AN INVESTIGATION OF BARRIERS AFFECTING THE USE OF SIMULATION IN THE HIGH SCHOOL DESIGN PROCESS

BY

MATHABATHA LEKOBA NORIA

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ABSTRACT

This research focused on the effective use of simulation in the high school design process. Technology develops learners' simulation skills in the design process. According to the CAPS document in technology, learners should be provided with the opportunities to use a variety of life skills to solve technological problems. Solving technological problems require learners to engage their simulation skills. This involves learners identifying problems, formulating problems, collecting real data, formulating and developing a model, validating the model, and documenting the model.

Technology as a subject considers simulation skills as important to learners in real situations. It seems that teachers find it difficult to use simulation effectively in the classroom. The literature also reports that technology teachers fail to develop learners' opportunities to handle the problems in the way of the goals that they need to achieve. This is a challenge in the teaching of technology. The study thus sought to investigate this challenge.

This study used Maria's (1997) simulation models: problem identifying, problem formulating, collecting data, developing model, validate model and documenting model. The study was also based on the design process, which includes: investigate design, make, evaluate and communicate. Maria's simulation models were used with the design process to demonstrate the way in which simulation skills can be used to solve technological problems using the design process. This study engaged qualitative research using a multiple case study design and purposive sampling. Technology teachers with less than five years and those with more than five years of experience teaching technology were considered appropriate for this study. Data was collected by means of observations and semi-structured interviews and was analysed using the simulation models.

A major finding of the study was that the technology teachers had inadequate knowledge of the use of simulation. The sampled technology teachers were unable to provide learners with opportunities to use simulation effectively in their classrooms. During the classroom observations, the participants did not engage the design process in the teaching of simulation. It appeared that these teachers were not aware of the requirements of CAPS. CAPS in technology stipulates that teachers should be aware that learners need to have knowledge of the design process (DBE, 2011).

The major recommendation of this study is that technology teachers should have adequate knowledge of the use of simulation, the skills to be used in the use of simulation, and the steps to be used in gaining problem-solving skills. It is also recommended that technology teachers should ensure that they use the design process in the teaching of simulation. The use of the design process may provide teachers with opportunities to use simulation effectively in the classroom.

Key words: Simulation, design process, problem solving skills, self-efficacy

DECLARATION

I, Lekoba Noria Mathabatha, declare that the mini- dissertation hereby submitted to the University of Limpopo for the degree of Master of Education in Technology barriers in the use of simulation has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all material contained herein has been duly acknowledged.

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Mathabatha L.N (Ms) **Date**

DEDICATION

This thesis is dedicated to my parents, Motšoadi and Matshipi, to my family, Hakeeb, Mochai and Makhukhu.

TO GOD BE THE GLORY

ACKNOWLEDGEMENTS

I am grateful to my supervisor, Doctor Malose Isaac Kola for the encouragement, guidance and assistance throughout the entire process of topic selection to the writing of the project report.

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I thank my parents and children, Mochai and Makhukhu for their support and encouragement. I am also indebted to my husband, Hakeeb, for his understanding, patience and encouragement during this stressful and demanding period.

ETHICAL CLEARANCE CERTIFICATE

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

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

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<u>PROJECT:</u>

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Researcher:	LN Mathabatha
Supervisor:	Prof RJ Odora
Co-Supervisor:	Prof I Kibirige
School:	Education
Degree:	Masters in Technology Education

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To whom it may concern

The dissertation entitled, "An investigation of barriers affecting the use of simulation in the high school design process" has been edited and proofread as of 13 December 2018.

As a language practitioner, I have a Basic degree in Languages, an Honours degree in French and a Master's degree in Assessment and Quality Assurance. I have been translating, editing, proofreading and technically formatting documents for the past seven years. Furthermore, I am a member of the South African Translators' Institute (SATI) and the Professional Editors' Guild (PEG).

Please take note that Exclamation Translations takes no responsibility for any content changes made to the document after the issuing of this certificate. Furthermore, Exclamation Translations takes no responsibility for the reversal or rejection of the changes made to this document.

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Melissa Labuschagne

Melissa Labuschagne trading as Exclamation Translations

http://www.exclamationtranslations.co.za

info@exclamationtranslations.co.za

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION AND BACKGROUND OF THE STUDY

1.1 BACKGROUND TO THE RESEARCH PROBLEM

The Department of Basic Education (DBE) in South Africa has introduced the Curriculum and Assessment Statement Policy Statement (CAPS), which promotes simulation as a teaching strategy that enables learners to identify and explain a problem, need or opportunity from a given real-life context (DBE, 2011:12). This research was conducted to reflect on the effective ways of using simulation in a design project. Simulation is one of a variety of contexts to be used and is also an assessment where demonstration and observation provides reliable and valid results (DBE, 2011). Educators should have knowledge of the teaching strategies to use in order to be able to use these effectively and efficiently.

The increasing role of simulation in design is well documented in engineering studies and other specialties (Adams, Reids, Master, Kagan, Perkins & Wiemman, 2008; Sinha, Parendis, Liang & Khusla, 2001; Hays & Singer, 2012), but is not as clearly defined for technology students in high schools in South Africa. As a teaching tool, simulation engages learners and allows for deliberate practice. Learning modalities such as procedural task trainers, as well as high- and low-fidelity simulation can help mitigate variations in learning experiences during design process tasks (Hays & Singer, 2012). High-fidelity simulation, especially when combined simultaneously with other teaching modalities, allows students to experience learning in an immersive environment (Hays & Singer, 2012). Unlike learning with real artefacts, simulation enables educators to control the environment and to meet the desired learning objectives (Adams et al., 2008).

Increasingly, engineering training programmes incorporate modelling and simulation as a teaching modality (Sinha et al., 2001). Although reports on the usefulness of simulation often focus on procedural skills revealing excellent student satisfaction, little data is presented to support improved educational outcomes (Hays et al., 2012). Modelling and simulation (Sinha et al., 2001) enables designers to test whether design specifications are met by using virtual rather than physical experiments. These further provide the designer with immediate feedback on design decisions.

The subject of technology was introduced in South African schools in order to produce learners who are innovative, creative and possess critical thinking skills. The subject gives learners the opportunity to develop and apply skills to solve technological problems (DBE, 2011). Simulation enables learners to solve technological problems in creative ways.

South Africa is rich in mineral resources, however, the deeper the mine, the more at risk the lives of the miners who work in it. Therefore, the use of simulation empowers learners to theoretically bid tenders for the construction of shaft head-gear suitable to transport miners to and from the work level. The use of simulation is also useful for teaching basic technology concepts in mechanical and electronic systems in countries such as United Kingdom, the USA, Canada and Australia (Paretis, 2001).

My experience in facilitating learning in a Grade 8 class is that learners at this stage of development are not yet familiar with the skill of interrogating the use of simulation for understanding. This is reflected in how they respond to simulation use. A big challenge in using simulation is that real-life situations are to be imitated into simulation, requiring an understanding of the problem first before attempting to respond to it. It is through observation and comparison that the simulation solution can be translated back into a real-life situation.

Technology in high school is also well suited to using simulation in a design project. It is therefore paramount to research on the use of simulation in a design project in Grade 8.

1.2 PROBLEM STATEMENT

South Africa has a low retention of beginner teachers in the teaching profession, especially those skilled in the use of simulation (Phurutse & Arends, 2015). This trend has serious implications for learner outcomes, given the contribution that teachers can make to learner achievement. A study by Ndlovu (2015) reports that a high school teacher training framework was developed that can help teachers in this country to maximise the utilisation of simulation in teaching and learning. Our teachers face many challenges due to a lack of knowledge, a lack of training and development, a shortage of resources, the motivation of teachers and so on. One or two, if not all of these challenges have, no doubt, contributed to the lower level of simulation among learners in classrooms.

The Department of Basic Education (DBE) and other stakeholders have paid more attention to the Further Education and Training (FET) phase, especially Grade 12, neglecting the lower phases (Govender, 2012). Govender (2012) furthermore argues that it is possible that this neglect has contributed to the poor state of teaching and learning in the use of simulation. Unless these problems are addressed, the quality in the use of simulation will remain compromised in the affected phases (Kuranteng, 2012).

Since the introduction of the CAPS document, technology educators have been working to incorporate the use of simulation into their classrooms. The reason is obvious, textbook and instructional resources have been the pillars of technology and engineering technology; however, they fall short in teaching learners critical thinking skills and making rapid decisions accurately (Asiz, Wahab, Ramli & Azhari, 2016). There is still a knowledge gap as a result of limited studies on the use of simulation in design projects (Trumble & Bell, 2011).

1.3 RESEARCH QUESTION(S)

The project's main question is:

> How effective are Grade 8 learners in using simulation in the design process?

The sub-questions are:

a) What is the importance of simulation in the design process?
b) What opportunities does the CAPS document provide in supporting learners to develop simulation skills?
c) What experiences do technology teachers encounter with regard to simulation-based programs?

1.4 SIGNIFICANCE OF THE STUDY

Investigating the use of simulation in the design process is important as it will help technology learners to prepare themselves for making decisions in the real world. Learners will experience situations that are true to reality. The findings also provide ways in which simulation may be promoted at high school level. Most importantly, this information could guide high school technology learners to make informed career choices. It will also guide high school technology educators on how to integrate the use of simulation into technology subjects, as prescribed in the CAPS document. As an educator who is actively engaged in the classroom teaching Grade 8 technology in high school, this research was conducted to reflect on the effectiveness of the use of simulation and the experiences of teachers in using simulation-based programmes. The research also looked at the strategies that can be used to support learners to develop simulation skills.

1.5 DEFINITION OF ESSENTIAL TERMS/CONCEPTS

CAPS - the Curriculum and Assessment Policy Statement is an amendment to the National Curriculum Statement Grade R-12 subject statements (DBE, 2011). For this study, CAPS is defined as a curriculum system implemented in South African schools to support learners in gaining simulation skills.

Design project – this involves decisions regarding how to search for alternatives so that the design targets can be achieved at a minimum cost (Panchal et al., 2013). For the purpose of this study, learners used a design project to develop a solution to the given problem.

Effectiveness – this refers to doing the right things, i.e. selecting and focusing on producing an output for which there is a demand (Sundqvist, Backlund & Chroneer, 2014). The purpose of this study was to describe the competencies and how to improve the use of simulation.

Self-efficacy - is concerned with a person's belief in his or her ability to succeed in a particular situation (Heidari & Dashtgard, 2014). For the purpose of this study, self-efficacy was observed in analysing the effectiveness of learners when using simulation in a design project.

Simulation - is the imitation of real conditions in the classroom. Learners work in the simulated situation as if it were the real one (Du Plessis et al., 2007). For this study, simulation was used to assess the self-efficacy of learners, where observation and demonstration provided the reliability and validity of the results.

1.6 THESIS STRUCTURE

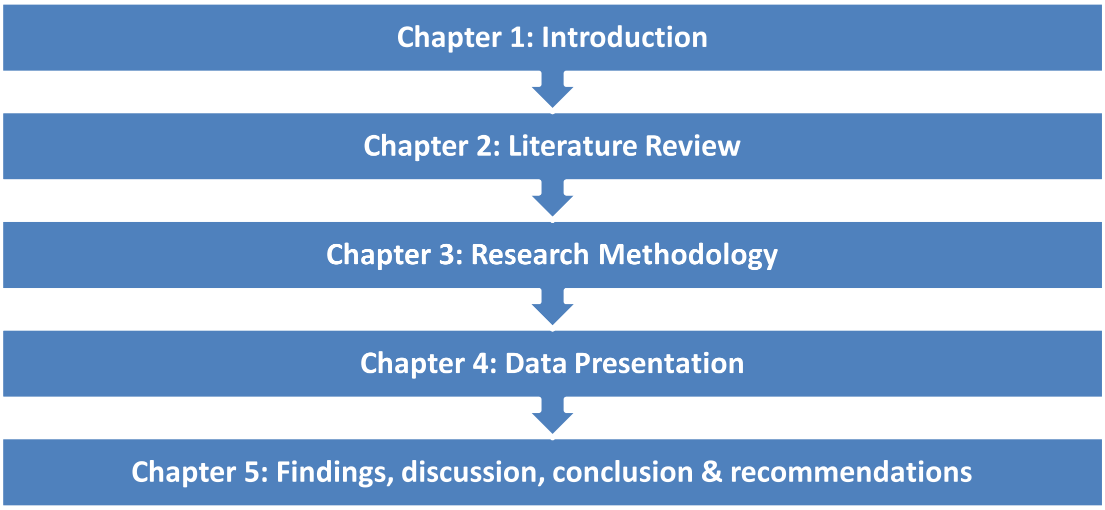

Figure 1.1: Graphic representation of the layout of the dissertation

Figure 1.1 provides a diagram of the dissertation's layout; further details of the dissertation's structure are provided below.

Chapter 1 contains the introduction/background to the study, statement of the problem, aims and significance of the study, as well as the research methodology. It also covered the limitations of the study and the definition of essential terms.

Chapter 2 comprises a review of the literature on the effective use of simulation, as well as the way in which Bandura's Cognitive Theory relates to the simulation model used in this study.

Chapter 3 covers the research approaches and methodology in this study. It further discusses the approach used in this study and why it is appropriate. This leads to an explanation of the research methods, sampling method, data collection method and analysis used, as well as the ethical considerations of this study.

Chapter 4 covers the presentation and analysis of the data collected during the investigation.

Chapter 5 presents a summary in which the main findings are discussed in the light of the research questions posed and the literature review. This chapter presents an overall discussion of the research, conclusions reached. I further make recommendations for improving the use of simulation in the high school design process. Areas for further research are then presented in conclusion of this study.

1.7 SUMMARY OF THE CHAPTER

This chapter gave a brief discussion of the research, including the background to the problem, the research questions posed, and providing an outline of this dissertation.

The next chapter addresses the literature reviewed on the effective use of simulation and how Bandura's Social Cognitive Theory (1977) and the Simulation Model (Maria, 1997) as related to this study.

CHAPTER 2 LITERATURE REVIEW

2.1 INTRODUCTION

The literature review has been divided into three major areas of study. The first section of the review focuses on Bandura's Social Cognitive Theory and the concept of self-efficacy in the use of simulation, which comprised the theoretical framework of this study. The second section focuses on the literature related to the use of simulation in a design project and its effect on the perceived self-efficacy of learners in solving problems. The third section of the review focuses on the simulation model as a teaching strategy, including the history behind simulation, the major accomplishments of simulation in design projects, and all the steps to be used in simulation. The literature review concludes with a brief summary.

2.2 THEORETICAL FRAMEWORK

This study was framed by Bandura's Social Cognitive Theory (Bandura, 1977), which describes how learners acquire behavioural patterns. This includes the impact of the environment, learners' behaviour capability, and their perceived self-efficacy. Bandura's theory is called the Social Cognitive Theory because it emphasises the fact that most of the information that learners gain comes from their interactions with other learners (Hergenhahn & Olson, 1997). In this study, learners performed a simulation activity in a group setting in order to gain more knowledge from their group members. According to this theory, behavioural competencies, social competencies and cognitive skills are acquired through observational learning (Bakhan; Bidita & Mridula, 2017). This theory describes learners as dynamic, information processing, problem solving and social organisms. The theory is founded on an agentic perspective operating through forethought, self-regulation and self-reflection as core features of human agency (Bandura, 2015).

In this study, learners observed the modelled event and formed a cognitive construct, which should shape their future behaviours. Learners must be responsible for their learning and therefore end up providing their own interest regarding what might happen in the future. This theory suggests that personal factors (including self-efficacy beliefs) and behaviour interact with the environment to influence each other through the process of reciprocal determinism (Tschannen-Moran & Hoy, 2007). Self-efficacy is defined as the belief in one's ability to obtain desired goals (Kelly, 2014). Furthermore, Bandura (1994) describes self-efficacy as a powerful predictor of performance. Learners who have strong self-efficacy in carrying out a particular task will make robust and persistent efforts and thus will be more likely to succeed.

Bandura (1977) believes that much learner behaviour is self-regulated. Perceived self-efficacy influences self-regulated behaviour in several ways. It determines what it is attempted, how long one persists at a simulation activity, and what is hoped for (Hergenhahn & Olson, 1997). Self-efficacy can affect the way in which learners approach challenging or complex situations. Studies have shown that learners who possess greater self-efficacy when responding to a particular situation exert increased effort and perseverance to master that situation (Kelly, 2014). Leigh (2008) states that self-efficacy may be dynamic and increase over time. In essence, learners' ability to learn new knowledge and to achieve a desired goal may be affected by self-efficacy. Bandura's theory guided this study in examining how an educational intervention using simulation in a design process affected the self-efficacy of learners over time.

Bandura (1977) proposes four sources of learners' self-efficacy, namely: mastery experience, vicarious experience (observing other learners and modelling), verbal persuasion, and emotional and physiological states. A mastery experience is considered to be the most influential source of self-efficacy because it provides authentic evidence that learners have the ability to succeed in a simulation activity (Tschannen-Moran & Hoy, 2007). Self-efficacy beliefs are informed only when experienced events and the results of actions are cognitively appraised (Bandura, 1977). After learners have completed a simulation activity, they quite naturally must interpret and evaluate the results obtained. They will then judge their competency according to their interpretations (Usher & Pajares, 2005). When learners believe that their efforts have been successful, their confidence to successfully accomplish similar or related tasks in the future is increased. Alternatively, when they believe that their efforts have failed to produce the desired effect, the confidence to succeed in similar tasks is decreased (Bandura, 1994; Usher & Pajares, 2005; Tschannen-Moran & Hoy, 2007). In this study, learners were exposed to mastery experiences through simulation. After learners complete their simulation activity, they interpret and evaluate the simulation results obtained. They (learners) judge their competency according to their interpretations of the simulation activity. In this study, a mastery experience was illustrated through a routine classroom scenario.

Learners also build their self-efficacy beliefs through the vicarious experience of observing the actions of others. It is for this reason that simulation can play a powerful role in the development of self-efficacy (Bandura, 1994; Usher & Pajares, 2005). Watching a similarly perceived classmate succeed at a challenging simulation activity may convince uncertain learners that they also can succeed. Palmer (2006) proposes modes of modelling influences: effective actual modelling, which occurs when one sees a person similar to oneself perform the task successfully; symbolic modelling, which occurs when learners are exposed to effective models provided by television and other visual media; self-modelling, which occurs when learners' performances are videotaped for them to watch; cognitive self-modelling, which occurs when learners visualise themselves performing successfully at the simulation activity; in this study, learners were exposed to effective actual modelling as they performed simulation activity in a group setting and observing the performance of their group members. Learners estimate their capabilities in comparison to other learners who have modelled the desired behaviour.

The third source of self-efficacy is verbal persuasion, which refers to situations in which learners are given positive feedback from others. If a learner is told that he/she does possess the capabilities to succeed in the activity then that learner will be encouraged to try hard to succeed (Palmer, 2006). Learners who are not yet skilled at making self-appraisals depend on others to provide evaluative feedback, judgements and appraisal of their simulation activity performance (Usher & Pajares, 2005). In this study, learners were evaluated when performing a simulation task and feedback was provided to them.

Lastly, the emotional and physiological state, which refers to learners' responses to their own stress, fear, anxiety and fatigue (Bandura, 1977; Usher & Pajares, 2005). This study addressed the emotional and physiological source of self-efficacy when learners feel joy or pleasure from the successful use of simulation, which increases their self-efficacy. The next section provides the definition of simulation.

