# Exploring learners' conceptual development using computer simulation in a Grade 10 Science class

By

Hodi Elias Tsamago

MINI DISSERTATION

Submitted in partial fulfilment of the requirements for the degree of

**Masters of Education**

In

**SCIENCE EDUCATION**

In the

Department of Mathematics, Science and Technology Education

**School of Education**

In the

**FACULTY OF HUMANITIES**

At the

**UNIVERSITY OF LIMPOPO**

**SUPERVISOR**: Prof. I Kibirige

**2017**

## ABSTRACT

*One of the effective ways of teaching science is by developing the thinking abilities of individuals by allowing them to engage in enquiry-based learning. Computer simulation (CS) can help improve understanding of scientific concepts and enhance conceptual development and performance. This study focused on exploring learners' conceptual development using CS in Grade 10 science class. A pre- and post-test research designs were used. 105 Grade 10 learners participated: 53 from one whole class were assigned to an Experimental Group (EG) and 52 from another class to a Control Group (CG). The EG was taught using CS while the CG was taught using the traditional approach. Data on learners' performance were collected using a performance test and interviews were employed to collect data on learners' attitudes towards science. The results revealed that the EG performed better than the CG (t-test, $p < 0.05$), (ANCOVA, $p < 0.01$). Girls in the EG performed better than girls from the CG (t-test, $p < 0.05$), and independent sample t-test revealed that girls in the EG were in the same range with boys after intervention suggesting that CS did not discriminate against gender in this study. Furthermore, the results from interviews indicate that learners from EG exhibited positive attitudes towards science, unlike their counterparts from the CG. This suggests that learners from the EG may have been excited to observe phenomena on the screen of a computer that they would otherwise not do due to lack of laboratory equipment in their school.*

**ACKNOWLEDGEMENTS**

I wish to thank the supervisor Prof. I Kibirige, schools that were involved and the Department of Education (Capricorn district) for both the cooperation and collaboration during the study. I would like to express my sincere gratitude and appreciation to all the learners who participated in this study.

## DEDICATION

This study is dedicated to my wife Tshidi, my daughter Mashau and my son, Seshudu for their continued and undying love, support and understanding. Without this lovely family none of this could have been realised.

## DECLARATION

I declare that this dissertation: ‘Exploring learners’ conceptual development using computer simulation in Grade 10 science class’ has not previously been submitted by me for a degree at this or any other university; that it is my own work in design and execution, and that all material contained has been duly acknowledged.

Tsamago Hodi Elias

Signed…… Date……..

## TABLE OF CONTENTS

## LIST OF TABLES

# CHAPTER 1: INTRODUCTION

## 1.1 Background to the study

The development of thinking ability in individuals has always been recognised to be of great importance to enable them to make decisions wisely and to solve problems efficiently (Abdullah & Shariff, 2008). Some countries like Malaysia developed their curriculum around thinking skills and are being referred to as a set of mental capabilities or patterns of thought which are rational or logical in nature (Abdullah & Shariff, 2008). Learner engagement has primarily and historically focused upon increasing learner thinking skills and achievement (Taylor & Parsons, 2011). However, it is a difficult exercise to fully engage learners in overcrowded and under-resourced classrooms (Hug, Krajcik & Marx, 2005). Osborne and Collins (2003) explain that lack of space for learners to engage personally with the subject contributes to their negative attitude towards the subject. As a result, alternative ways of engaging learners become essential (Hug, et al., 2005). More recently, learner engagement has been built around the hopeful goal of enhancing all learners' abilities to learn how to learn or to become lifelong learners in a knowledge-based society (Gilbert, 2007). The ability of learners to know how to learn makes a science class more interesting, active and productive (Folaranmi, 2002).

