the needs and bringing the solutions to the problem. So I use both discovery learning and problem-solving.*"

None of the teaching strategies cited in the quote above were observed in John's lesson. The type of teaching he followed disadvantaged the development of learners' critical thinking and creativity. The researcher observed that John did not follow the prescribed design process in teaching technology education. The policy of technology highlights that the suitable design skills must be achieved (DBE, 2011:33).

John did not help the learners to understand technological concepts, the learners were simply asked to read the meaning of words such as load, effort, input and output in the glossary of their textbooks. However, he was unable to lead learners to discover meaning for themselves. He explained the concepts and did not encourage learners to think and express their views about the given concepts. This finding corresponds to that of Kola (2015), where he established that technology teachers are unable to follow the design process when solving technological problems.

In order for the learners to write a design brief, generate alternative solutions, and use 2D and 3D drawings, they should read the scenario and understand the specifications needed to produce the design brief and the representation of the real product. John did not specify any activities as he did not have a lesson plan. A lesson plan is a vital component of the teaching-learning process as proper lesson planning keeps teachers organised and helps learners to reach objectives. When teaching the design process, the teacher has to set a scenario where learners have to investigate the problem and be able to list the specifications of the solution.

John missed the opportunity to support learners in writing a design brief because he did not have a lesson plan and did not have activities that would lead learners to write a design brief.

The implications here are that John did not allow learners to be involved in the lesson. The learners were not allowed to express their views and to direct their own learning. The lesson did not probe learners' understanding and creative thinking. According to his demographic profile, John had been teaching technology for six years, which means that he should have had the knowledge and inclination to use a learner-centred approach. His teaching did not promote social constructivism or CAPS, which both maintain that learners are required to socially construct their own knowledge and understanding. Moreover, John took on a prominent role in the direct-telling method of teaching, did not probe learners' previous knowledge, and learners were not allowed to explore the meaning of the concepts. This left little room for learners' activity, and was less effective in stimulating learners' interest. According to Moiduser and Levi (2008:263), the teacher should guide learners until learners can take responsibility for their own learning. John's lesson was restricted to being teacher-centred.

As a qualified teacher, John should have set a scenario and supported learners to be engaged in the design process stages in an appropriate manner. John did not specify the technological problem to allow learners to investigate the problem, to gather information about the problem, or to write a design brief with alternative solutions, to make the product, to evaluate or to communicate results. Johns' lesson was restricted to reading the textbook and explaining the related concepts. Although John possessed an ACE in technology, his teaching indicated that he lacked an understanding of the design process.

In the interview, John was asked how the learners evaluated their decision and used problem-solving methods. He mentioned that "time allocation for the subject is a challenge when coming to evaluation." In accordance with the design process, evaluation should be conducted at every stage of the design process. This implies that John did not encourage learners to evaluate the activities done. CAPS (2011:12) states that evaluation skills are used to choose ideas and to evaluate the existing and designed products against predetermined criteria. This indicates that John lacked an understanding of the use of evaluation during the design process.

It is interesting to note that John allowed very limited room for learner interaction and he sometimes answered the questions that were posed in the textbook to the learners "(*what do you see in that picture? You see a bicycle)".* The implication is that John did not allow learners the opportunity to evaluate the picture, and seemed to be in a hurry to end the lesson. As a result, the learners were not allowed to direct their own learning. His explanation followed procedural knowledge and did not encourage learners to think deeply and creatively about the content.

John did not link his lesson to the relevant previous knowledge of the learners, nor did he conduct any form of evaluation to ascertain whether the previous lesson's knowledge was still retained by learners in order to build the lesson on previous knowledge. The lesson was presented based on the assumption that the learners still remembered what they were taught in the previous lesson and that there were no misunderstandings held by the learners.

In teaching mechanical advantage in levers, John was supposed to set a scenario and describe a situation where mechanical advantage in levers could be used to meet a need (DBE, 2011:26). John gave learners an activity without setting a scenario. This shows that he lacked the critical knowledge needed in technology education.

During the interviews, John stated that he used problem solving and discovery to teach the design process. The observation revealed that John used the textbook and telling methods. John used a textbook for the delivery of his lesson as a means of directing learners to establish the formula for calculating mechanical advantage in levers. However, reading in the textbook does not encourage learners to be creative and critical thinkers.

John did not espouse the philosophy of technology in terms of a learner-centred classroom and Social Constructivism Theory. The implication is that John did not use problem solving or discovery in his lesson. According to CAPS (GDB, 2011:25), John was supposed to revise with learners the classes of levers, then introduce the lesson on calculating mechanical advantage in levers using ratios.

4.4.4 The fourth observation: Thandi

Context

Thandi taught at School D, which was situated in a deep rural area with 250 learners at the time of this study. The school consisted of three blocks of classrooms, and each classroom was used as the staff room and the office of the principal. School D was categorised under Quintile 1 (a no-fee school) and had five teachers. The five teachers were supposed to teach from Grade 8 to Grade 12. Thandi was the only female teacher who was responsible for Life Sciences from Grade 10 to 12, English Grade 10 to 12, and Technology education in Grade 8 and 9.

Introduction

During the observation, the researcher examined Thandi's file and it was revealed that she used lesson plans. Thandi presented a lesson on mechanical systems and control. In her lesson plan, the context and the content of the lesson were stated. The context was tendering for contracts and the content was a product with a mechanism for lifting a load. The specific aim of the lesson was developing and applying specific design skills to solve technological problems. An analysis of the lesson revealed that Thandi used the question and answer, instructional, discovery and problem solving teaching strategies to present the lesson on designing and making a lifting mechanism.