2.3 DEFINITION OF SIMULATION

The definition of simulation in the technology classroom has become difficult to understand for several reasons. There is no formal conceptual definition that has ever been agreed upon by experts in the field of Technology Education (TE). Duke (1980), the founder of simulation as a scientific discipline, notes that the meaning of ‘to simulate’ stems from the Latin *simulare*, meaning ‘to imitate’. Duke defines simulation as a conscious endeavour to reproduce the central characteristics of a system to understand, experiment with or to predict the behaviour of those systems. Du Plessis, Conley and Du Plessis (2011) describe simulation as a teaching technique that imitates a real situation in the classroom. The authors further report that learners form teams to identify and solve a problem being faced by the community.

Miller (2010: PAGE NUMBERS) describes engineering simulation as “the duplication of the physical and functional characteristic of the physical and functional characteristic of operational equipment within very tight tolerance specification.” Simulation is a highly effective tool that helps learners to develop higher learning levels of analysis, synthesis and evaluation. This will help technology learners to be better prepared to handle the decisions they will face in the real world. However, Kelly (2014) describes simulation as a strategy that is meant to replace real life, while Gough (2012) explains simulation as a teaching method used for learners’ safety and a method of facilitating improvement in interdisciplinary communication.

Classroom simulation offers the possibility of enhancing the practicum by providing new opportunities for pre-service teachers to practice their skills. According to Badiee and Kaufman (2015), simulation is a simplified but accurate, valid and dynamic model of reality implemented as a system. The literature is littered with a number of simulation definitions, which, in some cases, have contradictory views. Simulation in the Technology Learning Area refers to a classroom situation wherein a learner is presented with a situation, often a problem or an incident, to which he/she has to respond by assuming a particular role. A learner may be briefed on the particular role to be played. A learner will be engaged in investigating, designing, making, evaluating and finally, communicating solutions.

Emanating from the latter on the use of simulation as a teaching technique, the researcher therefore explored the current status of teachers' use of the simulation strategy in a South African context. The introduction of a new national curriculum, the National Curriculum Statement (NCS) for South African Schools compelled teachers to undertake a paradigm shift (Van Wyk, 2012). They shifted from using a teacher-centred to an active, learner-centred approach. Within the NCS curriculum, particularly in Technology Education, it is very important that learners learn how to gather relevant information and use that knowledge to develop skills. In other words, learners have to identify problems and find solutions to these problems by means of the strategies that are available to them, however, this study focused on simulation, a way for learners to prepare for action in the real world (Naude, 2016).

2.4 USING SIMULATION IN THE DESIGN PROCESS

The design process involves decisions regarding how to search the space of alternatives so that the design targets can be achieved at a minimum cost (Panchal et al., 2013). In a study on the inclusion of simulation in the design process, Hand (2012) notes that this teaching strategy acts on an abstract description of the design process via a syntax that expresses the underlying data model of the tool. Hand (2012), however, states that learners use simulation in a design process in order to explore new design concepts and to design questions, which often involves a sequence of specific topics that imply a level of descriptive detail.

According to Panchal et al. (2013), the use of simulation in the design process involves the decisions taken to decompose the design problem and to reduce the design space. Learners will also decide on the type of model to develop and how to invest the resources in order to achieve the design objectives. This is in line with Maria's simulation model in Step 6, wherein a learner has to develop a model for the solution.

Hand (2012) and Panchal (2013) are convinced that knowing how to use heuristics and strategies lies at the heart of what it means to understand them. Hand (2012) has discovered that including simulation in a design project is driven by economic, productivity or comfort issues. However, Panchal et al. (2013) explain that the goal of a design process is to reach a solution that satisfies the desired requirement. I agree with Panchal (2013) because learners should consider whether or not their activity is effective in solving the problem. Many teachers who use simulation tools claim that their programs offer substantial functionality in support of the design project (Hand, 2012). Siewiorek et al. (2012) reveal that the use of simulation in the design process is important because it allows experiments to be conducted within an imaginary situation to show real behaviour. Kelly (2014) reports that simulation in a high school design process increases learners' self-efficiency. According to Burgstahler and Doe (2012), simulation in a high school design process is reputed to change perspectives, increase empathy, self-awareness and tolerance of ambiguity.

Teaching and learning of the design process aims to develop solutions to problems, needs or wants. Learner should thus engage in a systematic process that allows them to develop solutions that solve problems, rectify design issues, and satisfy needs (DBE, 2011). The teaching design process using simulation is challenging since learners have to both understand general model concepts and be able to use particular local tools when learning to apply the model. According to Joolingen et al. (2005), there is a great demand for tools that can be used by learners to explore a task domain through simulation. Du Plessis et al. (2011) report that learners will be able to simulate the way the world performs, and bring appropriate technological solutions to problems wherever they need to be solved. Learners work in the simulated situation as if it were the real one. The greatest single advantage of simulations is that they are true to life.

It became explicitly evident that several studies have been conducted in an attempt to discover the importance of including the design process in the use of simulation, but no clear-cut directions for technology are provided, which is in part what inspired me to conduct this study. Naude (2016) presents different dimensions to be considered in using simulation in a high school design process as the purpose and aims of the simulation activity. A simulated environment could provide an ideal opportunity to do 'dry runs' of real learner experiences. An example of this is where a teacher is required to demonstrate the use of a pop rivet and provide suitable information to the learner.

Simulation could also be used to measure the competency level of the students and monitor their performance, i.e. the unit of participation in the simulation. Learners are required to work individually, or as members of a team (Jeffrie, 2005). The team could vary in size and could be small. Learners' skills, including communication, teamwork and work-readiness, could be enhanced through the use of varied simulated environments, i.e. the learners' experience level of simulation. The experience level of the learners will determine the difficulty level of each simulation exercise, and adjustments can be made when required to the domain in which the simulation is applied.

Technical and non-technical skill development could be enhanced through the use of simulation, e.g. the type of knowledge, skill, attitudes and behaviour addressed in the simulation (Du Plessis et al., 2011). Learners in classrooms where learning is simulated are required to respond as they would in real life in various situations that imitate reality. A learner could, for example, participate in a simulated activity where they are asked to show how to use a pop rivet. At the onset, they will require a theoretical understanding of the equipment used. Thereafter, they could be given various equipments to handle and demonstrate, thus demonstrating the discipline of learners participating in the simulation (Du Plessis et al., 2011).

The training of learners may be the focus of simulation. Learners might lose focus because they are working in a group, thus every learner should be given a role to play. Firstly, different locations could be used for simulation activities, but the environment should be safe for learners to work in it. Secondly, it is not always necessary to be directly involved in a simulation activity to derive benefit from it. While one or more learners participate in the simulation activity, the remaining learners could learn through observing and evaluating the activity. Lastly, giving feedback could enhance learning experience. Knowledge that is transferred during simulation is strongly linked to learning from mistakes, probably unexpectectly. However, Le Roux and Steyn (2012) show that feedback in simulation highlights learners' errors and, most importantly, shows the reasons why the mistakes were made and their consequent results. In simulation, we do things ourselves in order to really understand them. Shtub (2016) states that providing learners with feedback is an important development in the classroom environment. Naude (2016) concludes that effective learning through the use of simulation requires proper simulation design and suitable organisation of learners in the simulation.

2.5 PROBLEM SOLVING: THE KEY TO SIMULATION

Problem solving takes on many different meanings depending on the type of problem or specific need to be addressed. According to Makgato (2011), problem solving is defined as the process of understanding a problem, devising a plan, carrying out the plan, and evaluating the plan in order to solve a problem to meet a human need or want (Makgato, 2011). Problem solving refers to the systematic way of investigating a situation and implementing solutions (Koch & Sanders, 2011). Makgato (2011) states that problem solving is a critical thinking skill necessary for developing effective solutions to simulation problems. Problem solving is regarded as key to simulation activities.

Khan, Hafeez and Saeed (2012) explain that in a learning simulation, there are different problems to be identified and different ways of tackling the problem depending on the nature thereof. Therefore, Khan et al. (2012) define problem solving as the process of eliminating the discrepancy between the actual and the desired situation. When learners have a goal to achieve, they have to solve the problem at hand, yet they do not know how to handle it. A learner must acquire more knowledge on how to achieve his/her goal (Surif, Ibrahim & Dalim, 2014). However, the area of possible problems that require a solution is enormous, while the solution might be determined through ad hoc heuristic methods. Learners can acquire more knowledge through trial-and-error behaviour via the heuristic approach (Surif et al., 2014).

In addition, Koch and Sanders (2011) state that not all problems in simulation activities are the same and must be approached differently than rote or component skills (Koch & Sanders, 2011). Therefore, design process (investigation, design, making, evaluating and communicating) skills are important in problem solving. Problem solving is a key area in which learners should gain experience in a classroom simulation because problem solving can develop skills (Wartono, Suyudi & Batlolona, 2018). Learners use problem-solving skills to search for a solution to a simulated problem. The range of complex problems is heterogeneous, and it is hard to exhaustively define the common features of the problems used (Schoppek & Fischer, 2015).

Makgato (2011) states that problem-solving activities are classified by complexity and goal clarity where design is the key to technological problem solving. Design, involving ideation, identifying possible solutions, prototyping, and finalising the design, has become a dominant problem-solving process in classroom simulation (Makgato, 2011). According to Saruf, Ibrahim and Dalim (2014), problem-solving skills do not merely depend on learners' abilities to recall their knowledge, but can be developed through the visualisation of improvements such as through simulation. Simulation activities could provide teachers with a familiar vehicle to introduce problem solving skills into curricula to reap the pedagogy's benefits (Anderson & Lawton, 2007). Therefore, teachers are advised to use effective strategies to enable learners to make reasonable judgements that have a bearing on simulation problems.

Khan (2012) details various steps to be followed for effective problem solving in the use of simulation as follows:

- Collect the facts about the problem;
- Define the problem and the desirable solution;
- Find out how people feel about it;
- Identify the objectives;
- Generate possible solutions and select the most promising;
- Put it into action; and
- Evaluate the action.

The problem-solving skills required in the use of simulation are supported in the literature (Koch & Sanders, 2011; Makgato, 2011). Koch and Sanders (2011) and Makgato (2011) point out that problem-solving skills in the use of simulation, among others, include the following criteria: defining the problem, interpreting data, constructing models, designing, testing, and modelling.

After examining various sources of problem solving, it is clear that problem solving is a key factor in simulation. Unless a problem has been accurately defined and its causes identified, learners are unlikely to make an appropriate decision about how to solve it. For learners to be able to solve a simulation problem, there is a need to reflect on the situation in order to identify the proper arrangement of decisions and actions that may lead to a solution.

2.6 SIMULATION MODEL

Maria (1997) provides the three stages of simulation design that are required for learners' decision making. Those three stages are presented in Figure 2.1 as follows:

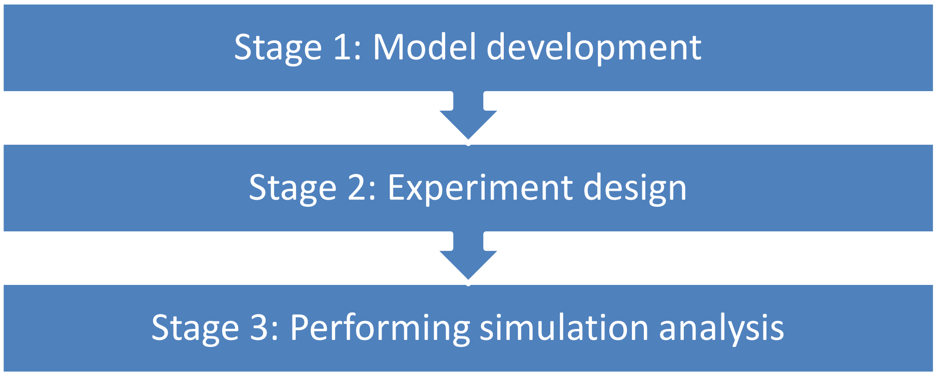

Figure 2.1: Stages of simulation design

Stage 1 (model development) is the process of creating and analysing a prototype of a physical model to predict its performance in the real world (Maria,1997). It is used to help learners to understand whether, under what conditions, and in which ways a part could fail and what loads it can withstand (Naude, 2016).

Stage 2 (Experiment design) refers to a series of tests in which meaningful changes are made to a simulation model in order to observe the problem solution (Maria, 1997). Learners should do experiments instead of only focusing on the questions being asked about the simulation model. Maria and Zhang (1997) assume that in order to successfully design a simulation experiment, learners should identify and define the data about the problems that need a solution.

Stage 3 (Simulation analysis) is the only stage where human intervention is not required.

It is therefore possible to view the simulation model (stage 1 of simulation design) proposed by Maria (1997) as the first model around which all other models seem to be centred. Six stages of simulation model are outlined in Table 2.1 and are discussed in the sections that follow.

Table 2.1: Simulation model (Maria, 1997)

Stage 1	**Identifying the problem**	- You have to identify the problem: - What is the problem? - What are the data? - What is the condition?
Stage 2	**Formulate the problem**	- Select the major problem and its categories; - Brainstorm issues to be addressed; - Identify the end-users; and - Define performance measures.
Stage 3	**Collect and process real system data**	- Collect data on system specifications, input variables, as well as the performance of the existing system.
Stage 4	**Formulate and develop a model**	- Develop a diagram for the solution.
Stage 5	**Validate the model**	- Compare the model's performance under known conditions with the performance of the real system. - Perform tests and examine the model. - Ensure that the model assumptions are correct, complete and consistent.
Stage 6	**Document model for future use**	- Document the experimental design.

The model from "Introduction to modelling and simulation" is where heuristics and the strategies for using simulation in a design process are emphasised. These are discussed in detail below.

2.6.1 Identify the problem

For simulation to be used effectively in a classroom situation, learners should identify the problem that exists in the system (Taylor, 2010). The situation should be sufficiently identified, and learners must understand its fundamental questions clearly (Shiflet & Shiflet, 2014). Real problems are those that generate enough dissatisfaction to justify that something should be done to reduce them (Romiszowski, 2016). When learners are faced with challenges in identifying a problem, their self-efficacy tends to reduce. Learners who are at this stage should be able to point out the principal parts of the problem, the unknown, the data, and the conditions attached to the problem (Romiszowski, 2016). Romiszowski (2016) further provides a new framework of simulation, which is referred to as 'thinking in system'. This 'thinking in system' helps learners to define the problem as clearly as possible, analyse the problem in order to identify a possible solution, select and develop the most viable solution, and lastly, implement the solution and evaluate the effectiveness of the use of the simulation. This is in line with Bandura's self-efficacy where learners' belief about their capabilities to produce designated levels of performance exercise influence over events that affect their lives.

2.6.2 Formulate the problem

The second model created by Maria (1997) involves the formulation of problems with simulation performance. The ability to formulate the problem includes how learners select the major problem and its categories, brainstorm issues to be addressed, identify the end-users, and define performance measures. This includes the time frame of the modelling. Learners should also identify the end-user of the simulation model. End-users are people who ultimately use or are intended to use the simulation product to solve a problem (Maria, 19997). For learners to identify the end-users, they should have the ability to make decisions. Problems must be formulated as precisely as possible. Once a learner has determined that a problem exists, the problem must be clearly and concisely defined (Taylor, 2010). If the problem is not properly identified, there will be no solution, or there will be an inappropriate solution (Gibson, 1992). Learners should be aware of the existence of the problem so that the objectives of the activity are met (Romiszowski, 2016). Learners should have the ability to identify a set of objectives to be achieved, activities and resources needed to accomplish those activities, and the process of capturing, identifying, collecting and analysing information on how well the plan objectives are being met (Maria, 1997). This study highlights the fact that even if we are aware of what we expect our learners to obtain through the use of simulation, it is also important to choose appropriate problem situations, thus providing a suitable way of supporting learners.

2.6.3 Collect and process real system data

A learner collects and processes real system data through the conversion of raw data to meaningful information through a simulation process (Jeffries, 2005). At this stage, data is manipulated to produce results that lead to a solution to the simulation problem (Romiszowski, 2016). In this study, learners used diagrams and reports to present informative output. Learners should clearly define and identify the problem before they attempt to collect and process real system data. The collection process provides both the baseline from which to measure the data and a target on what to improve.

2.6.4 Formulate and develop a model

At this stage of the simulation model, learners must develop diagrams of the model. They verify that the simulation model executes as intended (Maria, 1997). Shiflet and Shiflet (2014) propose three critical steps in formulating and developing a model. The first step is to collect relevant data to gain information about the simulation behaviour. The second is to frequently decide to simplify some of the factors and ignore other factors that do not seem important. Learners may decide to return to step 1 (identifying the problem) to further restrict the problem under investigation. The third is to determine the time and days needed to perform the simulation model. The recognition of the underlying structure of a problem is seen as fundamental in developing a model. Drawing a diagram can be effective in solving simulation problems. In this case, the learners needed to know which type of diagram to use, how to use it, and how to reason systematically in executing their actions. However, these claims cannot, in one way or the other, be divorced from the Theory of Perceived Self-efficacy.

2.6.5 Validate the model

Once the learners have a solution to the simulation problem, they should carefully examine the results to make sure that they make sense of them and check if the solution solves the problems that were identified in Step 1 (Maria, 1997). The process of validation determines whether the simulation satisfies the problem's requirements (Shiflet & Shiflet, 2014). According to Maria (1997), learners should compare the simulation performance under known conditions with the performance of the real system. The process of validation not only ensures that the simulation models are correct, complete, and consistent, but also enhances confidence in the model (Maria, 1997). Usher and Pajares (2005) initially state that after learners have completed their simulation activities, they must interpret and evaluate the results obtained. When they believe that their efforts have been successful, their confidence to successfully accomplish the task is raised.

2.6.6 Document model for future use

A document model outlines the steps used to complete the model. It is internal, on-going documentation of the process while the occurring-documentation cares more about the 'how' of implementation than the 'what' of model impact (Mehalik & Schunn, 2006). Documenting a model helps learners to identify the current state of the problem to know how they can improve it (Romiszowski, 2016). Documentation provides consistency for the model and allows learners to monitor and revise processes as they go along (Taylor, 2010). A document model helps learners to realise the changes in behaviour and attitudes needed to produce desirable results (Jeffries, 2005).

The outlined simulation models of Maria (1997) seem to be the foundation of all other models reviewed. Schoenfeld (1992) also conceptualised the use of simulation as being constituted by four key features, namely: the problem, making a plan, carrying it out, and checking the answers against the question asked. Meanwhile, D'Ambrosio (2007) also views the process as comprising four steps, namely:

- Given problems to identifying the problems (problem posing);
- Individual work to cooperative work (team);
- One solution problems to open-ended problems;
- Exact solutions to approximate solutions.

What appears to be at the core of Maria, Schoenfeld and D'Ambrosio's models is understanding the root cause of the problem before solving it as a learner cannot interact with his/her own environment if he or she cannot make sense of the problem.

After interacting with the environment, the learner needs to select or order the processes available to him/her. If the processes are not available to learners, then it will be hard to move forward in solving the given problems. Information accessing and processing skills, comparing, observing, interpreting and collating appear to be at the core of using simulation. Communication and recording as investigative skills in the design process are used to gather data and information, to grasp concepts and gain insight and skills (DBE, 2011). All of these processes contribute towards attaining the appropriate use of simulation as suggested by the CAPS document (DBE, 2011). Little is known about how learners select a process that they feel is appropriate to the circumstances or how they order processes. Observing and comparing, as processes, actualise the understanding of any problem given in any context. It is thus important to identify and understand the problem before planning for its solution.

