INVESTIGATING LEARNING ENVIRONMENT FOR TEACHING STRUCTURES IN TECHNOLOGY GRADE 9: A CASE OF SEKHUKHUNE EAST DISTRICT

by

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RESEARCH DISSERTATION

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DEDICATION

I dedicate this study to my family, beginning with my late parents, siblings, wife and children, special thankfulness to the Creator who has provided us wisdom to this day.

DECLARATION OF ORIGINALITY

University of Limpopo
Declaration of Originality

Full names of student: Jujuju Hlabje Viceroy

Declaration

I, Hlabje Viceroy Jujuju, declare that INVESTIGATING GRADE 9 LEARNING ENVIRONMENT FOR TEACHING STRUCTURES IN TECHNOLOGY: A CASE STUDY OF SEKHUKHUNE EAST: TUBATSE CIRCUIT SCHOOLS a dissertation for the degree of MEd in Technology Education at the University of Limpopo is my own work except where I have fully documented references. This dissertation had not been submitted to University of Limpopo or any other University before.

Signature of student……..

Signature of supervisor……

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My God who gave me wisdom and had directed me throughout this project.

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ABSTRACT

The purpose of this research was to investigate how Technology teachers in Grade 9 create an effective learning environment for teaching the topic of ‘Structures'. Technology is a new subject in the South African curriculum, therefore, the creation of a learning environment conducive to learning about Structures as one of the themes in Technology is crucial. In the South African curriculum for Technology, the Curriculum and Assessment Policy Statement (CAPS), learners have to be taught about the following design process: Investigating, Designing, Making, Evaluating and Communication. Besides, learners need to know strengthening and the functions of Structures. The design process will ultimately lead learners into modern structural engineering where the aim is to create structures that are up to standard and operational, as they are in the real world. The design process for structures needs to take into consideration three main aspects: mechanical concepts, aesthetic concepts, and sustainable development, which are independent while interrelated at the same time. Modern structural engineering needs to coordinate humanity and natural development. Structures, in broad terms, relate to buildings, dams and bridges, therefore, for structures to be designed, they need architects and structural engineers. Structures have been part of humankind for shelter, storage, communication and to solve many human problems.

The creation of a learning environment for teaching structures, which is the main focus of this research, was studied in relation to a constructivist learning environment, e.g. pre-conceptions, sensorial activation and the analysis of subject matter, in accordance with the Resource Theory. The Resource Theory calls them the ingredients believed to enhance learning, where a learning environment is created by physical facilities, human resources and fiscal resources. Studying technology using Resource Theory as the theoretical framework may give insight into the successful teaching of Technology as a subject in South Africa. Besides, the Resource Theory has characteristics of constructivist models like Education Reconstruction for Teacher Education (ERTE), which was used for studying science where learners’ preconceived knowledge, sensorial activation and subject matter analysis are considered as effective for creating a conducive learning environment. The Resource Theory

emphasizes that physical resources, human resources and fiscal resources enhance an effective learning environment.

The advantage of these constructivist models is that they represent the framework for an integrative approach to research on creating a learning environment for teaching topics such as Structures. The models firstly integrate sensorial activation; secondly, the empirical study of learners' pre-conceptions; and thirdly, an analysis of the subject matter. When creating a learning environment for structures using the analysis of subject matter, sensorial activation and learners' pre-conceptions, the pedagogical content knowledge for Technology teachers may also be successfully explored.

Currently in some schools in South Africa, the topic of 'Structures' as one of the Technology themes, is taught in a general classroom with no equipment, materials and teachers' lack of knowledge of the learning environment. Besides, the literature shows that there is no ordered environment earmarked for teaching and learning Technology. Some teachers are not able to teach effectively, as a result, there is no conducive learning environment for teaching the topic of Structures. This means that the learning environment in many schools in South Africa still leaves much to be desired. The main challenge is that teachers focus more on the curriculum and textbook's sequencing of topics in teaching in a context of classrooms where practical tasks are not emphasised. In addition, teachers do not always have a clear understanding of the structure of the curriculum or the demands of the curriculum. Teachers need to be trained on how to integrate various resources, as the literature suggests, not only to follow textbooks as a way of sequencing their teaching. Owing to the above-mentioned gaps a study was needed to investigate how Technology teachers create an effective learning environment for teaching the topic of Structures.

A qualitative approach and case study design were used to find out how a learning environment for Structures is created in Bohlabela Circuit. The data were collected using unstructured questionnaires and document or observation sheet for planning documents. Two Grade 9 Technology teachers participated in the study. Since this study was about investigating the learning environment created by Technology teachers when teaching the theme Structures, the findings revealed that these teachers had a knowledge of what creating a learning environment is, but it was not

clear if they practiced this in their classrooms. They seemed to have a knowledge of the essence of prior knowledge, resources and content knowledge of Structures.

The study recommends that curriculum advisors at Circuit level need to intensify workshops and visit Technology teachers in schools to check whether they have artefacts made by learners using the Design Process. Furthermore, observation during teaching is necessary, monitoring the effectiveness of teaching and learning of making Structures. The importance of this study is that the findings may be helpful to technology curriculum designers, teachers and learners, since workshops may be conducted in a proper way. Resources need to be coupled with teachers' content knowledge of structures and strategies for instruction.

Key concepts: Creation of learning environment; Content knowledge; Constructivists learning environment; Pedagogical content knowledge; Resource Theory; Sensorial activation; Structures; Technological pedagogical and content knowledge.

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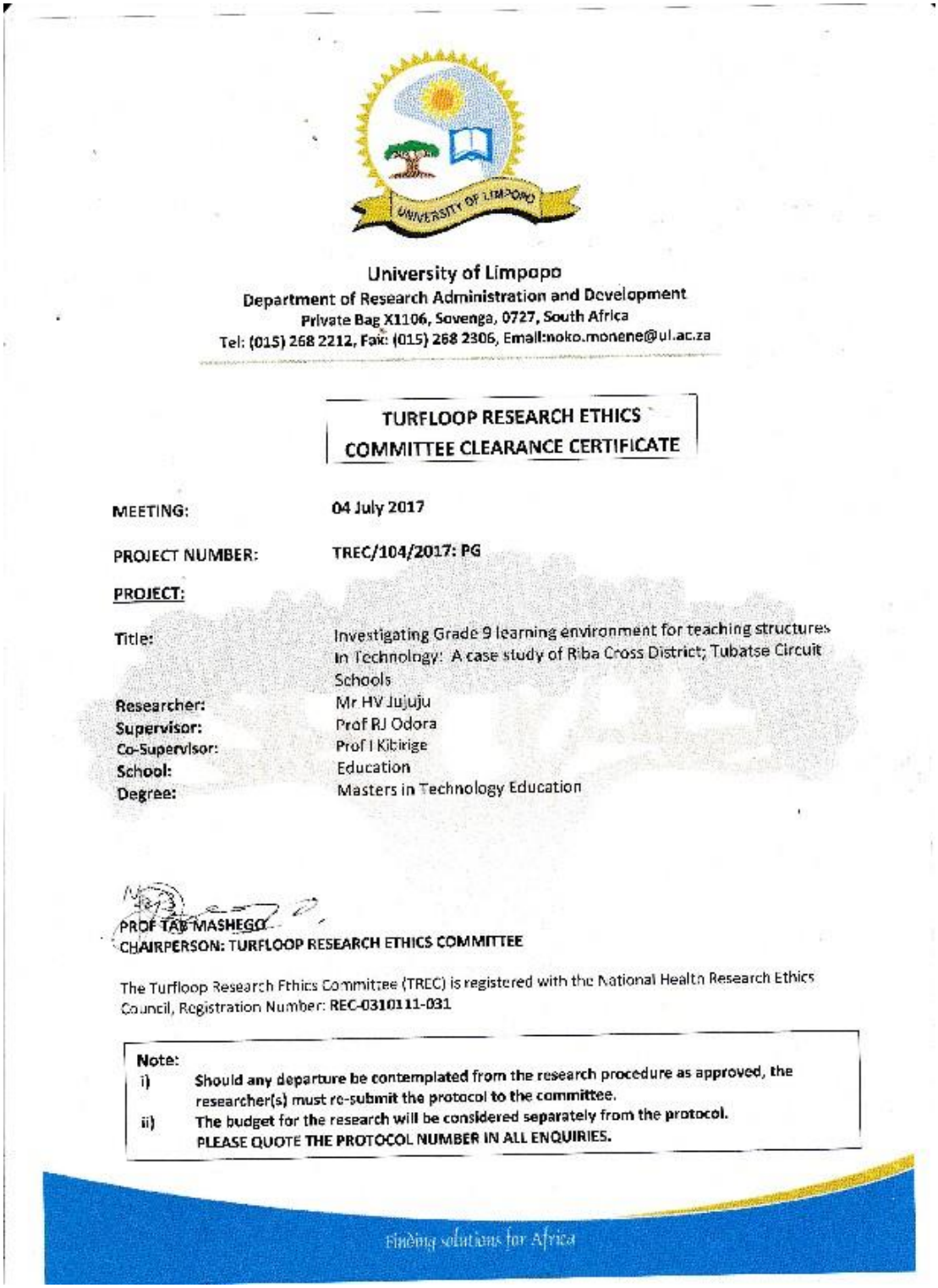

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TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING:	**04 July 2017**
PROJECT NUMBER:	**TREC/104/2017: PG**
PROJECT:	
Title:	Investigating Grade 9 learning environment for teaching structures in Technology: A case study of Riba Cross District; Tubatse Circuit Schools
Researcher:	Mr HV Jujuju
Supervisor:	Prof RJ Odora
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School:	Education
Degree:	Masters in Technology Education

PROF TAB MASHEGO
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CHAPTER 1 INTRODUCTION

1.1 OVERVIEW OF THE CHAPTER

The purpose of this research was to investigate how Technology teachers create a learning environment for teaching the theme of 'Structures'. The researcher believes that the findings will highlight research for further studies and will provide guidance to Technology curriculum advisors, in assisting teachers for workshops on how to create a conducive learning environment for teaching Structures. In this chapter, the researcher begins with the following sub-heading: Introduction and background of Technology teaching in the South African Technology curriculum. This is followed by the Rational; Purpose of the research; Research problem; Research questions; Significance of the study; Clarification of the concepts, Outline and organisation of the research.

1.2 INTRODUCTION AND BACKGROUND

The Department of Basic Education (DBE, 2011) introduced the Curriculum Assessment and Policy Statement (CAPS) for Technology, which, amongst others, requires learners to be taught knowledge and understanding of how structures are made and how they function in various environments. Therefore, learners need to know that the purpose of modern structural design (Lin & Zhen, 2016) is to provide a structure with up-to standard operational functions that can also withstand external interference. Learners must know structures like ultra-high-rise structures, ultra-long-span bridges and a collection of novel structures. For learners to understand structures (DBE, 2011), the CAPS document stipulates that teachers need to analyse the content, and sensorially activate learners through representations to demonstrate knowledge of structures. This comprises (Petrina, 2007) conceptual knowledge, which entails knowledge of the structures and their functions, as well as procedural knowledge referring to how structures are made and their ability to withstand various forces. Ahmad, Ali, Adil and Khan (2018) write that structures' performance in the past has led to huge losses of life and economy, like in the event of disasters and usage by consumers. As a result, learners need to have a thorough knowledge of structures as a preparation for real world survival.

Structures are objects that have been modified for a particular function (De Vries, 2004). Moreover, structures have collective intentionality (to be used by many) ascribed to them in function. The DBE (2011) CAPS document states that learners need to know the concepts of life span and about topics related to the strengthening of structures like triangulation, mass, density, hardness, stiffness, flexibility, corrosion prevention, resistance, tubing, corrugation, lamination and the forms of structures. The subject of Technology emphasises that structures are artefacts resulting from manufactured objects (DBE, 2011), therefore, artefacts are frequently regarded as the aim of technology (Stables, Benson & De Vries, 2011). McRobbie, Ginns and Stein (2000) highlight that technology leads to the manufacturing of artefacts. Frederik, Sonneveld, and De Vries (2010) also mention that structures such as buildings, cars, computers, and televisions are some of the artefacts manufactured using technology. For this study, artefacts refer to the result of projects. Ball (1997) states that engineering is one of the fields that essentially manufactures artefacts that achieve certain requirements, and the design process is used to produce artefacts. For learners to have proper knowledge of structures, teachers need to create an effective learning environment.

Technology teachers in South Africa still struggle with the teaching of the subject since its inception in 1998 and there are few studies to investigate this problem (Gumbo, 2016). Besides, Williams and Gumbo (2014) articulate that Technology as a subject in South Africa is relatively new and thus training teachers in the subject should be intensified. Engelbrecht, Harding and Velupillai (2008) also mention that Technology teachers in SA lack knowledge about creating learning environments. In a study comparing South African and New Zealand Technology education, Williams and Gumbo (2012) state that, other teachers in South Africa do not have a clear understanding of either the structure of the curriculum or the demand of the curriculum, and they only base their teaching on the textbook's sequencing of topics. Therefore, it raises questions regarding how teachers consider learners' prior knowledge, sensorial activation and integrate it into their content analysis for structures when planning lessons and evaluating teaching strategies. Considering the fact that Technology is a relatively new subject in the South Africa curriculum, studies need to be conducted on teachers' creation of a learning environment, for instance, in teaching about 'Structures'.

The creation of a learning environment for teaching Structures is necessary because South Africa has for some time been short of engineers, technicians and artisans for national development. In order to solve this problem, the DBE (2011), through the revised CAPS document, introduced Technology as a compulsory subject in the General Education and Training (GET) Band in order to "prepare learners to specialise in further education and training and tertiary education to satisfy the technological demands of our modern society" (DBE, 2011, p. 9). Moreover, it is to provide teachers with effective instructions that lead to learners understanding and mastering the content presented. The CAPS document stipulates that content knowledge is the ability to express oneself on the content of the subject. However, fulfilling this aim is greatly dependent upon having a safe and fruitful environment in which teachers can teach and learners are able to learn effectively (Solvberg & Rismark, 2012).

Loh (2019) emphasises that factors such as culture, environment and historical events, as well as prior learning experiences and the achievement of goals contribute to learners' ability. Irfan, Faris, Maflehi, Karim, Saad, Ponnamperumd and Ahmed (2019) believe that students' perception of their current learning environment is found to be a stronger predictor of learning outcome. Irfan et al. (2019) further elaborate that from an educational point of view, it is better to determine the learning environment such as pedagogical philosophy, curriculum design and social climate.

Without a conducive environment, instructional and learning time is lost (Strayer, 2012). A conducive classroom environment for teaching and learning can be created by the teacher maximising the time allocated for instruction and learning (Herrington & Herrington, 2007). Colvin and Lazar (1997) write that content knowledge, sensorial activation, proper curriculum planning, systemic assessment, correct strategies for delivering instruction, and classroom procedures for preventing and responding to learners' problem behaviour are considered key elements of an effective learning environment. In addition, Brooks (2011) highlights that, among other things, learners need a clean, bright, organised space to strengthen learning experiences. A learning environment that has little light, dirt on the floors, messy bookshelves and inadequate supplies is considered as an ineffective learning environment (Solvberg & Rismark, 2012).

Irfan et al. (2019) state that it might seem that the concept of a learning environment is rather intangible, yet its effects are influential and real, affecting learners' achievement, attitudes and well-being. Therefore, teachers need to spend a great deal of time in the classroom making the learning environment more attractive by colourful posters, clear and consistent rules, and fun and interesting teaching methods. An effective teacher pays close attention to creating a positive learning environment based on the physical, psychological and instructional atmosphere (Brooks, 2011). A negative learning environment or setting that is unproductive to learning can affect learners in many ways, such as learners' poor achievement, poor behaviour, learners' anxiety, or depression (Davies, Jindal-Snape, Cillier, Digby, Hay & Howe, 2012).

Williams and Gumbo (2014) emphasise that learning needs to take place in a conducive environment. Herrington and Herrington (2007) argue that a positive learning environment is one that is real and provides an authentic setting that reflects the way in which knowledge will be utilised in real life. To teach Structures effectively, teachers need to create a learning environment that promotes authentic activities, access to expert performance, and the modelling of processes, multiple roles and perspectives, collaborative construction of knowledge, reflection, articulation, coaching, scaffolding and authentic assessment (Herrington & Herrington, 2007). Hlalele (2014) mentions that a learning environment encompasses different activities like material resources, relationships and the interaction that emerge from them.

A positive learning environment allows learners to feel comfortable and confident as learners (Solvberg & Rismark, 2012). Weinstein (1979) states that there are three common types of learning environments: the physical, psychological and emotional environment. The physical appearance of a learning environment can affect learners emotionally, with important cognitive and behavioural consequences (Weinstein, 1979). Although emotional reactions to environmental stimuli have been shown to vary widely across individuals and activities (Weinstein, 1979), most learners would probably find learning difficult in an environment that is stiflingly warm, for example. An environment that elicits positive emotional responses may lead not only to enhanced learning, but also to a powerful, emotional attachment to that space (Weinstein, 1979).

Weinstein (1979) further elaborates that such an environment may become a place where students love to learn, a place they seek out when they wish to learn, and a place they remember fondly when they reflect on their learning experiences. Psychological environment in the classroom concerns how learners feel about their learning. Weinstein (1979) cautions that teachers who yell at learners, are random about behavioural consequences, and embody an overall negative attitude are not good for the learning environment. Strayer (2012) advises that using different teaching practices, such as hands-on activities, cooperative learning groups, small groups and individual practice make a meaningful and exciting learning environment. Consequently, the teaching environment for structures needs to be reconstructed, that is, through the use of a knowledge base regarding learners' preconceptions (Chamnanwong & Yuenyong, 2014), the sensorial activation of learners, and the teachers' knowledge of content, for instance, structures. Learners have to build on comparisons and be able to relate new materials to the content they have acquired previously, and that they have also organised and kept in their memories (Irfan et al. 2019).

1.3 RATIONALE

The effective teaching of Technology in the South African curriculum is essential (DBE, 2011), and teachers need to have knowledge of creating an effective learning environment for teaching Technology and themes like Structures. Consideration of the concepts of prior knowledge, sensorial activation and analysis of content knowledge in education are regarded as important, but there is limited research available in South Africa that can be used to guide teachers on how to take advantage of these concepts in creating an effective learning environment (Gumbo, 2016). The Resource Theory (Astin, 1984) affirms that resources like physical facilities, human resources and fiscal resources tend to serve as ingredients that facilitate a good learning environment.

Owing to the findings of Gumbo (2016), as well as Mapotse (2017) regarding South African Technology teaching, teachers struggling to teach the subject, that necessitated or prompted the researcher to conduct a research on how teachers create a learning environment for teaching Structures. Effective learning environment in teaching structures, must be indicated in planning, during the course of the lesson activities and the assessment feedback to learners.

1.4 PURPOSE

The purpose of this research was to investigate how Technology teachers create a conducive learning environment when teaching structures in Grade 9.

1.5 RESEARCH PROBLEM

The effectiveness of teaching of Technology as a subject in South Africa still needs attention (Gumbo, 2016). Currently, in other schools in South Africa, the topic of Structures as one of the Technology themes is taught, in general, in classrooms with no equipment, no materials, poor teacher knowledge, and a bad learning environment (Archer & Brown, 2013). Mapotse (2017) found that there is no ordered environment earmarked for teaching and learning Technology. Furthermore, in a study conducted by Engelbrecht, Harding and Velupilai (2008), as well as William and Gumbo (2014), it was found that some teachers are not able to teach effectively, as a result, there is no conducive learning environment for teaching technological themes like Structures. This problem necessitated the learning environment for teaching structures in most South African schools to be investigated. Archer and Brown (2013) emphasises that a lack of teachers' content knowledge, broken windows and furniture, vandalised electrical fittings, and other bad aspects all create a poor teaching and learning environment for teaching topics like structures. Consequently, this negative learning environment adversely affects learning in many ways in South Africa.

1.6 RESEARCH QUESTION

The main research question for this study was as follows:

How do Technology teachers create learning environment for teaching structures in Grade 9?

The following sub-questions guided the inquiry:

1. What is an appropriate environment for teaching and learning structures?
2. What is Technology teachers' experience when teaching structures?

1.7 SIGNIFICANCE OF THE STUDY

South Africa, as a third world country, is faced with many problems, one of which is poor Technology learning environments. This study may improve Technology teaching strategies based on the recommendations of the findings. The DBE may further find it informative in that it provides a practical framework for assessing the impact of quality education and enhancing Technology teaching in South African schools. It may also provide information that could be used to support teachers when creating effective learning environments in other subjects as well.

Knowledge of teachers' level of awareness of learners' pre-conceptual contributes to the recognition of a necessity (or not) to further strengthen teaching strategies in developing lessons. This could also assist management in schools with regard to curriculum management. The findings could also be helpful for Technology curriculum designers and workshop presenters of curricula. In this sense, this limited study may be viewed as a pilot investigation of both the conceptual framework and the research instruments.

1.8 CLARIFICATION OF CONCEPTS

In this section, the researcher provided the definitions of key concepts that are further substantiated and clarified in the literature review.

Content or subject matter analysis: studying content in order to develop it for effective teaching of subjects like technology, for example (van Dijk & Kattman, 2006).

Content knowledge: a person's ability to express himself/herself on the content of a subject, including understanding the structures of a subject and its basic concepts and principles.

Learning environment: the integration of the teachers' knowledge, their engagement with learners through instructions, the physical classroom and resource environments, as well as the learners' knowledge and understanding of technology-specific concepts form the learning environment (van Dijk & Kattman, 2006). It is thus the space of the teacher, learners, as well as a physical space wherein the learners' senses are used.

Pedagogic Content Knowledge: Shulman (1987, p. 8) defines this as "a blend of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented and adapted to the diverse interests and abilities of learners, and presented for instruction."

Pre-conceptual knowledge: this refers to information or conceptions that learners have about a subject before coming to school (van Dijk & Kattman, 2006). Learners have ideas about the application of structures/artefacts, e.g. houses, roofs and bridges.