Thandi introduced her lesson by asking the learners to name things that need a mechanical advantage to be lifted. From the observation of the lesson, it was exposed that the atmosphere in Thandi's classroom was learner-centred and learners freely answered the questions asked. This means that the learners were actively involved in their learning. The questions were used as a revision of the learners' prior knowledge. First they had to look at the picture and then orally answer the following questions.

1. *What is another name for a gear system that works like a bicycle gear system?*
2. *How are gears used to give the person turning the crank a mechanical advantage?*
3. *Work out the velocity ratio of this gear system*

Learners were provided the opportunity to present their answers verbally. The introduction was interesting as the learners were arguing about the answers, yet Thandi assisted them to come to the correct conclusion, which encouraged the learners to explain their answers.

Presentation

Thandi then followed up with the main lesson of the day (*I want you to read at the scenario in your books, after reading you are expected to answer the following questions: what is the* *problem you have to solve? Write down exactly what you have to do to solve the problem)*. The following was the scenario that Thandi gave her learners:

> *Imagine that a commercially-viable ore reef containing platinum has been found on land belonging to a tribe in rural North West Province. Drill samples have proved that the reef lies at a relatively shallow depth, only 500m below the surface. A decision was taken to sink a shaft to this depth. This will be used to conduct bulk sampling on a small scale before deciding on a mining method best suited for the size and value of the resource. In order to do this, a new shaft headgear is needed. It must be strong, rigid and stable steel frame structure. It must also include the mechanisms needed to lift miners to and from the work level, and to raise ore and waste in loads not exceeding 10 tons at a time. Imagine that you and your classmates are part of a mechanical engineering company. As a company, you decide to submit a tender for construction of the shaft headgear. You will have to submit design drawings, a realistic budget and a scale model of shaft headgear.*

As part of her discovery teaching strategy, she let the learners discover the problem. This means that she introduced the learners to the investigation stage of the design process. This was in line with what she said during the interviews when she was asked how she supported learners to gather data. She replied, *"I give them a scenario and tell them to search for the problem and the ways to solve it."* This shows that Thandi was knowledgeable about the technology policy (CAPS). According to CAPS, technology teachers should set a scenario and describe a situation where a lifting mechanism could be used to solve a technological problem (DBE, 2011:26).

The learners were given the opportunity to gather data and information by identifying, interpreting, comparing and classifying information. In terms of investigative activities, she gave learners an article about mineshaft head gears. This activity was in line with what CAPS (DBE, 2011:11) states, as learners need to have an understanding of the problem or need so that they are able to write a design brief. The learners were provided with the opportunity to write a design brief stating the specifications and the constraints of the problem. This confirms what Thandi said during the interviews (*they write and draw many solutions).* In her lesson, Thandi gave the learners a photograph from the textbook of a mineshaft headgear to identify the features and to choose some of the features to use in their own design. She also asked them to make free-hand sketches of their mineshaft head gear. The learners worked in groups to solve this technological problem.

She encouraged learner engagement in her class and promoted particular patterns of thinking amongst learners to write a design brief. She also used practical examples to scaffold understanding of how to write a design brief, e.g. "*The specifications are those things that must be included in designing and making your model. The constraints are those things that you are limited to when designing.*" The atmosphere in Thandi's classroom was nurturing and learner-centred, and learners were willing to participate in solving technological problems. The learners were confident in their learning and in dealing with the stages of the design process.

The teaching of the concept of mechanical advantage in levers was influenced by the teacher's content knowledge of levers. This was obvious in the way in which she explained the mechanical system for pulling a boat. Learners were granted the opportunity to search for the meaning of the following concepts: *gravitational force and formula.* In this regard, Thandi helped learners to understand the concept used in technology education and to use these concepts responsibly and purposefully. This was reflected in her views about how she supported her learners to understand technological concepts (*I give them an opportunity to explore and share knowledge in finding the meaning of the concept).*

It was interesting to note that evaluation was a continuous process throughout the lesson. Thandi used the questions to establish areas of difficulty as teaching and learning continued. To establish whether the learners understood the contents of the lesson, they were engaged in a group activity where they had to write a short proposal for their team that explained why their design would be the most suitable. Thandi was aware that there were certain sections within the levers where her learners would struggle. Her explanations thus followed procedural knowledge.

She followed the prescribed design process, but had a problem at the making stage as she pointed out that the time given to the subject was limited. This is reflected in the excerpt below:

> "*Mam, in this school, technology is not taken seriously by the management. The time allocated is not the recommended time from the policy. I do not have time for making stage but I try my best to teach the design process as prescribed.*"

The evaluation of the stages of the design process was done continuously throughout the lesson. This shows that Thandi was well informed about the design process. She also used a rubric to allow her learners to evaluate their decisions. Thandi had an ACE qualification in technology and also attended technology workshops for the implementation of the technology curriculum.

From her comments in the interview when asked what teaching strategies she applied to teach the design process, she stated clearly that problem solving leads learners to be critical and creative thinkers. This was evident when she provided learners with a scenario to investigate the problem and also to solve it. During the lesson presentation, she allowed learners to discover the problem for themselves. Her experience, as well as her in-depth content knowledge of technology education enabled her to teach the design process using problem solving, discovery and s learner-centred approach.