Schoenfeld's model does not seem to differ much from what Maria (1997) has already outlined because it encompasses the same six simulation models. Schoenfeld (1992) states that learners need to learn to define objectives and to self-regulate their problem-solving behaviour in order to improve the solving of non-standard simulation problems. However, when looking at the episodes as named by Schoenfeld (1992), they cannot be divorced from Bandura's Social Cognitive Theory. I therefore feel that it is important to explore further how this theory was used in various studies to enhance the use of simulation.

D'Ambrosio (2007) further provides a new framework of simulation model which is referred to as 'new thinking' in human activity. This 'new thinking' calls for what is sometimes called 'story problems' (D'Ambrosio, 2007). A story problem has multiple solutions and usually requires cooperative work. All four cases as presented by D'Ambrosio (2007) reflect back to what was initially proposed by Maria (1997). D'Ambrosio, in his first stage on posing a problem actually emphasises the aspect of building knowledge of one's own understanding as the difficulty of the problem augments.

Jeffries (2005) states that unlike the traditional classroom environment where learning is more teacher-centred, teaching using simulation is learner-centred, with the teacher taking the role of facilitator in the learning process. Jeffries' (2005) simulation model identifies seven principles that can be used to guide simulation design and implementation: active learning, feedback, learner interaction, collaborative learning, high expectation, diverse learning and time on task. He further explains that giving feedback could enhance a learner's learning experience. This model cannot be divorced from Bandura's Social Cognitive Theory, as he recommends feedback and learner interaction as these can also boost learners' effort and self-confidence.

According to Mehalik and Schunn (2006), knowledge needs to be taught so that the true science of the design process can emerge with effective methods of searching the space of solutions to satisfy goals and constraints. Mehalik and Schunn (2006) further provide new frameworks of simulation use in a design process wherein they emphasise that design mainly involves thinking about the artificial in a process involving mostly synthesis, whereas other types of thinking, such as scientific inquiry, focus more on analytical thinking. They reviewed the frameworks and techniques of systems analysis and designed these into seven stages that rely on interaction and iteration:

- Determine the goals of the system.
- Construct meaningful indices of performance.
- Consider alternate candidates for solutions.
- Rank alternatives.
- Validate solutions.
- Iterate.

Alfajjam (2013) further recommends interactivity as it enables learners to manipulate variables of an experiment. It can also show the learners the impact of this manipulation as immediate feedback. He highlights three types of interactions that may occur in the simulation classroom: learner-learner interaction, teacher-learner interaction and learner-content interaction. The current study focused on interactivity between the learners and aimed to create an effective simulation environment that would facilitate learners being involved and participating in the educational process. However, when looking at the recommendation of Alfajjam (2013), it cannot be separated from Bandura's Social Cognitive Theory as it explores the importance of interaction in learning through simulation.

Simulation skills within the IDMEC design process are outlined below (Table 2.2).

Table 2.2: Simulation models against the design process.

Investigation	**Design**	**Make**	**Evaluate**	**Communication**
Gather data: - Identify issues; - Exploration; - Follow procedure; - Decision making.	Design brief: - Group ideas; - Examining ideas; - Compare solutions.	Use of equipment: - Categorisation; - Classifying; - Analysing ideas.	Evaluate actions, decisions and results: - Interpret results; - Examine ideas; - Explain.	Presentation: - Reveal end-results; - Categorisation.
Conduct research: - Communication; - Organising ideas; -Classification.	Develop a solution: - Sort ideas; - Examine ideas; - Compare ideas.	Building and testing product: - Review ideas; - Assess solution.	Evaluate solutions and process followed: - Interpret ideas; - Examine ideas; - Analyse arguments; - Evaluate.	Record processes: - Planning.
Grasp concepts and gain insights: - Organising ideas; - Scrutinize ideas.	Draw initial ideas: - Explain ideas; - Recognise ideas; - Evaluate initial ideas.	Safe and healthy environment: - Classifying; - Examining ideas.	Suggest changes and improvement: - Examine ideas; - Compare results; - Evaluate.	

Investigation	Design	Make	Evaluate	Communication
Determine new techniques: - Sorting facts; - Analysing ideas; - Comprehend.	2D and 3D drawings: - Present results; - Decision making; - Enquire ideas; - Classifying ideas; - Peruse arguments.		Evaluate constraints: - Determination.	

2.7 CONCLUSION

This chapter provided an overview of the literature on Bandura's Social Cognitive Theory, the theory in which this study was located. It was stated that the Social Cognitive Theory embraces self-efficacy as this affects the way in which learners approach challenges or complex situations. Bandura's Social Cognitive Theory and the design process are considered appropriate in teaching technology since they are both used in the teaching of technology. The design process is also used by technology teachers as they develop solutions to technological problems. However, the design process does not highlight the essence of social interaction and experiences. Technological problems are solved collaboratively whereby learners work collaboratively with others and examine ideas, which makes social cognition essential.

Problem solving (the key element to teach the design process) enabled the researcher to understand the way in which knowledge is developed and applied in technological problems. It appears that knowledge and experience are the key aspects in problem solving. Technology teachers are expected to use knowledge and experience in order to solve technological problems.

The chapter also reviewed the literature associated with simulation skills in the design process. Thereafter, I discussed various studies that define simulation, after which I concluded that the skills to be used for effective simulation include skills such as problem identification, problem formulation, data collection, developing a model, analysing, evaluating and documenting. These skills are very important in enabling technology teachers to provide learners with the opportunity to solve technological problems. Problem solving originated from a quest to solve technological problems. Without knowing the principal parts of the problem, it is difficult to solve a problem. Therefore, the origin of the problem determines the root cause of the technological problem.

This chapter also outlined the effective steps to be used in simulation. It is essential for technology teachers to be familiar with the problem-solving skills required in the use of simulation, as it enables them to understand the nature of the simulation problem. It appears that the new South African Curriculum (CAPS) aims to establish simulation skills, but technology teachers can only achieve these skills if they are familiar with the effective steps in the use of simulation. The design process is considered important as it forms the backbone of technology, but simulation skills are not sufficiently emphasised, and this might lead to technology teachers not promoting these skills when teaching technology. The outlined simulation model that guided the study was also presented and discussed in this chapter. The next chapter addresses the research methodology of the study.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter starts with the research design that was adopted in this study. The research paradigm as well as its philosophical disciplines (i.e. ontology, epistemology and methodology) in this study are then outlined. The methodologies used in the constructivist research paradigm are then provided, followed by the research population and sampling methods. The data collection methods adopted in this study are then presented followed by the data analysis. The quality criteria and ethical issues considered in this study are provided respectively. The chapter concludes with a summary of the chapter.

3.2 RESEARCH DESIGN

A qualitative research design was adopted in this study using a case study approach. Qualitative research design studies people in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings that people bring to them (Ntjie & Asimiran, 2014). Qualitative research is specifically used to unravel a complex phenomenon, often with the purpose of understanding a situation or process from the participants' point of view (Leedy & Ormrod, 2005). The purpose of using a case study is to provide an understanding of the meaning of a phenomenon or events and derive rich, in-depth information (Meriam, 1998).

According to Babbie and Mouton (2015), a multiple case study involves the use of more than one method, multiple interviews or observation occasions, and a variety of informants. A single case may not provide a thorough understanding of the phenomenon being investigated, thus it was believed that the use of multiple cases would provide a better understanding of the effectiveness of the use of simulation in the technology classroom.

3.3 RESEARCH PARADIGM

It is of the utmost importance to identify the research paradigm under which a study falls as the research paradigm sets the context for the researcher's study (Ponterotto, 2005). Ponterotto (2005) highlights that the paradigm guides the researcher in the selection of tools, instruments, participants, and methods used in the study. In this study, a constructivist paradigm was selected. This paradigm enables the participants to actively construct or modify the meaning of their experiences to align with their unique worldviews (Taylor, Blount & Bloom, 2017). In this paradigm, there is interaction between the researcher and the participants where a deeper meaning is uncovered (Ponterotto, 2005).

Ponterotto (2005) states that both the researcher and the participants create findings from their interaction. In this study, a constructivist paradigm was selected in order to understand how teachers use simulation effectively in the design process. The most important questions, such as the ontology, epistemology and methodology, help define a particular research paradigm. Ontology refers to studying the nature of reality (Ponterotto, 2005), whereas epistemology is concerned with addressing the facts by searching for and defining acceptable knowledge (Norris, 2005). Finally, the methodological paradigm concerns the procedures of the research (Ponterotto, 2005)

3.3.1 Ontology

Ontology is concerned with the nature of reality (Ponterotto, 2005). From a constructivist perspective, the participants construct a unique knowledge base and experience a unique reality even within a shared context (Schraw, 2012). In the constructivist paradigm, there are multiple, often conflicting, constructions of reality and all are meaningful (Shwandt, 2005). According to Taylor, Blount and Bloom (2017), constructivism supports learners' self-expression while creating new realities. Therefore, constructivism is subjective and influenced by the context of the situation, such as the participants' experience and perceptions, and the interaction between the participants and the researcher. The researcher is able to identify a set of results that can be generalisable to a larger population (Ponterotto, 2005). For this reason, the researcher used four teachers, the results from whom could be used to generalise to the larger population.

The study investigated the effectiveness of the use of simulation in the design process. Teachers' experiences and perception of the use of simulation are important. As a result, teachers were interviewed and observed in different schools in order to understand their experience in using simulation in a classroom environment. Meriam

(1998) maintains that in constructivism, the researcher assumes that reality is constructed intersubjectively through meaning and understanding, which are developed socially and experientially.

3.3.2 Epistemology

Epistemology is concerned with the relationship between the research participants and the researcher (Ponterotto, 2005). Epistemology is concerned with addressing the facts by asking questions that allow the researcher to search for and define acceptable knowledge. This philosophy is most commonly used in scientific research as it searches for facts and information that can be proved without a doubt, rather than changeable situations and opinions (Norris, 2005). Constructivists recommend interaction between the researcher and the participants (Ponterotto, 2005). Therefore, this interaction between the participants and researcher comprised capturing and describing the experience and choices of the participants and the knowledge that they gained from their experiences and choices (Ponterotto, 2005).

In this study, the researcher had an opportunity to interact with the participants in order to search for facts and information in the use of simulation in the design process. The participants were interviewed to enable them to describe their experience of the use of simulation in the design process. Their experiences and the knowledge that they gained from their experiences were captured. The participants were also observed in order to prove and confirm the information that was captured during the interviews.

3.3.3 Methodology

Methodology refers to the process and procedures of the research (Ponterotto, 2005). Constructivists recommend a naturalistic approach, which enables the researcher to study things in their natural settings; and to interpret phenomena in terms of the meaning that people bring them (Ntjie & Asimiran, 2014). According to Ponterotto (2005), a naturalistic approach allows the researcher to dig deep to understand the situation through interviews and observation, which was the case in this study. The data were analysed to gain a deeper understanding of the research. The interview questions and the observation schedules were formulated and the data were analysed using Maria's (1997) Simulation Models. The participating teachers from the selected schools were interviewed face to face to express their experiences of the use of simulation in a classroom environment. The participants were also observed in their respective classrooms while presenting the topic of mechanical systems and control.

3.4 RESEARCH POPULATION AND SAMPLE

Due to time and cost constraints, it is seldom possible to include the entire population in a study (Maree, 2011). A population represents a group of individuals who share certain specific characteristics (Strydom, 2011; Babbie & Mouton, 2015). Sampling involves the selection of a workable number of participants from the research population under investigation (Babbie & Mouton, 2015). A research population does not always refer to people, but any collective phenomenon selected to form the focus of research, whether it is people, events or behaviour (Maree, 2011).

In this research, the purposive sampling method was used to understand the use of simulation and its importance in the design process. The population in this study comprised four technology educators (two males and two females) from two selected schools in the Tubatse circuit of the Riba Cross District as a representative of the larger population. This was done in order to gain insight into the status quo of simulation and its effectiveness so as to inform remedial efforts. The research investigated the importance of simulation in the design process, the opportunities that CAPS provides in developing simulation skills among learners, and the experiences of technology educators in the use of simulation.

The two selected schools in the Riba Cross District, Tubatse circuit were chosen for various reasons. One reason was that although the Tubatse circuit is within the periphery of Burgersfort Platinum City, which is rich in mineral resources, the majority of the learners analysed in this study were not skilled in simulation. Another reason was that no research has been conducted previously on the development of simulation skills in schools within the Limpopo Province.

There are 13 secondary schools in the Tubatse circuit, two of which were selected. The criterion for the selection of the two sampled schools was their over-crowding status. The focus of the research was on technology teachers' experience in using simulation and the importance of simulation in the Tubatse circuit. The selected schools are located in mining areas, and the mining industry requires the development of simulation skills; thus these schools were deemed to fit the requirements of this research.

The relevant individuals at the schools were contacted personally to ensure their willingness to participate in the study and to gain consent from the participants. Two teachers were selected from each school strictly on the basis of their capacity to represent the research population according to the needs of the study, as supported by the purposive sampling principle. These teachers were sub-divided into two categories as follows:

1. Teachers with more than five years' teaching experience in technology. This category consisted of technology educators who had more than five years of teaching technology in schools. The experienced technology teachers were interviewed to examine their competency level.
2. Teachers with less than five years' teaching experience in teaching technology. This category consisted of technology educators who had been teaching the topic for less than five years. They were chosen so that enquiries could be made about the effectiveness of CAPS programmes that are set up to support learners to develop simulation skills.

Permission was obtained from the Tubatse circuit authorities and direct observation with the participants was set up within the sampled schools. Observation was done in the participants' classrooms during technology lessons. A period of five weeks was taken to observe the participants. The observation of the teachers was done twice with the aim of assessing the intentionality of their responses, to correct obvious errors, and to provide additionally volunteered information (Maree, 2011). Upon obtaining permission from the authorities in the Tubatse circuit and setting up interviews with the sampled schools, individual interviews were carried out with the participants. The interviews were semi-structured; therefore, some questions were open-ended in order to allow the participants to further elaborate on their answers and to provide the researcher with leading questions. The interviews were voice recorded and transcribed into a written form that was further analysed using contextual analysis.

3.5 DATA COLLECTION

The data collection method included two processes: individual interviews and classroom observations. According to Stake (1995), the use of multiple sources of data, rich in real-life situations, is a distinguishing characteristic of case study methodology. A pilot study was conducted to ensure that the data collected were readable by the target audience (described in Section 3.5.1). Simulation models (Maria, 1997) were used to develop the interview questions and observation schedule.

3.5.1 Pilot study

Before the researcher uses interview questions, it is important to pilot the instrument. A pilot study allows the researcher to practice and assess the effectiveness of their planned data collection and analysis techniques (Doody & Doody, 2014). The pilot study should be conducted with many volunteers who can complete and critique the interview questions. Volunteers in the pilot study can evaluate the data collection instrument for effectiveness and it allows the researcher to make appropriate adjustments (Meyer, 2014). Yin (2012) highlights that a pilot study helps the researcher to refine the data collection and questioning processes.

To ensure that the interview questions were easily understandable for the participants in this study, I conducted a pilot study. A pilot version of the interview questions was administered to four participating teachers in two schools in the Riba Cross District. The teachers were asked to indicate areas that were unclear. All of the teachers were highly cooperative during the pilot study and commented on some items that they found confusing. Question 14, concerning the personal experiences of teaching, was adjusted to the personal experiences in developing a model that will solve simulation problems. Questions 6, 7 and 9 were also adjusted as the participating teachers stated that it was very difficult for them to give proper answers. Adjustments were thus made based on the teachers' feedback. The pilot study indicated that most of the interview questions were understood by the majority of the teachers.

In this study, I performed two pilot case studies of technology teachers. The first pilot case study focused on four technology teachers – two technology teachers with more than five years in teaching technology and two technology teachers with less than five years teaching technology. A four-week pilot study revealed the various challenges that technology teachers without simulation skills experienced in their classroom. I found that the problems reviewed in the literature on the use of simulation were evident. Simulation skills were deemed a serious problem as both teachers lacked knowledge of the design process (IDMEC) in the use of simulation.

The first pilot case study enabled me to understand the enormity of the data collection process. In this study, I collected 10 pages of transcribed interview information from each teacher during a three-week period, and had the chance to pilot my interview questions. I spent eight to 10 hours transcribing the data that was collected. As I continued with the interview questions, there was a need to adjust the interview questions based on the outcome of the observations.

The second pilot study, which lasted for two weeks, was with two teachers with less than five years of teaching technology. Again, as in the first pilot study, I was able to refine the questioning techniques and work on the data collection procedures. After reviewing the data, it was revealed that a lack of subject knowledge was the problem in the use of simulation. It was discovered that since the start of their teaching careers, there had never been an education specialist to monitor these teachers' teaching.

3.5.2 Interview

Qualitative research is research wherein the researcher relies on the views of the participants, and asks broad, general questions (Creswell, 2005). In this study, open-ended interview questions (see Appendix A) were asked to the sampled teachers to understand their knowledge and experience of the effective use of simulation. Open-ended interviews are used to offer richer and more extensive material, and take one or more hours to conduct (Yin, 2012). In this study, the interviews were scheduled for an hour, although most lasted between 50 minutes and an hour.

Open-ended interviews with 17 questions were used to allow the participants to express their opinions on the use of simulation and their experiences in presenting the use of simulation in a classroom environment. In the interviews, the participants were provided with a full explanation of the study and informed that the interview would be audio recorded in order to document their responses to the questions. The interviews helped me to gain insight into the experiences and understanding of the classroom simulation of the participants. The interviews were conducted individually during normal school hours in a vacant classroom to avoid any disruption during the interview session.

3.5.3 Observation

An observation schedule (see Appendix B) was used to observe the teachers. Creswell (2005) notes that observation is the process of gathering open-ended, first-hand information by observing people at a research site and recording information as it occurs in a natural setting in order to study the actual behaviour of people. Observations were conducted to verify the findings about the use of simulation obtained from the interviews. Observation was conducted during the participants' lesson presentation to examine the way in which they encouraged and developed simulation skills in the classroom. The teachers were observed while teaching the topic of mechanical systems and control at the beginning of the third term. Each observation was conducted for a period of 30 to 45 minutes. I used tick marks to mark the observed aspects of simulation skills during the lessons. Field notes were also taken in order to add information to the observation schedule. I observed how the teachers motivated learners through problem identification, formulating the problem, collecting data, developing a model, validating the model and documenting the model (Maria, 1997).

3.6 DATA ANALYSIS

This study used a multiple case study approach and the data that were collected from the interviews and observations were analysed using the simulation models. The transcripts were analysed using a thematic content analysis. Burnard et al. (2008) affirm that a thematic content analysis is the most suitable method when the researcher wants to transcribe data in to explore and interpret it. The data from the audio recordings were transcribed in order to make sense of the participants' explanations, and additionally, to identify statements that related to the effective use of simulation in the design process. The finalised set of questions was used to structure the narrative and obtain the participants' views.

The data collected from the observations were used to justify the findings from the interviews. In this study, I provide the context of each observation, followed by a table that summarises the observations. The findings from the observation are discussed in detail. In this study, I engaged in triangulation by using multiple methods of collecting data (interview and observations) to verify the findings obtained from the instruments. Maree (2007) defines triangulation as the most suitable method when a researcher wants to collect data from multiple sources at the same time regarding a single phenomenon. This allowed me to present a rich, detailed description of the use of simulation as well as validated conclusions. The simulation models (Maria, 1997) were used to develop the observation schedule and the data were analysed accordingly.

Ponterotto (2005) highlights that there is an interaction between the researcher and the participants wherein deeper meaning is uncovered; this was the case in this study as my interactions with the participants allowed me to gain deeper meaning of their experience with and teaching of simulation in the classroom.