Reconstruction of knowledge: Issues that were lost in the process of the initial formation of knowledge need to be reconstructed to make a subject understandable and meaningful to learners and perhaps to the teachers themselves (van Dijk & Kattman, 2006).

Representations: these are external objects that represent our understanding of concepts and procedures. In class, they include learners' and teachers' support materials and other relevant objects that will represent the topic being studied (Cox, 1999). Cox further writes that representations typically contain the re-ordering of information to translate it from one modality into another to aid explanation.

Resource Theory: this is a theory developed by Astin (1984) that holds that a learning environment is created by physical facilities, human resources and fiscal resources.

Sensorial activation: Sensorial experiences like hearing, vision, feeling and physical interaction with objects (Piaget, 1973).

Structures: these are artefacts, which are manufactured objects (DBE, 2011). Artefacts are frequently regarded to be key to the definition of technology (Stables, Benson & De Vries, 2011). McRobbie, Ginns and Stein (2000) highlight that technology leads to the manufacturing of artefacts. Frederik, Sonneveld and De Vries (2010) state that structures such as buildings, cars, computers, and televisions are some of the artefacts manufactured using technology. For this study, artefacts refer to the outcome or result of projects. Ball (1997) mentions that engineering is one of the fields that, in fact, produce artefacts that achieve a particular requirement, while the design process is utilised to develop artefacts.

1.9 OUTLINE AND ORGANISATION OF THE STUDY

This study comprises five chapters. Table 1.1 gives the outline and organisation of the research. *Table 1. Outlines and organisation of the study*

Chapters	Chapter headings	Chapter descriptions
1	Orientation of the study	Outlines the background and Rationale of the study, provides the Purpose, Problem statement, Research question, and Clarification of concepts.
2	Literature review	Gives an overview of the literature concerning the creation of a learning environment for structures. The following are also discussed: Conceptual framework, Structural engineering, Constructivist learning environments, Technological pedagogic content knowledge, Scaffolding on learners prior knowledge as learning environment, Learners' sensorial activation in learning environment according to constructivism, Using learner-teacher support materials, Setting goals, Content or subject knowledge analysis in the learning environment, Constructivist perspective on an educational learning environment and the Conceptual learning environment, and Conclusion of the literature.
3	Research design and methodology	The methodology of the study is detailed in this chapter. The Research approach, Research paradigm, Design, Ontology, Epistemology, Methodology, Population and sample, Data Collection, Instruments, Data analysis, Standards for research, including Ethical considerations, are mentioned in this chapter.
4	Discussion of the findings	The findings and interpretation of data are carried out in this chapter. The interpretation of the data based on the research questions and observation procedures in planning are discussed.
5	Summary of the Findings, Limitations, Discussions, Recommendations and Conclusion	Chapter 5 gives the discussions, Recommendations conclusions and Limitations of this study.

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

This study draws on literature from the fields of the Constructivist Learning Theory, and Resource Theory (Astin, 1984) as a conceptual framework, focusing on an effective learning environment for teaching the theme of 'Structures' in Grade 9. The following sub-headings are discussed: Resource Theory, A constructivist learning environment; The constructivist perspective on an educational learning environment; Conceptual knowledge of structures in a learning environment as prescribed by the CAPS document; Structural engineering and design; How to teach structures (PCK); Conceptual knowledge in the learning of environment and Technological pedagogical and content knowledge (TPACK). Thereafter, Technological PCK, Scaffolding on learners' prior knowledge as a learning environment; Learners' sensorial activation in a learning environment according to constructivism; Content or subject knowledge analysis in a learning environment; Content or subject knowledge analysis in a learning environment; Learner support materials; Using learner teacher support materials (LTSM); Setting goals; Design process; and Research findings on an effective learning environment for teaching Technology content in South Africa, and Conclusion of the chapter.

2.2 RESOURCE THEORY

This study was informed by The Resource Theory (Astin, 1984), coined from Student Involvement Theory, which is the amount of physical and psychological energy that students devote to academic experience. Involvement leads to development (Astin, 1984) since it creates an effective learning environment. Astin (1984) states that involvement has five basic postulates:

(i) Involvement refers to the investment of physical and psychological energy in various objects, the objects may be highly generalised (students' experience) or highly specific (preparing for a subject examination).

(ii) Involvement occurs along a continuum, that is, students manifest different degrees of involvement in a given object and the same student manifests different degrees of involvement in different objects at different times.

(iii) Involvement has both quantitative and qualitative features, like the extent to which a student's involvement in academic work can be measured quantitatively (how many hours) or qualitatively in whether the student reviews and comprehends reading assignments or simply stares at the textbook or spends time day-dreaming instead of studying, as well as comprehension of the lessons.

(iv) The amount of student learning and personnel development associated with any educational programme is directly proportional to the quality and quantity of student involvement in the programme.

(v) The effectiveness of any educational policy or practice is directly related to the capacity of that policy or practice to increase student involvement.

In the Resource Theory, the term resource includes a variety of aspects believed to enhance learners' learning (Astin, 1984), like: physical facilities like laboratories and libraries, and audio-visual, human resources, for instance, knowledgeable teachers and counsellors, which motivate high achieving learners. Astin (1984) further elaborates that if resources are brought together in one place, or integrated as in Shulman's (1986) Pedagogical Content Knowledge (PCK) ideology, then student learning and development will occur. The theory also espouses that the learner to teacher ratio produces an effective learning environment. In the case of counsellors, as is also mentioned in Vygotsky's (1978) scaffolding, Astin (1984) argues that the resource theory of pedagogy tends to include the belief that high-achieving students are resources, and increasing the proportion of high quality teachers and the production of high achieving learners will yield good results. This means that training teachers will enhance the effective creation of a good learning environment for teaching structures. The theory is represented in the following figure.

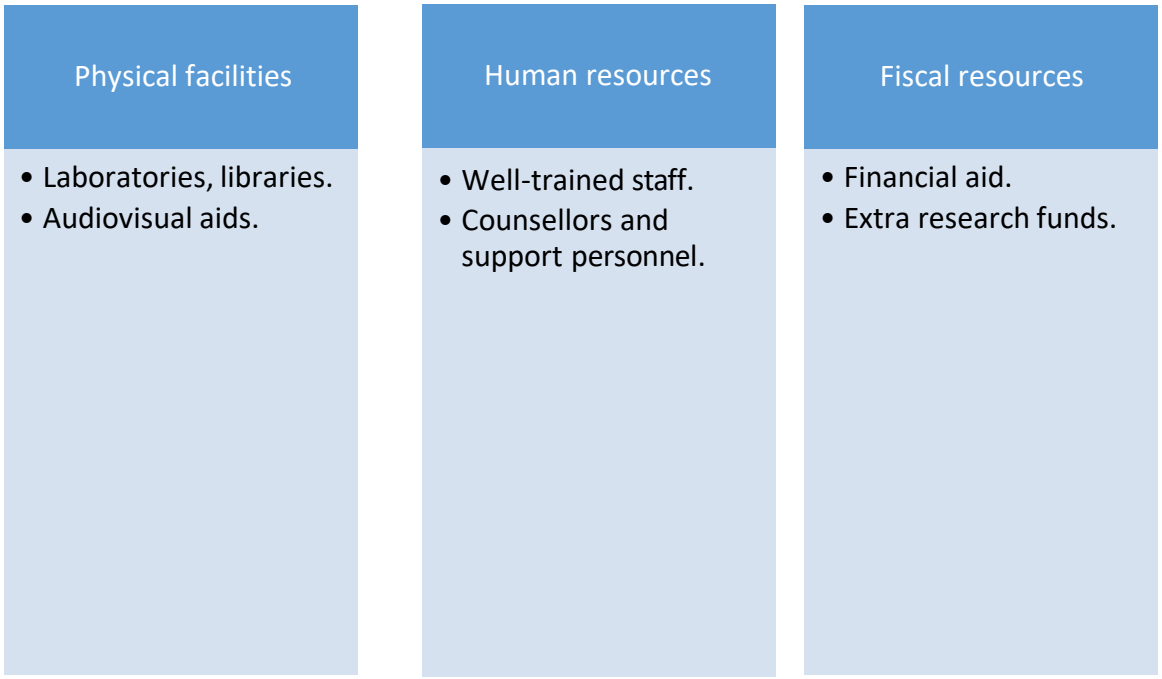

Figure 1. Resource Theory (Astin, 1984)

Astin (1984) indicates that Resource Theory has two main limitations, which are that certain resources, such as bright learners and a prestigious faculty are finite, and the other is that it focuses on the mere accumulation of resources with little attention to the efficient usage of those resources. Richardson (1997) also affirms that individuals create or construct their own new understanding or knowledge through the interaction of what they experience and believe, together with the ideas, events and activities that they come across in learning environments. Knowledge is acquired through involvement with content in the relevant learning environments (Richardson, 1997). Liu & Chen (2010) suggest that all learning should take place, or be anchored in a specific physical and social context to attain knowledge that is closely associated with those settings. Richardson (1997) writes that knowledge is acquired through involvement with content instead of imitation or repetition, as is indicated in Resource Theory (Astin, 1984), which can assist in teaching about structures in Technology.

2.3 A CONSTRUCTIVIST LEARNING ENVIRONMENT

Irfan, Faris, Maflehi, Karim, Gaminda, Pannamperuma, Saad and Ahmed (2019) mention that international trends in education show a shift from the traditional non-integrated, teacher-centred approach to an integrated student-centred approach. Studies looking into the learning environment of different health professional schools

worldwide have shown a trend of higher total scores in the student-centred schools as compared with the teacher-centred, traditional schools (Irfan et al., 2019). Regarding the creation of a learning environment, Piaget (1973) emphasises the importance of prior knowledge (schemata) where learners accommodate new knowledge. Piaget's theory underlies cognitive constructivism. Central to his theory is the idea that knowledge emanates from successive active constructions (Fosnot, 1996). The system of learning is the process of formulating equilibrium (Fosnot, 1996), where cognitive structures assimilate and accommodate to form possibilities. Therefore, the environment activates senses. Meaning that learners see, listen, touch and discuss in negotiated learning.

Vygotsky (1978) writes that dialectic engagement between the individual and society, and the effect of social interaction support peer learning. Vygotsky further explains that learning continues from a current low level to a higher level of learners' ability. This on-going motion takes place in the Zone of Proximal Development (ZPD), which is formulated by social interaction. Teachers and peers scaffold learners (Vygotsky, 1978) to their maximum potential, taking advantage of prior knowledge. Therefore, social interaction provides learning environments where learners acquire knowledge through their sense of sight, listening, hearing, speaking and touching. For the creation of an effective teaching environment, the following points need to be considered and integrated: school knowledge, subject knowledge and pedagogical knowledge.

According to Krajcik and Schneider (2002) creating a learning environment addresses each area of knowledge necessary for exemplary practices, content knowledge, pedagogy knowledge and situating teacher learning by enmeshing the content of the support to the actual lesson. Krajcik and Schneider emphasise that designing educative materials is essential to strengthening learning. The following concepts are further explained: content - the accuracy of content presentation for each concept of the unit; pedagogy - linking ideas across lessons and using artefacts to assess learners' ideas; and PCK - matching representations to recommended subject matter, and also matching the strategies used to recommended and give appropriate feedback, coaching or modelling of learners' ideas. Krajcik, and Schneider elaborate that the teacher's subject knowledge is transformed by his own pedagogy in practice and by the resources that form part of his school knowledge.

It is the “active interaction of subject knowledge, school knowledge and pedagogical understanding and experience that brings teacher professional knowledge into being” (Banks, Leach & Moon, 2005, p. 336). The other process is the ‘personal construct’ of the teacher, a complex amalgam of past knowledge, experiences of learning, a personal view of what constitutes good teaching, and beliefs in the purpose of the subject (Banks et al., 2005, p. 337). These hold the teacher’s professional knowledge and are what make a good teacher. Banks et al. (2005) also mention that expert and experienced teachers need to question their personal beliefs in the subjects that they teach as they work out the rational for classroom practice. Professional knowledge depends on the interaction of elements like school knowledge, subject knowledge and pedagogical knowledge, but are brought into existence by the learning context, the learners themselves, the setting, activity and communication, as well as the context in a broad sense (Banks et al., 2005).

As a result creating a learning environment links different knowledge areas with the lesson, making knowledge accessible to teachers by including short scenarios in the language of the teacher presenting the lesson, addressing immediate needs for understanding as teachers plan lessons that will be enacted within a short time. Krajcik and Schneider (2002) indicate that the urban system initiative of a large public schools district system reforms science and mathematics. In their study, curriculum materials were developed that were consistent with social constructivist ideas, that addressed national and local goals for students and learning, and that were educative for teachers. The authors also investigated the question of subject matter knowledge and how this knowledge could be acquired by others. They further developed curriculum materials based on the premise of project-based science. In doing so, they expounded that curriculum design is based on the principles that are consistent with that is known about teaching and learning (Krajcik & Schneider, 2002).

In the quest for knowledge, it is assumed that learners need to find solutions to real problems by asking and refining questions, designing and conduction investigations, gathering and analysing information and data, making interpretations, drawing conclusions and reporting their findings. Krajcik and Schneider (2002) write that teachers’ knowledge is a challenge, like inquiry, versus a more linear flow of information, thus various techniques need to promote learning such as coaching or

modelling, and specific instructional strategies such as prediction-observation-explanation, and the management of classrooms. Educative curriculum materials are designed to support learning by teachers to learners, but the materials cannot replace other professional development opportunities, even though these materials have a unique role. One way to support learners is through the designing of materials that are effective in learning and teaching. In Krajcik and Schneider's (2002) study, teachers are advised to use new ways of representing content and new strategies to support learners' construction of knowledge.

Krajcik and Schneider (2002) also investigated how teachers use educative materials, content knowledge, and pedagogical knowledge looking at both classroom observation and teacher interview data. They found that teachers use educative materials when planning, and teachers understand lesson-specific ideas (PCK) better than content or pedagogy when using educative materials. PCK may be a useful construct for designing educative curriculum materials. Teaching is a complex activity that requires teachers to understand content and pedagogy as they come together to support student thinking and learning in the context of their classroom (Krajcik & Schneider, 2002). Curriculum materials, by definition, are about specific lessons that are much easier to use in the support of PCK. Educative curriculum materials appear to be a promising approach to facilitating teacher instruction, which is necessary for improving practice. In order to create such materials, much research needs to be done. In relation to this, Krajcik and Schneider (2002) have found that educative materials or other professional development opportunities are important factors in teaching and learning.

2.4 THE CONSTRUCTIVIST PERSPECTIVE ON AN EDUCATIONAL LEARNING ENVIRONMENT

Technology is a practical subject that needs a hands-on approach for it to be mastered (De Vries, Custer, Dakers & Martin, 2007). Learners need to discuss, explore and relate the current lessons to their previous experience. Piaget (1973) calls this learning process the accommodation of schemata, which is building on learners' pre-concepts. Constructivism advocates for hands-on strategies coupled with collaborative learning while teachers' utilise learners' prior knowledge, sensorial activation and content

analysis in the planning and teaching process for authentic teaching (De Vries at al., 2007). Moreland and Wine (as cited in De Vries et al., 2007) apply prior knowledge by scaffolding on learners' knowledge in fermentation at home to teach biotechnology. They created a learning environment by requesting learners to display their work on the classroom walls, which became a colourful stimulus for teaching biotechnology and the lesson created real life technology (De Vries et al., 2007). Teachers group learning outcomes are related to procedural knowledge, conceptual knowledge and societal learning outcomes that are consistent with technology. The same applies to the findings of Novak and Foster (as cited in De Vries et al., 2007), as learners worked with an expert team from their community to build on the conceptions of the learners about the expert team's role in the community. Web-cam, e-mail and other programmes were used in the class, including workshops and jigsaw strategies to create an authentic experience.

In such cases, the teacher uses the expertise of the community of experts to facilitate knowledge development amongst learners. Pryde (as cited in De Vries et al., 2007) uses the dynamic engineering and industrial history of Glasgow city as a context for prior knowledge in learners. These learners live in an industrial area that creates an effective learning environment for teaching about energy. Learners see the operation of a sluice gate to maximise the flow of water as a source of energy, and they realise the evolution of technology because old technology forms the basis of new technology. Snape and Turnbull (2013) elaborate that authentic activities in teaching need to be situations that are real to learners' life experience.

Snape and Turnbull (2013) also explain that activities that use authentic practice are more likely to generate greater understanding and enable learners to identify, gain from simulations and to be in line with the tacit knowledge of technologists. Authentic practice is necessary in South African Technology teaching since simulation and identification lead learners to the real world. Applying the Resource Theory (Astin,1984) which is the constructivist approach to studying teachers' consideration of learners' prior knowledge, sensorial activation and content analysis in teaching structures may assist in the research areas that have been neglected in Technology.

2.5 CONCEPTUAL KNOWLEDGE OF STRUCTURES IN A LEARNING ENVIRONMENT AS PRESCRIBED BY THE CAPS DOCUMENT

The aim of the South African curriculum is to develop and apply specific aims for design skills, understanding concepts and knowledge of technological problems, and the appreciation of values and attitudes for constructing structures and artefacts (DBE, 2011). That is why this study focused on teachers' consideration of the creation of a learning environment comprising learners' pre-knowledge, sensorial activation and content knowledge of structures. These concepts are also highlighted in Resource Theory (Astin, 1984) where resources tend to facilitate an effective learning environment. The DBE (2011) expects learners to know and apply procedural skills like investigating, designing, making, evaluating and communicating. This process must be used to teach mini practical tasks known as MINI-PATS in Technology.

2.6 STRUCTURAL ENGINEERING AND DESIGN

Structures have been part of mankind since the beginning of human life on Earth (Beghini, Beghini, Katz, Baker & Paulino, 2013). In recent tradition, the goal of architecture has been learning towards aesthetics and the goal of an engineer has been focused on stability and efficiency. Lin and Zhen (2016) write that in ultra-high-rise structures and ultra-long-span bridges, the emphasis is on the functional requirements, energy conservation and being environmentally friendly. van Amsterdam (2004) affirms that structures, in broad terms, relate to buildings, bridges and dams, which serve many purposes. The most important function of a building is to provide shelter, and for dams to provide water storage. De Vries (2004) highlights that structures or artefacts are objects that have been modified for a particular function. The structure has a collective intentionality (to be used by many) ascribed to it in function.

The construction process is concerned with rationale and economics (van Amsterdam, 2004), while the design process for structures is concerned with size, shape, the nature and form of a building in relation to its function, loading parameters, and the materials used (van Amsterdam, 2004). Beghini et al. (2013) mention that there is a chasm between the vision of the architect and the sensibility of the engineer in aesthetics of the structure and its corresponding skeleton. Structures need to satisfy

three principles; strength, utility, and beauty. A structure that is built without the engineering to stand and without an architectural aesthetic is not acceptable (Beghini et al., 2013). In the design of a structure, it is essential to select the appropriate objective of function to solve the problem. Minimum compliance or maximum stiffness is one objective that can be used in its own merit and also as a surrogate to explore other metrics, such as ductility, natural frequencies, buckling and stability (Beghini et al., 2013). Nowadays, in high-rising structures, topology optimisation is used (Beghini et al., 2013), which is done to minimise the material consumption in a structure, while at the same time providing a tool to generate a design alternative of benefits to both engineering and architectural communities in the reductions of costs. This eliminates any redundancy in making structures in order to teach learners cost efficiency.

Achal, Mukherjee and Sudhakara (2010) maintain that natural processes such as weathering, faults land subsidence, earthquakes and human activities create fractures and fissures in concrete structures, which can reduce the life span of the structure. It also means that specific materials are necessary for a particular purpose in building structures. Agarwal and Varma (2013) indicate that it is also necessary to design and make structures in a particular form or shape for their stability. They further elaborate that in structures, all floors are designed for nominal dead load and live load values, which is in line with dynamic and static forces, as mentioned by the DBE (2011). The CAPS document requires teachers to analyse content, scaffold learners' knowledge and sensorially activate Senior Phase learners to demonstrate knowledge and understanding of how structures are constructed and how they are designed to withstand various forces. According to the DBE (2011), procedural knowledge comprises investigation, designing, sketching, evaluation and adapting, working to a design brief, making a flow chart, making a product, and communication. Conceptual knowledge in Grade 9 is knowledge of structures, working principles, rigidity, and withstanding forces like, tension, compression, bending, torsional and shearing. Teachers then use assessment rubrics to assess learners' procedural and conceptual knowledge of structures based on the aspects mentioned (DBE, 2011).

Learners need to know the concepts of life span and strengthening of structures, like using triangles for strengthening; mass; density; hardness; stiffness; flexibility; corrosion resistance; the prevention of corrosion; tubing; corrugation; lamination; and

forms of structures (DBE, 2011). Because of the fact that learners have been taught about structures in Grade 7-8, teachers can take advantage of scaffolding learning on this prior knowledge. When teaching in Grade 9, prior knowledge of strength, the life span of structures, sensorial activation of forms/shapes of structures like, triangulation, and content knowledge like, the type of structures, could make a lesson effective. This study focused on Grade 9 level because at this stage, learners have been exposed to designing structures in previous Grades, and therefore it is assumed that they possess some prior knowledge.

2.7 HOW TO TEACH STRUCTURES (PCK)

Although there is literature support on the effect of an effective learning environment (Irfan et al., 2019) on teaching and learning worldwide, not enough has been researched on this topic (Gumbo & Williams, 2014) in the Technology teaching of structures in South Africa. Mapotse (2017) states that, there is no ordered environment for teaching Technology in South Africa. Gumbo (2016) as well, write that teaching Technology still needs attention. As a result of their findings, further studies are needed to investigate teachers' consideration of learners' prior knowledge, sensorial activation, and the integration of teachers' content analysis when planning lessons and their teaching strategies, like for the topic of Structures. Another fact is that Technology is a relatively new subject in the South African curriculum (Gumbo & Williams, 2014), thus little research has been conducted on teachers' creation of a conducive learning environment for the teaching. Gumbo and Williams (2014) elaborate further that a study on the theme of Structures it is necessary to investigate the effectiveness of the learning environment in the teaching of Technology as a subject.