Her orientation towards social constructivism, and the use of the scenario in the textbook, had a direct bearing on her pedagogical knowledge in terms of the design process. Her PCK of the design process, in this case, simple mechanisms as components of more complex machines designed to provide users with a mechanical advantage served as a concept map that guided her instructional decisions. It is important to note that Thandi's teaching was aligned with the CAPS Senior Phase technology policy's notion of the design process (DBE, 2011:11). Thandi, being well informed about the content related to mechanical advantage in levers, modified explanations and activities to suit the needs of the learners. Therefore, Thandi was teaching for understanding (Geddis, Onslow, Beynon & Oesch, 1993).

Thandi also exhibited knowledge of the learners' understanding of mechanical advantage in levers and their areas of difficulty. She used simple analogies to show learners how to differentiate between the classes of levers. According to Shulman (1987:15), PCK includes an understanding of how a particular topic or problem is presented and adapted to the diverse interests and abilities of learners and presented for teaching. Shulman also suggests that PCK is the best knowledge base for teaching. The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge that she or he possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the learners. Thandi was aware of the individual cognitive differences amongst the learners in her classroom.

During the interview, Thandi was asked what strategies she used to teach the design process and she pointed out that problem solving and discovery were the best teaching strategies. As part of her knowledge on the strategies she mentioned, Thandi used questions to provide her with feedback on the progress of her learners, whether they grasped what had been discussed. She also used questions to give her a general sense of whether the learners were following her, the various cognitive levels of questioning allowed her to probe for deep understanding. Thandi acknowledged that learners learn in different ways and she expressed the need to engage with the learners in different ways to make learning meaningful for them.

In the calculation of mechanical advantage in levers, learners were allowed some independence to find solutions on their own. In other words, Thandi provided learners with the opportunity to solve problems and apply their own ideas to solve the identified problem. This embraces CAPS' (DBE, 2011) aims of producing learners that are able to identify and solve problems and make decisions using critical and creative thinking.

Thandi was of the opinion that the design process is grounded in problem identification (given scenarios), and forms the backbone of technology education. Thandi's teaching of the design process encouraged social constructivism as the learners were engaged in group work in searching for the problem in the given scenario, and information was conveyed in a logical way. It is evident from this study that context has a powerful influence on what is possible in a South African classroom. Unlike John, Thandi was able to use different teaching strategies that allow learners to socially construct their own learning. Thandi thus believed that the learners were responsible for their own learning.

Thandi adhere to the CAPS policy, which emphasises that teachers should cover the given scope in the term (DBE, 2011). Learners were exposed to the scenario and the stages of the design process. Regardless of the situation in which she was involved – a lack of resources, teaching under a tree, and teaching more than three subjects, Thandi remained enthusiastic about teaching technology. Thandi encouraged scaffolding in her teaching as scaffolding helps the learners to replace existing knowledge with new knowledge (Rowel, 2004).

From the abovementioned information, it is evident that Thandi understood the design process and how to facilitate the design process in the classroom. Thandi also understood the context in which teaching takes place and was able to teach in it. In her classroom, the learners had the freedom to participate and ask questions about the lesson. Mawson (2007) states that learners should be helped to discover their own abilities in reaching decisions. This was evident in Thandi's classroom. While teaching, she occasionally interrupted the lesson by asking the learners questions, which affirms the work of Hartfield (2012).

Rohaan, Taconis and Jochems (2010:15) state that outstanding teaching requires teachers to have a deep understanding of the subject matter and its structure, as well as an equally thorough understanding of the kinds of teaching activities that help learners understand the subject matter in order to be capable of asking probing questions. From the foregoing, it is evident that Thandi's view of teaching strategies influenced her teaching of the design process. Her teaching presented an indication of a rich store of pedagogical knowledge. The findings regarding the manifestation of PCK emerging from the case of Thandi were that expert content knowledge is essential for a developed PCK, and that knowledge of learners' understanding is vital in the alignment of the teaching strategies used.

It can be confirmed from this observation that content knowledge and congruency between Espoused Theory and Theory in Use is important. The definition of PCK as the amalgamation of content and pedagogy, according to Shulman (1986:7), has emerged as a vital theme. The observation showed that an understanding of the content, and knowledge of learners' understanding is essential for the effective teaching of technology education. The way in which a technology teacher teaches the design process is influenced by their views, which in turn are influenced by their PCK. Here, the views expressed by the individual teachers (Thulane, James, John and Thandi) were a reflection of their PCK, which also translated into their teaching and learning of the design process. Therefore, it can be concluded that the views of technology teachers have an impact on their teaching of the design process.

4.5 CONCLUSION

This chapter presented a detailed analysis that was collected by means of interviews and observations. The aim of the analysis was to attain data that could answer the research questions. The chapter firstly outlined the demographic profile of the participants, followed by discussions on the interviews and the observations. The research findings exposed the fact that the participants had limited understanding of the design process, and limited knowledge of the teaching strategies to employ when teaching the design process. This is cause for concern since the design process is the backbone of technology education and is used as a teaching strategy when teaching technology.

The findings further revealed that the participants neglected the other stages of the design process such as the making, evaluation, and communication stage, which means that learners were taught in a linear way. The findings also revealed that the participants were unable to state the teaching strategies that they used to teach the design process. The respondents only provided two teaching strategies, which were not even used during the lesson presentations. It is emphasised in the technology policy document (CAPS) that before the design process is taught, the teacher should set a scenario to help the learners understand the problem or need. However, only Thandi was able to use the scenario in the textbook that she used.