3.7 QUALITY CRITERIA

Trustworthiness is the degree of confidence in data, the interpretation, and the methods used to ensure the quality of a study (Connelly, 2016). This study took cognisance of credibility, transferability, dependability and conformability to ensure trustworthiness (Babbie & Mouton, 2015).

3.7.1 Credibility

To ensure credibility, I included multiple source of data (Babbie & Mouton, 2015). Interview sessions and two observations were conducted to enhance the credibility of the findings; and the data were interpreted with the use of simulation models (Maria, 1997). Credible research requires the researcher to remain neutral at all times in order to reduce the aspect of bias (Elo & Kyngas, 2007). In this study, I asked the sampled teachers open-ended questions and acted neutrally without showing any personal interest. All of the interviews were recorded with an audio recorder and were later transcribed using verbatim accounts. Observations were conducted to help confirm the data that were acquired through interviews, i.e. triangulation, as discussed above (McMillan & Schumacher, 2010). I used member-checking and participants' review to ensure the accuracy of the transcriptions of the interviews (Babbie & Mouton, 2010; McMillan & Schumacher, 2010).

3.7.2 Transferability

According to Babbie and Mouton (2015), transferability refers to the extent to which the findings can be applied in other contexts or with other respondents. As highlighted by Babbie and Mouton (2010), this study provided thick description from both the interviews and the observations to enable the reader to make judgements about the case. To facilitate transferability (Elo & Kyngas, 2007), I purposively selected these technology teachers to obtain insight, and a thick description of the phenomenon under study. I provide the reader with an inclusive description of the study's context from the interviews and observation schedules. Furthermore, field notes from both the interviews and observations were scrutinised.

3.7.3 Dependability

To ensure dependability, the notion of an inquiry audit, as highlighted by Babbie and Mouton (2010), was used to examine the field notes from the interviews and observations. This allows the reader to decide on the trustworthiness of the research. Raw data from both the interviews and observations were verified by means of triangulation to ensure dependability, especially where the findings were similar.

3.7.4 Confirmability

According to Babbie and Mouton (2015), confirmability is the degree to which the findings are the product of the focus of the enquiry and not of the bias of the research. Several strategies were used to validate the skewed views of the participants. Firstly, to confirm the results of the study, triangulation, as suggested by Denzin (2010), was used through multiple sources of evidence. Secondly, continuous member-checking was done as part of the reliability process (Havey, 2014). I rechecked the consistency of the findings from the interviews and observations as this enables the findings to be as robust as possible.

3.8 ETHICAL CONSIDERATIONS

Ethics are generally considered to deal with beliefs about what is right or wrong, proper or improper, good or bad.

3.8.1 Informed consent

Approval to conduct the research project was obtained from the Research committee (TREC). Permission was sought from the Riba Cross District manager and the school principals to conduct the interviews and observations. A short overview of the study and its purpose was provided to the participants with an explanation of what was required from them. Informed consent was thus given by the participants.

3.8.2 Respect

According to Cohen, Manion and Morrison (2010), respect requires that the equal worth of all people be respected. In this study, all of the participants were regarded as free and rational. All participants were given the opportunity to express their own ideas.

3.8.3 Anonymity and confidentiality

To ensure anonymity and secure the privacy of the participants, I used the letters A-D (TA-TD) to describe and discuss the views of the participants. The introduction to the questionnaire of the interview informed the participants that all of the information would be handled confidentially. The data gathered from the data instruments will remain confidential.

3.8.4 Discontinuance

Research participants have the right to withdraw from the research without penalty (Schaefer & Wertheimer, 2010). All of the participants were informed that they could withdraw from the study at any time if they were no longer interested in continuing with the study and there would be no negative consequences.

3.8.5 Security data

Data collection from the participants will be kept in a safe place to prevent it from falling into the wrong hands.

3.9 CHAPTER SUMMARY

This chapter began with an overview of the qualitative research method, which comprised the research design, research paradigm, population and sampling of this study. I then described the pilot study, which involved checking the comprehensibility of the interview questions and refined the questions. I presented the rationale for selecting qualitative inquiry using a case study to conduct this study. The ontology, epistemology and methodology were discussed in detail to help define the particular research paradigm selected. The setting and participation selection process detailed my decision to select the schools and teachers as the subjects of this study. Purposeful sampling was adopted to select participants who provided an information-rich group from whom to collect data.

Approval from the district manager and informed consent from the participants were provided to enable me to gain access and entry to the schools. A description of the observation schedules and interviews was then given. The interview questions and the method for validating the interviews and observations were then reported on to ensure the credibility and validity of the results. The data were coded and organised systematically to help me to reveal the main category of this research. In the next chapter, I present the findings of the study.

CHAPTER 4 DATA PRESENTATION AND ANALYSIS

4.1 INTRODUCTION

In this chapter, I present an in-depth investigation conducted on four technology teachers. I also report on the data analysis, which was collected by means of both the interviews and observations. This chapter starts with an outline of the participants' profiles in order to show their academic qualifications and experience in teaching technology. Subsequently, the participants' responses obtained from the interviews and observations are then discussed. The summary of the participants' responses will then be presented, followed by the conclusion to this chapter.

4.2 RESPONDENT PROFILE

The participating educators were qualified teachers with less than five years of teaching technology and more than five years of teaching technology in the Senior Phase. This information is important in analysing the data for better understanding, as the teachers' qualification and experience may influence learning and teaching in the use of simulation. The profiles of the educators are indicated in Table 4.1.

Table 4.1: Profiles of the participating educators

School	**Respondent**	**Gender**	**Experience in teaching technology**	**Qualification and major subjects**	**Age**
A	TA	F	3 years	BA, HED, ACE in technology; Maths Literacy	37
	TB	M	7 years	STD, ACE in technology. History and Life Science.	53

School	Respondent	Gender	Experience in teaching technology	Qualification and major subjects	Age
B	TC	F	1 year	BSC Physical science, ACE in technology	30
	TD	M	10 years	STD Afrikaans and Sepedi.	49

The above table shows that all of the participating teachers met the requirements in the stipulated sampling because they all taught technology. One participating teacher (TD) was purposively selected because of their technology teaching experience.

The responses from the educators are consistently reported according to two categories: the school category and the alphabet letter assigned to each educator, for example, teachers A and B fell under School A, while Teacher C and D fell under School B. School A had 199 Grade 8 learners distributed across four classes. School B had 159 Grade 8 learners distributed across two mobile classrooms. An example of the coding system is: school= SCH, Teacher= TA-TD.

The following research questions were helpful in conducting this study. The main question was:

- How effective are Grade 8 learners in using simulation in the design process?

The sub-questions are:

- What is the importance of simulation in the design process?
- What opportunities does the CAPS documents provide in supporting learners to develop simulation skills?
- What experiences do technology teachers encounter with regard to simulation-based programs?

4.3 THE INTERVIEWS

Seventeen questions were formulated based on Maria's (1997) simulation model (see Section 2.6), which were used to conduct the interviews. The first two questions focused on how teachers understand the effect of the use of simulation skills and how they assist learners to solve simulation problems in the technology classroom. Questions 4 and 5 were based on how technology teachers are affected in their use of simulation. The rest of the questions focused on the intellectual ability of the educators in the use of simulation.

A pilot study was conducted to ensure that the interview questions were comprehensible for the participants. The teachers indicated the areas that were unclear and adjustments were made based on the teachers' feedback. The findings will be presented as follows: the question that was asked will be stated followed by a discussion of the participants' responses. The discussion is then related to the theory and the simulation model, and presented in a narrative manner. The participants' utterances will be given to support the discussion. Thereafter, conclusions are drawn based on the participants' responses.

Question 1: What do you understand about the use of simulation in the design process?

According to Maria (1997), simulation skills (identifying the problem, formulating the problem, collecting and processing real system data, formulating and developing a model, validating the model and documenting the model) are required for learners' decision making in order to create and analyse a prototype of the physical model to predict its performance in the real world. These simulation skills were used as guidance in the interpretation of the participants' understanding of the use of simulation. The teachers described the importance of problem-solving skills in identifying simulation problems. To them, problem solving skills were the key element in the use of simulation. The utterances of the participants regarding how they understood the importance of problem-solving skills in the use of simulation include:

> *I think the use of simulation in a design process displays the creative mind of learners. It gives them better, free and critical thinking towards any task or project (Teacher A).*
>
> *Learners will be provided with an opportunity to use their mind critically (Teacher B).*

Innovative process is also important in the use of simulation in a design process (Teacher C).

It improves reasoning skill of a learner so that they can be able to identify and solve the problem (Teacher D).

From the above responses, the teachers seemed to understand the importance of problem-solving skills in identifying simulation problems. Their statements explained the effect of learners' problem-solving skills on identifying simulation problems. The responses also reveal what is needed for learners to be able to identify a simulation problem, namely: learners' creativity, reasoning skills, innovative thinking skills and critical thinking skills. Teachers should be aware that learners need to be creative in order to be able to identify and solve problems (DBE, 2011).

These responses seem to indicate that the teachers understood what reasoning skills are and the benefit thereof for learners. The respondents expressed that reasoning skills assisted learners to analyse, evaluate and synthesise the data that they collect in identifying the problem. Reasoning skills are important in identifying a problem in the use of simulation because it helps learners to develop higher learning levels of analysis, synthesis and evaluation (Miller, 2010). Related sentiments were also captured from one of the respondents:

A learner who thinks critically brings good results when identifying problem in the use of simulation (Teacher A).

Teachers need to have knowledge of the outcomes of CAPS, namely, to identify and solve problems using critical and creative thinking. This teacher evidently understood that critical thinking skills are important in identifying and solving simulation problems. Teacher A indicated that in teaching learners about problem identification in the use of simulation, they had an opportunity to think critically. Teacher A also indicated that learners identified simulation problems effectively because they had critical thinking skills. It is my understanding that teachers should be helping learners during the use of simulation to develop critical thinking skills, which will allow learners to identify problems. Problem identification is the first step to a successful solution (Maria, 1997).

This feature of using simulation is fundamental and thus justifies the selection of the framework of this study. Critical thinking is what allows the learners to ask vital questions and solve complex problems. This seems to be appropriate because when learners think critically, it becomes easier for them to identify simulation problems.

Question 2: How do you assist learners to identify, define and solve simulation problems?

Concerning Question 2, the teachers held varied opinions and beliefs about identifying the problem, explaining that identifying a problem is successful if learners understand the problem and are able to use the design process in the use of a simulation. Therefore, the teachers regarded understanding a problem as the crucial link to problem identification and effective use of simulation. Learners' ability to understand the problem in the use of simulation is affected by self-efficacy. These teachers seemed to believe that if learners understand the problem, it means that they are able to use the design process. Most of the participants seemed to understand the importance of the design process in understanding a problem. Teachers expressed their understanding in the following manner:

> *My learners will be exposed to making process which involves the latest 3D tools used in simulation (Teacher A).*
>
> *I will assist learners identify, define and solve problem by getting them involved in building and making process of the design process (Teacher B).*
>
> *I will assist learners by giving them a task in which a learner is involved in investigating the problem (Teacher C).*
>
> *They will investigate the problem to know the situation to the problem (Teacher D).*

Investigation is important in the use of simulation as it requires the learner to gather information. The responses above support the fact that in order for learners to be able to understand the problem, investigation should be included as the first step in the design process. However, the participating teachers seemed to understand that learners should be taught about the 'making' aspect of the design process.

From the responses above, it can be seen that the teachers were aware that the design process is the backbone of the use of simulation. However, the participating teachers mentioned only one step of the design process. The aspects of the design process should not be seen as separate skills; teachers should understand that the skills in the design process are inter-related (DBE, 2011).

Question 3: How do you motivate and encourage your learners to collect data effectively and efficiently?

According to Maria (1997), the third stage of the simulation model (collect and process real system data) involves the collection of data on system specifications, input variables, as well as the performance level of the existing system. These aspects show that the participants had inadequate information to answer Question 3. None of the participants mentioned how to involve system specifications, input variables and the performance levels of the existing system while motivating and encouraging learners to collect data.

Teachers should encourage learners to work collaboratively with other learners in order to investigate the problem effectively and efficiently. All of the participating teachers felt that working collaboratively with others encouraged learners to investigate the problem at hand:

> *I will encourage them to network with other peers (Teacher A).*
>
> *Working with peers will motivate learners to collect data effectively and efficiently (Teacher B).*
>
> *I will motivate and encourage them to collect data effectively and efficiently by seeking for help from their peers (Teacher C).*
>
> *Making them realise that their data may come from their peer (Teacher D).*

In accordance with Maria's (1997) simulation model, the collection process provides both the baseline from which to measure and a target of what to improve. From the above comments, it appears that the teachers understood the requirements of the CAPS document. Technology teachers should provide learners with an opportunity to work collaboratively with others (DBE, 2011). This will allow learners to improve their performance. The participating teachers were able to encourage learners to work with their peers to improve their simulation performance.

Question 4: Do you think learners are able to brainstorm on different issues that need to be addressed in the use of simulation?

Brainstorming, as a sub-skill of '*formulate the problem'* (see Section 2.6) could be regarded as a strategy in which learners have to list as many ideas as possible about a problem in a specified time (Du Plessis et al., 2011), and is one of the teaching strategies that are important in technology. Teachers should be aware that they should provide learners with the ability to brainstorm issues to be addressed in formulating a simulation problem. Learners should know that brainstorming on issues will help to formulate a problem as precisely as possible. From the responses given, there is no clear indication that teachers have knowledge on how to use brainstorming as a skill in formulating a simulation problem. The participating teachers were supposed to explain how useful ideas could be classified. 'Jotting down issues' could be used to classify useful ideas.

The participants reported that the learners lacked simulation tools to do practical work. The responses of the participants on brainstorming issues to be used in the use of simulation include:

> *No, I don't think so because they lack modern simulation tool (Teacher A).*
>
> *Yes, if they are grouped together to do a task and each member given a task to accomplish which will at the end build up a model (Teacher B).*
>
> *Yes, simulation includes time for reflection and processing, which allows learners to share their experiences, assess their learning and evaluate their assessments against the intended outcomes of the simulation (Teacher C).*
>
> *Yes, if a teacher could allow them to do practical or if a teacher can do practical with them (Teacher D).*

The participants' answers disclosed limited knowledge of effective problem-solving skills. According to Khan (2012), teachers should provide learners with the opportunities to collects the facts about the problem for effective problem-solving skills in the use of simulation. For instance, technology teachers should have more knowledge on how to collect the facts about a simulation problem and instil that knowledge in their learners. Once learners have developed skills in collecting the facts about a problem, they will be taught to share their experiences (as reported by the participants) in light of their outcomes. Identifying objectives is one of the effective skills in problem solving (see Section 2.4), however, none of the participants referred to this characteristic.

Question 5: When learners are formulating a problem, how do you assist them to define performance measures?

Defining performance measures is a sub-skill of the second phase of Maria's (1997) simulation model: *formulating the problem* (see Section 2.6). According to the CAPS document for technology, learners are required to collect and analyse information (DBE, 2011). Maria (1997) states that collecting, analysing and reporting information are also some of the aspects of the effective use of simulation. The participating teachers reported that learners were encouraged and guided on how to define performance measures correctly.

The learners were guided in terms of the motive for their simulation activity. Knowing the motive of a simulation activity provides learners with the opportunity to define performance measures. The learners in this study were encouraged to assess their simulation performance. Thereafter, the teachers enabled and assisted learners to document whatever information they had collected. The responses of the participants in terms of how they assisted learners to define performance measures were as follows:

> *I will administer learners to define performance measures by measuring their effort or progress against a set performance standard (Teacher A).*
>
> *I can encourage them to show and record everything used and done on paper (Teacher B).*
>
> *I will give learners a clear guideline about my expectations (Teacher C).*
>
> *I will facilitate them to define performance measures (Teacher D).*

These remarks suggest what these teachers did to ensure successful problem formulation in the use of simulation. Learners need to be given direction as far as simulation is concerned. Therefore, teachers should know that administering, assisting, guiding and facilitating must be used to define performance measures and monitor learner performance. All of the participating teachers seemed to understand that learners should actively participate in classroom simulations and that they as teachers should be a facilitator to guide and monitor learners' performance. It is therefore imperative for learners to actively participate and for teachers to facilitate them in each learning activity (Van Wyk, 2012; Jeffrey, 2005).

Question 6: How do you assist learners to identify the end-users of a simulation model?

According to Maria (1997), *identifying the end-users* should be done during the process of *formulating the problem* (see Section 2.6). CAPS stipulates that learners need to have the ability to present a solution effectively to the end-users (DBE, 2011). However, if the learners are unable to identify the end-users of a simulation model, then they will not be able to present the solution effectively. The participants reported that learners were assisted to gain knowledge on the subject, as well as the objective of a simulation model. In this regard, the participants had this to say:

> *If they understand the concepts and knowledge of the subject, then they will be able to know the end-users of the simulation model. I will assist them by informing or giving periodic information on where the simulation models will be displays or taken to (Teacher A).*
>
> *Any model prepared or made by a learner must be informed by a motive (Teacher B).*
>
> *I will refer them back to their group discussion and compare their ideas (Teacher C).*
>
> *I will remind learners about the problem which was identified. If the model does really solve the problem identified, this means that learners are able to identify the end users of the simulation model (Teacher D).*

Identifying the end-users of a simulation model refers to the ability to *make decisions* (Maria, 1997). CAPS stipulates that learners should be provided with the opportunity to use a variety of life skills in authentic contexts (DBE, 2011). It appears that the participants did not make an effort to provide learners with the opportunity to use the skill of decision making. *Decision making* is a sub-skill of *investigating*, which is regarded as the starting point for technology (DBE, 2011). The participants limited the simulation skills they promoted in the classroom to the formulation of the problem, whereas simulation requires the skill of decision making. Learners are required to make their own decisions in identifying the end-user of a simulated solution. In essence, decision making and investigation teach and allow learners to effectively use simulation.

Question 7: Learners need to know the major simulation problem when formulating a problem. How do you ensure that they select the major problem and its categories effectively?

Maria (1997) emphasises that it is important for learners to choose an appropriate problem situation. Therefore, teachers should be aware that they should suitably guide and support learners when formulating problems. Most of the participants reported that the uses of different teaching approaches allowed them to assist learners in selecting the major simulation problems. According to Du Plessis et al. (2011), it is vital to use certain strategies to mediate learning, thus teachers should have a broad knowledge of teaching strategies to be able to use the right one at the right time. The participants claimed that they were able to select and assist learners to find the major simulation problem. I, as the researcher, however, was not convinced that the participants did have broad knowledge on how to select the major problem in a simulation. The participants mentioned different ways in which they assisted learners in selecting major simulation problems. However, none of them explained how they would use these approaches. Teacher D of School B had this to say:

> *They select the major problem and its categories by doing case studies, oral interviews or written interviews (Teacher D).*

According to Du Plessis et al. (2011), case study is a presentation of a real, problematic situation that could possibly happen. This is done so that learners can analyse, investigate and discuss it and then suggest possible solutions. From the response above, the participating teacher did not seem to have broad knowledge of the use of a case study in technology. The participating teachers did not explain how a case study could be used to assist learners to select a major simulation problem. Teachers should be aware that they must teach learners how to use a case study in the design process (investigation, design, make, evaluate, communicate). The teachers regarded brainstorming as a strategy that assists learners to select the major simulation problems in a given scenario. Teacher A from School A and Teacher C of School B responded as follows:

> *Brainstorming will help learners to select the major simulation problems and its categories. Share their ideas with other learners (Teacher A).*
>
> *Jotting down the problem one by one will enable them to know which one is the major problem. I will guide them on the procedures/steps of getting to know the major problem. They have to list down the objectives and consider the materials they are going to use. This could be done through brainstorming (Teacher C).*

Brainstorming could be regarded as a strategy in which learners have to list as many ideas as possible about a problem in a specified time (Du Plessis et al, 2011). It is an important teaching strategy in technology. Teachers should be aware that they should provide learners with the ability to brainstorm any issues to be addressed in formulating a simulation problem. Learners should know that brainstorming issues will help to formulate the problem as precisely as possible. From the responses above, there was no clear indication that these teachers seemed to have knowledge on how to use brainstorming as a skill in selecting a major simulation problem. The participating teachers were asked to explain how useful ideas could be classified – they suggested that '*Jotting down issues'* could be used to classify useful ideas. This is confirmed as CAPS stipulates that communication in the design process can be done through various modes like writing.