Researchers have also studied learner engagement in a science class (Annetta, Holmes & Cheng, Minogue, 2009). Engagement is often defined as 'the mobilisation of cognitive, affective and motivational strategies for interpretive transactions with text' (Bangert-Drowns & Pyke, 2001). It is mostly associated with inquiry-based learning. Learners learn well when they participate in practical work (Hug, et al., 2005). There are many changes taking place in the way that other countries engage in science education, now there is great emphasis on adding creativity to science and making practical work a high priority in the classroom (Folaranmi, 2002). Shami (2001) suggests that in inquiry learning, learners acquire the skills of observing, classifying, measuring, conducting experimenting, recording, analysing, interpreting, making inferences, communicating and manipulating data. However, it is practically unachievable in an overcrowded science class where a teacher has 30 minutes period to do practical work (Annetta, et al., 2009).

The teaching of Physical Sciences, like other science subjects, should focus on the development of scientific concepts, attitudes and skills (Khan & Iqbal, 2011). However, in a large science class where the teacher cannot be able to reach out to every learner and there are no sufficient resources to perform practical work, it makes it difficult to achieve (Felder & Prince, 2007). In such class the only way teachers teach learners is by direct transmission of information from textbooks (Folaranmi, 2002). Yet, inquiry-based learning approach seems to have much potential to let learners learn effectively in a science class (Shami, 2001) and yet it is seldom used in rural South African Schools (Malcolm, 2010).

Research shows that learners learn better when they construct their own understanding of scientific ideas within the framework of their own existing knowledge (Bransford, Brown & Cocking, 2000). To accomplish this process, learners must actively engage with the content and must be able to learn from that engagement (Osborne, Simon & Collins, 2003). It has been indicated by Shami (2001) that laboratory inquiry enhances learner engagement and motivates learners to learn science with great interest, however laboratory enquiry alone is not sufficient to enable learners to construct complex conceptual understanding of the contemporary scientific issues. “If learners’ understandings are to be changed toward those of accepted science, then intervention and other teaching methods are essential” (Driver, 1995). Although many practitioners would agree that good quality practical work can engage students, help them to develop important skills, help them to understand the process of scientific investigation, and develop their understanding of concepts, other effective methods are needed to enhance conceptual development (Lazarowitz & Tamir, 1994). Other teaching methods may include interactive computer simulation to engage learners and develop their understanding of scientific concepts (Annetta, et al., 2009).

Over the last decade, new technologies have made rich and dynamic visual representations possible on common personal computers (Annetta, et al., 2009). This visual representation gives users of educational simulations the control and flexibility to make changes and see the effects in real time (Annetta, et al., 2009). With these advances, simulations can provide learners with opportunities for rich and

dynamic educational experiences as well as instantaneous feedback on the results of a virtual “experiment,” (Podolesky, Perkins, & Adams, 2010; Sentongo, Kyakulaga & Kibirige, 2011). Instead of teachers explaining what happens when one factor is controlled and another one is either decreased or increased, learners will be able to observe on the computer screen what happens. As a result, CS gives immediate feedback to learners and it helps them to develop understanding of science concepts.

This is seen as a possible solution to science classes where teachers save time that might be spent on assembling apparatus in schools. This helps teachers in schools that do not have laboratory equipment to demonstrate on the computer (Annetta, et al., 2009; Podolesky, et al., 2010). However, CS cannot replace the science laboratory, but it can support with virtual reality.

The use of CS could help in classes with many learners wherein a projector can be made available for all learners to observe on the screen even if the school has just one computer in a science class that is not well resourced (Annetta, et al., 2009; Podolesky, et al., 2010). In essence, the activities that learners engage in with CS can be quite different from those in traditional educational environments (Podolesky, et al., 2010; Van der Meij & de Jong, 2006). CS provides learners with access to questions and methods of inquiry which are well aligned with the ways scientists use experiments for exploration and discovery (Podolesky, et al., 2010).

Learners live in a world that engages them differently when compared to the world their parents experienced. These learners respond to this world which has changed over the last twenty years in response to their engagement with a technology rich society (Taylor & Parsons, 2011). It will be beneficial to learners if teachers take advantage of this rich technology opportunity. Involving learners in CS will be in line with Project Tomorrow of 2010 which indicates that we need to meet the needs of learners who have grown up in a digital world and are heading into different cultural and economic futures rich in ever-advancing technology and information (Taylor & Parsons, 2011). This also supports the notion of inquiry based learning that, according to Shami (2001), has much potential for learning in a science class.