Fundamentally, the participants disadvantaged the learners in not providing the opportunity to develop critical and creative skills in solving technological problems. According to CAPS (DBE, 2011:11), learners should work collaboratively with others to investigate, design, make, evaluate and communicate as this is what the South African curriculum promotes. The South African Curriculum aims to produce learners that are able to: identify and solve problems; make decisions using critical and creative thinking; work effectively as individuals and with others as members of a team; organise and manage themselves and their activities responsibly and effectively; collect, analyse, organise and critically evaluate information; and also communicate effectively using visual, symbolic and language skills in various modes (DBE, 2011:5). A social environment is essential as this study embraces the Social Constructivist Theory. By implication, social constructivism construes learning as a non-linear building process by active learners interacting with their physical and social world. This implies that learners need to work collaboratively with others in solving technological problems.

The way in which a technology teacher teaches the design process is influenced by their views, which are in turn influenced by their PCK. This is because the views expressed by the individual teachers were a reflection of their PCK, which also translated to their teaching and learning of the design process. Therefore, it can be said that the views of technology teachers have an impact on their teaching of the design process. The following chapter will present the discussion, conclusion and recommendations for future research stemming from this research.

CHAPTER 5 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter begins with a description of the key aspects of the previous chapters. This presentation is based on the data from the interviews and observations. This was necessary to cross reference, compare and triangulate the data. The presentation is carried out using the research questions. The differences as well as similarities between the findings from the participants are highlighted in the discussion below. This is followed by the limitations of the study, recommendations for future research, and a conclusion.

5.2 CHAPTER SUMMARY

In Chapter 1, the purpose of this study was explained, i.e. exploring the effectiveness of the teaching strategies that technology teachers apply to teach the design process. The importance of using the design process when teaching technology was addressed, and the fear that teachers find it difficult to teach the design process in the classroom was discussed. Attention was drawn to the fact that CAPS fails to assist teachers in teaching the design process. The main research question was: What are the teaching strategies that technology teachers apply in order to teach the design process? Three sub-questions were developed to address the main question. Chapter 1 concluded with a clarification of the key concepts of this study.

Chapter 2 presented a review of the literature regarding social constructivism, design, and the design process, which forms the basis of teaching and learning in technology education. The design process as the realisation of a need and a problem activity was discussed. It was pointed out that the prescribed design process gives the opportunity for learners to develop critical and creative skills in solving technological problems. Technology teachers should create a scenario to actualise design process skills in their classrooms. The chapter ended with a presentation of empirical studies relevant to this topic.

In Chapter 3, the research design, research paradigm, population, and sampling used in this study were discussed. Furthermore, the instruments used to collect data were explained. This was followed by a description of how the data was analysed and the chapter also addressed the rigour and ethical considerations of this study.

Chapter 4 comprised a representation of the findings of the study. The chapter outlined the demographic profile of the participants to show their qualifications and experience in teaching technology. The views that were obtained during the semi-structured interviews were discussed. This was followed by a discussion of the data obtained from the classroom observations.

5.3 DISCUSSIONS

In the following section, a discussion of the research questions is presented. The main research question was: What are the teaching strategies that technology teachers apply in order to teach the design process while solving technological problems? This question guided this study through three sub-questions. Each of the key findings are discussed in relation to the questions.

5.3.1 What are the teaching strategies that technology teachers apply in order to teach the design process?

This study revealed that although technology teachers are familiar with problem solving and discovery learning, the majority still struggle to apply these teaching strategies when teaching the design process. The teachers observed applied the direct-telling teaching strategy, which did not allow enough time for learners to solve problems.

The participants claimed that they used problem solving and discovery in teaching the design process. However, the study revealed that their focus was on direct teaching, where the learners were passive recipients. This is evident in Chapter 4, Section 4.4.2, where the type of activities that learners were engaged in is shown. This might be a sign of having insufficient proficiency in teaching technology (Kola, 2015).

Three sub-questions were formulated to clarify the main question:

(iv) To what extent do technology teachers support learners to follow the design process methodically?

(v) How effective are the instructional strategies that technology teachers apply in teaching the design process?

(vi) What are technology teachers' experiences in teaching technology?

5.3.1.1 To what extent do technology teachers support learners to follow the design process methodically?

This sub-question sought to understand how these technology teachers supported learners in understanding the design process. This study adopted the stages of the design process, which are: investigate, design, make, evaluate, and communicate. The study revealed that all of the participants had limited understanding of how to teach the design process. Firstly, teachers should set a scenario and describe a situation where a solution could be used to meet a need (DBE, 2011:35). However, the participants gave learners activities without setting the scenario. One of the participants claimed that in his teaching of the design process, he set the scenario for learners to understand the problem that needed solving, but this was not evident in his lesson.

5.3.1.2 How effective are the instructional strategies that technology teachers apply in teaching the design process?

The literature in Chapter 2 revealed that learners in technology classrooms should generate knowledge through the interpretation of materials and use of tools as part of scaffolding (Rowel, 2004). The study established that the type of activities that the teachers planned normally addressed the design process as a series of steps rather than a method of delivering technology. The teachers found it difficult to articulate the nature of the instructional strategies to apply to technology activities. What they said during the interviews differed from their lesson presentation. The participants were not clear on how to incorporate different teaching strategies in teaching mechanical systems and control (Section 4.4.2 - 4.4.4). The teacher-centred approach was a hindrance to social constructivism in each classroom since no opportunity was allowed for learner interaction.

The teachers were unclear on how to apply effective teaching strategies, despite the outline of these activities in the textbooks that they used. Rohaan, Taconis and Jochem (2010:15) suggest that teaching requires teachers to have an understanding of the subject and its structure, and if they are unsure of it, it could pose a threat to their classroom teaching.