Chamnanwong and Yuenyong (2014) find that a learner constructs or even creates his/her knowledge on the basis of prior knowledge. Chamnanwong and Yuenyong (2014) further elaborate that the process of construction of knowledge is embedded in a particular social setting where the individual belongs. Learners possess meaningful knowledge through discussions, reflection, and bargaining for the purpose of exchanging ideas (Chamnanwong & Yuenyong, 2014). This interaction helps leaners to restructure ideas and meaning. Liu and Chen (2010) expound that constructivism is a learning theory that explains how people acquire knowledge in learning, like

through the reconstruction of ideas. The learning environment in the class facilitates and advances conceptual and procedural knowledge (Brooks, 2011). Learners never learn in a vacuum (Solvberg & Rismark 2012), they interact with fellow learners, teachers, learning aids and other technologies. Therefore, as according to Wilson (1996), a good learning environment is a fruitful place for teaching and learning.

The setting for learning involves the learner, and needs to allow learners to act using tools, collecting and interpreting information. Learning is fostered and supported (scaffolding) by peers (Vygotsky, 1978) or instructors. Herrington and Herrington (2007) write that learners engage in motivating and challenging activities that need collaboration and support. Therefore, constructivism is a framework of learning that explains the way in which learners construct knowledge based on past learning (Liu et al., 2010). Moreover, this knowledge is subjective to each individual. Constructivism gives opportunities for learners to be self-directed, creative and innovative, while drawing upon visual/spatial, logical/mathematical, interpersonal, intrapersonal and naturalistic intelligences (Von Glasersfeld, 1989). The tasks in which the learners engage in structures reflect the activities that they see in real life. According to Herrington and Herrington (2007), this means that the creation of an effective learning environment is characterised by the provision of real settings that reflect knowledge of the real world, relevant activities, access to expert performance and modelling the process, a variety of roles and perspectives, collaborative construction of knowledge, reflection, articulation, coaching and scaffolding, and proper assessment.

Herrington and Herrington (2007) further state that what is also crucial is the fact that an effective learning environment encourages learners to be involved with one another and with what is happening around them during the lesson. A learning environment encourages personal development and authentic learning (Strayer, 2012). For learning environment of structures to be effective, it depends solely on teachers' integration of prior knowledge, sensorial activation and content knowledge where learners are motivated to learn in rich, relevant and real contexts (Herrington & Herrington, 2007).

When Technology teachers teach the topic structures, the class setting needs to establish a link between learners and their preconceptions. In addition, according to Afari, Aldridge and Fraser (2013), the quality of the classroom environment in schools

is a crucial determinant of learning. Brooks (2011) explains that stimulations and visualisations (sensorial activation) in an active learning environment are designed to facilitate learners' interaction, conceptual understanding and improve their problem-solving skills. Shernoff, Tonks and Anderson (2014) elaborate that a learning environment creates engagement and positive experiences that advance the mastering of content by learners, like Structures. Therefore, a positive learning environment could enhance the quality of teaching Structures in South African classrooms.

2.8 CONCEPTUAL KNOWLEDGE IN THE LEARNING ENVIRONMENT

McCormick (1997) finds that conceptual knowledge directs learners to 'tell why', which elucidates the 'know how' for procedural knowledge. According to Petrina (2007), propositional (conceptual, declarative) knowledge deals with conditions and meanings working with semantic memory that stores factual information. De Vries (2004) argues that teachers need to have the notion of the physical nature of the artefact, like the non-intentional aspects where the user identifies whether the physical nature is suitable for the function. The arithmetic aspects thereof are related to data, therefore, a Technologist must have mathematical knowledge to design the structure according to specific measurements. The structure will need a space to occupy, so spatial aspects created by the designer (the space it has to cover) will be necessary. The structure will also have to resist forces, which include movement, in the kinematical aspect.

The Technologist needs to consider the physical aspects of properties like weight, hardness and strength. De Vries (2004) mentions that knowledge of a physical nature always accompanies knowledge of a functional nature. The CAPS document outlines the following core content knowledge areas of Technology: Structures, Processing, Mechanical systems and control, and Electrical systems and control. The CAPS document states that the four content areas form the basic strands that every Grade must learn. De Vries (2004) further writes the normative components for technological knowledge, which are similar to the four strands in the CAPS document.

2.9 TECHNOLOGY CONTENT KNOWLEDGE IN THE LEARNING ENVIRONMENT

Knowledge is a justified true belief in terms of what a person knows or believes to be true, and it is subjective (Verloop, Van Driel & Meijer, 2001). Furthermore, knowledge and beliefs are inseparable (Pajares, 1992). Verloop et al. (2001) write that knowledge is content and context related, and in education it is meant for immediate use in teaching and learning practice. According to McCormick (1997), knowledge consists of procedural and conceptual knowledge; it is often seen as separate and the relationship between the two is sometimes ignored. Petrina (2007) calls it procedural and propositional knowledge of Technology. Procedural knowledge entails deductive reasoning (convergent) and propositional knowledge goes hand in hand with inductive reasoning (divergent). Procedural and propositional forms of knowledge are integrated and become sociotechnical (Petrina, 2007). The integration of procedural and propositional knowledge is suitable for teaching Technology content. In the Technology curriculum in CAPS document (DBE, 2011), procedural and propositional knowledge cannot be used separately when teaching Technology content like Structures because they depend on each other (DBE, 2011).

The DBE (2011) requires procedural and conceptual knowledge to be taught in order to accomplish the design processes of investigation, designing, making, evaluating and communicating. Technological knowledge is universally available in the real world and has been presented in various models. De Vries (2004) also classifies types of Technology knowledge as conceptual, procedural, visualisation and normative. Ropohl (1997) developed a model categorising knowledge into five groups: technological laws, functional rules, structural rules, technical knowledge and socio-technological understanding. Pavlova (2005) characterises Technology as tacit, prescriptive and descriptive knowledge, while McCormick (1997) argues that conceptual knowledge equates to the ‘know what’ and the procedural knowledge of Technology as well, as the ‘know how’, which consists of design process knowledge. Jones and Moreland (2001) suggest that teachers need to know and develop a strong teacher-knowledge base in the areas of content knowledge, general pedagogy, curriculum pedagogy content, the learners’ educational context, and educational ends.

Vincenti (1990) classifies Technology as: fundamental design concepts (operational principles and normal configurations); design criteria and specifications; theoretical

tools (mathematical, reasoning, laws of nature); quantitative data (descriptive and prescriptive); and practical implications and design instrumentalities (procedural knowledge). The author further states that these six categories are visible in the design of artefacts. Therefore, it could be assumed that Technology teachers should be required to have these kinds of technological knowledge and teach them in the context of the South African curriculum. For the success of teaching, teachers have to use "the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8). The emphasis of PCK is on the approaches to defining what teachers have to know and how knowledge is to be facilitated to learners. The assessment approach used by the teacher needs to be inclusive, reliable and valid to learners. This is crucial in teaching instruction, hence South Africa uses a mechanism called the Integrated Quality Management System (IQMS) to evaluate teachers' capacity to teach (DoE, 2003).

PCK is defined as knowledge of the general principles of instruction, knowledge related to classroom management, and knowledge about the aims and purpose of education. "Knowledge of context includes knowledge of school setting for example culture, and knowledge of individual students" (van Dijk, Kattman, 2006, p. 889). Shulman's (1986) findings are supported by van Dijk and Kattman (2006), thus it is clear that PCK is a teacher's integrated understanding of three components: pedagogy, subject content, learners' characteristics and the environment context where learning is taking place. It is the theory of describing an effort to conceptualise and develop measures of teachers' combined knowledge of content like Structures. PCK is also referred to as "propositional knowledge, declarative knowledge or factual knowledge" (Bzdak, 2008, p. 1). Moreover, know-how is applied knowledge, practical knowledge, procedural knowledge, and knowledge that directs how to do something not just knowing something. Stanley and Williamson (2002) argue that know-how is a species of know-that. However, Bzdak (2008) conducted an experiment where he tried to prove Stanley and Williamson's (2002) claim, and his findings did not agree with theirs regarding know-how and the nature of knowledge.

Pedagogical knowledge comprises an understanding of 'how to do something' in terms of the knowledge of the teacher like, how to make learning more comprehensible to

the learners and how to realise when content is difficult or too simple for learners. This further alludes to considering the different ages of learners and how to teach them, planning, strategizing how to assess, and being able to discern when learners are beginning to be fatigued. The teacher has to know the affective state of mind of the learner and how to choose the right time for teaching (level of the learner) and how instruction can foster learning. If children are not interested in a lesson, they lose concentration and the material cannot enter their minds. In teaching, Technology teachers need to believe that Technology comprises a type of formal knowledge that can be reduced to curricular elements. Lewis (1992, p. 136), for instance, contend that Technology teachers "have two clear responsibilities, first to articulate the disciplinary structure of Technology and secondly to provide for its authentic expression in the curriculum." Teachers need to know that Technology has to be concrete for the sake of establishing itself as an academic discipline. Knowing how to teach and when to assess the success of the lesson is thus so important in pedagogical knowledge.

De Vries, (2004) writes that, as far as Technology content knowledge is concerned, there was a misunderstanding between the subjects of Technology and Science in the olden days because Technology was regarded as part of Science, and this misunderstanding limited the study of Technology education. "Science is concerned with developing new knowledge about reality since Science uses abstractions and idealization in order to make reality more fit for mathematical description and is problem orientated, Science is universal whether on earth, on the moon, in water or air" (De Vries, 2004, p. 38). Technology aims to change reality according to our needs and desires, moreover, Technology is solution-orientated and is "related to one specific situation and not automatically applicable to all other situations" (De Vries, 2004, p. 38). Technology deals with concrete reality and its full complexity. So, in explaining knowledge, De Vries (2004, p. 30) defines it as a "justified true belief", further explaining that Technology knowledge is about changing the environment to suit our own needs, like making structures.

Technology knowledge has a normative component in that knowledge is judgemental in its nature and it tells us whether such knowledge functions well or not. "In knowledge of technical norms, rules and standards as another type of technical knowledge we also find normative components" (De Vries 2004, p. 83). In this quote, norms refers

to limitations like safety laws (De Vries 2004), while technological knowledge refers to "things that do not exist and they are yet to be designed, that is why it is not the same as scientific knowledge where truth is the ultimate condition" (De Vries, 2004, p. 83). Technology learners have to make judgement on the effectiveness of the artefact as such knowledge is the main characteristic of technology knowledge, and is the reason why a normative component is essential here. De Vries states that, when teachers teach Technology as a subject, they need to teach the ethics and values of making a project. The normative component includes: (a) Functional knowledge, like, the artefact is still to be designed but it is known that fire can produce steam, which results in massive energy for engines, (b) The physical nature of knowledge**,** for instance, the materials that are suitable for a purpose, like thermal insulation*,* (c) The relationship between the physical and functional nature, a combination of properties that relate to changing a situation, like fire heating water to produce steam, and (d) Process knowledge, like when water is boiled steam is produced and this energy is used to fulfil mechanical needs. Norms in technological knowledge can apply at various levels as a token for a type of brand or all types of artefacts in that category, for instance, all chisels are good regardless of the brand.

Vicenti (1990) states that teachers need to know (i) Fundamental design concepts (operational principles and normal configurations), (ii) Design criteria and specifications, (iii) Theoretical tools (mathematical, reasoning, laws of nature), (iv) Quantitative data (descriptive and prescriptive), (v) Practical consideration, and (vii) Design instrumentalities (procedural knowledge). Vicenti indicates further that these six categories are visible in designing artefacts like cars, for example, in terms of the image of the car, the four wheels, a body, an engine, speed, safety regulations, the laws of mechanics, and material properties.

De Vries (2004) explains that teachers need to have knowledge of the physical nature, or rather the non-intentional aspects in which the artefact can serve as a subject. The *arithmetic aspect* (data aspect) in the designing of a computer will need the engineer to have mathematical knowledge since the computer will use numbers. The artefacts will also need a space to occupy where the s*patial aspects* (the space it has to cover) will be necessary. The computer will have moving parts like cooling motors, which are the *kinematical aspect.* The *physical aspects* (properties like weight, hardness and

strength) and the *biotic aspects* (will interact with people) are also important. De Vries (2004) further mentions that the knowledge of physical nature goes with the knowledge of functional nature (intentional aspects in the artefact can only serve as an object to which a subject ascribes a function). In light of this, an artefact has *sensitive aspects* (the artefact will be touched by people), *logical aspects* (rules that human have developed), *historical aspects* (developed over a period of time), *lingual aspects* (written information of development), *social aspects* (used by people), *economic aspect*s (price tag), *aesthetic aspects* (appearance which people like or dislike), *juridical aspects* (protected by patents), *ethical aspects* (privacy in the access of data) and *pistic aspects* (beliefs in the power of technology).

The type of Technology knowledge mentioned by De Vries is also cited by Vincenti (1990) where he identifies six categories of technological knowledge which will now be described. Descriptive knowledge describes things as they are, whereas prescriptive knowledge prescribes what has to be done in order to achieve the desired outcome. Tacit knowledge is implicit in activities, is embedded in the subconscious, and is evidenced in practice (Vincenti, 1990). Vincenti agrees with Ropohl (1997) about implicit knowledge as Ropohl developed five categories which are: technological laws; functional rules; structural rules; technical know-how, and socio-technological understanding. Bayazit (1993) also speaks about declarative knowledge, procedural knowledge and design normative knowledge. In technology education, teachers need to establish these types of knowledge in order to equip learners with knowledge and guide them in the right direction. The discussions of Ropohl and Vincenti indicate that the technology education curriculum needs to be adjusted in such a way that it provides room for descriptive, prescriptive and tacit knowledge.

“Content knowledge entails the amount and organization of knowledge itself in the mind of the teacher about a particular subject” (Shulman, 1987, p. 9). In terms of Technology teaching, how well does the teacher know the content? Content knowledge is the ability to express oneself in the subject matter, and requires an understanding of the structure of the subject. Content knowledge includes the basic concepts and principles of the subject and its valid sets of rules. Teachers have to understand the language or syntax of the subject, including what materials are to be used in instruction. “CK contains both deep and broad knowledge of subject matter,

the facts and concepts of a subject discipline as well as multiple ways of thinking about the subject matter" (Barrett & Green, 2009, p. 18). Shulman (1986, p. 8) emphasises that "the amount of knowledge and organizational of knowledge per se in the mind of the teacher" is essential.

The above statement is supported by project–based science, which states that teachers have to facilitate extended inquiry as they learn (Marx, Blumenfield, Patrick & Krajcik, 1996). The issue of project-based science is coined by the belief of constructivists, who find that a successful lesson is achieved when learners find solutions by interacting with the problem and inquiring and analysing. This is the reason why learners' conception is important in Resource Theory. Questions like how to make learning more comprehensible for learners are important in teaching. Rogers (1993, p. 51) states that "the only man who is educated is the man who has learned how to learn, the man who has learned how to adapt and change; the man who has learned that no knowledge is secure, that is only the process of seeking knowledge gives a basis for security." Jones and Moreland (2001) also suggest that an effort needs to be made to enhance and promote teachers' knowledge in terms of their CK, curriculum knowledge, assessment of learners' context and prior knowledge, and educational ends. CK speaks to the subject matter to be presented, which is a factor of teachers' knowledge that impacts their activities as classroom and subject experts in the learning area. Pedagogy describes the way in which the content knowledge is supposed to be presented.

2.10 TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

In trying to find the effectiveness of the environment, Jang and Chen (2010) highlight the importance of comprehension, initiative, transformative and integrative views to explore the impact of Technological Pedagogical and Content Knowledge (TPACK). Jang and Chen add that TPACK is informed by Shulman's (1987) PCK. This model is used to assist pre-service Science teachers in giving instruction using technology with PCK, which is in agreement with the Resource Theory model used in this study regarding creating learning environments of structures through the effective usage of teaching materials. Jang and Chen were prompted by the fact that the world is now surrounded by digital technology, learners are now faced with electronic information inquiry and most things are being stored electronically these days. Jang and Chen

(2010) used a transformative model and online systems, which were designed to restructure Science teacher education courses. The TPACK model could help inexperienced Technology teachers to develop technological pedagogical methods and strategies for integrating subject-matter knowledge into Technology lessons and further enhance their TPACK in creating leaning environment for teaching structures. TPACK highlights the connections and interactions among content, pedagogy and technology. Bingimlas (2018) further affirms that TPACK assists teachers in their effectiveness in the classroom.

Initially, TPACK was complex among the three kinds of knowledge and was reframed as Technological Pedagogical and Content Knowledge, describing TPACK as the total package required to integrate technology, pedagogy and content knowledge into the design of curriculum and instruction. “TPACK is the dynamic transactional relation between content, pedagogy and technology” (Jang & Chen, 2010, p. 555). In the theoretical framework, Jang and Chen (2010) emphasise the three categories of TPCK: subject matter knowledge, pedagogic knowledge, and curriculum knowledge. The authors further clarify that, “TPCK involves the transformation of other types of knowledge into viable instruction so that it can be used effectively and flexibly in the communication process between teachers and learners during classroom practice” (Jang and Chen, 2010, p. 554).

Jang and Chen’s (2010) study provides empirical evidence showing that the transformative model did have some impact on pre-service teachers’ TPACK in particular topics of subject matter. However, there have been few studies on TPACK and the relation between technology-based models and the PCK of pre-service teachers. According to an integrative viewpoint, “TPACK is not considered a distinct form of knowledge, but a body of knowledge, which is made up of other forms of teacher knowledge that are integrated during the act of teaching” (Jang & Chen, 2010, p. 554). The integration of technology and an innovative model is a way to develop pre-service teachers’ TPACK. It is also a good strategy for promoting the utilisation of instructional technology in teaching pre-service teachers for creation of effective learning environment for structures.

2.11 SCAFFOLDING ON LEARNERS' PRIOR KNOWLEDGE AS PART OF THE LEARNING ENVIRONMENT

Cagiltay (2006) explains that scaffolding is a learning process where experts create a supportive situation for learners to construct their knowledge or skill to a required learning level. Scaffolding reduces doubt in learning because it offers multiple growth opportunities that direct a learner to internalise the process that he or she is learning. According to Cagiltay (2006), there are four types of scaffolding: conceptual or supportive (learner is guided in terms of what he/she considers as associations), metacognitive or reflective (helps learners to answer questions), procedural (emphasises various ways to utilise the available resources and tools for the given environment), and strategic or intrinsic (guides learner in analysing and approaching learning tasks or problems).

Jonassen (1991) claims that in a constructivist stance, reality is constructed by the knower based on mental activity, just like in the case of conceptual scaffolding. Bednar et al. (1991) write that learners build internal representations of knowledge from personal interpretations of learning experiences, which is in line with metacognitive scaffolding. Due to the fact that constructivism supports the creation of a learning environment through the combination of prior learning, sensorial activation and content analysis, it was deemed suitable to use Resource Theory (Astin, 1984) in studying teachers' teaching environment when presenting the topic of structures. Constructivist concepts like resources, compelling tasks, templates, guiding, provision of coaching, modelling a task, and giving advice are crucial in Resource Theory.

Constructivism is a learner-sensitive form of teaching designed to stimulate learners to construct effective and personalised ways of tackling academic problems (Rosenshine, 1979; Winograd., & Hare, 1988) as cited in Pressley, Karen and Harris, (1992). Learners' pre-conception as considered in teaching and learning has been crucial to the effectiveness of the lesson in every subject. Dewey (1930, p. 3) once said, "but every individual is in his own way unique. Each one experiences life from a different angle than anybody else, and consequently has something distinctive to give others if he can turn his experiences into ideas and pass them on to others."

Crawford (2001) also indicates that *transferring,* which is using knowledge in a new context or novel situation that has not been covered in class, is crucial to learning. Expert and experienced teachers need to have a thorough understanding of the value of pre-conception of knowledge in learners. “Professional knowledge depends on the interaction of elements like: school knowledge, subject knowledge and pedagogical knowledge but brought into existence by the learning context, learners, setting, activity and communication as well as context in its broad sense” (Banks, Leach, Moon, 2005, p. 337). Pre-conception links the known with the unknown knowledge, and the learner builds on known ideas. Borko and Putnam (2000) suggest that all learning should take place, or be situated in a specific physical and social context to acquire knowledge that is intimately associated with those settings.

Borko and Putnam (2000) advocate further that for transference of learning to occur effectively, learners must be provided with multiple similar experiences allowing an abstract mental model to form. Ritz (2009) also developed a meaningful instruction programme for technology goals that need to be in place to direct the outcomes of curriculum development and teaching. The goals “go beyond everyday teaching objectives; they are directed for long term learning and programmatic outcomes” (Ritz, 2009, p. 50). Goals are set from different sources such as empirical, philosophical, or subject matter sources. Empirical goals are usually developed by surveying members of society and using this analysis to determine the direction of education that is in accordance with learners’ pre-conception of knowledge in the ERTE model, which was developed by van Dijk and Kattmann (2006). Moreover, “subject matter sources for curriculum goals are commonly used by professionals to structure the importance of their subject to the greater education of all” (Ritz, 2009. p. 50).

2.12 LEARNERS’ SENSORIAL ACTIVATION IN A LEARNING ENVIRONMENT ACCORDING TO CONSTRUCTIVISM

Learners’ sensorial activation refers to the use of representations in the learning environment (Cox, 1999). This may include modern technologies in the Technological Pedagogic Content Knowledge of teachers. Bingimlas (2018) argues that teachers’ professional development affects their performance in the classroom with the use of Information and Communication Technology (ICT). Piaget (1973) names the outcome

of learners' progressive reorganisation of mental processes gained from an environmental experience as schemata (experiences). Learners construct an understandingof the world around them, which is stored as schemata. The schemata consist of recognising a particular situation, making associations within a particular activity and having the expectation of particular results. Von Glasersfeld (1989) highlights the issue of adaptation to support sensorial activation, which means that species are characterised by their ability to live in a given environment (learners' ability to learn in a conducive learning environment, as expounded by Resource Theory). Concerning sensorial activation, Piaget (1973) further writes that learners grasp the world by co-ordinating sensorial experiences like hearing, seeing, feeling and physical interaction with objects. As a result, they assimilate and accommodate new information on schemata.