The responses from Teacher C of School B indicated that learners should be assisted on how to brainstorm issues to be addressed, i.e. jotting down issues one by one. Jotting down issues one by one will assist learners to cut down the issues to a manageable size in order to consider useful ideas (Du Plessis et al., 2011). The teachers also indicated that they were required to teach learners that sharing their ideas with other learners is important in selecting a major problem and its categories. It appears that the participant believed that learners would develop the skills to justify their ideas if they were supported in sharing their ideas and relating them to other learners' ideas. Therefore, teachers are adviced to use effective strategies to enable learners to justify their ideas that have a bearing on selecting major simulation problems.

According to Khan (2012), identifying the objectives is one of various steps to be followed for effective problem formulation (see Section 2.4). Therefore, teachers should be aware that learners should be assisted in identifying the objectives and considering the materials they are going to use in the simulation. Identifying objectives and materials will help learners to make a step-by-step list of how they will go about planning. Planning is included in the making and communicating skills of the design process. During the individual interviews, Teacher B expressed his views on selecting a major simulation problem as follows:

> *As learners start on making a model, they start to write note complexity arising in the process. They will know their strength and weakness as they proceed in the project with my guidance (Teacher B).*

From the above response, it appears that this teacher knew the requirements of CAPS. According to CAPS, learners should record and present their progress in a written form on an on-going basis (DBE, 2011). Therefore, teachers should provide learners with the ability to use the design process and report on their progress. Communication is integral to the design process and it enables learners to select the major simulation problem in a given situation. Communication includes the assessment evidence of the processes followed in any given project, i.e. the ability to analyse, investigate, plan, design, draw, evaluate and communicate (DBE, 2011).

Question 8: How do you ensure that learners develop a diagram that will solve the problem identified?

Developing a diagram includes three fields: free hand sketches in the design stage, a working drawing in the making stage and artistic impressions in the communication stage (DBE, 2011). According to Maria (1997), developing a diagram involves the type of diagram to use, how to use it and how to reason systematically in executing the relevant actions. Learners are expected to use the three stages of the design process (design, make and communicate) when developing a diagram that will solve the problem identified. Once learners are able to understand the problem fully, they should be supported in writing a design brief. At this stage, learners should be taught to write a short and clear statement that gives the general outline of the problem to be solved and generate possible solutions (DBE, 2011). The participants claimed that they taught learners how to develop a diagram that will solve the problem identified. In this regard, Teacher A had the following to say:

> *During the training session, I'll make sure that I give them thorough explanation and give them typical examples (Teacher A).*

This response shows the insight of the respondent regarding the importance of regular training. From the response above, the teachers seemed to know that they should train learners to design a model that will solve the simulated problem. Teachers should thus understand the importance of model development strategies. Teacher A of School A explained what she did during the training session.

Explanation and *exemplifying* are important in developing a model. During the training and workshop on model development, teachers should have knowledge of the importance of strategies in developing the model's solution. Teachers A's response above explained the role of the teacher during training sessions, namely, to explain and give examples. However, Teacher A did not indicate whether she used the policy document in developing a model.

Some of the teachers used modelling strategies and methods interchangeably. Teacher B of School A and Teacher D of School B indicated the strategies that they used in developing a solution model as follows:

> *Sometimes I teach my learners how to mind-map (Teacher B).*
>
> *For now, I advise my learners to use mind-mapping and then begin to address the issues on the mind-mapping one after the other (Teacher D).*

Mind-mapping is important for developing learners' model solution because learners are able to choose a solution that will contain all the details needed for making the product (DBE, 2011). At this stage, learners will also decide on the type of model to develop and how to invest the resources in order to achieve the model's objectives. Learners should engage themselves in a systematic process that allows them to develop a solution that solves problems, rectifies design issues and satisfies needs (DBE, 2011). Teacher D from School B's response shows clearly that they understood the importance of explanation in creating a mind-map. Mind-mapping enables learners to list the specifications that will help them to develop a solution model. In this regard, Teacher D of School B and Teacher A of School A stated:

> *Advise them to come up with different sketches and the list of some specifications (Teacher A).*
>
> *They will also write a design brief with specification which will help them to know the problem and how to solve the problem (Teacher D).*

The ability to write a design brief teaches learners to give the general outline of the problem to be solved, as well as the purpose of the proposed solutions (DBE, 2011). Therefore, teachers should understand that learners need thorough knowledge of how to write a specification in developing a solution model. Once learners are able to write a specification, they should be able to define the problem, materials, end-users of the solution model and safety measures. From the above responses, it appears that the participants had not established any materials and safety measures to be used in developing a model. However, the participating teachers seemed to understand that drawing skills are important in developing a model. Teachers A and B of School A and Teacher C of School B commented:

> *Learners need to develop drawing skills. I will teach them on how to draw 3D (Teacher A).*
>
> *I will advise them to make a drawing in 3D using isometric projection (Teacher B).*
>
> *I will teach them how to present their ideas through drawing (Teacher C).*

These responses seem to indicate that the teachers understood that learners should be provided with the skills to develop a solution. Drawing skills as necessary in developing a diagram for the model solution (Maria, 1997). Therefore, learners should be assisted with drawing skills, how to use a diagram and how to reason systematically in executing their actions. Learners should be supported in building their self-efficacy beliefs through a vicarious experience of modelling. Effective actual modelling occurs when one sees a person similar to oneself perform a task successfully (Bandura, 1977). The participating teachers in this case study seemed to understand that learners' self-efficacy could be increased if they compared their models to those of their peers. Teacher A of School A supported this when she said:

> *They will compare their sketches with their group members to select the one that will solve the problem identified (Teacher A).*

From the response above, the learners were able to develop a solution model only if they could compare their sketches to those of their group members. Comparing sketches with group members provides learners with an opportunity to describe the similarities or dissimilarities between two solutions. During the individual interviews, some of the teachers remarked that they used drawing to visualise and present their ideas to learners. Teacher C of School B illustrated the point as follows:

Learners can be taught on how to visualise and present their ideas through drawing (Teacher C).

From the above response it can be seen that teachers should provide learners with knowledge on cognitive self-modelling, which occurs when learners visualise themselves performing successfully at a simulation activity (Bandura, 1977). Therefore, teachers should understand that learners' self-efficacy could be increased if they visualise themselves performing a task. The participating teachers seemed to understand how to increase learners' self-efficacy, as well as the requirements of CAPS. CAPS provides learners with an opportunity to communicate effectively using visual skills in various models (DBE, 2011).

Question 9: CAPS provides learners with an opportunity to collect, analyse, organise and critically evaluate information. How do you assist learners to scrutinise the data they have collected?

'*Scrutinising data'* is a simulation skill used for problem identification. Miller (2010) states that teachers should teach learners to develop higher levels of examining, organising and evaluating data. The participating teachers reported that they believed that learners should be guided to scrutinise whatever data they collected. If learners have skills in formulating a problem, this means that they are able to arrange the data they collected in an orderly manner. Teachers C and D from School B expressed their understanding in the following manner:

Learners need skills on how to gather information procedurally (Teacher C).

Learners will be taught to arrange data they have collected in a serial order and they begin to address them by knowing the frequency (Teacher D).

These responses indicated that these teachers seemed to know that learners need to be provided with the required skills to scrutinise data. According to CAPS, the use of simulation enables learners to collect, analyse, organise and critically evaluate data (DBE, 2011). This implies that during teaching, teachers need to provide learners with the ability to scrutinise data, meaning that learners should observe the actions of others when scrutinising their data (Bandura, 1994). The participating teachers seemed to understand the skills of scrutinising data when formulating a problem. The following remarks from the participating teachers during the individual interviews bear testimony to this:

> *The only way is by checking and comparing data with the similar other project data from different group members (Teacher A).*
>
> *They use their peer to assist them to evaluate their work (Teacher C).*
>
> *It is very important to guide learners on the use of peer assessment, to compare data (Teacher D).*

Working with peers in formulating a simulation problem is important. From the responses above, the teachers seemed to be aware of the importance of working with peers. Learners should know that working with peers enables them to get more information and compare and evaluate their data. The responses show that the teachers were aware of the aim of CAPS that learners should be taught to work with others as a team. Teachers therefore need to guide learners on how to observe the action of others.

A learner should be encouraged to watch a similarly perceived classmate who has succeeded at a challenging simulation activity, which may convince him/her that he/she can also succeed (Bandura, 1994; Usher & Pajares, 2005). From the response of Teacher A of School A, it can be seen that teachers should teach learners to work as a group and subsequently work with different groups in order to compare their group ideas with those of different groups. During the individual interviews, some of the teachers remarked that they preferred learners to reflect back to their working group in order to compare ideas. Teacher C of School A illustrated this point as follows:

> *I prefer to go back to their working group and compare ideas (Teacher C).*

The above response shows that reflection is vital in the use of simulation. This provides learners with the opportunity to compare their ideas. Teacher D from School B gave a negative response regarding the issue of peer assessment and highlighted the essence of individuality:

> *I will assist learners by allowing them to do it by themselves. If learners formulate problem by themselves, they will be able to define the performance measures (Teacher D).*

From the above response, it can be seen that this teacher believed that learners are able to scrutinise the data they collected only if they can formulate the simulation problem on their own. The participating teachers seemed to be aware that learners should be guided to use peer assessment in order to compare and evaluate their data. In support of the above responses, Maria (1997); Schoenfeld (1992) and D'Ambrosi (2007) emphasise that teachers must encourage learners to do group work. Learners should be aware that comparing and observing are some of the skills that are core to the use of simulation (Schoenfeld, 1992 and D' Ambrosi, 2007). Teachers should be aware that comparing should be done at various phases of the simulation, namely, in the investigation, design, make, evaluate and communicate phases (DBE, 2011).

> *I teach learners to use all the steps in design process when comparing and evaluating their data (Teacher C).*

This response indicates that teachers should be aware of the use of the design process when scrutinising their data. This implies that the use of the design process should be practiced at all times. Le Roux and Steyn (2012) support this statement as they find that using the design process allows learners who are participating in a simulation activity to learn through observing and evaluating the activity. The participating teachers revealed their opinions on, as well as the way in which they assisted learners to examine the data they had collected.

> *Learners need to be guided on how to examine data they collected (Teacher B).*

From the above response, we can see that the participant seemed to be aware that formulated problem quality deals with examining how well the problem definition is structured and how completely and accurately the real problem is included in the problem definition. This implies that teachers need to guide learners to examine the data that they have collected. In order for learners to do well in problem formulation, they should be assisted to define performance measures. Teachers therefore need to teach learners about the motive for the simulation activity as this will assist them to define performance measures.

Question 10: Do you think learners are able to compare the model's performance with the performance of the original data?

According to Maria (1997), learners should compare the simulation's performance under known conditions with the performance of the real system. Teachers should thus teach learners to compare their model with the original one. The participating teachers in this study were aware of this as they explained how learners were unable to compare the model's performance with the original data. The teachers acknowledged that there were learners in their classrooms who lacked knowledge on comparing models, this is shown in the remarks of Teachers A and B from School A and Teachers C and D from School B:

> *No, I don't think learners are able to compare the model's performance with the original data because they lack the necessary knowledge, ideas and skills to do that (Teacher A).*
>
> *No, they don't have knowledge and skills in drawing the original system. They need to know how to draw the original system, in order to be able to compare it with the model's performance (Teacher B).*
>
> *They lack knowledge on how to use the first step of design process, i.e. 'investigation' to gather information from the original data (Teacher C).*
>
> *My learners get confused on how to compare the model's performance because they lack knowledge (Teacher D).*

It is evident from the responses that the teachers had problems in getting their learners to compare their model's performance with that of the original data. The teachers did, however, understand that there is a need to develop adequate knowledge and skills to ensure the effectiveness of validating a model. *Validating the model* is the fifth stage of Maria's (1997) simulation model (see Section 2.6). During the individual interviews, the teachers explained their negative views about learners' ability to compare the models' performance. From Teacher B of School A's response, it can be seen that teachers should be aware that learners should be provided with the ability to draw a working drawing in sufficient detail for the task (DBE, 2011). In addition, learners should be engaged in all steps of the design process. The teachers seemed to understand that a lack of adequate knowledge and skills affects learners' emotions. Learners should thus be provided with adequate knowledge to enable them to compare the model's performance with the original data, this is reflected in the responses below.

> *They need to know if the model has fulfilled the specification and constraints (Teacher A).*
>
> *Learners cannot write a design specification (Teacher B).*

The above responses indicate that the teachers were aware that they should assist learners with a variety of skills in the design process, specifically design skills, and promote knowledge of how to use the design process. They stated that learners need improved skills in writing a design specification. The teachers acknowledged that their learners could not compare their model with the original data, as captured from the responses of Teachers C and D from School B:

> *They cannot decide if the product is an improvement of the existing model (Teacher C).*
>
> *Learners do not know if the model fulfils the function of the product it was designed for (Teacher D).*

In order for a learner to effectively compare the model's performance with the original data, they should know the function of the original model and how to improve on the original data. According to Maria (1997), the process of validation not only ensures that the simulation models are correct, complete, and consistent, but also enhances confidence in the model. Therefore, this behaviour should be gained through the practice of comparing models. The teachers seemed to understand that they should assist learners to compare the model's performance with the original data, as shown in the response below:

> *They need to be given a comprehensive workshop and training to be able to do that alone without assistance (Teacher A).*

This response highlights that there is a need for workshops and training to assist teachers to teach learners how to compare data. Once a learner has completed the simulation model, they must interpret and assess it. During the individual interviews, teachers expressed their views regarding this topic, this will be discussed below.

Question 11: What strategies do you use for learners to test and examine the model correctly?

This question served as a follow-up to Question 10 as a means of allowing the participants to substantiate the manner in which they supported learners to validate the model correctly. Maria (1997) states that testing and examining the model refers to ensuring that the simulation models are correct, complete, and consistent, as well as enhancing confidence in the models. Although it seemed difficult for learners to compare their models' performance with the original model, the teachers seemed to be aware of what was expected from them in assisting learners to test and examine the model correctly. One participating teacher indicated that they would prefer outsourcing to get adequate knowledge on the strategies to be used to assist learners to assess the model correctly, this is illustrated in the excerpt below:

> *I will seek for help and support from other teachers. Those teachers will tell them the areas where they are weak and give advice on how to improve it (Teacher A).*

From her response, the teacher seemed to value gaining information on the different ways of getting adequate knowledge. Teachers should be aware that inadequate knowledge can hinder learning instead of promoting it. The participating teacher appeared to be aware of the purpose of outsourcing as one of the strategies of assessment. The participant also illustrated the purpose of outsourcing.

Her response shows that she was aware that getting information from other teachers would allow her to provide quality education and other related facilities to learners. Some teachers preferred to start with assessment, followed by peer groups and whole assessment. The following statements from Teacher B of School A and Teacher C of School B serve as evidence thereof:

> *Firstly, I will give learners time to use their models to do the work the original model could do. This will help to list the areas that need improvement (Teacher B).*
>
> *First of all, they will check their model then they present the design to their peer, to the group and lastly, to the class as a whole (Teacher C).*

From the above responses, it seems that the teachers used the same method when assisting learners to test and examine the model. The teachers seemed to assist learners in assessing the model by doing self-assessment first. The participants understood the requirements of CAPS, specifically that learners should be provided with an ability to work effectively as individuals and with others as members of a team (DBE, 2011). Teacher B seemed to be aware that learners should be assisted in assessing the simulation model so that they will know the areas that need to be improved.

In the constructivist approach (see Section 3.3), learning is not a passive process, but rather an active one. Therefore, teachers should understand that learning is a social process where learners acquire knowledge through interaction with other learners instead of relying on the teacher (Du Plessis et al., 2011). These teachers seemed to understand that self-assessment, peer-assessment and group assessment allow learners to learn from and reflect on their own performance (DBE, 2011). In addition, during the individual interviews, the teachers indicated the importance of demonstration as one of the strategies to be used in assessing a model. Teachers C and D from School B highlighted the point as follows:

> *I will assist them to do demonstration in the classroom (Teacher C).*
>
> *Let say I am doing the model of a table with my learners, and then I will advise them to make different types of tables. They will use those in order to know the table that will solve the problem identified. This simply means that demonstration is very important (Teacher D).*

Demonstration is the part of the project that allows for the holistic assessment of learners' abilities to apply knowledge, skills and values in the context of a project (DBE, 2011). From the responses, it emerged that most of the teachers were aware that demonstration is important for learners to be able to discover the model that will solve the problem identified. Once a learner is able to demonstrate the model, he/she would also know the strengths and weakness of the model. During the individual interviews, Teacher A explained:

> *Demonstration will assist them to make a list of strengths and weaknesses (Teacher A).*

From the individual interviews, Teacher A was the only one who mentioned the issue of strengths and weaknesses. These teachers need to be aware of the fact that during assessment, learners are provided with an opportunity to know their strength and weakness. This could result in learners understanding how to improve the model.

From the individual interview, it can be seen that the teachers felt that the method of motivating learners should be sustained because according to their understanding, this method was important in testing and examining the model:

> *Awarding marks or prizes depending on the rate of performance helps to motivate them (Teacher B).*

From this response, it seemed that this teacher was aware that there is a need for learners to be awarded as they test and examine the models. Another important point raised during the interviews by Teacher B from School A is that there is a need to motivate learners as they work with the simulation model. The teachers who participated in this study seemed to understand and value the role that they play in teaching learners how to test and examine the model correctly. In order to motivate learners to test and examine the model correctly, the teachers would award prizes to them depending on their level of performance.

The aspect of assessment in validating the model elicited extensive discussion amongst the teachers. Some of them seemed to know the strategies to be used for learners to test and examine the model correctly, which will be discussed below.

Question 12: Validating the model is one of the important skills in the use of simulation. How do you support learners to justify their results?

Justifying the results is an essential skill in the fifth stage of the simulation model (see Section 2.6). Question 12 was a follow-up to Question 10 and 11, and was intended to determine whether the participants were able to support learners in validating the model. Maria (1997) states that justifying the results refers to the ability to examine the results to make sure that they make sense and to check if the solution solves the identified problem. Teachers should support learners in proving the results they have obtained from the model that they have compared and assessed. The four participating teachers in this study indicated how they supported learners to justify the results.