5.3.1.3 What are technology teachers' experiences in teaching technology?

The study revealed that the technology teachers had challenges, like a lack of resources such as technology textbooks, classrooms, technology tools and materials, and the time allocated for the subject was inadequate. Technology tasks need teachers who can use the design process to teach technology and can interpret technological problems. However, the study reveals that some technology teachers find it difficult to support learners to understand the design process and to follow it methodically.

The teachers seemed to embrace individual outsets of teaching and learning that seemingly had an effect on how they taught, which also influenced how the learners learned and the achievement of learning outcomes. An understanding of the design process and how to teach it was shown to be essential. The findings of this study confirm that some teachers are set in their teaching strategies, and these teachers need to learn how to support learners to engage in the design process while solving technological problems.

It was revealed that a teacher who is knowledgeable about the of subject technology will surely teach irrespective of the learning environment. One of the participants was able to teach the design process under a tree, the unavailability of a classroom was not a limiting factor for him. Therefore, it has been noticed that the knowledge that the teacher possesses and his/her views may or may not transform lesson presentation in the design process.

Even though the use of a problem-solving activity in the design process has been seen as a potentially rich ground for collaborative learning, this was not always the case in the lessons observed. John did not provide opportunities for collaborative learning amongst the learners. In John's classroom, the learners were passive recipients of information and were not allowed to interact with others. Social constructivism was not promoted in his classroom. Most of the teachers deprived their learners of the opportunity to solve technological problems in their own way. It was evident that the participants were unable to support learners to be critical and creative in solving a technological problem using the design process.

5.4 CONCLUSION

The introduction of technology education was faced with many challenges like a lack of trained technology educators, and a lack of resources to use when teaching the subject. The shift from teacher-centred teaching to learner-centred teaching and the problem-solving method has posed challenges for teachers teaching technology as a result of the struggle and the insecurity that they encounter during the teaching of the design process. The teaching strategies used by technology teachers to teach the design process are essential in achieving the aims of the South African curriculum. This study investigated the teaching strategies that technology teachers employ to teach the design process.

The findings disclosed that the participants were not conversant with the teaching strategies to employ when teaching the design process. The participants in this study were unable to support learners to acquire design skills such as investigation, designing, making, evaluation and communication. CAPS stipulates that the specific aims of technology as a subject contributes to learners' technological literacy by giving them opportunities to develop and apply specific design skills to solve technological problems and to understand the concepts and knowledge used in technology. The participants used textbooks and the CAPS document, which supported them to teach design skills.

The textbooks used by the participants outlined the steps that technology teachers should adhere to while teaching mechanical systems and control, although the participants demonstrated that they did not follow the textbook as they were supposed to. The design process was compromised as the participants were not successful in supporting their learners to apply design skills in solving technological problems.

When teaching the design process, technology teachers are supposed to set a scenario in order to demonstrate how a particular activity meets a need and solves a technological problem. Setting a scenario helps the technology teacher to stimulate learners to be creative and to develop design skills. Unfortunately, the participants did not set a scenario. This implies that learners were deprived of the opportunity to develop design process skills, which are regarded as vital to teaching and learning technology. The design process as the backbone of technology is used to solve problems encountered in real situations.

Teachers should select situations that will engage the learners in realistic, problem-centred activities that will support the knowledge to be acquired. During the technology lesson, teachers are expected to be facilitators by building collaborative learning environments and helping learners to become aware of appropriate signs.

5.5 LIMITATIONS OF THE STUDY

Limitations that might have had a negative impact on the findings of the study have been identified. The first limitation was that the study and its findings were limited to the Rakwadu Circuit where most of the schools are categorised under Quintile 1. These schools were not well-resourced; if the study was conducted at well-resourced schools, the results might have been different.

Another limiting factor was time. The data collection was conducted during the examination sessions of the schools involved. The lesson observed per participant was restricted to one, and as a result, the participants might not have had the opportunity to teach all of the stages of the design process. According to CAPS (2011:8), the design process consists of investigating, designing, making, evaluating and communicating and it is impossible to cover all these stages in one lesson. Observing a single lesson per participant was not sufficient.

The study used a qualitative research approach, which was useful to inform how and what technology teachers employ to teach the design process. The subjectivity of qualitative research helped the researcher to expand and obtain a thorough understanding of the cases in their natural setting (Simons,2009). However, a subjective interpretation of data brings aspects of bias into the study, which could be seen as a limitation.

5.6 RECOMMENDATIONS

From the findings of this study, the following recommendations have been made to improve the teaching and learning of the design process. The recommendations relate to group work and PCK.

5.6.1 Group work

From a social constructivist perspective, the responsibility of the teacher is to create and maintain a collaborative problem-solving situation for learners where they are allowed to socially construct their own knowledge. The National Curriculum Statement (NCS) for South African schools moved from a teacher-centred to a learner-centred approach. To ensure that the learning objectives set in the CAPS document for technology are achieved, the technology teacher has to consider different teaching strategies and methods. By using new strategies and methods, the teacher can ensure that effective teaching and learning takes place to develop technologically literate and skilled learners who will become life-long learners.

It is essential that technology teachers have a concrete grasp on the concept, design process, and its skills. Technology teachers should create a space that will allow learners to work with tools and materials when solving technological problems. During the teaching of technology, teachers should give more attention to the following steps: setting the scenario, analysing the problem, and evaluating each process to arrive at a solution.

Group work that ensures effective member participation should be encouraged as this has the potential to support learners' critical and creative thinking skills in a collaborative manner. When group learning is encouraged in solving technological problems, this can promote cognitive development, which helps them to improve their problem-solving skills and their understanding of the design process. It has been stated by Vygotsky (1978:57) that knowledge is based on real-life adaptive problem solving, which takes place in a social manner through shared experience and discussion with others. This is supported by Von Glasersfeld (1989:165), who stresses that learners should learn from the world through continuous interaction with others. Effective group work should be encouraged in the design process where every member has a role to play.