Since Resource Theory emphasises the value of the creation of effective learning environment, as suggested by the constructivist theoretical framework, it was deemed suitable for studying teachers' consideration of effective teaching strategies like sensorial activation.

2.13 CONTENT OR SUBJECT KNOWLEDGE ANALYSIS IN A LEARNING ENVIRONMENT

In subject knowledge analysis, like for structures, there is the issue of finding an effective way of supporting teachers since Technology needs drastically change in teachers' construction of knowledge (Schneider & Krajcik, 2002). Teachers' construction refers to the concepts or subject matter of which teachers possess in knowledge. Teachers' construction as knowledge as discussed by Schneider and Krajcik supports the Resource Theory model (Astin, 1984). Teachers need to develop and assess quality learning based on thorough knowledge of the relevant technological practice. Engelbrecht, Harding and Velupillai (2008) conducted a study on how teachers in the General Education and training level (Senior Phase) in the South African school system go about teaching problem-solving skills, reasoning and communication in the mathematics curriculum. Their study could help Technology as a subject because the aspect of arithmetic is important in producing artefacts. Engelbrecht et al. (2008) study followed an earlier study by Rogan (2004) conducted

regarding the subject of Science where he found that no change had been made to the Science classroom since the inception of Outcomes Based Education (OBE) in South Africa, which meant that if there was no progress in the learning of Science, then Technology was also affected.

Teachers have to consider the factor of relevancy or authenticity of the tasks in relation to the learners. The Integrated Quality Management System (IQMS) (DoE, 2003) is used presently in South Africa to assess teachers and train them according to curriculum needs. The IQMS contains 12 performance standards that assess the Skills, Knowledge, Values and Attitudes (SKVAs) of teachers; the method also tries to assess teachers' PCK. It also comprises Development Appraisal for the teacher.

The idea is to promote teachers' ability to integrate and design a curriculum for innovative teaching, and enhancing their PCK. PCK is essential in teacher-education revolution. PCK has attracted much attention and different interpretations have since arisen and therefore PCK is regarded as the amalgam of teachers' strategies and understanding of subjects like Technology, Mathematics and Science. McEwan and Bull (1991) studied the theory of PCK and found that beyond pedagogical knowledge, teachers may also possess particular CK as well as knowledge of particular processes.

McEwan and Bull mention that the function of the teacher is to make a point of putting hidden information into familiar words and images for learners. Technology requires the teacher to have appropriate content knowledge and the cognitive and manual skills to create a positive learning environment. Teachers need to know technological processes, as this is the core of Technology. Over and above this, the imagination and dedication of teachers are vital. Shulman (1986, p. 9) states that:

> Teachers possess pedagogical content knowledge, which is defined as going beyond the knowledge of the subject matter per se, to the dimension of subject knowledge for teaching ways of representing and formulating the subject that makes it comprehensible to others.

The above statement tries to explain that pedagogical content knowledge is the main aspect that a teacher must have for successful teaching.

Barrett, and Green (2009) offer a working model of a transferable teacher preparation programme that is founded on the concepts of being a reflective practitioner (a person is eager to analyse and reflect on the lesson) and the teacher as a researcher. Barret and Green agree with the Resource Theory model and mention that “pedagogical content knowledge is the interaction of subject matter and effective teaching strategies to help students learn the subject matter” (Barrett & Green, 2009, p.18). Furthermore, PCK “requires the thorough understanding of the content to teach it in multiple ways, like drawing on the cultural background and prior knowledge and experiences of students” (Barrett & Green, 2009, p. 18). The paper also mentions the model of combining content knowledge, specialised content knowledge, knowledge of content and students, as well as knowledge of content and teaching. This definition explicitly connects the learners and the teaching process to the content, with no separate category of pedagogical knowledge.

The teacher cannot teach a subject without knowing the content of the subject well. “A strong PCK teacher is well versed in the content” (Barrett & Green, 2009, p. 19). PCK includes constantly viewing the material from different perspectives, considering the application of the content, and maintaining an active link with current developments in the field. These teachers make constant assessments (formative) to stay informed about the context of learning in which they work. All subject areas lead to a unique PCK for that particular subject, thus teachers need to consider the supposition that candidates would be best served by focused learning within their content areas as “it will necessitate separate teacher preparation programmes for each subject with no common coursework possible, even in pedagogical or professional background” (Barrett & Green, 2009, p. 20). Teachers need to be prepared with base concepts in content and pedagogy, developing skills in implementing various teaching strategies, and understanding the ways in which learners’ learning develops.

PCK is the relationship between teaching and scholarly knowledge of subject matter. Pavlova (2005) addresses two closely interrelated issues in technology education, which are knowledge and values. This deals with the analysis of the nature of Technology knowledge, as subject matter analysis and learners’ pre-conceptions are also mentioned in the Resource Theory model. There is an interpretation of technological knowledge for the purpose of its classification, as well as problems

establishing a consistent approach to distinguishing common features of technological knowledge. The major approaches to theorising knowledge in Technology education provide a starting point in Pavlova's study, which explains that "there are three features of Technology knowledge. Tacit, prescriptive and descriptive knowledge" (Pavlova, 2005, p. 134). The paper argues for theorising knowledge in Technology education and its relationship to value, and also provides the intellectual foundation for the further development of Technology. Tacit, descriptive and prescriptive knowledge constitute the structure of technological knowledge. Tacit knowledge is implicit and is the outcome of an individual's judgement, skill and practice. Tacit knowledge cannot be expressed formally as it is a personal and subjective knowledge. Furthermore, tacit knowledge is transmitted mainly from one individual to another and "is derived from working side by side with an experienced person, it is knowledge through experience" (Pavlova, 2005, p. 134).

In the Resource Theory model, including CAPS there is an emphasis on subject matter analysis and designing a learning environment, which touches on the 'know that' and 'know how' in McCormick's (1997) study. An understanding of the nature of the relationship between the two is crucial to the teaching and learning of Technology since in Technology learners need to be exposed to 'know that' and 'know how' types of knowledge. The two ideas of conceptual and procedural knowledge are often seen as separate, but they are inseparable in teaching Technology. McCormick (1997) states that "some see the distinction as a contrast between the tacit knowledge of Technology and the explicit knowledge of Science" (p. 142). The 'know how' is the procedural knowledge and the 'know that' is the conceptual knowledge. The conceptual knowledge allows learners to explain why, hence 'know how' is related to procedural knowledge. McCormick (1997) also mentions that 'know how' attributed to Technology is what cognitive psychologists call procedural knowledge, which is simply knowing how to do it. It links with process, problem solving, and strategic thinking, which in turn requires distinguishing different levels of procedure.

Banks, Leach and Moon (2005) mention that subject matter knowledge and pedagogical knowledge need further exploration for the betterment of education as it is in the Resource Theory model. The focus is on the definition and interrelation of these three concerns: knowledge, school knowledge, and pedagogy for teacher

education. For theoretical purposes, this study used the curriculum-orientated work of Shulman (1986), the cognitive approach of Gardener (1983; 1991) and the interrelated tradition of didactics and pedagogy in continental Europe. Furthermore, Banks et al. (2005) explain that “pedagogy content as defined by Shulman requires the subject specialist to know the most useful forms of analogies, illustrations, examples, explanations and demonstrations, in other words the ways of representing and formulating the subject, in order to make it comprehensible to others, it neglects the process of learning” (Banks et al. p. 333). In understanding teachers’ pedagogical knowledge for the creation of a positive learning environment, this study lists school knowledge that is an analytic category in its own right, which is a transposition of subject knowledge, subsuming the curricular knowledge of Shulman (1986).

2.14 LEARNING SUPPORT MATERIALS

Krajcik and Schneider (2002) conducted a study in an on-going urban system initiative in a large public schools district system to reform Science and Mathematics. Curriculum materials were developed that were consistent with social constructivist ideas, and they addressed the national and local goals for learners and learning, and were educative for teachers. Krajcik and Schneider (2002) investigated subject matter knowledge and how that knowledge could be acquired by teachers and students. The research group developed curriculum materials and were based on the premise of project-based Science. They write that: “Our curriculum design is based on the principles that are consistent with what is known about teaching and learning” (Krajcik & Schneider, 2002, p. 222). In the quest for knowledge, the assumption is that learners will find solutions to real problems by asking and refining questions, designing and conducting investigations, by gathering and analysing information and data, making interpretations, drawing conclusions and reporting findings (Krajcik & Schneider, 2002).

Krajcik and Schneider (2002) write that various techniques need to promote learning, such as coaching or modelling, specific instruction strategies such as prediction, observation, explanation and classroom management. As this study indicated before educative curriculum materials are designed to support learning for teachers as well as for learners, but even though materials have a unique role, they cannot replace other professional development opportunities. One way to support learners is through

designing materials that are effective in learning and teaching. Krajcik and Schneider (2002) suggest that teachers are advised to use new ways of representing content and new strategies to support their learners' construction of knowledge.

2.15 USING LEARNER TEACHER SUPPORT MATERIALS (LTSM)

Krajcik and Schneider (2002) investigated how teachers use educative materials, content knowledge and pedagogical knowledge through classroom observation and teacher interview data. Krajcik and Schneider (2002) found that teachers use educative materials when planning and that they understand lesson-specific ideas in PCK better than content or pedagogy when using educative materials. PCK may be a useful construct for designing educative curriculum materials as "teaching is a complex activity that requires teachers to understand content and pedagogy as they come together to support student thinking and learning in the context of their classroom" (Krajcik, & Schneider, 2002, p. 240). Curriculum materials, by definition, concern specific lessons that are much easier to use in the support of PCK. Educative curriculum materials appear to be a promising approach to facilitating teacher learning, which is necessary for improved practice. Krajcik and Schneider (2002) advise that much research needs to be done to create such materials. Krajcik and Schneider (2002) also advocate that educative materials or other professional development opportunities are important factors in teaching, like creating learning environment.

2.16 SETTING GOALS

Ritz (2009) developed meaningful instruction programmes aimed at the technology education goals needed to direct the outcomes of curriculum development and teaching. These go beyond everyday teaching objectives as these goals are directed at long-term learning and programmatic outcomes. Goals are set from different sources which are empirical, philosophical, or subject matter related. "Empirical goals are usually developed by surveying members of society and using such analysis to determine the direction of education", (Ritz, 2009, p. 50). This statement is in accordance with learners' pre-concept knowledge as discussed in Astin's (1984) Resource Theory and the ERTE model by van Dijk and Kattmann (2006). "Subject matter sources for curriculum goals are commonly used by professionals to structure the importance of their subject to the greater education of all" (Ritz, 2009, p. 50).

According to Ritz (2009), from the year 1991 ten years were set to achieve particular goals based on empirical sources in the USA. These goals comprised school readiness, the success rate, competency in subjects, the quality of Maths and Science, the Literacy of the nation, and freedom from social ills. Schools started examining their effectiveness in fulfilling these goals. The goals are:

> (1) to develop in each student insight and understanding of industry and its place in our culture, (2) to discover and develop the talents of students in the technical fields and applied sciences, (3) to develop technical problem-solving skills related to materials and the process, (4) to develop in each student a measure of skill in the use of the common tools and machines (Ritz, 2009, p. 52).

The panel of professionals in the USA produced a document outlining the content of Technology with a focus on the technological systems of communication, construction, manufacturing, and transportation. The outlines include: the appreciation of evolution and the relationships between society, beliefs and values based on the impact of Technology and the way it alters the environment, the proper use of resources and tools, the provision of creative solutions for the present and for the future, and the exploration and development of human potential related to responsible work. The goals ranked as most important by designers are to describe the social, ethical and environmental impact associated with the use of technology. Ritz (2009, p. 60) further writes that "when designing curriculum instruction for Technology education, it is important that the content taught includes a social constructivist outcome."

The standards for Technology literacy in the area of Technology and society suggest having comprehensive units of content from elementary through to high school level. Ritz (2009) indicates that whether teaching a general course on Technology literacy or one that develops high levels of technological capabilities, consumerism should be included because learners use technology and are the future consumers of technology. Ritz (2009, p. 61) explains,

> Our classrooms and labs provide an ideal environment for learners to learn skills (especially consumer skills) so that in future they can safely replace an automobile battery or sketch a diagram of a home problem that they could solve, or find a service technician to help them to solve it.

Ritz (2009) further mentions that it is essential for learners to use technology to solve problems although people know that not all problems are technological, but many could be solved using technology.

2.17 DESIGN PROCESS

Petrina (2007) writes that procedural knowledge has strategies that form metacognition and episodic memories, which are specific personal experiences reflecting an awareness of how the learner proceeds step by step. In Grade 9 (the level at which this study was focused) the CAPS syllabus specifies that Technology learners have to be taught procedural knowledge, which refers to how to construct structures using the design process skills: Investigation, Designing, Making, Evaluation and Communication (IDMEC). For teaching and learning environment for structures, according to the CAPS document (DBE, 2011), Technology as a subject has to contribute towards learners' technological literacy. The following table shows the intricacies of the design process in CAPS.

Table 2. Design process in the CAPS document (DBE, 2011)

The process	Activities
Investigation	Seek information. Conduct the relevant investigation. Grasp concepts and gain insight. Determine new techniques.
Design	Design briefs. Generate possible solutions. Draw and develop ideas. Graphics (2/3D). Make decisions. Choose the best solution with justification.
Make	Use tools and equipment. Building, testing, and modifying a product. Safety and health atmosphere.
Evaluate	Evaluate artefacts, decisions, and results. Evaluate solutions and the process followed. Suggest necessary improvements. Evaluate constraints.
Communicate	Presentation. Record of the process and marketing products.

Learners are expected to design and make structures using conceptual and procedural knowledge, which could be guided by schematics (mind maps) (Petrina, 2007). Vincenti (1990) writes that procedural knowledge is prescriptive, which orders what has to be done to attain the desired outcome. In the CAPS document, procedural knowledge also includes sketching, adapting, and designing a brief and flow chart. As mentioned before conceptual knowledge in the Grade 9 CAPS document is the knowledge of structures, their working principles, rigidity, and withstanding forces like tension, compression, bending, torsional and shearing. Teachers use assessment rubrics to assess learners' procedural and conceptual knowledge of structures. As the researcher indicated earlier on, in assessing structures, CAPS requires teachers to look at originality and aesthetics, value for money, fit for purpose and suitability of materials, ease of manufacture, safety and ergonomics, environmental impact, and bias towards or against a group. These were the concepts that the researcher used to analyse the teachers' documents.

In teaching procedural knowledge, teachers may begin the lesson from learners' prior knowledge for the purpose of scaffolding learners' knowledge and sensorially activating them by using demonstrations, oral or written instructions. This will give learners opportunities to develop and apply specific design skills to solve technological problems. In addition to understand the concepts and knowledge used in Technology, and use them responsibly and purposefully, and appreciate the interaction between people's values and attitudes, technology, society and the environment.

Structures have been part of mankind since the beginning of time. Beghini et al. (2013) write that traditionally, especially in recent tradition, the goal of architecture has been leaning towards aesthetics, and the goal of the engineer has been focused on stability and efficiency. In medieval times, the organisation of architecture and engineering that exists today did not exist. Beghini et al. (2013) further mention that there is a chasm between the vision of the architect and the sensibility of the engineer, for instance, the aesthetics of a structure and its corresponding skeleton. Structures need to satisfy three principles: strength, utility, and beauty. A structure that is built without the engineering to stand and is not architecturally aesthetic is not acceptable (Beghini et al., 2013). In the design of a structure, it is essential to select the appropriate objective

function to solve the problem. Minimum compliance or maximum stiffness is one objective that can be used in its own merit and is also a surrogate to explore other metrics such as ductility, natural frequencies, buckling and stability (Beghini et al., 2013). Nowadays, in high-rising structures, topology optimisation is used (Beghini et al., 2013) which minimises the consumption of material in a structure, while at the same time providing a tool to generate design alternative of benefit to both engineering and architectural communities in the reduction of costs. This eliminates redundancy in making structures for the purpose of teaching learners in a cost efficient way.

Achal, Mukherjee and Sudhakara (2010) write that natural processes such as weathering, faults, land subsidence, earthquakes and human activities create fractures and fissures in concrete structures which can reduce the life span of the structures. This means that specific materials are necessary for a particular purpose in building structures. Agarwal and Varma (2013) indicate that it is also necessary to design and make structures in a particular form or shape for its stability. They further elaborate that in structures, all the floors are designed for nominal dead load and live load values, which is in line with static and dynamic forces, as mentioned in the CAPS document (DBE, 2011). The CAPS document requires teachers to analyse content, scaffold learners' learning and sensorially activate Senior Phase learners to demonstrate knowledge and understanding of how structures are constructed and how they are designed to withstand various forces.

De Vries (2004) explains that structures or artefacts are objects that have been modified for a particular function. The structure has a collective intentionality (to be used by many) ascribed to it in its function. Learners need to know the concepts of life span and strengthening of structures, including the aspects of using triangles for strengthening, mass, density, hardness, stiffness, flexibility, corrosion resistance, corrosion prevention, tubing, corrugation, lamination, and forms of structures (DBE, 2011). Due to the fact that leaners have been taught about structures in Grades 7-8, teachers can scaffold on this prior knowledge. When teaching in Grade 9, prior knowledge of strength, the life span of structures, sensorial activation of forms/shapes of structures, triangulation, and content analysis could make a lesson effective. The study focused on Grade 9 level because learners have been exposed to designing

structures in previous Grades, and therefore it is assumed that they possess some prior knowledge.

2.18 RESEARCH FINDINGS ON AN EFFECTIVE LEARNING ENVIRONMENT FOR TEACHING TECHNOLOGY CONTENT IN SOUTH AFRICA

Research findings indicate that a learning environment is an integral part of learning. Chamnanwong and Yuenyong (2014) affirm that teachers should encourage or stimulate learners to be participants and active in making learning decisions like planning, evaluating activities and carrying out discussions in the classroom. This interaction (Chamnanwong & Yuenyong, 2014) will also facilitate the relation of real life experience (prior knowledge). The aspect of everyday experience in learning serves as a meaningful context for learners' cognitive development in Technology. Solvberg and Rismark (2012) highlight that a learning environment, which comprises the interrelationship between people and the dialogical activities in which they take part, is suggested as a learning asset. The authors further elaborate that a learning environment demonstrates the value of human interaction in a Technology rich learning environment. Shenoff, Tonks, and Anderson (2014) mention that in a good learning environment, structured individual or small group work with the teacher monitoring the situation appears to produce optimal learning. Rutland and Barlex (2007) support the environmental aspect of the classroom and agree that it affects the creative process of the learner positively.

In the South African context, the creation of a learning environment for teaching structures would be extremely beneficial to Technology teaching. Mapotse (2017) affirms that there is no ordered environment earmarked for teaching and learning Technology. Engelbrecht et al. (2008) state that teachers in South Africa lack knowledge on creating a positive learning environment. Besides, in a study comparing South African and New Zealand Technology education, Williams and Gumbo (2012) assert that more needs to be done in South African education. They further elaborate that research into Technology education generally has the potential to enhance understanding of what constitutes an expert teacher. An effective learning environment could really benefit the teaching of structures.

2.19 CONCLUSION

From the literature, it is clear that a learning environment is the integration of the teachers' knowledge, their contact with learners through instruction, the physical classroom and their resources, as well as the learners' knowledge and understanding of Technology-specific concepts. The process of creating a learning environment for teaching about structures goes with the teachers' proper selection of presentation materials according to a rigorous process of analysing the subject. Technology teachers therefore, need to create, select and use representations of structures in the classroom as Technological Pedagogic and Content Knowledge is advocating. This must be done to stay abreast with the Fourth Industrial Revolution, and in order to activate learners' senses for them to understand the structural principles. This may include the use of pictures, videos, teachers' explanations, electric pylons outside the class and so forth. This will prepare learners for real world life and challenges.

The literature indicates that the integration of new knowledge with what learners have experienced before forms the basis of learning. It is also suggested that all learning should take place, or be anchored in a specific physical and social context to attain knowledge that is closely associated with those settings. The acquisition of new information in learners could be used to refine something known previously. This means that teachers need to provide relevant and sensorially activating representations for the learners in their lessons. From the literature, it is clear that there is much to be done in the South African curriculum, and this prompted the researcher to investigate the required learning environment for teaching Structures in Grade 9. This resulted in finding that in their planning, they seem to understand how to create a conducive learning environment, but the implementation thereof remains elusive. In the next chapter, the researcher outlines the research Methodology of this study.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 OVERVIEW OF THE CHAPTER

This chapter presents the Research approach, Research paradigm, Research design, Ontology, Epistemology, Methodology, Population and sample, Data collection, Interviews, Document analysis, Data analysis, Open coding, Axial coding, and Selective coding. Thereafter, Quality criteria, Trustworthiness, Credibility, Dependability, Confirmability, Transferability, Ethical consideration, Informed consent, Respect, Anonymity and confidentiality, Discontinuance, Securing data and a Summary of the chapter .

3.2 RESEARCH APPROACH

To investigate an effective environment for teaching about structures, the study followed a qualitative research approach. Qualitative research is used in an attempt to collect rich, descriptive data about a particular phenomenon or context with the intention of developing an understanding of what is being studied (Creswell, 2008). Stake (1995) writes that qualitative research is inductive in nature and employs inductive data analysis to give a better understanding of the interaction of mutually shaping influences (Lincoln & Guba, 1985), and to explicate the interacting realities and experiences of the researcher and the participant/s. This study used a qualitative approach in order to view and understand the requisite Technology learning environment for teaching about structures and constructing meaning out of technology teachers' experiences. In addition, this approach was used to make sense of the multiple interpretations as multiple realities are present in any given context because both the researcher and the participants construct their own realities (Lincoln & Guba, 1985). The researcher collected data in a non-disturbing manner and allowed events to unfold in a natural way with no predetermined constraints or controlling the study or the outcomes. This choice was also prompted by Maree's (2007) argument that a qualitative approach is used mainly in constructivist research in studying participants' uniqueness in their natural environment and focusing on meanings and interpretations through the eyes of the participants.