> *Learners need teachers' support in all steps of design process. They will succeed in justifying the results (Teacher C).*

> *Give them support while assessing what they have done will results in great success (Teacher D).*

Learners should be supported in all the steps of design process as they need to be aware that the design process is important in every stage of a simulation. Therefore, they need to be supported and guided on how to justify the results of the simulation problem. Some teachers used methods interchangeably. Teachers A and B of School A and Teacher C of School B indicated the methods that they used in justifying the results. They responded as follows:

> *They have to be given support and advise them on how to improve the model (Teacher A).*
>
> *I will guide and support them in testing the model because they lack knowledge on how to test and prove the results (Teacher B).*
>
> *I guide my learners while critically looking at the data they have collected and give support if there are errors in their activity (Teacher C).*

Guiding, advising and supporting learners in teaching model validation is important as it provides them with the ability to justify the results. These responses seemed to indicate that the teachers understood that learners need to be guided and fully supported as they show their mistakes. This was related to the following comment from Teacher A of School A when she said:

> *Learners cannot justify their results alone because they lack technical expertise. They need someone to observe their work and tell them their weak points (Teacher A).*

This teacher evidently understood that learners should be supported and guided since they lack adequate knowledge to justify the results. Therefore, there is a need for experts to assist learners to justify the results. When learners have contact with their teacher, individual attention becomes easier as the teacher observes them in the validating stage. Teacher A of School A and Teacher D of School B supported this idea during the individual interviews:

> *I will observe them while justifying the results in order to check the areas where they are still lacking (Teacher D).*

In the individual interviews, the respondents seemed to know the purpose of observing learners while validating the model – it allows learners the opportunity to identify the weak points and improve the results of the model. Therefore, learners' confidence to successfully accomplish the task will be raised because they believe that their efforts have been successful (Maria, 1997). Teacher B of School A and Teacher C of School B had the following to say in this regard:

> *I will also monitor them to ascertain whether they can validate the model well. As soon as the models are tested and accepted to function well on what it has been designed for, then the group or individual that performed well should be appreciated with an award to support such group or individual (Teacher* B).
>
> *It is also good to monitor them. I ask them to check if their drawing matches with their peers' design (Teacher C).*

From the above responses, the teachers seemed to be aware that there is a need for learners to be monitored as they justify the results during the validation of the model. The teachers therefore checked if the learners indeed had adequate knowledge in justifying the results. Some of the teachers indicated that they attracted learners' attention throughout the process of validation by asking individual learners to match their designs with those of their peers.

The participants seemed to know that monitoring is necessary during the process of validation to enable learners to justify their results. In order to manage learners, the teachers asked them to check the work of other learners as they would know their strong and weak points. Some of the teachers felt that learners' confidence in justifying the results should be raised through appreciation. It seemed that the teachers were aware that there is a need for learners to be appreciated as a group or individually as they justify their results.

It appears that learners should be encouraged to record and capture all of the stages during the use of simulation as this enhances their ability to justify the results. My argument is that in order for learners to become successful in justifying the results of a simulation, they should be actively involved in the process of validation and self-monitoring during the process. The method of checking their peers' models may have positive effects as this will provide learners with an opportunity for cooperative learning. Teachers should teach learners to work cooperatively when justifying their results.

Question 13: Documenting the model is an important aspect that learners need to consider in a simulation model. How do you encourage learners to record the full details of the model for future use?

Recording (reporting) the details of the model is a sub-skill of ‘documenting’ (see Section 2.6). Thus, Question 13 served as a follow-up question intended to examine whether the participants could substantiate the ability to encourage learners to record details of the model while identifying and formulating the problem, as well as developing and validating the model. Romiszowski (2016) states that documenting the model is a fundamental technique used to assist learners to identify the current state of the problem to know how they can improve. CAPS stipulates that during the design process, learners are required to record and present their progress in written and graphical forms on an on-going basis (DBE, 2011). While investigating the problem, learners should also be encouraged to take notes of whatever information they have gathered. This was supported by Teacher D of School B:

> *I will guide them on how to take notes of the information. Documenting should start from the first stage of modelling. All the information gathered should be documented in order for the coming generation to be able to get it (Teacher D).*

Teachers should understand that they should teach learners how to record and capture the data they have collected. The participants acknowledged that they guided the learners, but that it was not easy to identify strategies that are relevant to recording details of the model. For instance, when the teacher presented a lesson on gear systems, the learners should have understood how to present gear systems graphically as this would allow learners to monitor and revise the process as they go along.

> *I think models that have been certified complete and passed through the final stage of assessment should have a full detailed record of how, where and what have been used for the model. This must be kept in archives future use (Teacher B).*

It should be noted that some of the participants found this question difficult to understand. It seems that the participants found it difficult to encourage learners to record details of the models for future use. This implies that learners were deprived of the opportunity to build their communication skills as an integral part of the design process.

Question 14: What are your personal experiences in developing a model that will solve a simulation problem?

Bandura (1977) and Usher and Pajares (2005) state that learners' self-efficacy is increased when they feel joy and take pleasure from the use of simulation. In addition, this emotional and physiological source of self-efficacy will increase active and critical learning (Bandura, 1977). The CAPS technology document is aimed at encouraging an active and critical approach to learning rather than rote and uncritical learning of given truths (DBE, 2011). Active learning could be used to guide learners in model development (Jeffries, 2005). Question 14 was asked in order to provide the participants with the opportunity to explain their experiences in classroom simulation when developing a model. The participating teachers expressed their feelings of concern about teaching learners how to develop a model that will solve the problem identified. They seemed to be overwhelmed by what they experienced in developing a model. The participants indicated that learners' active participation would assist them in developing the solution model. It is therefore imperative for learners to be actively involved in developing the solution model. However, this was not the case for the participants, as indicated by Teachers A and B from School A and Teachers C and D from School B:

> Very few learners are active in developing a model (Teacher A).
>
> CAPS require learners to participate actively in teaching and learning, so learners are doing the opposite (Teacher B).
>
> Learners are not participating at all (Teacher C).
>
> Learners are not participating actively in teaching and learning (Teacher D).

The participating teachers seemed to understand that the South African Curriculum (CAPS) requires active and critical learning, which encourages an active and critical approach to learning (DBE, 2011). While teachers are required to implement the CAPS curriculum in teaching and learning, it is questionable whether the teachers themselves believed the CAPS curriculum to be important (Dube, 2016), as seen in the responses of Teachers C and D of School B:

> *I am still using the old method of teaching (Teacher C).*

I am still using traditional way of teaching because my learners are performing poorly. CAPS require various skills to be used to enabled learners to develop a solution model but I don't see those skills helping my learners to develop a model (Teacher D).

These teachers did not seem to be knowledgeable about the requirements of the CAPS document. Teachers should use the current national curricular statements for teaching and learning, which expresses the knowledge, skills and values worth learning in developing a model. There is a contradiction and some confusion in Teacher D from School B's statement because the participant was supposed to use the CAPS curriculum to assist learners to develop modelling skills, but this teacher was using the old curriculum which does not develop those skills. This idea could be related to what Teacher A from School A and Teacher C from School B highlighted during the individual interviews:

CAPS requires more practical than theory. I am still using textbook and chalkboard to write notes. I am doing everything for learners (Teacher A).

They want a teacher to do everything for them (Teacher C).

What they want is to copy whatever is written on the chalkboard (Teacher D).

These teachers were doing all the work, while the learners did not actively take part in learning. Teachers should understand that every learner should be given a role to play. While one or more learners are doing a practical, the remaining learners should learn through observing and evaluating (Le Roux & Steyn, 2012). According to Shtub (2016), teachers should provide learners with feedback, which will also help to increase their self-efficacy when developing a model. Teachers should also understand that it is important to involve learners in teaching and learning. During the individual interviews, some of the teachers commented on how the learners enjoyed the old method of teaching as the teachers had to do all the work.

The teachers seemed to understand that there is a need to assist learners in how to use the textbook. Learners should be aware that textbook serves as a guide in teaching and learning. According to Saruf, Ibrahim and Dalim (2014), learners can also develop their knowledge through visualisation.

From the individual interviews, it is clear that the teachers did not experience any positive effect in teaching learners how to develop a model. They seemed to have some ideas on why teaching and learning in developing a model is not effective, which will be discussed next.

Question 15: What challenges do you experience in assisting learners in formulating and developing a simulation model?

Formulating and developing a model seemed to be a challenge for these teachers and learners. The participants expressed feelings of concern and fear that instead of improving, the situation had become worse. The needs of the teachers were not always considered, and this might have resulted in them feeling disempowered. The responses from the teachers about their challenges in developing a model showed their opinions about learners' poor performance in model development. Teacher B from School A and Teacher C from School B had this to say:

> *I am unable to check learners' work individually because the classroom is overcrowded. For this reason, learners are performing poorly (Teacher B).*
>
> *The mobile classroom is overcrowded with more than 60 learners per classroom. There are no enough chairs and tables. Three learners are sharing one table (Teacher C).*

The above remarks highlight a lack of space for practicals as one of the challenges in assisting learners to develop a simulation model. It is evident from the responses that the conditions for classroom simulations were not conducive to the positive effects of teaching. Moreover, overcrowding has implications for health precautions. During the individual interviews, the teachers expressed their unhappiness about the situation. Instead of feeling motivated, they stated that they were stressed and frustrated to have learners who were unable to develop a simulation model. The following remarks by Teacher A from School A and Teacher D from School B represents these sentiments:

> *The teaching of simulation is really stressing us because learners are unable to formulate and develop a model (Teacher A).*
>
> *Developing a simulation model is frustrating to have learners who cannot really develop a model (Teacher D).*

The use of the plural by Teacher A from School A during the individual interviews indicates shared feelings, which confirms that developing a simulation model is indeed a challenge for teachers. However, the teachers in this study still needed to be motivated to assist learners in developing a simulation model. Teachers should be aware that emotional and physiological sources of self-efficacy lead to the successful use of simulation (Bandura, 1977; Usher & Pajares, 2005). These teachers seemed to acknowledge that their frustrations and stresses in developing a model were the result of a lack of knowledge, as shown below in the remarks of teachers A and B from School A and Teacher C of School B:

> *You cannot provide learners with a skill to develop a model if you lack knowledge in developing a model. There is no senior education specialist to train us on how to develop learners' skills in developing a model (Teacher A).*
>
> *There is no adequate knowledge to assist learners in developing a model. There are no subject advisors to visit our schools and assist us to improve the results (Teacher B).*
>
> *I am not trained on how to teach simulation; as such I lack more knowledge on how to teach learners. No workshop on how to teach simulation. As such, I am not sure whether I am doing the correct things or not because there is no government officials to moderate my work (Teacher C).*

It appears that a lack of knowledge was a challenge in developing a model. It can be seen that there is a need for teacher training to assist learners in developing a simulation model. Alternatively, the teachers were of the opinion that there is a need for monitoring, supervision and workshops in order to reduce the stresses and frustrations experienced in the work place.

It is evident from the responses that the teachers had problems, which resulted in learners' poor results. It is significant that the teachers seemed to have no solution to this challenge since there are no government officials to empower them to improve their teaching and thus learners' results. It seems that the teachers were aware that there is a need for training and workshop to improve learners' performance. The teachers were also of the opinion that more time should be allocated to the use of simulation to improve learners' performance in developing a model. In their opinion, time allocation was a challenge. Teachers A and B from School A shared their views:

> *This process needs more time because I am teaching many learners with different levels of thinking (Teacher A).*

I am having only two periods a week, which is not enough for my learners to grasp every data (Teacher B).

The respondents' remarks indicated that they needed more time to assist learners in developing a simulation model. The instructional time in the senior phase for technology is two hours a week (DBE, 2011). Teacher A from School A's response during the individual interviews indicates that the teachers seemed to be aware that learners should be exposed to all levels of thinking in finding the solution to a simulation problem (Du Plessis et al., 2011). Even if teachers have ample time, the use of simulation cannot take place without resources. Learners should therefore be exposed to the necessary resources. Unfortunately, the teachers in this study did not have enough resources to teach simulation in developing a model. This was evident in the words of Teacher B from School A and Teacher C from School B:

I have to write notes for them because textbooks are not enough for all learners. I teach them more on theory than practical (Teacher B).

CAPS textbooks are not enough to cater for all learners. I spent more time writing notes instead of doing practical (Teacher C).

It is clear from the responses of the participants that the adequate teaching of the modern generation needs good technical resources for learners to observe practically as we know that what you see is easier to remember than what you hear (Dube, 2016). It is evident from the responses that the teachers understood that there is a need for textbooks to guide learners on how to formulate and develop a simulation model.

It is evident from the responses that the teachers had problems and that learners could thus not develop a simulation model. Teachers should be aware that learners need to be taught about the skills that will enable them to develop a simulation model. Once a learner has formulated and developed a simulation model, they should carefully examine the results to make sure that they make sense and check if the solution solves the problems that have been identified.

Question 16: Has CAPS any effect in developing learners' knowledge in identifying a simulation problem?

Identifying the problem is the beginning of every problem-solving scenario (Maria, 1997). Therefore, the accuracy of problem identification greatly affects the acceptability and credibility of the simulation's results (Balci, 2012). Teachers must understand that learners should have more knowledge of CAPS, which will assist them in identifying the problem. CAPS provides technology learners with the ability to identify problems using critical and creative thinking, and the ability to collect, analyse, organise and critically evaluate information (DBE, 2011). This question intended to provide the participants with the opportunity to express their opinions on how CAPS affected learners' ability to identify a problem.

Most of the participating teachers commented about learners' way of thinking in classroom simulations as learners did not seem to take any responsibility for their own learning activities. They seemed to enjoy a classroom that is teacher-centred. Teachers should be aware that the use of simulation in CAPS does not involve a traditional classroom environment wherein learning is more teacher-centred. Teaching using simulation is more learner-centred; with the teacher taking the role of the facilitator in the learning process (Jeffries, 2005). The following quotes from Teacher A of School A and Teachers C and D of School B serve as evidence of their learners' thought processes:

> *My learners think that a teacher had to do everything for them in the classroom. I don't see any development with CAPS because it is learner-centred (Teacher A).*
>
> *Changing from teacher-centred to learner-centred is not easy. My learners are not doing well. They don't participate actively in identifying the simulation problem (Teacher B).*
>
> *They think is good for teachers to prepare notes for them. My learners are happy if the chalkboard is full of notes (Teacher C).*
>
> *They think is the teachers' responsibility to give everything in the classroom (Teacher D).*

In order for learners to do well in identifying simulation problems, the active participation of the learner is needed and s/he needs to practice the activities s/he learns in the classroom and from other learners. Learners must be aware that they should combine thinking and doing in a way that links abstract concepts to concrete understanding (DBE, 2011). Therefore, this behaviour should be gained both inside and outside the classroom. In Chapter 2 in Bandura's Theory, the process of self-efficacy is supported by learners' engagement in information processing, problem solving and social organisms. In the constructivism approach mentioned in Chapter 3, learners have to experience and observe so that they can represent, produce or construct a simulation solution.

In identifying simulation problems, the participants did not view CAPS as solution orientated. According to the teachers' comments on the effects of CAPS in simulation, it is obvious that they felt that it was affecting their teaching in a negative way. It is clear that teachers should provide learners with the opportunity to participate actively in identifying simulation problems. Therefore, there is an indication that the participating teachers were aware of the requirements of CAPS, and also had some ideas regarding why simulation problem identification and CAPS were not effective.

There is contradiction and confusion in the participants' responses because they had knowledge of the requirements of CAPS but did not use the knowledge, which would provide learners the ability to participate actively in identifying simulation problems.

The participants showed an indication of learners' attitude in a situation wherein the teachers did not comply with the CAPS requirements. During the individual teacher interviews the participants also indicated their attitude in using CAPS knowledge to identify simulation problems.

The participants had a negative attitude towards the use of CAPS in identifying simulation problems and did not seem to be knowledgeable of the purpose and aims of CAPS. Identifying the simulation problem was also not effective because these teachers were not capable of using CAPS correctly.

Question 17: How do you assist your learners to use simulation in the design process?

Understanding the problem entails how one defines the solution to the problem that has been identified. The technology CAPS document states that the design process exposes learners to a problem, need or want (DBE, 2011). Teachers should understand that learners should be able to point out the principal parts of the problem, the data, and the conditions attached to the problem (see Section 2.6). Teaching and learning in technology involves a creative and interactive approach to develop solutions to identified problems or human needs (DBE, 2011). Therefore, teachers should be aware that they should utilise the design process (investigation, design, make, evaluate, communicate) when developing original ideas to meet needs or wants, and to solve problems. Teachers should teach learners to engage in a systematic process that allows developing adequate knowledge to solve a simulation problem. The participants were aware that it is important to understand the simulation problem and they had knowledge of the design process, as evidences in the remark made by Teacher A from School A:

> *Firstly, I explain the importance of the design process. I'll explain the design process one by one (Teacher A).*

The design process is a fundamental technique used in technology to solve simulation problems. The goal of the design process is to reach a solution that satisfies the desired requirement (Panchal et al., 2013). Thus, the design process can be used to achieve effective simulation in the classroom. The above statement from Teacher A revealed that teachers should introduce learners to the use of the design process in order to understand a problem. The response showed that the concept of 'explanation' is essential as teachers should be able to explain the design process thoroughly. As the learners progress through their simulation activity, they must be taught how to associate knowledge and skills to design and create a problem solution (DBE, 2011).

Teachers need to be aware of the fact that in the classroom, there are learners who cannot use such knowledge. Learners may get lost because they cannot associate the knowledge with the requisite skills. It may be an unfortunate situation for learners who cannot use this knowledge because they cannot develop situations that solve problems. Learners should be taught on the use of simulation in the design process, which involves the decision to decompose the design space (Panchal et al., 2013). Some of the participating teachers seemed to be aware that for learners to understand the problem, they should first be exposed to the problem, they should know the cause of the problem and develop a solution afterwards. The following statements from teachers B of School A and Teacher C of School B serve as evidence:

> *Learners should know the problem first. Knowing the problem will enable them to know the cause of the problem (Teacher B).*

I think it is very important to assist learners on how to get the problem first. Learners can never solve the problem if they don't know how to get the problem and where the problem derived from (Teacher C).

From the participants' responses, it appears that the teachers used the same approach when teaching learners how to identify the problem. The teachers seemed to understand that there are steps to be followed before getting to the solution of the simulation problem. By the time learners understand the problem, they already know the cause of the problem and the solution to the problem. When learners are able to identify the problem, they should understand the principal parts of the problem, which will eventually increase their self-efficacy (Romiszowski, 2016). At this stage, learners should be fluent in the procedures of understanding the problem, which is the goal of simulation, and if learners use simulation without steps/procedures that help to understand the problem, then they do not understand the use of simulation (Taylor, 2010). The comments of Teacher B of School A and Teacher C of School B showed that the teachers understood the principal parts of the problem.

The next section outlines a discussion of the classroom observations that enabled me to confirm the interview data. The participants were asked about the effective use of simulation in the design process. They mentioned that they encouraged learners to participate actively when identifying simulation problems while using the design process. The classroom observations enabled a confirmation of whether the participants were able to encourage learners to actively participate while identifying simulation problems. However, the classroom observations showed that the participants did not engage in the design process in the teaching of simulation use.

The participants were also asked to explain their personal experiences in classroom simulations. They expressed their frustration in the teaching of simulation. During the classroom observations, I observed the participants' stresses and frustrations. An observation schedule was used to record the simulation skills when they were observed during the lessons. During the classroom observation, it was noticed that the participants did not comply with CAPS requirements when teaching the use of simulation. This is further discussed in the sections below.

4.4 OBSERVATIONS

I observed four participants (Teachers A, B, C and D) during their technology period. The observation schedule (see Appendix B) focused on Maria's (1997) simulation model and the design process as prescribed by CAPS (DBE, 2011). The observation schedule was structured using a simulation model with the sub-skills and the steps of the design process. This assisted me to be able to observe the way in which the learners used the design process in a simulation model. I used ticks (√) to indicate the design process and simulation model that were observed. Field notes were taken in order to amplify the observation schedule. I will discuss each case separately, beginning with what was observed, followed by a table to summarise the facts. Lastly, full details of the findings will be provided.