5.6.2 PCK

There must be continuous training of teachers in teaching technology education. This is vital as some teachers still use their outdated knowledge of arts to teach technology. This places more emphasis on the investigation of the problem at the expense of the whole design process. There should be frequent support for technology teachers, especially those who are in disadvantaged communities, to address issues of concern in teaching technology education. Such teachers should be encouraged to attend the relevant workshops on teaching the design process.

It is of the utmost importance for teachers to have knowledge about the design process and its skills. Technology teachers should help learners to develop the skills to investigate, design, make, evaluate and communicate. These skills are important and should be taught in the classroom so that learners understand and can use them. These skills will help learners to be creative in solving real problems in their social contexts.

In order to provide quality teaching to all learners, teachers need to differentiate their teaching strategies to suit the needs of the learners. Effective teaching requires thorough planning, especially in terms of the design process. Teachers must have mastery of the subject of technology education, which they then can then present to learners in a systematic manner. The findings of this study confirm that some experienced teachers are set in their ways, specifically in terms of teaching strategies, and that these teachers need to learn how to teach the design process. In as much as PCK is seen to be a consequence of experience and practice, it vital that education for the professional development of technology teachers be provided. This is due to the fact that most technology teachers still use their knowledge of arts to teach technology, as stated in their demographic data. There should be frequent in-service training for technology teachers to address the issue of teaching the design process as this subject could benefit our learners if taught in the correct manner.

5.7 RECOMMENDATIONS FOR FUTURE RESEARCH

The focus of this study was on how teachers teach the design process in rural areas. A follow-up study focusing on former Model C schools is recommended.

Further research should also be conducted to ascertain the effectiveness of technology education in society. This will help curriculum developers to revisit subject policy for technology education.

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APPENDIX A

INTERVIEW QUESTIONS

1) Technology education was introduced in South Africa to produce learners who are able to identify and be able to solve the identified problem. How do you support learners to gather data when investigating the technological problem?

2) How do you support learners to understand technological concepts?

3) Are learners able to develop new techniques to solve technological problems? Explain.

4) Are learners able to write a design brief, generate alternative solutions and use 2D and 3D drawings? Substantiate.

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5) How do you support learners to use tools, build, test and modify the technological solutions?

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6) How do learners evaluate their decision and problem solving techniques?

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7) Communication is one of the most important stage of the design process and in this stage learners are expected to justify the procedures followed in the design process. How do you support learners to communicate the procedures and techniques followed when solving technological problems?

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8) How effective are learners when presenting the procedures, they followed in solving the technological knowledge? Kindly give examples.

APPENDIX B

OBSERVATION SCHEDULE

CAPS DESIGN PROCESS (DBE, 2011)

1) **Set the scenario:** describe a situation where the technological problem can be used to meet a need, or create an opportunity

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Investigation

2) Gather data and information

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3) Technology concepts understood and gain insight

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4) New techniques to solve technological problems

Design

5) Design brief

6) Generated alternative solutions to the problem

7) Drawn on paper

8) Use graphics (2D/ 3D drawings) to sketch their possible solutions

9) The best solution that satisfies the specification was chosen and justified

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Make

10) The opportunities to use tools and equipment to develop the technological solutions (list the tools that were used)

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11) Build, test, and modify the products to satisfy the specifications

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12) Learners work in a safe and healthy environment

Evaluate

13) Learners evaluate their decisions and problem solving methods

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14) Suggest changes and make necessary improvements

Communication

15) Learners provided evidence of the process followed when following the design process

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16) Learners provide an oral, written, graphic or electronic representation

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17) Learners produce a record of the process from conception to realisation of the technological solution in a form of a portfolio

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APPENDIX C

FIELD NOTES

Participants	What are the teaching strategies you apply to teach the design process?	Categories
Thulane	I think the design process is problem solving..so when teaching it you have to use problem-solving and as learners investigate they have to discover the problem.	Problem-solving discovery
James	In teaching the design process learners are solving identified problem, as a technology teacher the best teaching strategy I use is problem-solving	Problem-solving
John	The design process is similar to problem-solving and also encourage learners to think critically. I think problem solving is the best	Problem-solving
Thandi	Ok, the teaching strategy I use is problem-solving. Learners are exposed to the problem and the problem must have solutions. Discovery is also used as I asked learners to look at what other designers did to solve similar problem.	Problem-solving Discovery
Participants	How do you support learners to gather data when investigating?	categories
Thulane	Here I give my learners a problem and ask them questions based on the problem. in this way you are able to let the learners investigate on ways to solve the problem.	Explaining the problem Problem identification
James	OH, for learners to investigate there must be a problem. as it said the learners themselves have to identify the problem in their area. So, I let them to identify the problem and allow them to investigate ways to solve that problem	Problem identification Problem-solving
John	In the design process learners are expected to solve real problem. they should gather information regarding the	Problem identification