3.3 RESEARCH PARADIGM

This study followed a constructivist/interpretive paradigm to investigate the environment required for teaching about structures, which was analysed mostly through qualitative methods and a data analysis that was done inductively. The constructivist paradigm was deemed suitable to fit in with Resource Theory (Astin, 1984) because Resource Theory contains characteristics of the interpretivism needed in this study. Denzin and Lincoln (2008) write that interpretivism makes a particular demand on a researcher from the questions that the researcher asks and the interpretations he/she brings to them. Merriam (2002) writes that qualitative case studies in education are often framed by concepts, models and theories. An inductive model is utilised to support or challenge theoretical assumptions. Interpretive theorists believe that reality is not objectively determined and that people build a social life by sharing meanings (Hutchins, 1995).

The researcher believes that facts do not speak for themselves. Sarantakos (2005) writes that reality is constructed and constructivism is about psycho-social realities and relationships (cognitive development is affected by interaction with society). Therefore, data on, for instance, teachers' facilitation of cooperative, experimental learning, scaffolding, and sensorial activation as creation of a learning environment formed part of this study. Constructivism foregrounds the meaning that individuals or communities assign to their experiences because inter-subjective meanings are essential to achieving understanding and meaning in a unique way (idiographic) (Sarantakos, 2005). This means that the researcher considered how teachers understand learners' prior knowledge, how they should scaffold upon prior knowledge of structures, and how they use sensorial activation or representations and analyse the content of structures.

Teachers need to understand that behaviour is constituted by social conventions, therefore interpretations are required. Hutchins (1995) indicates that there must be no distinction between the researcher and the event being studied. Unlike in positivism, the interpretative paradigm indicates that social context, conventions, and the norms and standards of the particular person or community are crucial elements in assessing and understanding human behaviour and they are parallel with hermeneutics and phenomenology. "Social constructivism and psychological constructivism they

together form social aspect of the classroom" (Richardson, 2003, p.1624). The interpretative paradigm focuses on the notion that peoples' subjective experiences on how people construct the social world is created by sharing meaning and the way in which they interact with each other (Hutchins, 1995).

The theoretical constructs of research should reflect the same everyday construct that people use to interpret social life (Hutchins, 1995). Hutchins further clarifies that the interpretive approach focuses on the notion that people's subjective experiences of how they construct the social world are created by sharing meaning, like reciprocal peer teaching and jigsaws. For this study, sharing meaning refers to teachers' responses to gaining information about the learners' prior knowledge. This goes together with teachers' representation of structures to clarify learners' sensorial activation and conceptual knowledge. These considerations should be indicated in the lesson plan. This simply means that the researcher investigated how the teachers considered prior knowledge, how they used teaching materials. This was done by conducting interviews, examining their lesson plans, preparation, their work schedules as well as assessment processes. The research design in terms of the ontological, epistemological and methodological implications of selecting a constructivist/interpretative paradigm are discussed next.

3.3.1 Research design

This study used a case study design because it explains effective way of teaching structures (Stake, 1995). A case study is useful for the study of a phenomenon in its natural context (Stake, 1995). A case study design was appropriate in this study because the aim was to gain an in-depth understanding of the extent to which teachers take advantage of learners' pre-conceptions and activating their senses and teachers' content analysis through the purposeful creation of a learning environment in the concept of structures. In addition, the researcher chose a case study because Stake (1995) and Creswell (2008) describe a case study as a strategy of enquiry in which the researcher studies a process, an event, an activity, a programme of one or more individuals in-depth. In this way, a case study enabled the study to produce established cross-contextual generalities. Apart from the interviews, lesson plans, the teachers' lesson preparation notes, work schedules, and the teacher assessments constituted the data sources. The design was suitable for gaining in-depth

understanding of the extent to which the teachers took advantage of learners' pre-conceptions, creating a learning environment that activates senses and provides engagement with content (knowledge) that is appropriate to the specific concept, like structures. The researcher selected two technology teachers in Grade 9 from one school. A case study was appropriate because an understanding is gained from a small number of individuals. Stake (1995, as cited in Creswell, 2008) describes a case study as a strategy of enquiry in which the researcher does an in-depth study of a process, an event, an activity, or a programme of one or more individuals.

Mason (2002) as cited in van Niekerk, 2009) describes a case study in qualitative research as containing an unrivalled capacity to create compelling arguments. It concerns how things work in particular contexts. In addition, it stimulates further questions and suggests possible strategies to accommodate the findings in particular interventions or theories. In this way, qualitative research enabled the researcher to produce established cross-contextual generalities.

The study focused on describing and understanding a phenomenon, as advocated by Creswell (2008), within its naturally occurring context with the intention of developing an understanding of designing a learning environment, like seeing through the eyes of the participants. The study investigated evidence of how teaching takes place, examined contents of documents, like lesson plans and work schedules, which are prescribed by CAPS (DBE, 2011) for systematic teaching of Technology. Furthermore, notes from the audio recordings of the interviews constituted other data collected. The study also examined how teachers select teaching materials in relation to their teaching plans. Yin (2009) affirms that case study research includes single and multiple-case studies. Yin (2009) also outlines four applications where case studies can be used: to explain the presumed causal links in real life interventions that are too complex for a survey or experimental strategies; to describe an intervention and the real life context in which it occurred; to illustrate certain topics within an evaluation, again in descriptive mode; and to enlighten those situations in which the intervention being evaluated has no clear, single set of outcomes.

3.3.2 Ontology

Pontoretto (2005) mentions that ontology concerns the nature of reality and being. In this study, the researcher investigated what the form and nature of structures known in the multiple meanings of structures in the minds of teachers teaching learners in Grade 9. The researcher had to take into consideration that reality is subjective (Hutchins, 1995), just like the way PCK is constructed by Technology teachers for teaching about structures. Hutchins (1995) writes that the world is complicated, not static, constructed, interpreted and is experienced in interaction with wider social systems. People experience reality in different ways as reality is subjective and cannot be perfectly understood (Hutchins, 1995).

This further explains that technology teachers' creation of a learning environment for structures as PCK is subjectively constructed and understood. Following the constructivist paradigm, the researcher conducted this study in natural settings to determine how teachers considered the learners' prior knowledge, sensorial activation and content analysis when creating a learning environment for structures in their instructions. The way in which their workstations were arranged as sensorial activation gave the reality of what was happening in each class. Each teacher had to create an environment for the teaching of structures and its unique function in various contexts as knowledge of teaching about structures.

3.3.3 Epistemology

Ponteretto (2005) explains that, according to constructivists, learners learn in a transactional and subjective way. How learners acquire or learn structures is due to their interaction with a wide range of resources like teachers, high achieving learners and other human resources (Astin, 1984). According to constructivists, knowledge is not an isolated or static process and does not happen in a space vacuum. Learning is the process of accommodation and assimilation (Piaget, 1973), or a rejection of the construction of new conceptual structures, meaningful representations or new mental models (Von Glasersfeld, 1989).

Human beings enter into environments with prior knowledge. As they interact with the world, there are endlessly different images, concepts, information and other stimulating processes around them (Von Glasersfeld, 1989). As a result, people

constantly construct, revise and reconstruct their knowledge and beliefs to form a new understanding of knowledge. Knowledge is constantly reconstructed, it is dynamic, evolutionary and a developmental process. Richardson (2003) writes that interpretivists regard knowledge as multiple, similar and equally valid. Moreover, knowledge is socially constructed and reality is subjective but the truth is objective.

The participants' role and interactions assisted the researcher to gain the meaning of and insight into their lived experiences. The researcher adopted the notion that acquiring knowledge concerns the way in which people experience their lives. Therefore, the study relied extensively on naturalistic information given by the participants, as suggested in Resource Theory (Astin, 1984) for an effective learning environment. It also included examining the embedded meaning through the work done by the teachers in their planning, the textbooks that they used, their work schedules, their assessments, and the physical environment of the Technology workstation for teaching structures.

3.3.4 Methodology

Methodology refers to the process and procedures used to conduct the research (Ponterotto, 2005). This study followed a qualitative research method using the constructivist paradigm because the researcher wanted to understand the issues being researched, which was the creation of a conducive learning environment for teaching the theme of Structures in Grade 9. This was researched from the perspective of the participants and thus they played a major role in the research. Ponterotto (2005) indicates that naturalistic inquiry leads to qualitative research methods such as in-depth face to face interviews and participant observations. The purpose of this study was to see the situation through the eyes of the participants, not to report the views of the participants but interpret the data in a manner that is distanced from them (Struwig & Stead, 2003).

3.4 POPULATION AND SAMPLE

McMillan and Schumacher (2010) define a sample in research as the source of information used by researchers. It comprises individuals, groups, document reports, and sites. According to McMillan and Schumacher (2010), there are two sampling

methods used in qualitative research: probability and non-probability methods. A non-probability method was suitable for this study because it caters to purposive sampling and criterion sampling. The participants needed to fulfil certain criteria, like teaching Technology in Grade 9, and they needed to have extensive experience. Within the non-probability sampling method, there are three types of sampling according to McMillan and Schumacher (2010): convenience, purposive and quota sampling. The researcher used purposive sampling and criterion sampling alternatively because they enable searching for cases or individuals that meet certain criteria (Palys, as cited in Lisa, 2008). Besides this, purposive sampling usually ensures high participation, assures receipt of the needed information, and generalisation is possible to similar subjects (McMillan & Schumacher, 2010).

Furthermore, for this study, the sample consisted of two technology teachers sampled from a privately owned school in the Sekhukhune East District who were teaching Grade 9 girls and boys. The researcher chose these participants because they were teaching Grade 9 Technology at the time of this study and were readily available after hours and were also willing to participate in the study. In addition, to achieve the purpose of this study, it was important to select participants that had the relevant qualifications and experience in teaching Technology. The participants' qualifications and experiences were essential since teachers with suitable qualifications and experience in teaching Technology could provide a better understanding of how an effective learning environment is created for teaching structures. Technology teachers who had qualifications such as a Higher Diploma in Education (HDE) or a Bachelor of Education (BEd) with Technology as a major subject and had been teaching the subject for at least four years were considered as experienced teachers in the case of this study. Technology teachers in the Limpopo Province of South Africa were considered as the population of this study. Grade 9 teachers were chosen since Grade 9 is the exit year of the Senior Phase and it is assumed that these teachers should be able to implement CAPS properly and be capable of creating an effective learning environment for covering the topic of structures.

3.5 DATA COLLECTION

McMillan and Schumacher (2010) state that data is the evidence gathered by a researcher, which is information collected and interpreted and from which conclusions

are drawn. Generally, data are sources or evidence derived from interviews and planning documents (Creswell, 2008). Creswell, (2008) writes that collecting data means identifying and selecting individuals for a study and obtaining their permission to study them. For this study, the researcher used semi-structured interviews and teachers' planning documents to collect data. A semi-structured interview was used because the researcher could prompt and probe deeper into the given situation (Kajornboon, 2004). Moreover, this type of interview gives the researcher a chance to probe the views and opinions of the interviewee (Kajornboon, 2004). The interview questions and examining schedule were based on the Resource Theory conceptual framework, which is mentioned in Chapter 2. A recorder was used to record (Creswell, 2008) in each interview, which lasted for 35 minutes with each participant. After the interviews, the researcher wrote down comments, which helped to explain the data (Kajornboon, 2004).

3.6 INTERVIEWS

An interview is a conversation between an interviewer and the interviewee where the respondent is asked specific questions related to a particular topic in a qualitative study (Babbie & Mouton, 2001). There are various types of interviews (Kajornboon, 2004): open-ended, semi-structured and structured interviews. For this study, the researcher used semi-structured interviews consisting 23 items or questions on specific topics as an interview guide, to explore the participants' own views about the creation of a Technology learning environment in teaching Structures for Grade 9. Kajornboon (2004) emphasises that semi-structured interviews give the researcher opportunities to probe for the views and opinions of the interviewee and further explore new paths that were not initially considered.

In a semi-structured interview, the order of the questions can be changed depending on the direction of the interview (Kajornboon, 2004). It has the advantage of both structured and semi-structured methods. In addition, the order in which various topics are dealt with and the wording of the questions are left to the interviewers' discretion (Kajornboon, 2004). Maree (2007) adds that an interview is a two way conversation in which the interviewer asks the participant questions to collect data and learn about their ideas, beliefs, views and opinions. He further says that a qualitative interview is meant to allow the researcher to see the world through the eyes of the participant, and

it can be a valuable source of information, provided it is used correctly. Therefore, it is different to a survey or questionnaire because the participants' responses are seen through what they say, but also through body language and eye contact.

Within each topic, the interviewer is free to conduct the conversation as he sees fit, to ask the questions he deems appropriate in the words he considers best, to give explanations and ask for clarification if the answer is not clear, to prompt the participant to explain further if necessary and to establish his own style of conversation (Kajornboon, 2004). The interviewee is the primary data for a study (Kajornboon, 2004). The researcher ought to have the following skills (Kajornboon, 2004): the ability to listen, be non-judgemental, have a good memory and the ability to think on his/her feet. In addition, the strength thereof is in that the researcher can prompt and probe deeper into the given situation. Patton (2002) advises that researchers need to explore, probe and ask questions that will elucidate and illuminate that particular subject and to build a conversation within a particular subject area. The author further advocates wording questions spontaneously and attempting to establish a conversation style but with the focus on a particular subject that has been predetermined. Besides this, the researcher can explain or rephrase the questions if participants do not understand the question.

Kvale (1996) writes that the use of interviews in research marks a move away from seeing humans as simply manipulative, and data as somehow external to individuals and towards regarding knowledge as generated between humans, often through conversation. Kvale (1996) further states that an interview is an exchange of views between two or more individuals on a topic of mutual interest. Kvale (1996) sees interviews as the centre of human interaction for knowledge production, and emphasises the social situatedness of research data. Therefore, interviews are a systematic way of talking and listening to the participants and are a way of gathering data from participants through conversational interaction.

Cohen, Manion and Morrison (2007) find that the interview is not only concerned with collecting data about life, it is part of life itself and its human embeddedness is inescapable. The questions have to extract or elicit valid responses from the participants. The interviews in this study were audio recorded to document the participants' responses and descriptions of their experiences. The researcher

interviewed the participants individually in a private place with no disturbance in order to encourage freedom of expression. The interview questions were clarified to the participants without interrupting their responses. Both of the participants were interviewed using the same interview guide. The interview took place after school so as not to disturb teaching and learning at the site, as per the permission given by the school and the teachers.

3.7 DOCUMENT ANALYSIS

A document analysis is a systematic approach to qualitative data analysis that identifies and summarises the message of the content (Maree, 2008). Content analysis refers to analysing things like books, written documents, transcripts and visual media. It is skimming, reading and interpretation by iteratively combining elements of content analysis and thematic analysis. Thematic analysis is a form of pattern recognition within the data, with emerging themes becoming categories for analysis (Bowen, 2009). Document analysis is often used in combination with other qualitative research methods as a means of triangulation (Bowen, 2009). By triangulating data, this study attempted to provide a confluence of evidence (Bowen, 2009), which breeds credibility. Bowen also writes that it is used to draw on multiple sources of evidence to seek convergence and corroboration through the use of different sources and methods.

To examine the teachers' planning documents, the researcher considered the following concepts in their planning for teaching structures: originality and aesthetics, value for money, fit for purpose and suitability of materials, ease of manufacture, safety and ergonomics, environmental impact, and not being biased towards other groups. These concepts were adapted from the CAPS document (DBE, 2011) designing process (IDMEC), which enabled the study to process data from different angles with the view of identifying keys in the text that assisted the researcher to understand and interpret the raw data.

Content analysis in this study was an inductive and interactive process where the researcher looked for similarities and differences in the text that would corroborate or disconfirm theory in the effective teaching of structures. The creation of a learning environment for structures could be found in the lesson plans and filing. The

researcher therefore administered an examining tool that consisted of 19 items to check the planning and files (Thomas, 1998). Each item was scored Yes or No to indicate the availability or unavailability of the document mentioned. The researcher presented the availability of the documents as the creation of a learning environment for teaching structures. The researcher carried out a document analysis of the teachers' planning, work schedules, and lesson preparation to establish any evidence of corroboration of interviews that address the creation of a learning environment. The documents had to show evidence of learners' pre-conceptions, planned and appropriate sensorial activation, and content analysis during teaching activities. To analyse the documents, the researcher examined the relevance in the planning as identification of teachers' usage of suggested constructivist teaching strategies. In a concept analysis, MacMillan and Schumacher (2010) suggest that in analysing the document the researcher needs to apply internal and external criticism, identify factual evidence, and develop generalisations and interpretations.

3.8 DATA ANALYSIS

The study used a case study approach as mentioned in the research design and data collected from interviews and planning documents using an examining or document analysis sheet. An analysis was done using the Resource Theory (Astin, 1984) conceptual framework. Transcription was done from the audio recorded data emanating from the Technology teachers' views and experiences in order to make sense of the explanations about the creation of a learning environment for teaching structures. Burnard, Gill, Stewart, Treasure and Chadwic (2008) write that the process of thematic content analysis is the same as it involves identifying themes and categories that emerge from the data, discovering themes from the interview transcripts in order to verify, confirm and qualify them by searching through the data and repeating the process.

The process of data analysis starts with categorising and organising the data in search of patterns, critical themes and meanings that emerge from the data (Strauss & Corbin, 1990). It is a process called 'open coding' according to Strauss and Corbin, (1990). The purpose is to create descriptive, multi-dimensional categories that give a preliminary framework for analysis. Stake (1995) writes that analysing is a matter of giving meaning to first impressions as well as to final compilations. To analyse the

qualitative data collected through the audio recorded interviews, the researcher used three types of coding (Gallicano, 2013): open coding, axial coding, and selective coding.

An examination of the document was done for the purpose of verifying the findings from the interviews. The findings were shared with the participants and comparing interviews with planning documents for the purpose of triangulation. Triangulation allows the researcher to compare and contrast various findings to reach a valid conclusion using the conceptual framework. The data combined from various sources like interviews and document examination support the issue of the phenomenon being studied, which is to be understood from different angles (Ary, Jacobs & Sorensen, 2010). These techniques are briefly discussed below.

3.9 OPEN CODING

Open coding consists of naming and categorising data (Strauss & Corbin, 1990). The researcher transcribed the data from audio recordings and rearranged it. Themes/patterns were identified using the Resource Theory conceptual framework and the data was presented in a narrative way. The researcher took each transcript and conducted an analysis line by line. Once the researcher had identified concepts, the researcher grouped them to minimise their number. Grouping concepts that belong to the same phenomenon is called categorising. The researcher labelled a phenomenon by breaking down an observation into sentences and paragraphs and giving each discrete incident or even a name, something that represents the phenomenon.

The researcher did this by comparing incidents so that the same incidents were given the same names to avoid too many names being used (Strauss & Corbin, 1990). The researcher reviewed the interview for the purpose of grouping concepts or themes with similar properties. The researcher arranged and rearranged the categories until they were saturated, meaning that this was done until the researcher was satisfied that the concepts were similar and should be put together. It further means that the researcher read through the transcripts several times line by line in order to create tentative labels for chunks of data that summarised what the researcher had seen happening (Stake,

1995). The researcher also recorded examples of the participants' words and established the properties of each code.

Three major categories emerged in the open coding: (1) Learners' pre-conceptions, (2) The physical appearance of the class, and (3) Content knowledge. In coding, the researcher not only grouped categories together, the researcher also examined the categories as well as the dimensions or ranges of the properties. The properties of the categories helped the researcher to understand the categories and ensure that they were properly grouped together or were saturated. The researcher also transcribed the data for a visual review using large margins for additional comments and coding, like identifying small pieces of data that stand alone (segments), leaving space for interviewer questions and participants' responses (MacMillan & Schumacher, 2010). The researcher highlighted headers, questions, as well as different participant responses and comments, including typing words to record what was happening during the session which could be important, for instance, a pause, long silence or a cell phone call. Besides this, an interpretation was made through a hand analysis of the data, making memos, and writing down any impression used in the in vivo coding in the labels that used the participants' wording (Creswell, 2008).

The researcher interpreted and formed conclusions from the data about the participants' conceptions and teaching of the content of the theme 'Structures' in Grade 9. Qualitative data analysis is a systematic process of coding, categorising, interpreting perceptions, attitudes, understanding, knowledge, values, feelings and experiences in an attempt to approximate participants' construction of their phenomenon (Maree, 2007). Maree goes further by saying that qualitative data analysis tends to be an ongoing and iterative (non-linear) process, meaning that data collection, processing, analysing and reporting are intertwined, not only successive steps. Creswell (2008) states that data analysis is inductive in form, going from a particular or detailed data, meaning transcription or typed notes from interviews, to the general codes and themes found in reading the transcription line by line.

In the categories, the first category is learners' preconceptions, which refers to their previous knowledge about the topic of structures. Learners know about structures from previous Grades, for instance Grade 7 and 8. Teachers create a learning environment by linking their lessons with what learners already know. Thus, learners can

comprehend better if teachers consider their prior knowledge. The second category is the physical appearance of the class, which motivates learners to be part of the lesson. Learners are sensorially activated by what they sense, like seeing, touching or hearing in relation to the topic of structures and how these are made to resist different forces. Teachers need to take advantage of the appearance of the teaching area. The third category is teachers' content knowledge, which means that a resourceful teacher creates an effective learning environment. Teachers have to get information from books and electronic media. This enables Technology teachers to plan and teach effectively and to know when and how to involve learners in a form of group and individual teaching for the sake of the creation of a positive learning environment.

3.10 AXIAL CODING

Axial coding involves placing qualitative data back together in new ways after open coding and making connections between categories and their sub-categories. In axial coding, the researcher identifies relationships among the open codes. After the researcher has identified major themes, he should follow a second coding level called axial coding. In this study, the researcher put the data back together in a new way by making connections between the categories. The researcher identified a single category as the main phenomenon and explored its relationship to the other categories (Stake, 1995). The researcher identified the main phenomenon together with the conditions that gave rise to it, the context in which it was based in the action or interactional methods through which it was managed, and the outcomes of those methods.