The observations were conducted while the teachers were teaching the topic of Mechanical Systems and Control in the third term. All of the participants were observed in terms of mechanical systems and control wherein learners should have known how the lever and linkages are used to move mechanical systems, the relationship between the input and output and the process of movements, be able to draw the isometric projection of a gear system, and design and make mining headgear.

4.4.1 Teacher A's first observation

Teacher A entered the classroom with a textbook, piece of chalk and duster. She began her lesson on Mechanical Systems and Control (lever and linkages) with notes. Too much time of the first observation was spent on writing notes on the chalkboard. After writing the notes, the learners were given a class activity to write. The activity was as follows:

1. *List five examples of levers*
2. *List five examples of linkages*
3. *Give the meaning of the following words:*
    - 3.1. *Mechanism*
    - 3.2. *Lever*
    - 3.3. *Input*

3.4. *Pivot*

3.5. *Output*

Teacher A (TA) instructed learners to do peer assessment. TA did not explain the notes and the questions of the class activity to the learners; the answers were given to the learners without giving them time to give their own views. Afterward, the learners were instructed to return the book to their peers to write corrections. Although TA provided answers to the learners, her lesson's introduction did not motivate the learners. During the individual interviews, TA responded that: "motivating a learner in every stage is very important." TA was aware that there is a need to motivate learners in every stage of teaching simulation yet in her own classroom the learners lacked motivation right from the beginning of the lesson. TA ended her lesson with a homework activity as follows:

Draw the diagram of the following:

1 a) First-class lever

b) Second-class lever

c) Third-class lever

2. Drawing of a pair of scissor. Show the input, process and output on pair of scissor given.

I noticed that notes were given to the learners because there were no textbooks. During the first observation, the emphasis was only on the theoretical part of the lesson instead of teaching them through both theory and practicals. There was no equipment to do practicals and the teachers did not teach simulation strategies to the learners.

In order to verify whether TA used simulation in the design process effectively during the lesson, I tested her teaching strategy. Du Plessis, Conley and Du Plessis (2011) point out that teachers should have a broad knowledge of teaching strategies in order to achieve specific goals. Additionally, teaching strategies allowed me to address the sub-question in Chapter 1: What experiences do technology teachers encounter with regard to simulation-based programs?

The aim of the lesson was to know how the lever and linkages are used to move mechanical systems. The aim was not achieved since TA did not use any equipment that shows a lever or linkages. TA was supposed to use a pair of scissor as the most accessible equipment, however, a pair of scissors was drawn on the chalkboard. TA was not a facilitator because she used the traditional teaching strategy; learners were not given any chance to dominate in the lesson.

During the observation, TA could not provide enough knowledge on the design process (investigate, design, make, communicate and evaluate), which forms the backbone of technology (DBE, 2011). Learners were not given any opportunity to investigate the situation or how mechanical systems can solve a problem. In order to solve a problem, learners need to have the ability to identify the problem. The introduction of a lesson develops learners' ability to identify the problem. TA introduced her lesson without motivating the learners to actively participate and show interest. Teaching strategy should be taken into consideration in a classroom simulation because it motivates learners to participate actively in the classroom.

Technology teachers should familiarise themselves with the CAPS document, the Learning Programme Guidelines and the Subject Assessment Guidelines. The purpose of these policy documents is to address barriers in the classroom. Teachers should address these barriers by using various curriculum differentiation strategies in the use of simulation (DBE, 2011). TA lacked strategies to motivate the learners in her teaching and learning activities. There is furthermore no evidence that TA followed the policy documents in her teaching because she failed to provide a lesson plan. According to Kola (2017), lesson planning should be used to safeguard the alignment of classroom teaching with the curriculum.

Concerning the activities that were given to the learners, TA asked questions based on lower-order thinking, which assisted learners to recall the information and reproduce it in exactly the same form in which it was first presented. It is very important for learners to have basic knowledge so that they are able to identify the problem. However, TA was supposed to test learners with questions that could assist her to understand the information and to provide proof by formulating the problem, and comparing it with other information.

TA did not meet the CAPS requirements because she was only testing knowledge. TA was supposed to ask questions that encouraged the learners to identify and formulate problems. TA gave learners the class activity to list the types of levers and linkages. The learners gave correct answers whilst referring to their notes. TA was supposed to encourage them to identify the end-users of the product or define performance measures. This could provide learners with the skills to use simulation effectively.

The skills that were observed during the first observation are summarised in Table 4.2 below. The observation schedule was used to capture the design process that was practised during the classroom observation.

Table 4.2: First observation of Teacher A (TA)

SIMULATION MODELS / DESIGN PROCESS	**Problem identification**	Identify problem	Define problem	Scrutinise data	Identify constraints	**Formulate the problem**	Categorise	Brainstorm ideas	Identify end-users	Define performance measures	**Collect and process real data**	Collect data	**Formulate and develop model**	Plan solution	Develop diagram	**Validate model**	Compare model	Test and examine the model	Justify the results	**Document model**	Record details
Investigation																					
Determining new techniques																					
Sorting facts																					

Analysing ideas																					
Comprehend												√									
Design																					
Design specification												√			√						
Identifying constraints																					

TA’s observation focused on the class activity and the homework activity given to the learners. The class activity required only one skill from the design process, i.e. investigation. TA only tested knowledge through the sub-skill of investigating, i.e. comprehend. The homework activity required two skills of design in the use of simulation, i.e. developing a diagram and collecting data. This is a clear indication that TA lacked knowledge of the simulation skills and steps used in the design process.

According to the observation schedule, TA addressed only two simulation skills: collecting and processing real data; and formulating and developing a model. TA was supposed to introduce her lesson with machines that learners use in everyday life and how those machines help to make their life easier. This provides learners with the skill to formulate problems and categorise and brainstorm ideas.

During the individual interview, TA responded that she taught many learners with different levels of thinking ability. TA was aware that there was a need to ask learners questions that would test their knowledge, show their understanding, and demonstrate their ability to apply the given knowledge to solve problem. Asking those kinds of questions enables learners to investigate, design, make and communicate. Learners were not provided with an opportunity to identify the problem, which is the first skill in using a simulation model.

The questions from the class and home activities concerned listing, defining and drawing some concepts on Mechanical System and Control. The learners gave correct answers, and instead of TA encouraging them to give answers verbally themselves, she wrote the correct answers for them on the chalkboard. Learners’ active involvement is one of the skills in the use of simulation as this allows learners to have knowledge about ‘the data’ in the use of simulation. This was another opportunity to bolster the effective use of simulation. ‘What are the data’ is a sub-skill of the first stage of using a simulation model, which is to ‘identify the problem’.

4.4.2 Teacher B’s first observation

The first observation of TB concerned a structure with a mechanism for lifting a load. TB did not adhere to the CAPS requirements since he did not teach this session in the stipulated period. The content was supposed to be the last session of the chapter. TB indicated that he wanted to present this session to prepare learners for formal assessment. It was important to observe this lesson because it required learners to be able to investigate lifting the mechanisms of headgear.

TB began his lesson with some short notes on the chalkboard, thereafter learners were given some pictures of concrete mining headgear. TB asked the learners if they had visited any of the neighbouring mines. All of the learners responded that they had never visited a mine, but they had heard about it. TB told the learners to look at the picture that was given to them. Instead of the teacher giving them an opportunity to discuss the picture, TB explained the picture to the learners. This was an opportunity to provide learners with the skill to identify and define a problem, scrutinise data, categorise, brainstorm ideas, identify end-users, and collect data.

During the individual interview session, TB indicated that for learners to be able to produce good results in the use of simulation, teachers should provide them with an opportunity to think critically. However, this skill was not observed while he was teaching because he did not give learners opportunity to voice their existing knowledge regarding what they observed in the picture of headgear. The skills observed in TB's first observation are summarised in Table 4.3 below.

Table 4.3: First observation of Teacher B (TB)

SIMULATION MODELS / DESIGN PROCESS	**Problem identification**	Identify problem	Define problem	Scrutinise data	Identify constraints	**Formulate problem**	Categorise	Brainstorm ideas	Identify end-users	Define performance measures	**Collect and process real data**	Collect data	**Formulate and develop model**	Plan solution	Develop diagram	**Validate model**	Compare model	Test and examine the model	Justify the results	**Document model**	Record details
DESIGN																					
Initial idea sketches														√							
design specification														√							
Identify constraints														√							

Teams prepare budget																					
Evaluate individual sketches																					
MAKING																					
Draw working drawing															√						
Make a structure																					

The table shows the simulation model skills that were observed from the observation schedule. Ticks (√) were used for the skills that were captured in the classroom observation. The researcher observed that the main focus of TB's lesson was formal assessment instead of teaching learners the steps to be used in the use of simulation.

The learners were not given a scenario to use in order to identify a problem. Kola (2017) states that teachers are required to set a scenario that will assist learners to describe the context in which the specified problem could meet a specific need. When introducing the lesson, TB was supposed to have knowledge of what technology learners are required to achieve, as stipulated by CAPS. TB did not assist learners to develop simulation skills since only one design process skill was achieved. Looking at TB's strategy, as far as the design process in the first observation was concerned, he focused on the 'design' and 'making' steps of the design process. This is a clear indication that TB lacked knowledge of how to use the design process in the use of simulation as there were no lesson preparation as evidence of what he was teaching. TB asked learners to draw an initial sketch of the mining headgear that they wished to make. This is the first stage, 'design', in the design process. In designing the initial sketch, TB asked learners to label the parts and materials carefully and write notes on the making method and the working of the mechanism.

TB's first observation provides a clear indication that this teacher did not adhere to the CAPS document for technology. TB taught his lesson without any evidence from the lesson plan to indicate what he wanted to achieve at the end of the lesson. The lesson preparation was supposed to show how the teacher would use the design process. Table 4.3 indicates TB's evidence on how to use simulation in a design process effectively. TB presented learners with an activity that focused on designing and making only. He did not present all the steps of the 'design', instead he did only two steps, namely, the initial idea sketch and design specification, and identifying constraints. As a result, learners were able to plan the solution and develop a diagram. 'Making' was also recognised as the learners were able to draw a working drawing.

TB did not motivate learners in the use of simulation skills. He gave learners a picture of mining headgear. Learners were not given any opportunity to discuss the picture as TB explained the content of the picture. This is an indication that TB's lesson was teacher-centred and not learner-centred. It is clear that TB did not adhere to the new

South African curriculum, which states that the teachers must shift from a teacher-centred to an actively learner-centred approach. TB was supposed to provide learners with a clue to what had transpired in the picture and give learners an opportunity to give their own view of the picture. It is my conclusion that a teacher should have knowledge on how to motivate learners in the use of simulation.

Motivation stimulates learners to participate actively in the classroom, which gradually enables learners to categorise ideas. TB did not give learners the opportunity to categorise ideas because according to the geographical site of the sampled school, TB could have used the lift at the town mall, which is 7km from the sampled school, as an example. Most of the learners in her class had probably been to the mall at some point or another, thus TB missed an opportunity to motivate learners to categorise and brainstorm ideas on the mechanism needed to lift a load.

During the individual interview session, TB was asked if the learners were able to compare the model's performance with the performance of the original data. TB responded, "No, I don't think so because learners lack the necessary knowledge, ideas and skills to do that". TB did not give learners an opportunity to express their knowledge and ideas as he explained the content of the picture to the learners.

TB misguided learners in his teaching because one cannot design and make a working drawing without knowledge of problem identification. The headgear picture was supposed to be given to learners with a scenario where after each learner would be able to describe a situation where headgear could be used to solve a technological problem. Learners were designing and making a working drawing without knowledge of the problem of the situation. For simulation to be used effectively, learners should identify the problem that exists in the system.

4.4.3 Teacher C's second observation

TC expressed to the researcher her challenges regarding the teaching conditions she taught in, which were not conducive to teaching and learning. She indicated that it was difficult to teach learners the subject without resources. Like TA and TB, TC wrote notes for the learners on the chalkboard. She came to class with a textbook and pieces of chalk.

During the second observation, TC presented a lesson on gear systems. She went further to explain the types of gears. The learners were not given any written activity during the second observation. TC asked questions and the learners responded verbally. She asked learners to explain how the car gear worked and the learners responded that a car cannot move without a gear. Instead of TC asking learners what influences the gear to cause the movement of the car, the teacher asked another question. TC denied learners the opportunity to identify the problem. At this point, TC should have allowed learners to point out the principal parts of the problem, the unknown, the data, and the condition attached to the problem.

Like TB, TC gave learners a picture of different types of gears. She gave them time to look at the picture to see the different types of gear systems. This is a clear indication that TC understood the importance of the pictures in the effective use of simulation. However, these teachers did not have sufficient knowledge on how to use pictures to investigate the situation and the solution. During the interview session, TC was asked how she assisted learners to identify, define and solve a simulation problem, she responded: “I will engage my learner in the learning process through requiring that problem solving and decision-making skills be used to make the simulation run”. However, these skills were not observed during her teaching.

Table 4.4 below summarises TC’s observed simulation skills in the design process. It can be seen that TC’s lesson focused on ‘investigation’ only.

Table 4.4: Second observation of Teacher C (TC)

Simulation model / **Design process**	**Problem identification**	Identify problem	Define problem	Scrutinise data	Identify constraints	**Formulate problem**	Categorise	Brainstorm ideas	Identify end-users	Define performance measures	**Collect and process real data**	Collect data	**Formulate and develop model**	Plan solution	Develop diagram	**Validate model**	Compare model	Test and examine the model	Justify the results	**Document model**	Record details
Investigate																					
Gather data							√		√												
Identify issues																					
Exploration																					
Follow procedure																					

Decision making																					
Design																					
Design specification																					
Identify constraints																					

Table 4.4 indicates that TC addressed two simulation skills, namely ‘scrutinise’ and ‘categorise’. According to the textbook that TC was using, two gears are intermeshed and can regulate the speed or force of motion. TC was supposed to explain the process of movement while teaching. Instead, she continued to another question. During the interview session, TC was asked what she understood about the use of simulation in the design process. She responded that the innovation process is important in the use of simulation in the design process but this skill can be achieved through investigation. If TC showed learners the gear systems inside a car engine, learners could have provided more information about the gear system. Learners could have been identifying and defining the problem before analysing data. TC did not provide learners an opportunity to identify the problem, identify constrains, and collect data. This is a clear indication that TC lacked knowledge on how to assist learners in the effective use of simulation.

While explaining the pictures, TC indicated the different types of gears. She did not explain anything about the shape, size and number of teeth that enable gears to control the speed, direction and turning force in a machine. Through the use of pictures, TC could have provided learners an opportunity to analyse the idea of a gear system, which would enable them to scrutinise data. Scrutinising data is one of the skills in problem identification. TC thus lacked knowledge on how to motivate learners in analysing data.

During the interview session, TC was asked how she ensured that learners select the major problem and its categories effectively. She indicated that she would guide them regarding the procedures/steps of getting to know the major problem and this could be done through brainstorming. During the observation, the skill of brainstorming was not observed. TC did not provide learners an opportunity to formulate the problem. As a result, learners were not given opportunity to develop simulation skills to be effectively used in the design process.

4.4.4 Teacher D’s second observation

Teacher D from School B was purposively observed because she had been teaching technology for more than 10 years. During her second observation, TD’s lesson concerned gear systems. TD came to class with a notebook and papers; she wrote notes on the chalkboard and issued papers to the learners. The notes summarised the concept of gear systems, while the papers concerned the class activity of the gear system. In the class activity, TD asked learners to look at the picture and label it from letter A to letter F.

The picture of the gear system was pasted into learners' classwork books to be able to label the gear system. TD advised learners to revise the work about gear systems to be able to answer the activity. The textbook that TD used provided some questions on the investigation of meshed gear systems. These questions could provide learners with an opportunity to investigate how gear systems rotate. TD did not allow learners to answer those questions. After completing the activity, the learners exchanged their books for peer assessment. TD then gave the learners answers on the chalkboard.

TD did not give learners the opportunity to participate in the lesson. However, she was aware that peer assessment is important in the use of simulation because it provides learners an opportunity to compare ideas. Comparing ideas is an essential skill in the 'design' stage of the design process. During the interview session, TD was asked how to assist learners to scrutinise the data they had collected. She replied that they used peers to assist them in comparing their work. This skill of designing was observed during the second observation when learners used peer assessment.

Table 4.5 shows a summary of the skills observed in TD's classroom observation in terms of the use of simulation in relation to the design process. TD's lesson focused on 'design' and no other step of the design process was presented.

Table 4.5: Second observation of Teacher D (TD)

Simulation model / **DESIGN PROCESS**	**Problem identification**	Identify problem	Define problem	Scrutinise data	Identify constraints	**Formulate problem**	Categorise	Brainstorm ideas	Identify end-users	Define performance measures	**Collect and process real data**	Collect data	**Formulate and develop model**	Plan solution	Develop diagram	**Validate model**	Compare model	Test and examine the model	Justify the results	**Document model**	Record details
DESIGN																					
Initial idea sketches																					
design specification																					
Group ideas							√														

Examining ideas																					
Compare solution							√														
MAKING																					
Draw working drawing																					
Make a structure																					

The table shows that TD did not have skills in the use of simulation because her lesson did not represent all the steps in the design process. TD's activity focused only on the 'design' stage whereby learners compare their solution through peer assessment. During the observation, learners were able to categorise ideas.

Just like TA in her first observation, TD asked learners to label a diagram. The learners were not given an opportunity to explore their ideas of the diagram. TD used questions that used lower-order thinking. TD missed the requirements of CAPS when assessing learners as she did not encourage learners to be creative when asking questions. During the interview session, TD was asked how to ensure that learners develop a diagram that will solve the problem identified. She answered: "learners can be taught on how to present their ideas through drawing". However, the skill of presenting ideas was not observed in this regard.

According to CAPS, technology teachers should provide learners with a diagram/picture together with a scenario that will enable learners to deal with all the steps in the design process. However, TD provided learners with questions that did not encourage learners to deal with all the steps in the design process. During the interview session, TD was asked how to support learners in justifying their results, she responded: "All steps of a design process will help them to justify the results". It is clear that TD was aware that learners should be provided with an opportunity to use all the steps in a design process. However, TD did little to support learners in developing simulation skills in the design process.

4.5 CONCLUSION

This chapter outlined the analysis of the data which, was collected through the use of interviews and observations. The chapter began with the participants' profile. The data analysis process was then discussed in terms of the interviews and observations conducted. In the data analysis process, the researcher presented a summary of the themes that emerged from the data analysis. It was evident that these technology teachers lacked knowledge in teaching the use of simulation. Most of the teachers could not use the design process (IDMEC) in their lessons. This was confirmed during the classroom observations.

The interview questions concerned how the teachers understood the use of simulation in the design process, their personal experiences in classroom simulations, as well as their challenges in the use of simulation. They indicated their views and opinions and reported that they had many challenges in the use of simulation.

From the individual interviews, it can be seen that the teachers were concerned that there was a need for motivation in the classroom for learners to actively participate in classroom simulations. The classroom observations also confirmed that the teaching of simulation was a challenge and that the strategies used in the teaching of simulation were mostly important.

The participating teachers in this study showed a clear indication that they lacked knowledge in the use of CAPS policy documents. The teachers were not able to give learners opportunities to explore their own views. The teachers did not engage learners in the use of simulation skills such as problem identification, formulation of a problem, collecting and processing real data, formulating and developing a model, and validating and documenting a model. None of the four observed participants provided lesson plans to evidence their lesson presentation. Therefore, the sampled teachers did not adhere to the CAPS document.