	problem. Ijooo... I just give them the problem and let them seek necessary information.	Seek necessary information
Thandi	I give the learners the scenario in the textbook so that they will be able to solve the identified problem in the scenario.	Problem identification scenario
participant	How do you support learners to understand technological concepts?	categories
Thulane	Mam, teaching technology is difficult as there are lot of concepts even myself sometimes I find challenging to understand. I give learners an opportunity to search for meaning in the dictionary	Search for meaning
James	I prefer to use the glossary at the back of the textbook we are using.	Search for meaning
John	I write the meaning of the concept on the chalkboard and allow them to use the concept in their own sentences to show that they understand the word.	constructivist
Thandi	I give them an opportunity to explore and share knowledge specially in finding the meaning of the concept.	Collaboration Search for meaning
Participant	Are learners able to develop new techniques to solve technological problems?	categories
Thulane	To show creativity they must have new techniques	Creativity New techniques
James	Sometimes learners may have better solution than what I thought of	creativity
John	Yes, as they have to create their own design.	create
Thandi	It depends. Usually I follow the design process step by step, because it is very important to make learners understand all the steps to be easy to solve problem as technology is all	Step by step Problem solving

	about problem solving.	
Participant	Are learners able to write a design brief, generate alternative solutions and use 2D and 3D drawings?	categories
Thulane	Yes, they write. After investigation learners have to write the specifications of the problem to be solved. Unfortunately, the lack of resource jeopardise	Lack of resources The design brief
James	Mmm…. When you design a product you have to write all the procedure followed to reach the solution. yes. They write	The design brief
John	I have a challenge on 2D and 3D drawings so I usually ask for assistance from mathematics teacher	assistance
Thandi	They write and draw so many solutions	The design brief
Participants	How do you support leaners to use tools, build, test and modify the solution?	Categories
Thulane	Mam, you see---- in my situation these learners are taught theory practical part is a challenge as you see we do not have even a classroom. But try my best	Lack of resources
James	Mm! this stage is a challenge as we do not have tools and materials. But I bring boxes and other things. Now I am teaching mechanical systems and control I have nothing to display	Lack of resources
John	Technology is an interesting subject learners have to design and make products to solve a real problem but here “dololo” no tools even the classroom to store the equipment	Lack of resources
Thandi	I collect papers and glue to design the solution	improvise
Participants	How do you evaluate their decision and problem solving methods?	categories

Thulane	The time allocation for technology is limited to 2hours per week. And here those periods are during Friday, sometimes I do not teach as the learners need to clean the classrooms.	Time frame
James	The time given to this subject is limited.	Time frame
John	No evaluation because of time given to the subject	Time frame
Thandi	I give rubric for learners to evaluate their decision	Self- evaluation
participants	How do you support learners to provide evidence of the process after following the design process?	categories
Thulane	I asked them to submit a project profile	Project profile
James	I give learners opportunity to their design process through writing the procedures followed	
John	They present their work in groups	Group work
Thandi	I give them an opportunity to present the evidence of the process followed in arriving at the solution. They present it in project portfolio	Project portfolio

APPENDIX D

Transcript Semi-structured interviews

Case, 1(Thulane)

School A

R: Sir, thank you for allowing me the opportunity to interview you. I have few question in relation to the teaching of technology

P: Ok

R: tell me about your experience in teaching technology especial the design process?

P: Eish---from the introduction of this subject I am the only teacher in this school to agree to teach technology. But is very challenging to teach this subject because we do not have proper materials.

R: How do you support learners to gather data when investigating the technological problem?

Case 2 (James)

School B

R: Morning, I would like to ask you the following questions, so if you did not understand the question you are free to tell me.

R: Tell me about your experience in teaching technology especial the design process?

P: Well, firstly, I normally give learners opportunity to read the case study in their textbooks and asked them to identify the problem.

R: How do you support learners to gather data when investigating the technological

Case 3 (John)

School C

R: You are welcomed to this interviews.

R: tell me about your experience in teaching technology especial the design process?

P: This is an interesting subject, but in schools the authorities never take it seriously. During my period they usually give learners time to clean the school surrounding.

R: How do you support learners to gather data when investigating?

P: I give them the scenario in the textbook and asked

Case 4 (Thandi)

School C

R: Tell me about your experience in teaching technology especial the design process?

P: During the introduction of this subject I volunteered to teach it. After going to the first workshop I realised that this is a unique subject. When taught correctly will make life easier for our people. But it is not given the attention needed by the department.

R: How do you support learners to gather data when investigating?

P: I give them a scenario to investigate the

P: mmm--- I use the information in the textbook I use then allow learners to gather information from the newspapers and magazines I brought to school.

R: Probe is the information in the newspapers relevant to the topic?

R: Yes. As they have to cut pictures relevant to the problem.

R: How do you support learners to understand technological concepts?

P: Mam—as you see here we do not have a classroom and there is no other means. I give them a dictionary to search for the meaning of the concept and some learners use the glossary at the end of the page.

R: Are learners able to develop new techniques to solve technological problem?

P: I give the investigation activity as a home work, where they have to search all information about the problem.

R: How do you support learners to understand technological concepts?

P: Mam, is very difficult to make learners understand the technological concepts. There are lot of concepts used in technology. At the end of the textbook I use there is a glossary is where they have to get the meaning of the concepts.

R: Are learners able to develop new techniques to solve technological problem?

P: I give them to investigate what is the problem and allow them to write on the paper the problem.

R: How do you support learners to understand technological concepts?

P: I like to write the concepts on the chalkboard and try to explain the meaning of the concepts. Learners are then asked to use the concepts in the sentence to see if they understood them.

R: Are learners able to develop new techniques to solve technological problem?

P: Yes, they use their own ways to solve the identified problem.

R; Are learners able to develop new techniques to solve technological problem?

P: I give them the problem so that they develop creative and critical thinking skills.

R: How do you support learners to understand technological concepts?

P: I give learners opportunity to explore and share knowledge while finding the meaning of the concepts.

R: Are learners able to develop new techniques to solve technological problem?