3.11 SELECTIVE CODING

Selective coding is the process of selecting the core category, systematically relating it to other categories, and validating these relationships. In the selective coding in this study, the researcher re-read the transcripts and selectively coded any data that related to the core variable identified (Stake, 1995). The researcher built a story that joined the categories, and also generated a discursive set of propositions. He then validated these against the story of creating a positive learning environment.

3.12 QUALITY CRITERIA

Trustworthiness is essential in qualitative studies because it leads to the credibility of the study (Creswell, 2008). For the research to be credible, the findings must accurately describe the phenomenon being researched (Cohen et al. 2007). The researcher submitted the findings to a Technology expert to analyse the data for verification. In accordance with the findings of MacMillan and Schumacher (2010), the researcher conducted a participant review to modify any information from the interview data for accuracy. The data from the participants were analysed for a comprehensive integration of the findings (MacMillan & Schumacher, 2010). For dependability, the researcher used member checking for accuracy, and kept coding consistency checks (Creswell, 2008). In order to confirm the findings, the researcher conducted replication as according to Onwuegbuzie and Leech (2006) to assess the replicability (external generalisability) of previous emergent themes (research driven). Onwuegbuzie and Leech (2006) further elaborate that this technique helps to provide legitimation to previous qualitative interpretations.

3.13 TRUSTWORTHINESS

Standard rigour in research (Houghton, Casey, Shaw, Murphy, 2013) was used according to: credibility, transferability, dependability and confirmability.

3.13.1 Credibility

Credibility refers to the value and believability of the findings, it involves two processes: conducting the research in a believable manner and being able to demonstrate credibility (Houghton et al., 2013). For the research to be credible, the findings must accurately describe the phenomenon being researched (Cohen, Manion & Morrison, 2007). Therefore, it was important for the researcher to devise strategies to minimise threats so that the interview results were credible. The researcher triangulated the data by comparing the data gathered from the interviews, confirmed with participants and planning documents to explore the extent to which the findings could be verified. Member checking allows participants to read the transcription of the interviews to ensure that they were accurately recorded and are therefore credible.

3.13.2 Dependability

Houghton et al. (2013) write that dependability is often compared to the concept of reliability in quantitative research and refers to how stable the data are. For dependability, the researcher examined the process through which the end product has been achieved and presents faithful descriptions that are recognisable to the reader.

3.13.3 Confirmability

Confirmability refers to the neutrality and accuracy of the data and is linked to dependability, and the practice of establishing both is similar (Houghton et al., 2013). For confirmation, the researcher conducted a replication of qualitative studies according to Onwuegbuzie and Leech (2006) to assess the replicability (external generalisability) of previous emergent themes (research-driven). Furthermore, the researcher used an audit trail outlining the decisions made throughout the study process to provide a rationale for the methodological and interpretation judgements of the study (Houghton et al., 2013). Onwuegbuzie and Leech (2006) further elaborate that this technique will help to legitimise the previous qualitative interpretations.

3.13.4 Transferability

Transferability refers to whether or not the particular findings can be transferred to another similar context or situation while still preserving the meanings and inferences from the completed study (Houghton et al., 2013). In this study, there are thick descriptions (Houghton et al., 2013), which means that the researcher adequately described the original context so that a judgement can be made. The researcher provided detailed descriptions for the reader to make informed decisions about the transferability of the findings to a specific context. The process of data verification was carried out according to the model of trustworthiness described by Houghton et al. (2013). According to MacMillan and Schumacher (2010), trustworthiness is assured through external review to confirm that the interview questions are valid and reliable.

3.14 ETHICAL CONSIDERATIONS

This study conformed to the ethical issues in educational research (Fraenkel & Wallen, 2003). Before conducting the interviews, all of the participants were told that their participation in the study was voluntary and the information they provided was kept confidential and used for research purposes only. This was done to satisfy the principle of anonymity (Creswell, 2008). In the case of transferability, the researcher sampled a private school that is monitored by the DBE in the Limpopo Province.

3.14.1 Informed consent

MacMillan and Schumacher (2010) write that one cannot anticipate what may be intrusive for each participant, therefore typical protocol does not always fit all qualitative research. The researcher requested permission from relevant school and consent letters from possible participants (Creswell, 2008). In addition, the participants were informed about the purpose of the research (Gay & Airasian, 2003).

3.14.2 Respect

Respect requires that the equal worth of all people be held as valuable and inviolable (Cohen, Manion & Morrison, 2007). It requires that people be regarded as free and rational. Participants need to know the purpose and aim of the study and how the results will be used, and the likely educational consequences the study will have on their lives (MacMillan & Schumacher, 2010). Moreover, the participants have a right to gain something from the study. In this study, the teachers might learn effective teaching strategies in Technology (MacMillan & Schumacher, 2010). The researcher was also honest and transparent in reporting the research findings (Babbie, 2001).

3.14.3 Anonymity and confidentiality

Anonymity refers to concealing the identities of the participants of a study in all documents resulting from the research (Israel & Hay, 2006). The settings and participants should not be identifiable in print (MacMillan & Schumacher, 2010). The participants and the researcher had a clear understanding of the confidentiality of the data, results and findings of the study. The selected school was disguised (identification hidden) to appear similar to several other possible schools. The

researcher explained the rights of the participants to them so they understood the power they had in the research process. MacMillan and Schumacher (2010) indicate that the power and mutual problem solving that result from it (power) may be an exchange for the privacy lost by participating in the inquiry. All the participants' information shared during the study was kept private and was presented anonymously. The pseudonyms of Job and Marry were used to discuss the participants in order to conceal their identity. The researcher stuck to the negotiation regarding the data (Creswell, 2008).

3.14.4 Discontinuance

According to Schaefer and Wertheimer (2011), participants have the right to withdraw from a study without penalty. Therefore, this right was made known to the participants by the researcher at the start of the research (Schaefer & Wertheimer, 2011). Furthermore, the researcher informed all of the participants of their right to withdraw at any time. Confidentiality and anonymity, according to Creswell (2008), must be maintained by the researcher to protect the participants' privacy and anonymity and also maintain trust in the research relationship.

3.14.5 Securing data

The data collected from the participants were kept in a safe place to prevent them from falling into the wrong hands and the researcher did not carelessly discuss such information with any other person. The data was kept for period of five years (Zuch, Mason-Jones & Mathews. 2012) for further verification and possible review of the findings.

3.15 SUMMARY

This study focused on the creation of a learning environment for teaching 'Structures' in Grade 9. The sample comprised two teachers teaching Technology, who were sampled purposively. The study followed a qualitative methodology using a case study design. The researcher tried to make sure that the findings were not biased and had used the participants' responses directly. The researcher did not influence their responses and the research design and sampling method enabled the study uniquely to conduct the research according to the needs of the study as they arose. As the

researcher indicated earlier on, there are different types of data gathering methods, in this study, face to face interviews were deemed suitable for this study. The chapter explained the data collection and the data analysis quality criteria. The next chapter details the findings of this study.

CHAPTER 4 DISCUSSION OF THE FINDINGS

4.1 OVERVIEW OF THE CHAPTER

This chapter provides an analysis of the data that was collected through the process of interviews and examining planning documents. It begins with an outline of the biographical information of the participants in order to show their academic qualifications and experience in teaching Technology. This is followed by a discussion of the participants' responses that originated from the semi-structured interviews. The participants' responses are presented in a narrative manner and conclusions are reached accordingly following the Resource Theory (Astin, 1984) conceptual framework. A discussion of the examined documents is presented, whereby the context is also explained. Thereafter a summary of the examination is provided.

4.2 BIOGRAPHICAL INFORMATION OF PARTICIPANTS

Two Grade 9 teachers were purposively selected as participants for this study (see Chapter 3). The researcher sampled two participants because they met the criteria stipulated in the sampling and the site had only two teachers teaching Grade 9 Technology. The gatekeeper allowed the participants to participate after school hours. The researcher used the pseudonyms Job and Marry to ensure the confidentiality of the participants. Table 4.1 summarises the participants' biographical information in terms of their gender, age, qualifications and experience in teaching Technology.

The data were collected by means of semi-structured, face to face interviews and an examination of planning documents. The interviews were conducted first and the documents were examined on same day as the interview.

Table 3. Summary of participants' biographical information

Name	Gender	Age	qualification	Teaching Experience
Job	Male	46-50	Bed Hons Maths and Technology Education	5-15

Marry	Female	41-50	PTD and Ace Technology Education	5-15

4.3 THE INTERVIEWS

Twenty three (23) questions were set and used in the interviews based on the Resource Theory conceptual framework (Astin, 1984), focusing specifically on the creation of a learning environment for teaching structures. The first two questions ascertained the teachers' understanding of the creation of a learning environment. The third one focused on the creation of a learning environment for topic of structures. The rest of the questions focused on how to create a learning environment and learners' role in the created environment. Since the researcher conducted the interviews in person, it was easy to simplify the questions posed to the participants, and clarify some concepts that the participants may have misunderstood. It ensured that the participants understood the questions well before responding. Stake (1995) writes that analysing is a matter of giving meaning to first impressions as well as to final compilations. As the researcher indicated in Chapter 3, after analysing the qualitative data collected through the audio recorded interviews, the researcher used three types of coding (Gallicano, 2013) which are open coding, axial coding and selective coding.

An examination of the planning documents was done for the purpose of verifying the findings from the interviews. The findings were shared with the participants for the purpose of triangulation. Triangulation allows the researcher to compare and contrast various findings to reach a valid conclusion using the conceptual framework. Data combined from various sources like interviews and document examination support the inquiry into the phenomenon being studied, which is to be understood from different angles (Ary, Jacobs & Sorensen, 2010). An analysis was done inductively using the actual data itself from which to derive the structure of analysis (Burnard, Gill, Stewart, Treasure & Chadwick, 2008). The transcripts were read and notes made in the margins regarding words and short phrases that summed up what was being said in the text (Burnard et al., 2008). The researcher did this for the purpose of giving a summary statement or word for each element discussed in the transcript. Thereafter, the researcher collected and grouped all the words and phrases from the interviews on a clean set of pages, and worked through all duplications, which were then

discarded to reduce the numbers of categories. The participants' responses were stated to support the discussions and conclusions drawn based on what they said.

4.3.1 Question 1: Understanding of a learning environment

According to Resource Theory (Astin, 1984), a learning environment is created by factors believed to enhance student learning: physical facilities, like laboratories, libraries, and audio-visuals aids; human resources; and fiscal resources. In this study, these components of a learning environment were used as criteria that acted as a guideline in the interpretation of the participants' explanation of creating a learning environment for structures. Their answers in this regard are presented below:

> **Job:** *Yes, learning environment I believe has got something to do with eh, the conditions in which teaching and learning can take place. These are, be… should the room be well lit, is the chalkboard clear, are windows… can open and close. Is the noise in the classroom controlled so that the learners can understand what is happening? Eh, is there no (pause) are no disturbances in the classrooms, and make sure that all learners are attentive.*
>
> ***Marry:*** *Yes, my understanding is that… is that the place where a teaching and learning takes place actively by asking them the… about the previous knowledge, how to clean the environment and how to… … then cause of and how to clean the environment.*

It appears that the participants knew what a learning environment is as they spoke about physical and sensorial activation, like chalkboards. The participants explained a learning environment for structures as pinned in the Resource Theory components of the factors believed to enhance learning. The participants mentioned that a learning environment is a place where teaching and learning take place. Both mentioned that in a learning environment, learners actively answer questions and also stated the importance of a clean classrooms. They further explained that this includes a well-lit classroom, clear chalkboard, no unnecessary noise and movement, and learners paying full attention. The way in which learners construct knowledge from the learning environment is also found in the constructivist framework (Lu, Lajole & Wiseman, 2010).

4.3.2 Question 2: the creation of a learning environment in your class

Resource Theory (Astin, 1984) argues that physical resources facilitate an effective learning environment. The respondents explained their view of this as follows:

> ***Job:*** *Learning environment in classroom is created by addressing learners by name, eh, try to use please and address learners and thank you, when they answer questions, also listen to the learners 'views. Is not always that they, some of the learners do their private studies, they can bring in something in the classroom…Use eye contact and don't allow bullying in the classroom, there should be exchange of information between learners, instead of the information coming from the educator.*
>
> ***Marry:*** *By arranging learners in groups, sitting in rows and also monitoring the groups.*

Well-trained faculty staff, as indicated by the Resource Theory conceptual framework, have knowledge of creating a learning environment, however, further investigation is needed to ascertain whether they practise this during the lesson. One participant mentioned the arrangement of learners into groups and monitoring these, while the other participant goes further by mentioning addressing the learners by name, thanking them after their participation in the lesson, allowing them to share their views, learners bringing their findings from their individual research to the class, and using eye contact and not allowing bullying in the classroom but rather exchanging information in class.

4.3.3 Question 3: the learning environment affecting the teaching of structures in the lesson

The participants answered this question as follows:

> ***Job:*** *Yes, structures, yes is an area that must be dealt with learners participating practically. So, the learning environment here comes in where you can group learners so that they can interact with each other. The first thing that you can do, you can just give them to bring up their own structures in the form of… per pairs or in groups.*
>
> ***Marry:*** *Learners to construct the… you must use different types to construct …and even how to build or how to reinforce it.*

Regarding the influence of the learning environment on teaching structures, Job spoke about groups, enabling learners to make structures and allowing them to interact, while

the other Marry mentioned that learners should be able to understand different types of structures. The learning environment encourages personal development and authentic learning (Strayer, 2012). The effectiveness of a learning environment depends solely on teachers' integration of prior knowledge, sensorial activation and content knowledge where learners are motivated to learn in rich, relevant and real contexts (Herrington & Herrington, 2007). When technology teachers teach the theme of structures, the settings need to establish a link between learners and their preconceptions because the quality of the classroom environment in schools is a significant determinant of learning (Afari, Aldridge, Fraser & Khin, 2013). Brooks (2011) writes that stimulations and visualisations (sensorial activation) in an active learning environment are designed to facilitate learners' interaction, conceptual understanding and improve skills in problem solving. According to Shenoff, Tonks and Anderson (2014), learning environments promote engagement and positive experiences, which is likely to advance the mastering of content by learners.

4.3.4 Question 4: the relevancy of the learners' prior knowledge to planning lessons

In response to this question, the participants revealed the following information:

> **Job:** *This is quite relevant because prior knowledge is the best of your lesson. So, if the person is not strong, then that means your lesson will be effective. Yes, you can bring in prior knowledge by checking first whether learners know the lessons, asking questions related to the prior knowledge. Once you see that they are not well vested in the prior knowledge then you have to start from the prior knowledge.*
>
> ***Marry:*** *Ah… is relevant because the… yes… they remind learners about their previous lesson. All participant affirm that leaning environment is important when the teacher teaches, it is supported by their previous responses where the indicated how to create effective learning environment.*

The relevancy of prior knowledge it was clear as the participants mentioned that prior knowledge is best for making a lesson more effective. Marry mentions that prior knowledge reminds learners about previous lessons, while Job mentioned that prior knowledge gives direction to the teacher because learners might not know what the teacher is going to teach about, therefore it is better to build on prior knowledge, which enhances learning in a big way. Sensorial activation is revealed here, which is

supported by the aspect of physical resources in Resource Theory (Astin, 1984), which link learners' past and present experience. Jonassen (1991) writes that in other learning theories, like those based on constructivism, reality is constructed by the knower based on mental activity, just like in the case of conceptual scaffolding. Bednar (1991) states that learners build internal representations of knowledge from personal interpretation of learning experiences, the statement is in line with metacognitive scaffolding. Because constructivism supports the creation of learning environments through factors like knowledge of prior learning, sensorial activation and content analysis, it is in line with the components of Resource Theory, which formed the theoretical framework that guided this study.

4.3.5 Question 5: reasons for the use of prior knowledge in teaching

Both participants agreed that without prior knowledge, teaching and learning would not be effective. This is supported by the constructivist view that this is a learner- sensitive form of teaching designed to stimulate learners to construct effective and personalised ways of tackling academic problems (Rosenshine, 1979; Winograd & Hare, 1988). Concerning sensorial activation, Piaget (1973) explains that learners grasp the world by co-ordinating sensorial experiences like hearing, vision, feeling and physical interaction with objects. As a result, they assimilate and accommodate new information into schemata. Learners construct an understanding of the world around them, which is stored as schemata. The schemata consist of recognising a particular situation, making associations within a particular activity and having the expectation of particular results. Von Glasersfeld (1989) mentions adaptation, which means that species are characterised by their ability to live in a given environment (learners' ability to learn in a conducive learning environment), which is supported in Astin's (1984) Resource Theory regarding the integration of resources. The participants had the following to say regarding this aspect:

> ***Job:*** *Prior knowledge is relevant, eh, in teaching cause once you have the knowledge of the prior knowledge, then, you have the right direction that you can follow ahead. Is the best of the lesson that you have is not strong, if it is shaken, they, you have to correct it here and there, 'cause learners might not have been taught about what you say is prior knowledge, and build on your lesson.*

Marry: *Yes it can help the learners to learn more and in and even open their minds and finally show them how… show them in teaching a… concerning their topic.*

4.3.6 Question 6: enhancing learning through an effective environment

Job: *Yes, it can enhance learning in the form or in the manner that once you have created a learning environment that means participants also have that feeling that they are in a lesson, and you can conduct your lesson effectively. Yes, look, when you go into a classroom, then you… the whole classroom is, that means you haven't taken, you should have created a learning environment, learners should feel that now we are starting a lesson by making sure the room is clean first.*

Marry: *What you are going to do, or teach.*

The participants believed in creating effective learning environment for the teaching of structures, although Marry appeared to not have much to say, but her response suggested that an effective learning environment is a necessity in teaching and learning. Moreland and Wine (2007) write that in creating a learning environment, fermentation at home, for example, can help in teaching biotechnology. Moreland and Wine (2007) created learning environments by requesting learners to display their work on the classroom walls, which became a colourful stimulus for teaching biotechnology and the lesson created real life technology (De Vries, Custer, Dakers & Martin 2007). Teachers group learning outcomes related to procedural knowledge, conceptual knowledge and societal learning outcomes consistent with technology. It was similarly found by De Vries et al. (2007) that learners work with an expert team from their community to build on the conceptions of learners regarding the expert team's role in the community. Web-cams, email and other programmes are used in the class, including workshops and jigsaw strategies to create an authentic experience. The teacher uses the expertise of the community of experts to facilitate knowledge development amongst learners as in the Resource Theory that advocates the use of counsellors who assist teachers in their practice.

4.3.7 Question 7: the best time to build on prior knowledge

Job: *The first time to build on prior knowledge is the first five minutes of your lesson, before you go any further build on that one first. And make sure you*

are in… at the same level with the learners. Are they well aware of what is going to happen in the lesson first, before you introduce your new material?

Marry: *When you start the lesson by asking… the previous questions lesson. By sharing some structures, how to build some structures, how to test the… the qualities and also the teacher has to know the subject.*

In responding to this question, it appeared that they linked it with what learners know. In the planning, as discovered in the examining sheets of the participants, it could be seen that they had given consideration to building on learners' prior knowledge of structures. They emphasised that questions at the beginning of a lesson would serve as a foundation for teaching the topic of structures. If the creation of a learning environment is effectively used timeously, as stated by both participants, it would be in line with the findings of Verloop, Van Driel and Meijer (2001), who expound that knowledge is content and is context-related, and in education this can be applied through immediate use in teaching and learning practice. McCormick (1997) writes that knowledge consists of procedural and conceptual knowledge, often seen as separate and the relationship between which is sometimes ignored. Petrina (2007) calls it procedural and propositional knowledge of technology. Procedural knowledge entails deductive reasoning (convergent) and propositional knowledge goes with inductive reasoning (divergent). Moreover, the procedural and propositional forms of knowledge are integrated and become sociotechnical (Petrina, 2007).

4.3.8 Question 8: the manner in which prior knowledge, sensorial activation and content knowledge could assist (or not) in your instruction as a teacher

Job: *Prior knowledge will assist you in introduction of the lesson, they build on how you are going to approach the lesson that you have and then content knowledge will assist you in a, yes… at a large scale cause now should show how the learners, you know, what are they doing as you present your lesson. A sensorial activation***,** *Yes, you can present your lesson in such a way that you even bring in your material and in your material that they know this is what our educator is talking about.*

Marry: *Mm, by sharing some structures, how to build some structures, how to test the… the qualities and also the teacher has to know the subject. Yes… for example with the learners build or mould some structures you must test I to make sure that the structure is stable.*

Both participants indicated how they used representations to foster learning, and highlighted the importance of material and teachers' knowledge of content, Marry in particular. The integration of prior knowledge, sensorial activation and content knowledge was mentioned by the participants, particularly that prior knowledge can be used in the introduction to the lesson and content knowledge can assist the teacher in teaching, while sensorial activation creates a learning environment, according to Job. Marry mentioned that prior knowledge, sensorial activation and content knowledge could assist in building structures and a teacher having the prerequisite knowledge of structures. The integration of procedural and propositional knowledge is suitable for teaching technology content. In the Technology CAPS curriculum (DBE, 2011), procedural and propositional knowledge cannot be used separately when teaching technology content like structures because they depend on each other. Furthermore, the CAPS document requires procedural and conceptual knowledge to be taught to accomplish the design process of: investigation, designing, making, evaluation and communication.

4.3.9 Question 9: action taken in an unsuccessful lesson to build on the learning environment required to teach 'structures'

> ***Job:*** *Yes, if your lesson has not been successful, you are going to build on initial lesson and give them a further lesson on the same topic. So that they can understand and actually what has happening and what you are trying to deliver to the learners. You can offer them remedial lessons, or extra lessons and then you can also give them one on one lessons. Sit down with individuals, find his areas of weaknesses and correct on that.*
>
> ***Marry:*** *Mm, as a teacher I will make sure that all learners are coping in them, there is a learner who is lacking behind I'll make sure that I arrange some afternoon hours like afternoon studies, Saturday classes and to help the learners.*

Both participants agreed on remedial work for lessons that were unsuccessful. This means that they would go the extra mile to have their learners understand the lesson. Job mentioned that he would support learners through extra classes, Saturday classes and arranging with learners to conduct one on one lesson, which would serve as scaffolding, which is where teachers help struggling learners using physical facilities like audio visuals (Resource Theory) (Astin, 1984). Cagiltay (2006) finds that

scaffolding is a learning process where experts create a supportive situation for learners to construct their knowledge or skill to a required learning level. Scaffolding reduces doubt in learning because it offers multiple growth opportunities that direct a learner to internalise the process that he or she is learning. Cagiltay (2006) mentions four types of scaffolding:

(i) Conceptual or supportive (the learner is guided in terms of what he/she considers as associations);

(ii) Metacognitive or reflective (helps learners to answer questions);

(iii) Procedural (emphasises various ways to utilise the available resources and tools for the given environment); and

(iv) Strategic or intrinsic (guides learners in analysing and approaching learning tasks or problems.