This study embraced the Social Cognitive Theory, which considers learners' self-efficacy. Self-efficacy allows learners to gain more knowledge from their group members (see Section 2.5). Evaluation is a design process step that provides learners with an opportunity to determine whether the model has solved the problem identified. The next chapter will provide a summary of the study, as well as conclusions and recommendations for further research.

CHAPTER 5 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 OVERVIEW OF THE CHAPTER

This chapter begins with a summary of the previous chapters, highlighting the most important aspects of each chapter. The research questions are examined in order to answer each sub-question and consequently the main question. The limitations of the study, recommendations, suggestions for future research and conclusions are also presented in this chapter.

5.2 CHAPTER SUMMARY

Chapter 1 reported on the importance of simulation for learners, i.e. to produce learners who are more innovative, creative and possess critical thinking skills. The importance of using simulation in technology classrooms was addressed. Teachers' difficulties in the teaching of simulation was one of the aspects explained. A lack of CAPS knowledge with regard to the use of simulation in the design process inspired the main research question in this study, which is: How effective are technology teachers in using simulation in the design process? Three sub-questions were formulated to address the main question. The key terms in this study were also explained.

Chapter 2 provided a review of the literature regarding the use of simulation in the design process, problem-solving skills as a key element of simulation, and the Social Cognitive Theory. A discussion was further conducted on the various studies defining the use of simulation. Chapter 2 concluded with a discussion of the simulation models that were used to guide this study.

In Chapter 3, the research design, research paradigm, population and sampling were presented. The data collection methods were also discussed, followed by a description of the data analysis and the quality criteria for this research. The chapter ended with the ethical considerations of this study.

Chapter 4, which consisted of the data presentation and analysis, commenced with the participants' profile of their academic qualifications and experience in teaching technology. This was followed by the data analysis process. The results and findings from the data analysis were also discussed, followed by the data obtained from the classroom observations. The chapter also provided a summary of the teachers' responses.

5.3 IMPLICATIONS OF THE FINDINGS OF THIS INQUIRY

Technology aims to develop a technologically literate population for the modern world. It seeks to stimulate learners to be innovative and develops their creative and critical thinking skills (DBE, 2011). The features of technology describe what technology teachers should teach learners in order to use simulation effectively. Technology teachers should provide learners with opportunities to learn through practical projects using a variety of technological skills (investigate, design, make, evaluate and communicate) that suit different learning styles (DBE, 2011). The study shows that teachers should possess various skills that will assist them to use simulation effectively. The next section describes the answer to the main research question by addressing each sub-question.

5.3.1 What do you understand about the use of simulation in the design process?

Since the focus of the research was the effective use of simulation in the design process, I sought to gauge the extent to which the participating teachers understood the use of simulation in the design process. The teachers were asked to indicate what they understood about the use of simulation. While responding to this question, they also touched on what they regarded as 'the unlock' when teaching the use of simulation, which will be addressed in research sub-question 1. The data gathered during the individual interviews revealed that the participating teachers understood the concept of simulation.

There was a general feeling among the teachers that the use of simulation entailed understanding the problem. Teacher B explained that "learners should know the problem first, knowing the problem will enable them to know the cause of the problem".

Teacher C mentioned that “it is very important to assist learners on how to get the problem first”. Based on their responses, one would expect that they were teaching learners self-regulating learning strategies. However, the findings from the classroom observations revealed that although the participating teachers said they understood the use of simulation, there was no correlation between what they said and what they did in their classrooms. During the classroom observation, the use of simulation was taught haphazardly. The teachers spent more time explaining the notes than using simulation strategies with the learners. According to Du Plessis et al. (2011), teachers should have broad knowledge of teaching strategies in order to achieve specific goals. In addition, more opportunities should be provided for learners to practise the use of simulation strategies. Teachers should teach learners how to identify simulation problems. During the teachers’ individual interviews, the participants in this study expressed a common understanding of the use of simulation, yet in the classroom they did not clearly apply their knowledge of a simulation problem. Identifying a simulation problem was not taught in their classrooms, thus this was out of line with what they averred during the interviews.

In many instances, the observations indicated that the teachers asked learners questions based on low-order thinking only. It was very difficult for the participating teachers to use both lower-order and higher-order levels of thinking while asking learners questions. The participants also emphasised various skills in the use of simulation to enable learners to identify simulation problems. According to the CAPS technology document, learners should be provided the opportunity to use a variety of life skills in authentic contexts (DBE, 2011). The manner in which the participants asked learners questions differed from this CAPS requirement.

My understanding is that the aim of simulation is to imitate a real situation, to perform the demonstrated activities in simulated conditions, as well as experiencing the consequence of their actions and decisions. Du Plessis et al. (2011) concur, arguing that simulation is a teaching technique that imitates a real condition in the classroom. Therefore, there is a need for a practical where one imitates a real condition. However, from the classroom observations conducted, the participating teachers spent more time explaining notes than doing practicals.

Bandura regards learners' behavioural capability as important for enhancing the use of simulation. Learners must be able to gain further knowledge from their group members or environment. This idea is echoed by Bakhan, Bidita and Mridula (2017), who find that during the use of simulation, learners learn from the behaviours of their group members, which in the context of this study, were teachers and peers (Chapter 2, Social Cognitive Theory).

5.3.2 What are the opportunities that CAPS provide in supporting learners to develop simulation skills?

The DBE (2011) clearly states that the design process should be used as the backbone of teaching technology. In CAPS, learners are provided with opportunities to "use knowledge, skills, values and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration" (DBE, 2011:PAGE NUMBER).This indicates that CAPS supports the use of simulation in the design process.

'Investigate' as the first step of the design process encourages learners to gather data, grasp concepts and gain insight (DBE, 2011). These activities are opportunities for the effective use of simulation where learners are required to investigate solutions to simulation problems. When learners are collecting data, they are required to have simulation skills. The ability to collect data provides learners with the opportunity to identify simulation problems, which clearly shoes that CAPS supports learners in the use of simulation skills.

The 'design' step of the design process requires learners to write a design brief and draw initial idea sketches (DBE, 2011). All of these activities are design opportunities that are offered in CAPS for the effective use of simulation. In order to draw initial idea sketches, learners require the ability to decide on what the model must do in order to solve the problem identified. In order to write a design brief, learners should have simulation skills because they need to know the problem and the solution to the problem. This means that learners should possess simulation skills before writing a design brief.

The design process also allows learners to 'make' a simulation model. Making requires learners to use tools and equipments, build, test and modify the product; while measuring and marking it (DBE, 2011). It is very important for learners to choose the correct tools and equipment while making a simulation model. Learners should use appropriate measuring and marking equipment while building a simulation model. Once the simulation model is built, learners should test the model's performance under known conditions against the performance of the real system. This requires simulation skills because learners must ensure that the model's assumptions are correct, complete and consistent. Learners must evaluate the model in order to modify it.

CAPS states that every stage of the design process should be evaluated (DBE, 2011), thus learners are required to evaluate every step of the design process. This will provide them the opportunity to seek a solution to simulation problems. 'Evaluation' offers opportunities to support learners in using simulation skills because learners can use this to select only the best ideas. 'Evaluation' is necessary as a simulation skill because learners can then suggest some changes or improvement where necessary.

During the 'communication' step of the design process, learners are required to record and present their progress in written and graphical forms. CAPS states that recording should be done from conception to realisation of the solution (DBE, 2011). Simulation skills require learners to provide evidence of the process they have followed while investigating, analysing, planning, designing and evaluating the solution. All the steps of the design process should be presented verbally or electronically. 'Communication' requires learners to 'document the model for future use', which is the sixth stage of the simulation model followed in this study (Maria, 1997). Thus, 'communication' provides an opportunity to support learners to develop simulation skills.

5.3.3 What experiences do technology teachers encounter with regard to simulation-based programs?

The aim of the South African curriculum (CAPS) is to ensure that the educational imbalances of the past are redressed (DBE, 2011). In technology, teachers should associate the knowledge and skills needed to design and create a solution. In addition, they should know how to use knowledge through the design process, which forms the backbone of the subject (DBE, 2011). The results of this study indicate that all of the participants had challenges in the use of knowledge through the design process. Teacher C reported that for her to assist learners to scrutinise data, "learners need skills on how to gather information procedurally”. ‘Scrutinise data’ is the sub-skill of ‘investigation’ (see Section 2.6). Teacher D mentioned that “he teaches learners to arrange data they have collected in a serial order and they begin to address them by knowing the frequency”. During the classroom observation, Teacher C and D could not verify how they assisted learners in the process of ‘investigation’ as the first step in the design process. This implies that these teachers lack the knowledge to provide learners with the opportunity to investigate.

During the ‘design’ stage of the design process, learners are required to write a design brief, generate possible solutions, draw initial idea sketches, group and examine ideas (DBE, 2011). The results revealed that the participants were ineffective at supporting learners to group ideas and compare technological solutions. For instance, Teacher B indicated that “learners need to be guided on how to examine ideas”. However, Teacher B did not stipulate how to support learners to develop the ability to examine ideas.

The process of ‘make’ in the design process requires learners to use appropriate tools and equipment to build a simulation model. Because they use tools and equipment, the simulation skills that technology teachers should use with this aspect of the design process is the capacity to ‘develop a diagram for the solution’. The study revealed that the participants were unable to encourage learners to ‘*develop a diagram’* for the simulation solution. During the classroom observation, Teacher A denied learners the opportunity to *develop a diagram* because there was no equipment used during her lesson. However, Teacher B asked learners to draw a working drawing of mining headgear. Teacher C indicated that “it was difficult to teach learners without resources”. Teacher D also denied learners the opportunity to ‘develop a diagram’ during the design process.

The stage of ‘evaluate’ allows learners to choose the best idea. According to Maria (1997), learners should evaluate the simulation’s performance under known conditions against the performance of the real system. At this stage, learners are required to suggest improvements to their simulation model. CAPS states that the ‘evaluate’ stage is essential in all stages of the design process and determines the next step to be carried out (DBE, 2011). During the interviews, the participants were asked to explain whether their learners were able to compare the model’s performance against the performance of the original data. This activity is included in the ‘evaluate’ step of the design process. The findings revealed that the learners were unable to evaluate a simulation model. The participants indicated that their learners lacked adequate knowledge and the necessary skills in the process of ‘evaluation’.

‘Communicate’ requires learners to record and present the process from investigation to communication (DBE, 2011). The findings revealed that the learners were unable to record the details of a model for future use. Teacher D indicated that “learners fail to present in the classroom whatever they have modelled”. Therefore, the learners were unable to participate actively because they could not associate the knowledge and skills needed to design and create a simulation solution. The implication is that the learners were unable to use simulation effectively because they lacked knowledge and skills in using the design process.

All of the participants explained that their learners did not actively participate in the use of simulation. My understanding was that this was the case because the teachers’ work was not planned. According to Kola (2017), when teachers plan sufficiently, it allows and assists them to place emphasis on learners’ active participation in the learning environment. The participants were aware that the technology CAPS document requires learners to be active and critical in learning (DBE, 2011). The teaching venue was also a challenge for these technology teachers. Designated technology classrooms should have the minimum requirement of tools and resources (DBE, 2011). During the interviews, the participants indicated that their classrooms were overcrowded and without resources. This lack of resources compelled these teachers to use the old method of teaching instead of using the methods promoted by CAPS.

Teacher A asserted, “I am still using textbook and chalkboard to write notes”, while Teacher D mentioned, “I am still using traditional way of teaching because my learners are performing poorly”. All four participants admitted that they had problems providing learners with the opportunities to actively participate in classroom simulations. The participants did not derive any solution to the problem of passive participation in the use of simulation. Instead, they used the old method of teaching.

CAPS stipulates that the time allocation for technology is two hours per week (DBE, 2011). During the interviews, the participants explained that the given teaching time was not enough to provide learners with the ability to use various skills in the development of a simulation model. Teacher A indicated that “CAPS require more practical that theory”. The implication is that these teachers used the old, outdated method of teaching because they claimed that CAPS is too time consuming.

One of the requirements of the technology CAPS document is that learners should be provided with a designated teaching venue with a teacher who is developed in the appropriate knowledge and skills (DBE, 2011). This study adopted Maria’s (1997) simulation models, which are: identifying a problem, formulating the problem, collecting and process real system data, formulating and developing a model, validating the model and documenting the model for future use. Teachers should have developed skills in the effective use of simulation. The results of this study indicate that all of the participants had problems in the effective use of simulation due to a lack of training and workshops. Teacher A alluded to the fact that “there is no senior education specialist to train us on how to develop learners’ skills on developing a model”. Teacher B responded, “There is no subject advisor to visit our schools and assist us to improve the results”, which was echoed by Teacher C, who stated, “I am not sure whether I am doing the correct thing because there is no government official to monitor my work”. This implies that these teachers could not provide learners with the ability to use simulation effectively because they lacked the appropriate knowledge and skills.

5.4 LIMITATIONS OF THE STUDY

While technology is offered from Grade 4 to 9, the focus of this study was on the effective use of simulation in the high school design process. Interviews with intermediate phase teachers would have been ideal to determine their experiences in using simulation in the classroom. During the individual interviews, the participants complained about the teaching methodology in technology. The participating teachers thus may not have used the design process as it is the key element used to approach tasks in the subject of technology.

During the classroom observation, the participants were uncomfortable. They demonstrated a limited understanding of the use of simulation in the design process. The technology CAPS document stipulates that teachers need to have knowledge of the design process (DBE, 2011). In this study, the teachers were not successful in connecting the opportunities offered by CAPS to simulation in their classrooms.

Teachers' training has a strong influence on practice. Teachers are the key role players in teaching learners how to use the design process in the use of simulation. Throughout the interviews, the teachers indicated that the training of and workshops for teachers are very important.

Maree (2011) highlights that due to time and costs constraints, it is seldom possible to include the entire population in a study. Sampling involves the selection of a workable number of participants from the research population under investigation (Babbie & Mouton, 2015). In this study, I selected two sampled schools in the Tubatse circuit. Two sampled schools were selected for the study due to a lack of funds. However, there were no resources in the two sampled schools. School B used mobile classrooms, which were overcrowded. School A was also overcrowded. The two sampled schools were not conducive to learning as they presented a hazard to learners' health. The researcher was expected to observe the effectiveness in the use of simulation while working safely and using appropriate tools in the classroom. According to CAPS, learners must have a designated teaching venue with a teacher who has developed the appropriate knowledge and skills (DBE, 2011). A well designated teaching classroom might have produced different findings.

The first classroom observation was conducted at the beginning of term 3, which meant that some learners from the two sampled school were absent due to cultural activities that took place in their community. This, to some extent, hindered this study because there was no actual observation of how the learners used simulation effectively in the classroom.

5.5 RECOMMENDATIONS

It is important that technology teachers have adequate knowledge on the use of simulation and the skills required to make simulation effective. Teachers should enrol at higher education institutions to upgrade their knowledge in the teaching of technology. Teachers should further provide learners the ability to identify and formulate a problem, collect data, develop a model, validate the model and document the model for future use. These skills will help learners to be successful in the use of simulation. These skills also require learners to participate actively in their classroom simulation. Learners should not depend on the teacher; the teachers are there simply to guide and motivate them, this can be done by giving awards or prizes to motivate learners to participate actively in the classroom simulation.

To uphold the value of technology, teachers must be well trained in order for them to equip learners with information and be able to connect CAPS to the use of simulation. The effective use of simulation requires teachers to be able to contextualise the principles of CAPS to suit their particular situation. Teachers should be empowered, supported and monitored in the use of simulation. Teachers must have a workshop on how to use a work schedule with lesson plans, and how to follow that work schedule. They must be aware of the importance of using a lesson plan in their everyday teaching. I recommend that the Department of Basic Education should employ technology Senior Education Specialists (SES) in all circuits to monitor and support technology teachers in their pursuit of teaching technology using simulation.

5.6 SUGGESTIONS FOR FUTURE RESEARCH

Future research is recommended on the effective use of simulation in the intermediate phase (Grade 4-6). The two sampled schools were overcrowded with no resources to be used in simulation. It is further recommended that investigation should be conducted in a well designated classroom with all the necessary tools and resources.

5.7 CONCLUSION

This study investigated the effectiveness of the use of simulation in the high school design process. The findings of the study revealed that the participants were not conversant with the use of simulation. The participants in this study indicated their challenges, which affected the use of simulation in the high school design process. The participants were unable to provide learners with opportunities to develop simulation skills such as identifying and formulating a problem, collecting data, formulating and developing a model, validating a model and documenting a model for future use. The implication is that the participants lacked adequate knowledge of the purpose and aims of technology.

Technology is the use of knowledge, skills, values and resources to meet people's needs and wants. The participants demonstrated a lack of knowledge, skills and resources as required by CAPS. The participants were thus not successful in teaching learners the knowledge and skills needed to design and create a simulation solution. This implies that the content of the CAPS document was compromised and this is where simulation, as a new teaching approach in technology, could have been developed.

Technology tasks should be approached through the use of pictures and scenarios, which requires a teacher to understand all the steps in the design process. This should be done in order to demonstrate how a technology task meets and solves a simulation problem. The participants should have provided learners with opportunities to understand how a gear system meets and solves a problem/need. The participants used pictures without a thorough interpretation given to the learners. Instead, the participants asked the learners to label the gear parts system. In essence, the use of pictures enables technology teachers to teach learners to use a variety of life skills in authentic contexts, such as creative thinking, problem solving and needs identification. This study emphasised the opportunities that affected the development of simulation skills, such as problem identification. By failing to teach learners how to interpret a picture, the participants deprived their learners of an important opportunity to develop simulation skills in technology.

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APPENDIX A

Open ended questions

1. What do you understand about the use of simulation in a design process?

2. How do you assist learners to identify, define and solve simulation problem?

3. How do you motivate and encourage your learners to collect data effectively and efficiently?

4. Do you think learners are able to brainstorm different issues that need to be addressed in the use of simulation?

5. When learners are formulating a problem, how do you assist them to define performance measures?

6. How do you assist learners in identifying the end users of the simulation model?

7. Learners need to know the major simulation problem when formulating the problem. How do you ensure that they select major problem and its categories effectively?

8. How do you ensure that learners develop a diagram that will solve a problem identified?

9. CAPS provide learners with an opportunity to collect, analyse, organise and critically evaluate information. How do you assist learners to scrutinise data they have collected?

10. Do you think learners are able to compare the model's performance with the performance of the original data? Please explain.

11. What strategies do you use for learners to tests and examine the model correctly?

12. Validating the model is one of the important skills in the use of simulation. How do you support learners in justifying their results?

13. Documenting model is an important aspect learners need to consider in simulation model. How do you encourage learners to record full details of the model for future use?

14. What are your personal experiences in developing a model that will solve the simulation problem?

15. What challenges do you experience in assisting learners in formulating and developing a simulation model?

16. Has CAPS any effect in developing learners' knowledge in identifying simulation problem?

17. How do you assist your learners to use simulation with design process?

APPENDIX B

SIMULATION MODEL / DESIGN PROCESS	**Problem identification**	Identify problem	Define problem	Scrutinize data	Identify constraints	**Formulate problem**	Categorize	Brainstorm ideas	Identify end users	Define performance measures	**Collect and process real data**	Collect data	**Formulate and develop model**	Plan solution	Develop diagram	**Validate model**	Compare model	Test and examine the model	Justify the results	**Document model**	Record details
INVESTIGATION																					
Investigate the problem																					
Investigate the solution																					
DESIGN																					

Initial idea sketches																					
design specification																					
Identify constraints																					
Teams prepare budget																					
Evaluate individual sketches																					
MAKING																					

Draw working drawing																					
Make a structure																					
COMMUNICATE																					
Team presentation																					