P: Usually I allow them to follow the steps of the design process.

R: Are learners able to write a design brief, generate alternative solutions and use 2d and 3D drawings?

problem?

P: Yes, they do. As learners progress through a task they use different techniques and—and modify their ideas. R: that means you allow them some freedom to develop their own techniques. P: Yes, of cause.

R: Are learners able to write a design brief, generate alternative solutions and use 2D and 3D drawings?

P: ahaah ---yea, I first give them the case study in their books then tell them to follow the steps of the design process. they must write the specifications in this way they are developing a design brief. When coming to drawings I am not perfect but I ask a mathematics teacher to teach the skills of 2D and 3D drawings.

R: How do you support

P: Yes, as I teach my lesson on design process I tell them to identify the problem and come up with their own solutions. Some develops better solutions than what I thought of.

R: Are learners able to write a design brief, generate alternative solutions and use 2D and 3D drawings?

P: Yea, Yea! They write as they supposed to state the specifications and procedures followed. When coming to drawings learners love that the most.

R: How do you support learners to use tool, build, test and modify the technological

to write a design brief, generate alternative solutions and use 2D and 3D drawings?

P: Mm… I have a challenge on drawings I usually ask for assistance. Learners write the design brief during the investigation process.

R: How do you support learners to use tools, build, test and modify the technological solutions?

P: Ogosh! Technology is interesting but not here in this school. We do not have any tools. Really, I teach only theory not practical.

R: How do learners evaluate their decision and problem solving

P: Mam! These are important skills in design and make firstly you must be able to write the design brief where you have to write the specifications of the product, and have different solutions to choose in. my learners are able and they like drawing.

R: How do you support learners to use tools, build, test and modify the technological solutions?

P: I bring the tools from home in order for the learners to build the product. We simply use old newspapers and glue.

R: How do learners evaluate their decision and problem solving methods?

learners to use tools, build, test and modify the technological solutions?

P: Ok! Mam, this is a serious challenge as you see yourself… there is no tools nothing but I try to bring empty boxes and old newspapers for them to make projects. But the project they make does not meet the specifications for example I teach mechanical system and control and I suppose to have heavy duty stapler, pair of scissors but nothing

R: How do learners evaluate their decision and problem solving methods?

P: You know that there are a lot to do in the design process. So by all means there are so many aspects like evaluation……not attend cause of time constraints. R: probe Do you mean the time allocated for the solutions?

P: I give them a case study that present the problem, and they need to follow the steps of the design process until their design a solution. But we have a challenge, as we lack the materials and tools.

R: How do learners evaluate their decision and problem solving methods?

P: Mam, there is no time for evaluation as this subject consists of two periods per week and I only teach one period because the other period is on Friday during the time of cleaning. The leadership here do not take this subject methods?

P: Time allocated for the subject is a challenge. But learners have to mark their work using a rubric.

R: How do you support learners to provide evidence of the process after following the design process?

P: I give them opportunity to present their project in a group.

R: thank you.

P: Iyoo it was though.

P: I give learners to evaluate their decisions looking at the specifications and also I provide a rubric.

R: How do you support learners to provide evidence of the process after following the design process?

P: I support them to bring their product or solution in a project portfolio.

R: Thanks very much

P: Not to mentioned. You must visit us again.

subject is limited? P: Yes, only two periods per week is not enough for such work.

R: How do you support learners to provide evidence of the process after following the design process?

P: they submit the project portfolio.

R: Thank you for your time and deliberations.

P: No problem.

seriously.

R: How do you support learners to provide evidence of the process after following the design process?

P: Learners present their evidence by bringing a project.

R: Thanks very much.

APPENDIX E

CONSENT FORM

Dear Participant

You are invited to participate in a research project, which is aimed at exploring the effectiveness of the teaching strategies technology teachers apply to teach the design process. The process will include interviews and observations on how the technology teacher introduce a lesson on design process.

Your participation in this study is voluntary and confidentiality of information is guaranteed. You have the right to withdraw yourself from participating in the study at any time in any stage of the study. There would be no payment of incentives during the participation process.

The findings from this study will be used to identify the challenges that teachers may be experiencing in teaching the design process. The identified challenges will inform the future research.

If you are willing to participate in this study, please sign this letter as a declaration of your consent.

Participant signature--Date: -----------------------------------.

Yours Faithfully

Sibongile Sephoto (Mrs)

APPENDIX F

Permission letters to school principals to conduct research in their schools

The principal

Matome secondary school

Dear Sir/ Madam

Permission to conduct research

I hereby request permission to conduct a research in your school. I am a Masters student in education at the University of Limpopo. The purpose of the study is to explore teaching strategies technology teachers apply to teach the design process.

The process of the research methodology will include interviews and observations with the technology teachers in grade 8. The process will not affect the smooth running of the school even though observations will be done during teaching periods.

The results from this study will be used to identify the challenges technology teachers encountered in teaching the design process.

I will appreciate if my request is granted.

Yours Faithfully

Sibongile Sephoto (Mrs)

APPENDIX G

Permission letter to the circuit manager

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

(RAKWADU CIRCUIT)

ENQURIES : MASHAKENI LA
DATE : 2018-07-17

The Director
The University of Limpopo

Request to conduct research Sephoto S.A

The above matter refers:

Your request to conduct research to explore the effectiveness of the teaching strategies technology teacher apply to teach the design process in Rakwadu Circuit has been approved hence it will not affect smooth running of the schools.

Your positive response will be highly appreciated.

Yours Faithfully

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SETHABA M.D.B

CIRCUIT MANAGER