4.3.10 Question 10: the response of learners to the learning environment and the action taken

> ***Job:*** *Once we start to make sure that the room is quiet and learners are attentive, and then there are those learners who'd want to disturb your lesson. The best thing you can do is to take off those who are disturbing the lesson. So that you continue in an atmosphere which is conducive to learning and teaching. That's a very good idea, you can bring on those ideas so that learning can in future make sure they have understood what structures are all about. Constructivism, yes, I have heard. That's very good approach because there is peer learning where learner can teach the other effectively, 'cause their level of understanding is not the same, because someone may understand the topic better than the other. So you give them room to sit together and explain to each other.*
>
> ***Marry:*** *Yes… they must respond by answering questions, to sit down with them and show them the consequences of not answering questions. Learners must always benefit from teaching in the learning environment.*

The strategies for attracting learners' attention appeared to be important to Marry and Job. Job seemed to be knowledgeable as he mentioned a constructivist learning environment. Regarding learners' response to the teacher's created learning environment, the participants mention that when the classroom was quiet and learners

were attentive, this indicated that the learning environment was conducive. Marry stated that when learners responded to questions, that would mean that the environment is good. The factor of physical facilities highlighted in Resource Theory states that learning will occur if various resources are brought together by a trained personnel. If it is seen that the learners are not responding well, as shown by them misbehaving, Marry would deal with them and make them aware of the results of not paying attention.

De Vries, Custer, Dakers and Martin (2007) use the dynamic engineering and industrial history of the city of Glasgow as a context for prior knowledge in learners. These learners live in an industrial area that creates an effective learning environment for teaching about energy. Learners see the operation of a sluice gate to maximise the flow of water as a source of energy, and they realise the evolution of technology because old technology forms the basis of new technology. Snape and Turnbull (2013) elaborate that authentic activities in teaching need to be situations that are real to learners. Snape and Turnbull (2013) also explain that activities that use authentic practice are more likely to generate greater understanding and enable learners to identify, gain from simulations, and be in line with the tacit knowledge possessed by technologists.

4.3.11 Question 11: the benefit of a learning environment to your teaching

> ***Job:*** *It is greatly beneficial to teaching, always what you consider teaching in an environment you will find out, at the end of the day when you evaluate yourself, you find that you have achieved something, after creating a learning environment.*
>
> ***Marry:*** *Yes, learners must always be benefit in teaching the learning environment.*

Both participants felt that when they had created an effective learning environment for teaching the topic of structures, their learners performed well. Astin (1984) writes that the Resource Theory pedagogy also tends to include the belief that high-achieving students are a resource and enhance the quality of the learning environment. The participants highlighted the issue of always being beneficial to create and effective learning environment, the fruits of which could be seen after assessing the quality of a lesson. Marry stated that it has to produce good results. van Dijk and Kattmann (2006) write that the learning environment is the integration of the teachers'

knowledge, their contact with learners through instruction, the physical classroom and its resources, as well as the learners' knowledge and understanding of technology-specific concepts. The process of designing a learning environment goes with the teachers' proper selection of presentation materials according to a rigorous process of analysing the subject content (van Dijk & Kattmann, 2006). Technology teachers therefore need to create, select and use representations of structures in the classroom to activate learners' senses for them to understand structural principles like pictures, the design behind the very roof above the classrooms, videos, the teachers' explanations, or even something like the electric pylons outside the class for the benefit of learning.

4.3.12 Question 12: causes of success when teaching structures

> ***Job:*** *Yes, to what I observed in the past, the best way to teach structures is to make sure learners do a practical lesson where you give them an assignment to build something like a bridge together or as a groups or in partners. And then from there you can evaluate the structures, is it going to be a strong structure or is it going to be a weak structure. So, groups here work effectively. Strong yes, the strength of the structure. Yes, you can test some structures in the classroom and show them that this one is not strong and bring structures that are weak and show them this one is weak, and this one is strong. Yes, structures.*
>
> ***Marry:*** *Yes. I… yes… when you teach the learners to make sure that learners… the learners must understand… the leaners must… will understand it, then… your teaching… you must show that in learning aid, like pictures and posters and models.*

Marry initially appeared to be lost, but in the end was able to mention some causes of success in her classroom as she listed models, pictures and posters as the cause of a successful lesson. Resources, which refer to representations and a hands-on approach, appeared to be important to Job as he listed pictures, posters and models, which stress the point of using a hands-on approach in having learners make structures. Moreover, Marry highlighted the idea of groups making structures and evaluating themselves. The CAPS document (DBE, 2011) requires teachers to analyse content, scaffold learners' learning and sensorially activate Senior Phase learners to demonstrate knowledge and understanding of how structures are constructed and how they are designed to withstand various forces. Resource Theory

highlights the idea that well-trained faculty members will facilitate an effective learning environment. Von Glasersfeld (1989) states that teachers need to provide opportunities for learners to be self-directed, creative and innovative, while drawing on visual/spatial, logical/mathematical, interpersonal, intrapersonal and naturalistic intelligences. The tasks that learners do in the topic of structures reflect the activities that they see in real life. This means that the creation of an effective learning environment is characterised by the provision of an authentic context that reflects knowledge of the real world, authentic activities, access to expert performance and modelling the process, multiple roles and perspectives, collaborative construction of knowledge, reflection, articulation, coaching and scaffolding, as well as authentic assessment (Herrington & Herrington, 2007).

4.3.13 Question 13: understanding of technology content knowledge

> ***Job:*** *Technology content knowledge, yes, I believe is to do with having the core knowledge about yes for example, If I give the example of machines, you should be able to know how the machine operates and how it is build. You can also break it down and build it back, where our best in that are content.*
>
> ***Marry:*** *Yes, as a teacher I must know the content and the lesson, especially the learning structures.*

Marry and Job agreed on having knowledge of the content as they gave a description of the content as well as examples.

Regarding content knowledge, the participants stated that the teacher must know the content of structures well to be able to teach it or create an effective learning environment. Job mentioned that a teacher must know how structures and functions, while Marry explained that content must be found from reading books. The participants also mentioned that not having enough resources for learners to access content knowledge is not good

. Astin (1984) talks about libraries and laboratories where learners can get content knowledge, however, this is not always an available resource in South African schools. Nonetheless, in the CAPS document (DBE, 2011), procedural knowledge refers to investigation, designing, sketching, evaluation and adapting, designing a brief or flow chart, making, and communication. Conceptual knowledge in Grade 9 according to

CAPS is knowledge of structures, their working principles, rigidity, and being able to withstand forces like tension, compression, bending, torsional pressure and shearing. Furthermore, it is prescribed that teachers use assessment rubrics to assess learners' procedural and conceptual knowledge of structures.

4.3.14 Question 14: the importance of knowing the content of structures

> ***Job:*** *It is very important because always as a teacher you must always be at a higher level from the learner. So, make sure you have content, so that when you explain to the learners you won't stutter.*
>
> ***Marry:*** *Yes. It is very important because yes, it teaches the learners. The teacher will understand to create the effective learning environment and be able to guide the learners and giving them examples.*

The participants explained that the teacher needs to be up to date with the content to enable themselves to give examples to learners and explanations. Both participants emphasised that teachers need to have knowledge of the content of structures. Astin (1984) emphasises the training of personnel, which was also alluded to by the participants. De Vries (2004) indicates that structures or artefacts are objects that have been modified for a particular function. A structure has a collective intentionality (to be used by many) ascribed to it in its function. Learners need to know the concepts of the life span and strengthening of structures, as well as aspects like using triangles for strengthening, mass, density, hardness, stiffness, flexibility, corrosion resistance, prevention of corrosion (DBE, 2011), as well as strengthening a structure with tubing, corrugation, lamination, and the forms/shape of the structure.

4.3.15 Question 15: factors that enable you to understand the content

> ***Job:*** *You must be up to date with the changes. Technology, all the time you must research. You must read and you must always use the latest textbook and you also you must watch much of the television material because this is where much of the technology is brought out. The media, yes. The best way to tell them to use media is to bring it to them, the teaching material to the classroom and the television if it is there, you show them some videos.*
>
> ***Marry:*** *Reading books. When you read books, you'll get more information.*

The sources of knowledge are mentioned by participants in answering this question regarding gaining knowledge for the teacher to create an effective learning environment for teaching structures. In this question, the participants stated that teachers need to be up to date with their content knowledge. This means that teachers should use current books and electronic teaching aids like TVs. Astin also mentions the use of audio-visuals as important in teaching and learning. Moreover, Jones and Moreland (2001) suggest that teachers need to know and develop a strong teacher-knowledge base in the areas of (i) Content knowledge, (ii) General pedagogy, (iii) Curriculum pedagogy content, (iv) Learners' educational context, and (v) The educational ends or purposes. The integration of these five areas of mastery by the teacher and their expression in practice may be viewed as PCK (Jones & Moreland, 2001).

In relation to the five areas of knowledge to be mastered (Jones & Moreland, 2001), Vincenti (1990) classifies technology as:

(i) Fundamental design concepts (operational principles and normal configurations).

(ii) Design criteria and specifications.

(iii) Theoretical tools (mathematical, reasoning, laws of nature).

(iv) Quantitative data (descriptive and prescriptive).

(v) Practical implications.

(vi) Design instrumentalities (procedural knowledge).

Vicenti (1990) explains that these six categories are visible in the design of artefacts. Therefore, it could be assumed that Technology teachers could be required to have these kinds of technological knowledge and teach them in the context of the South African curriculum. According to the Technology CAPS document (DBE, 2011), teachers are provided with work schedules, assessment guidelines and textbooks. Textbooks need to have representations of structures to enable learners to visualise structures. The question is, however, how do teachers utilise these resources in dealing with learners' prior knowledge of structures and its working principles? Technology teachers need to use good quality books with illustrations and explanations of how structures work. The CAPS Technology Grade 7-9 document

(DBE, 2011) further stresses the knowledge of the design process and the choice of materials.

4.3.16 Question 16: challenges in understanding knowledge of structures

> ***Job:*** *Yes, it is quite a challenge. I've also observed it and then the only way that you can resolve this is to make sure that you open up, and stay in touch with other educators from other areas, and then you can also form a group or you can discuss issues that are giving you problem.*
>
> ***Marry:*** *Challenges I come across is I must attend the workshop, furthering my studies, group with other eh… educators to understand the content.*

As Marry stressed, consultation and advice from colleagues, as well as enrolling with higher education institutions appeared to solve the challenge of understanding the content better. Workshops, as suggested by both participants, assisted and make them to understand and circumvent the challenges related to the knowledge of structures. Astin (1984) writes that counsellors, which refers to curriculum advisors who conduct workshops, assist teachers in understanding the content. De Vries (2004) highlights that technology knowledge is universally available in the real world and has been presented in various models. . De Vries further classifies technology knowledge into types, such as conceptual, procedural, visualisation and normative knowledge. Ropohl (1997) developed a model for categorising knowledge into five groups which are: technological laws, functional rules, structural rules, technical knowledge, and socio-technological understanding.

Pavlova (2005) as well, characterises technology as tacit, prescriptive and descriptive knowledge. So, the participants highlighted that teachers who like using books as a resource will be up to date with knowledge of structures, which is in line with Pavlova's research. Further related to knowledge, Grossman (1990) identified four knowledge components within PCK:

(i) Knowledge of the curriculum;

(ii) Knowledge of assessment;

(iii) Knowledge of instructional strategies and methods; and

(iv) Valuing the influence of teachers' orientations.

van Dijk and Kattman (2006) identify PCK as an abstract idea that is a subjective representation of an element of teachers' professional knowledge. They write that it is personal and private knowledge. Hashweh (2005, as cited in van Dijk & Kattman, 2006) finds that PCK includes a distinction between ideas that concern the integrated area of content and the pedagogy used in teacher education.

4.3.17 Question 17: suggestions for teachers to understand the content better

> ***Job:*** *Yes… only thing that I can think of here for educators to understand content of knowledge better is one of the ideas that I have mentioned previously. They should stay together and form a group where they discuss the content. And also keep abreast of that is happening around the areas of technology.*
>
> ***Marry:*** *Yes. This is new book. Yes, system. Learners, I encourage teachers to attend the workshop, furthering studies, reading books and grouping* with others eh… teachers.

The participants agreed regarding the use of group discussions to further studies so as to keep teachers abreast of new content. It would appear that the analysis of content was essential to the participants. Astin (1984) expounds that teachers need to come together to be trained in order to keep abreast of new technology knowledge. In relation to this, Marry stressed the fact that teachers need to study. This means that both participants had an idea of how to get content knowledge. Technology content knowledge refers to knowing the depth and breadth of the subject matter, knowing the facts and concepts of technology as a subject, and utilising multiple ways of thinking (Barrett & Green, 2009). According to the DBE (2011), learners are expected to investigate, design, make, evaluate and communicate their MINI-PAT projects. Rasinen (2003) indicates that various Countries have their own technology curriculum knowledge, for example, in England, pupils have to concentrate on design and technology through the development of a range of ideas. Learners need to combine practical skills, aesthetics, social and environmental issues, and reflect on and evaluate present and past design and technology, as well as its uses and effects (Rasinen, 2003). Pupils should be taught to:

(i) Develop, plan and communicate ideas;

(ii) Work with tools, equipment, materials and components to make quality products;

(iii) Evaluate the process and the products; and

(iv) Know and understand materials and components.

4.3.18 Question 18: guiding learners to understand the aspects of the content of structures

> ***Job:*** *Yes, to guide learners you have to approach the lesson which you guided, approach where you take learners out, just give them the guidelines of what to do and then you give them to do whatever they are going to do alone. Then you can evaluate what they come up with. Yeah. This is quite a challenge as well. We have textbooks but these textbooks may not be enough for every other learner. They have to share the textbooks. We use hand-outs where we photocopy some of the pages from the textbooks, then the learners can use them. Alright. And then you see, earlier on you spoke about the learning theory that is constructivism, then they usually, they suggest that learners could have collaborative learning, or other things that improve learning. We have collaborative learning, but it is not only collaborative learning that they suggest. Then, do you believe, Yeah, I do believe collaborative learning where learners help or assist each other at their level. Because you allow learners and encourage them to visit places like the library where they pick up other material. When they come back from the library then they can share the information with their peer groups. And when they come back and share and report what is happening in the… in the industries.*
>
> ***Marry:*** *Mm. to take learners… the… the educational tours where they must learn and share the ideas, the content like in the industries. They learn more about things that they don't know.*

Using external resources like going on a tour to foster understanding of structures seemed to be important to both participants. Job had quite an extensive answer, however, both participants supported the idea that this is an effective way of guiding learners to understand the content of structures. Job stated that tours within industries would enable learners to better understand the content of structures. Resource Theory highlights the fiscal resources that enable an effective learning environment, thus allowing learners to go for an educational tour is part of the creation of a learning environment. Based on Job's extensive answer, this shows that these participants had an idea of creating a learning environment for the teaching of structures, but the question remains as to whether they were they practicing these ideas in the class. This

needs to be investigated. Borko and Putnam (2000) advocates that for transference of learning to occur effectively, learners must be provided with multiple similar experiences allowing an abstract mental model to form. Astin's (1984) Resource Theory states that learners will learn from a combination of a wide range of ingredients.

4.3.19 Question 19: collaborative learning or other strategies that improve learning

> ***Job:*** *You can give them room to one side of the class they ask questions and the other side of the class can answer questions. You divide the class into two. And then you award marks or award point for the… for the two sides of the classroom. And then you take it as a challenge, with sides. After the lesson you evaluate which side has got higher points and which sides have got lower points. And then you can do that next time.*
>
> ***Marry:*** *Mm. all of them must participate and as a … as…as an educator or as a mentor of them, I'll monitor each and every group discussion.*

The notion of using groups was used by both participants, who also detailed how they would go about making sure that learners participate in groups. In their teaching strategies, like collaborative learning, the participants mentioned that learners learn from others like in groups. An idea was discussed regarding having one group in class ask question and having the answers given by another group, then both the learners and the teacher would evaluate the responses afterwards, as Job stated. In Resource Theory, this is referred to as a human resource. Marry brought up the idea of learners reporting back after a class site visit, as well as group discussions and individual records sharing. Knowledge is acquired through involvement (Richardson, 1997) with content instead of imitation or repetition, thus, in theory, these are very good ideas for the building of knowledge.

Moreover, the acquisition of knowledge can be achieved by means of Problem Based Learning (PBL) (Lu, Lajole & Wiseman, 2010) where a teacher poses a problem to a group, which is then individually researched, and data is gathered and analysed, with learners presenting solutions collaboratively. This is adaptive learning where learners accommodate new learning based on prior experience, which might also prove to challenge any misconceptions. Learners are actively involved in discovering solutions by means of hands-on learning, and their senses being activated by the learning

environment. Learning is interactive and the teacher acts as a facilitator instead of being the sole provider of learning. Also, learners are engaged in a product that is constructed through thinking (Lu et al., 2010). In facilitating learning, teachers use a selection of facilitation strategies in constructivism, including guided instruction, anchored instruction, cooperative learning, jigsaw and reciprocal peer teaching.

4.3.20 Question 20: strategies applied to cause learners to learn from other learners

> ***Job:*** *You can give them room to one side of the class they ask questions and the other side of the class can answer questions. You divide the class into two. And then you award marks or award point for the… for the two sides of the classroom. And then you take it as a challenge, with sides. After the lesson you evaluate which side has got higher points and which sides have got lower points. And then you can do that next time. Yes, this should be allowed. This should be allowed to happen in any lesson. First, you can start with individual lessons and then in that lesson you allow the learners to work in groups, especially where structures are concerned. This bring in the idea of sharing views in a group.*
>
> ***Marry:*** *By using the group discussions. Yes, they must participate, all of them. Mm. all of them must participate and as a … as…as an educator or as an mentor of them, I'll monitor each and every group discussion. They will show how the content is interesting.*

In discussing possible strategies to cause learners to learn from one another, the participants listed group discussions as a strategy, monitoring done by the participants and guidance offered to make lessons conducive to learning, as well as assessments being conducted. The participants seemed to agree that the strategies for peer learning are important. Astin (1984) indicates that high achieving learners are a resource, which means that learners can learn from their high achieving peers. Learning is affected by the (Herrington & Herrington, 2007) context in which an idea is taught, as well as by learners' beliefs and attitudes. Teachers have to scaffold learners' learning in order to support the learning process (Sawyer, 2006), which is tailored to the needs of learners with the intention of helping them to achieve learning goals.

4.3.21 Question 21: working individually and in groups

> ***Job:*** *Yes, this should be allowed. This should be allowed to happen in any lesson. First, you can start with individual lessons and then in that lesson you allow the learners to work in groups, especially where structures are concerned.*
>
> ***Marry:*** *For example, when I give them a task then they must go and write. This bring in the idea of sharing views in a group, and then groups are also easy to monitor than monitoring individual learners, class, as a group you can discuss issues with the group. There are always such chances that when you put learners in a group, some people tend to draw back and they don't want to participate. So, that your duty now, to go into each and every group to encourage those who are passive to make sure they also try.*

Individual learning was encouraged by the participants as they discussed writing and learners taking turns to present content. The participants agreed that group work as part of the creation of a learning environment is important, as this is where learners can discuss issues, especially when constructing structures. Marry indicated that when learner completed tasks, they had to share their findings in class. Interactions (which refers to acquiring prior knowledge) fundamentally shapes and transforms the way in which we think (Vygotsky, 1978). In the Zone of Proximal Development (ZPD), Vygotsky writes that in the process of problem solving, learners have to be guided. This means that teachers guide them to use what they already know as knowledge scaffolding, also using their peers as a resource. Subsequently, learners have to be given a chance at a later stage to perform their tasks (what was learnt) independently. Vygotsky (1978), in explaining how knowledge is acquired, writes that new knowledge is a constructed synthesis that resolves the inevitable contradiction arising during the course of such interactions. This means that learners compare new information with what they know and eradicate contradictions by themselves during and after lessons about structures.

Piaget (1973) mentions the importance of social interchange, which is the formulation of pre-conceptions in learners. Piaget also mentions the sequencing of instruction, which begins with known to unknown and cognisance of error, which is taking note of the value of learners' wrong answers. The latter supports the contradictions in Vygotsky's process of learning. Teachers' recognition of learners' pre-conception in technology or any other subject is important for effective teaching and forms part of

the PCK of effective teachers. In Ausubel (1968)'s dimensions of learning, reception learning, discovery learning, meaningful learning and rote learning, learners add and integrate new knowledge to their existing cognitive structure.

4.3.22 Question 22: the role played as a teacher during the construction of knowledge about structures

> ***Job:*** *Your role is to go to into those groups and then to check what is happening. You don't instruct learners on what to do, yours is just to check what happen them. If corrective measures… because if you instruct them now you are taking knowledge out of them, allow them to work freely and they bring out what is inside them. Yes.*
>
> ***Marry:*** *To monitor each and every group… every group, every minute, until they finish the construction. If they… I'll monitor them, then sometimes when the… the … they do some construct, question must be there. Yes, for example with the learners build or mould some structures you must test, to make sure that the structure is … is stability is stability is … and is stable.*

The teacher's role is that of a facilitator and someone monitoring learners' progress. Both participants agreed that the teacher has to facilitate learning, gives learners tasks and monitor their work, especially when constructing structures. Bauersfeld (1995) writes that teachers are regarded as facilitators who help learners to get to their understanding of the content. As in a constructivist learning environment (von Glasersfeld, 1989), Teachers need to allow learners to be self-directed, creative, innovative, drawing upon visual/spatial, logical/mathematical, interpersonal, intrapersonal and naturalistic intelligences.

4.3.23 Question 23: assessment of knowledge of structures in groups and individually

> ***Job:*** *Allow learners to bring out structures and then you can use the rubric to assess what would have come out, what the earners would have brought out as a structure, and then award marks from the rubric. Yes, some structures that they can do in class, they just bring in their material, but some structures they just bring their material, but some structures that are … require a lot of time and effort you can allow those to be done at home. You use the rubric, Especially when you allow practical work to take place, learners enjoy bringing out what is in their minds then you telling them every*

day on the chalkboard what to do. Allow them to go and do something and bring it back you will see the learners enjoying

Marry: *By giving classwork and home works, by handwriting. A case study or go and research about structures. By choosing one who want to represent each and every group.*

Assessment was done by both participants as the participants indicated that they used a rubric for mini-pats assessment of knowledge. Marry highlighted class work, homework and projects, as well as using a tool to mark. Rasinen (2003) explains that learners need to combine practical skills, aesthetics, social and environmental issues, and reflect on and evaluate present and past design and its uses and effects. Pupils are taught to (i) Develop, plan and communicate ideas, (ii) Work with tools, equipment, materials and components to make quality products, (iii) Evaluate the process and the products, and (iv) Know and understand materials and components.

4.4 EXAMINING PLANNING DOCUMENTS

For the purpose of analysing documents the researcher considered the following concepts in their planning for teaching structures: originality and aesthetics, value for money, fit for purpose and suitability of materials, ease of manufacture, safety and ergonomics, environmental impact, and not being biased towards other groups. An analysis of documents was done using examining or document analysis sheet with 19 Yes or No items. The researcher examined the participants' files, consisting of planning and records of assessment for both participants (Marry and Job).

- Work schedules or (Pace setters) were provided by the Limpopo Province to Technology teachers.

- Lesson planning was also done on a form (Sample) supplied by the Province.

Planning was done together because they taught the same Grade. The researcher looked at the relationship between what the participants said, about an effective learning environment in the interviews and what they indicated in their planning for the purpose of triangulation. Bowen (2009) writes that document analysis is often used in combination with other qualitative research methods as a means of triangulation. In triangulating data the researcher shared the findings with the participants, compared

the findings of interviews and planning documents, like, lesson preparation and lesson plan. There was a similarity of facts as indicated in their lesson plans, and what they said in their verbal responses (participants' interviews). There is evidence that, they posed questions in consideration of prior knowledge and sensorial activation of learners at the beginning of each lesson from their planning documents. These procedures appeared in their lesson plans for Marry and Job. At the end of each lesson, there are some assessments, as they indicated during the interviews and served as corroboration of interviews and documents. Planning documents for participants after analysis appeared as follows:

Examining sheet on the planned documents. Table.4.

	Aspect	Yes	No	Comments
1	Linking lesson with previous lesson?	y		Questions before the lesson
2	Learners' pre-conceptions considered?	y		Questions posed
3	Indication of learners involved in the lesson?	y		Learners given chance to answer
4	Usage of learners support materials?	y		Indicate on the plan
5	Learners' senses activated, like, touch?	y		Stated
6	Content relevant to planning?	y		For structures
7	All learners catered during learner involvement (diversity)?	y		Various activities indicated
8	Presentation is in sequence?	y		Layout in sequence
9	Content knowledge?	y		Structures are explained
10	Practical work given to learners?	y		Activities available for learners
11	Group work encouraged?	y		Available

12	Lesson was a success/failure evidenced from assessment?	y		Remedial activity available

Checklist for file document

	Aspects	Yes	No	Comments
1	Work schedule available?	y		Attached in the file
2	Lesson plan available?	y		Attached in the file
3	Learners' pre-conceptions considered?	y		Plan filed
4	Teacher support materials indicated?	y		Indicated in the plan
5	Learner activities available?	y		Attached in the file
6	Learner group work available?	y		Attached in the file
7	Different types of items available (assessment tasks)?	y		Various activities available

CAPS document (DBE, 2011) requires learners to be assessed using a rubric regarding making structures. The usage of learners' support materials is also indicated in the lesson plan (sensorial activation). In the lesson plans, the content is about Structures and the plans indicated a remedial lesson. CAPS document for Technology stresses that before the teacher scaffolds learners in solving a technological problem, while using the Mini-PAT, a scenario should be presented to learners (DBE, 2011). In setting a scenario, the Technology teacher can help learners to understand how Structures can be constructed to solve technological problems, and the purpose of meeting human needs and wants, the scenario appeared in the planning. Planning also indicated the process of making a project for the Structure, a suspension bridge, where the project was planned for group work in class. The main aim of CAPS is to enable learners to "work effectively as individuals and with others as members of a team" (DBE, 2011:5). Besides, CAPS stresses that the design process "forms the backbone" of teaching Technology (DBE, 2011:12). This emphasises that Technology

in South Africa needs team effort in solving technological problems, and the design process is used to solve such problems.

Evaluation is a crucial step in the design process, it provides an opportunity for learners to determine whether the artefact is able to satisfy human needs and wants (DBE, 2011). An assessment rubric was mentioned. The file had a work schedule, lesson plans, and pictures of different bridges to show the learners, as the participants stated. There was also evidence of assessment records in their files.

4.5 CONCLUSION

This chapter presented a detailed analysis of the data that were collected by means of interviews and document analysis sheet. In the first instance, the chapter outlined the biographical information of the participants. This was followed by the findings and discussions on the interviews and document analysis sheet. The findings revealed that the sampled Technology teachers had an idea of how to create a learning environment. However, this does not mean they practiced this in their classrooms. Nevertheless, it is important that Technology teachers have a basic knowledge of the creation of a learning environment for learners in making projects. The chapter also revealed that the respondents were trying to make learners understand the topic through various strategies.

The findings explain how teachers understand an effective learning environment and it is clear that they knew how to create a conducive learning environment. According to the participants' planning, they introduced their lessons, linking these to prior knowledge. These questions were based on the functions, strength and life span of structures. Job (participant 1) suggested that prior knowledge helps learners to build on what they know, and content knowledge assists the teacher on a large scale level in showing learners where to go in the lesson. In terms of sensorial activation, the teachers brought all the necessary material for learners to see what they were speaking about. The second participant (Marry) also indicated that teachers need to create a learning environment that is beneficial to learners. Technology teachers need to use innovative teaching strategies to create a learning environment that enables learners to master the content. In this study, theoretically speaking (because the study

investigated participants outside their class), these technology teachers appeared to understand how to create a conducive learning environment.

In the CAPS document (DBE, 2011), Technology curriculum emphasises that teachers need to support learners in solving technological problems while using the Mini-PATs (DBE, 2011). That is, using the design process, which is Investigation, Designing, Making and Communication (IDMEC). In addition, the other CAPS requirement is setting a scenario. Technology teachers can assist learners with conceptual knowledge of how artefacts can be used to solve technological problems, and meet people's needs. In fact, if these participants practised what they discussed in their responses then they were definitely able to help learners in achieving the CAPS educational goals. Technology teachers should provide learners with the opportunity to learn from others (counsellors or high achieving learners) as Astin (1984) indicates in Resource Theory. Vygotsky (1978) sees the interaction of learners as scaffolding. The aim of the CAPS curriculum is to produce learners that are able to work effectively as individuals and with others as members of a team (DBE, 2011). In addition, CAPS indicates that the design process is the backbone of teaching Technology (DBE, 2011). It shows that technology in South Africa requires team effort in solving technological problems, and the design process is meant for solving such problems.

This study required Technology teachers to possess knowledge of creating an effective learning environment for the purpose of teaching skills to solve technological needs. A learning environment is essential in teaching and learning as the proper environment enables learners to be part of learning, not simply passive recipients. In this study, the participants stressed the importance of creating a learning environment that suits the content. Technology is a practical subject, therefore an effective learning environment enables learners to construct artefacts that are useful in real world (DBE, 2011). Teachers need to create a learning environment that provides a space for learners to participate well and allows best and sound practices. The following chapter will present a discussion, conclusion, and the provision of recommendations for future research.

CHAPTER 5 SUMMARY, LIMITATIONS AND RECOMMENDATIONS OF THIS STUDY

5.1 OVERVIEW OF THE CHAPTER

The chapter begins with a summary of the previous chapters, stating the key aspects relevant to each chapter. The research questions are revised in order to answer each sub-question, and consequently, the main research question. This is followed by the limitations of the study, recommendations for future research and the conclusion of this research.

5.2 CHAPTER SUMMARY

In Chapter 1, the purpose of technology was explained, i.e. to support learners to be creative and develop creative skills from the learning environment created by Technology teachers. The importance of creating a learning environment for teaching the topic of 'Structures' was addressed, together with the strategies that teachers seem to have the idea of using. Chapter 2 presented a review of the literature regarding the creation of a learning environment for teachers to teach structures. The teaching strategies and the design process, which is procedural knowledge, as referred to in the CAPS document that are used to solve technological problems were also discussed. It was highlighted that the prescribed design process provides opportunities to develop making skills. Technology teachers should identify and take advantage of creating an effective learning environment for teaching about structures in their lessons. The chapter ended with a presentation and explanation of the conceptual framework that was used for this study.

The research design, research paradigm, population and sampling used in this study were explained in Chapter 3. Thereafter, the strategies in this study, including the instruments that were used to collect data, were explained. This was succeeded by a description of how the data were analysed and how the standards of the research were applied. The chapter also took note of the ethical considerations of conducting research. Chapter 4 described and discussed the findings of the study. The chapter started by outlining the biographical information of the participants to show their

academic qualifications and experience in teaching Technology. The participants'

responses, obtained from semi-structured interviews, were then discussed. This was followed by a discussion of the data obtained from the planning document or observation sheet.

5.3 REFLECTING ON THE RESEARCH QUESTIONS

This section presents the research questions that were formulated in Chapter 1. The main research question was:

Main question: How do Technology teachers create learning environment for teaching structures in Grade 9?

Two sub-questions were formulated to explain the main question:

(i) What is an appropriate environment for teaching and learning structures?

(ii) What is Technology teachers' experience when teaching structures?

The first sub-question sought to determine Technology teachers' knowledge of an effective learning environment. This study adopted Astin's (1984) Resource Theory, where a wide range of ingredients are believed to enhance students' learning like physical facilities, human resources and fiscal resources. The findings of the study highlight that both participants had some understanding of the concepts that define the creation of an appropriate learning environment, as shown in the excerpt below.

> ***Job:*** *Yeah, learning environment I believe has got something to do with eh, the conditions in which teaching and learning can take place. These are, be… should the room be well lit, is the chalkboard clear, are windows… can open and close. Is the noise in the classroom controlled so that the learners can understand what is happening? Eh, is there no (pause) are no disturbances in the classrooms, and make* sure that all learners are attentive.
>
> **Marry:** *Eh… my understanding is that… is that the place where a teaching and learning takes place actively by asking them the… about the previous knowledge, how to clean the environment and how to… … then cause of and how to clean the environment.*

They appeared to have the ability to describe an effective learning environment. The findings explain how these teachers understood an effective learning environment and it is clear that they knew how to create one. According to the participants' planning,

they introduced their lessons by linking each with the learner' prior knowledge through the use of questions. These questions were based on the functions, strength and life span of structures. Job suggested that prior knowledge helps learners to build on what they know, and content knowledge assists the teacher on a large scale level in showing learners where to go in the lesson. In terms of sensorial activation, the teachers brought all of the necessary material for learners to see what they were speaking about. Marry also indicated that teachers need to create a learning environment that is beneficial to learners. Technology teachers need to use innovative teaching strategies to create a learning environment that enables learners to master the content. In this study, theoretically speaking, the Technology teachers seemed to understand how to create an effective learning environment.

The DBE (2011) stipulates that the design process should be used as the corner stone for planning Technology teaching. The CAPS document (DBE, 2011) stipulates that learners have to be allowed opportunities to solve problems in a creative way using authentic contexts derived from real situations outside the classroom. Besides this, they must be given opportunities to combine thinking and doing, this is a way that links abstract concepts to concrete understanding (DBE, 2011). Therefore, CAPS advocates teaching that creates an effective learning environment.

For the creation of a leaning environment for teaching structures, in terms of *investigation* as the first step of the design process, learners are encouraged to seek information, conduct relevant research, understand concepts and gain insight, and determine new techniques (DBE, 2011). These activities are opportunities for scaffolding knowledge in the learning environment regarding structures and should be used by teachers when learners are required to investigate solutions to authentic technological problems. In the case of *design* as the second step of the design process, learners are required to write a design brief, generate alternative solutions, draw ideas, make decisions, choose the best solution, and justify their choices (DBE, 2011). All of these are design-related opportunities that are offered in the CAPS document to establish an effective learning environment. For example, in order to write a design brief, a learner has to think creatively or innovatively due to the fact that the design brief determines a technological solution. Generating alternative solutions reflects the ability to suggest more than one idea. For the sake of deciding well,

learners have to be able to predict the ultimate outcome of their decisions. This means that learners need to be innovative when deciding to make a project, and come up with the best solution.

In *make* as the third step of the design process, learners must handle tools and equipment, construct, test, and modify the product and adhere to safety and healthy guidelines in the class atmosphere (DBE, 2011). It is crucial to use the right tools and equipment for a particular project as it shows learners' ability and knowledge of tools. When the artefact has been constructed, it has to be tested to determine whether it is suitable for the intended purpose. This requires the creation of an effective learning environment because learners have to evaluate the artefact and find out if it serves the intended purpose and, if possible, make the necessary changes. When building the artefact, learners have to take into consideration the safety of others and follow safety precautions.

Evaluation is the fourth step of the design process where learners need to evaluate their actions, decisions, and results; evaluate the solutions and process followed; suggest necessary improvement; and evaluate constraints (DBE, 2011). Evaluation is important in the construction of structures because it guides leaners to their end product and shows their ability to serve the intended purpose. Evaluation in the design step requires learners to evaluate each process they engaged with while finding a solution. CAPS explains that all of the steps of the design process should be evaluated as *evaluation* guides the next step of the design process (DBE, 2011).

Communication as the last step of the design process requires learners to provide a record of the process from inception to final solution (DBE, 2011). Learners need to give evidence on how they analysed, conducted an investigation, planned and evaluated the solutions during the design process. The process followed may be presented orally, written, presented graphically, or electronically. The last step of the design process indicates that *communication* encompasses all of the design process.

The first sub-question asked about the appropriate environment for teaching and learning structures. The sub-question was covered in Item 7 of the instrument. The participants agreed that this is when the lesson starts. The results of the study revealed that the participants were in touch with the concept of an effective environment. In sub-

question two, the Technology teachers' experience when teaching structures was addressed by Item 16 and 14 where the participants hinted that workshops and further studies enabled them to teach about structures.

5.4 LIMITATIONS OF THIS STUDY

Data were gathered after school, not during teaching the subject. The study involved limited representation and a lack of generalisability because of its qualitative nature and its relatively small sample. This case study used a purposeful sampling method and only participants who taught Technology in the Senior Phase in Grade 9 were sampled. The findings do not necessarily generalise the teaching practices in Technology in schools, the entire District, the Province or the Country (South Africa) as this research is limited to only two participants in a private school. However, the study gives us an idea of what is happening in South African schools in terms of Technology teaching. Some of the limitations found or identified in this study may pave the way for further studies. The other limitation of the research was that the participants were not observed while teaching. The researcher is not certain as to whether the participants practiced what they said and planned. The focus of the study was on Technology teachers and how they create an effective learning environment.

Therefore, interviews with learners and observation of actual teaching would have been ideal to support what they said. The learners' involvement in the Technology classroom is important in determining the success of the teachers' creation of an effective learning environment for teaching structures. Due to insufficient funds and resources, the study was confined to the sampled school in the Riba Cross District. The data was collected after school with limited time. Therefore, this resulted in time constraints as there was no time to conduct a pilot study. Nevertheless, the interview questions were made clear during the interviews to maintain that the participants understood the questions before responding, and follow-up questions were asked in instances where the participants did not grasp the questions well.

The researcher acknowledges that because of the nature of qualitative research, there was some subjectivity during the interpretation of the data. If data is interpreted subjectively, this tends to be regarded as bias in the research, which could be regarded as a limitation. Flyvberg (2006) finds that case studies are subjective and allow

researchers to interpret their own data and, as a result, the validity of case studies may be questionable. For this study, a case study was used to gain insight. The researcher is of the opinion that if quantitative methods are studied, it could further help to determine the extent to which Technology teachers understand the creation of an effective environment for teaching structures. Thus qualitative research was conducted to gain insight.

5.5 RECOMMENDATIONS

Technology teachers need to create a learning environment to enable learners to develop creative skills, such as to interpret information, analyse information, evaluate statements, draw credible inferences, provide an explanation, and conduct self-regulation to be used in the IDMEC process of CAPS (DBE, 2011). Although the School Management Team‘s (SMT) role was not part of the study, it had come clear that it could assist in making sure that teachers work according to their plans. Apparently, these teachers knew what they were supposed to do in their lessons to create an effective learning environment. Although the study cannot form a conclusion as to whether they actually practised these, their responses certainly indicated that they knew about effective learning environments. This could be seen in the performance of learners in subjects like physical sciences at the learners' exit in Grade 12. Therefore, a further study needs to be conducted on an effective way of monitoring teachers' work in the classroom to investigate as to whether they practice what they say and plans. Further recommended research topic that might assist from this study as well is, “Investigating Learning Environment for Teaching System and Control in Technology Grade 9 classes: Comparing Rural and Urban schools”.

5.6 CONCLUDING REMARKS

Technology has become an essential subject in curricular development in the modern world. To be successful in the classroom, teachers need to have a high level of Technology teaching strategies. De Vries (2004) explicated that teaching Technology at all levels of education can only succeed when teachers know how to teach it and analyse the content well in order to create an effective learning environment. Astin's (1984) Resource Theory states that a wide range of ingredients are believed to enhance student leaning. It goes further by explaining that the creation of a learning

environment in all subjects is crucial because teaching and learning have to take place in a fruitful environment. Therefore, teachers have to be equipped with knowledge of invoking prior knowledge, sensorial activation, and content analysis, and these need to be integrated for the benefit of learning (van Dijk & Kattmann, 2006). The study was conducted to investigate as to whether Grade 9 Technology teachers create an effective learning environment for teaching structures. It was conducted using two participants. The results of this study do not necessarily mean that all teachers have the same experience and feelings as those in the findings. The participants agreed in most of their responses about the importance of creating a learning environment for structures, as to whether it is what they practice in the class, it is still a question, this could be investigated by further research. This study may assist the research in the literature for Technology teaching and the methodology thereof in South Africa. As a result, it could contribute to improving the Technology teaching strategies encapsulated in the CAPS document (DBE, 2011).

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ANNEXURES

ANNEXURE A

ST. THOMAS COLLEGE

(INDEPENDENT COMBINED SCHOOL)

(Registered with Limpopo Department of Education Reg. No. 996502106)
UMALUSI ACCREDITATION NO. SCH 001001 PA

P.O. Box 228
Burgersfort
1150

Portion 10
Lion Valley Farm
Ohrigstad Road
Burgersfort 1150

Tel:- (013) 231 8391
Fax:- (013) 231 8465

20 January 2017

Mr. Jujuju H.V

Manok Secondary School

Dear Mr. Jujuju

Sub: Permission to interview the Technology Educator

Your request to interview the Grade 9 Technology teacher, as part of your M. Ed dissertation, is given due consideration. I grant you permission to interview Mr. Muzenda S, the Grade 9 Technology Teacher, on any day suitable to him, after the school hours. I hope this will fulfill your request.

Wishing you the best in your research

TGK John

Principal

ANNEXURE B

Instrument for interviewing participants

1. What do you understand about learning environment?
2. How do you create learning environment in your class?
3. How does learning environment affect your teaching of Structures in the lesson?
4. Are learners' prior knowledge relevant or not for planning lessons?
5. Why do you think prior knowledge is relevant or not in teaching?
6. Do you believe that creating effective learning environments can enhance learning and how? if no why?
7. When do you think is the best time to build on prior knowledge or why if not?
8. How prior knowledge, sensorial activation, content knowledge could assist you or not in your instructions as a teacher?
9. If teaching not successful what do you do for learners to build on learning environment and why?
10. How do learners respond to your learning environment if not what do you action do you take?
11. Do you regard your learning environment as always beneficial to your teaching if not why?
12. What do you think makes your teaching a success when teaching Structures?
13. What do you understand about Technology content knowledge?
14. Why do you think knowing the content is important if not, why?
15. What enables you to understand the content and why?
16. How do you solve challenges of understanding the content?
17. Is there anything that you can suggest to teachers' understand knowledge of content better?
18. How do you guide learners to understand content of Structures?
19. What do you understand about collaborative learning, or other things that improve learning?
20. What strategy do you apply to make learners learn from other learners?
21. Do you allow them to work individually and groups if not why?
22. What role do you play as a teacher during learners' construction of Structures?
23. How do you assess knowledge of Structures groups and individually?

ANNEXURE C

Examining sheet on the planned documents

	Aspect	Yes	No	Comments
1	Linking lesson with previous lesson?			
2	Learners' pre-conceptions considered?			
3	Indication of learners involved in the lesson?			
4	Usage of learners support materials?			
5	Learners' senses activated, like, touch?			
6	Content relevant to planning?			
7	All learners catered during learner involvement (diversity)?			
8	Presentation is in sequence?			
9	Content knowledge?			
10	Practical work given to learners?			
11	Group work encouraged?			
12	Lesson was a success/failure evidenced from assessment?			

Checklist for file document

	Aspects	Yes	No	Comments
1	Work schedule available?			
2	Lesson plan available?			
3	Learners' pre-conceptions considered?			
4	Teacher support materials indicated?			
5	Learner activities available?			
6	Learner group work available?			
7	Different types of items available (assessment tasks)?			