While the use of technology can assist to improve learner engagement in a science class, it has not been clarified on how technology can improve learner engagement and no relationship between the use of technology and learner performance as well as conceptual development has been established (Taylor & Parsons, 2011). This study will focused on exploring learner conceptual development using CS in a science class.

## 1.2 Statement of the problem

Teaching science requires resources so that learners can handle and manipulate apparatus. During that process learners learn many invaluable skills in science concepts. Unfortunately many schools lack science resources (Howie, 2003, Xulu, 2012) and as result these schools do not perform practical work in science classrooms. Thus, the problem is that schools do not conduct practical work. The CS is envisaged to compensate for resources required to perform practical work. CS could provide the demonstrations using the software that provides the use of the apparatus that the school does not necessarily have adequate financial means to purchase them. Engagement is mostly associated with inquiry-based learning, a by-product of practical work (Folaranmi, 2002). Learners learn well when they participate in practical work (Annetta, et al., 2009). Hug, et al. (2005) explain that when learners are actively engaged in inquiry learning, their conceptual development improves significantly. CS will not be a challenge since many schools have started using computers (Dix, 2003). Many teachers are now familiar with the use of computers (Dix, 2003). Since the simulation programs need to be purchased, if one computer is loaded with the program it can be able to run for the whole school for learners who enrolled in Physical Sciences.

## 1.3 Aim of the study

The aim of this study was to explore learners' conceptual development using computer simulation in a Grade 10 science class.

## 1.4 Objective of the study

The objectives of the study were to:

- establish whether the visualization of phenomena through CS can contribute to learner's conceptual development in science;
- establish whether learners' performance increases when they are taught using CS; and
- explore learners' attitudes after using CS in a science class.

## 1.5 Significance of the study

The study was vital to teachers who teach Grade 10 science classes without resources in order to mimic practical work. Practical work was done on the computer using CS. Learners used the computer to observe how "waves" behave. This experiment enabled learners to develop conceptual understanding of transverse and longitudinal waves. Though some experiments on waves are dangerous, CS is mostly safe to perform even those that might be dangerous to perform in a laboratory. The learners would be able to simulate the experiment and observe what happens when they changed the frequency, the amplitude or the wavelength of the transverse wave and they can measure wavelengths of both high and low frequency and get the same results like someone using physical laboratory equipment.

## 1.6 Theoretical Framework

The theoretical framework of this study is the on Piagetian cognitive theory. Piaget (1952) believed that the cognitive development of learners towards formal thought could be facilitated through assimilation, accommodation and reorganization. Learners might experience cognitive conflict when trying to understand new information which raises questions that they cannot resolve with their existing knowledge. This cognitive conflict can be resolved through visualization of physical phenomena via dynamic CS which develops conceptual understanding on science. Research suggests that CS is one of complementary activities that support practical work to facilitate learner interaction with science concepts in ways which are

otherwise difficult to achieve (Taylor & Parsons, 2011). It makes learners recognise in what ways their current thinking fall short and reorganize their beliefs.

Computer simulation may be seen as a way to promote learner engagement and interactions. Although the way in which information is distributed does not necessarily change the message, the method of delivery and incorporation of technology can change the way the information is absorbed and how much of the information is retained (Gitlin, 2001; Thurlow, Lengel, & Tomic, 2004). The incorporation of technology in the classroom can be quite useful, as “the use of virtual environments for collaboration and learning can result in unprecedented flow of ideas, leading to higher levels of productivity” (Chandra, Theng, Lwin, & Foo, 2009). CS creates such virtual environment that learners might perceive to be true and useful for their conceptual development (Podolesky, et al., 2010).

## 1.7 Definition of key concepts

Computer Simulations- Are computer programs that can be either small, running almost instantly on devices to simulate scientific situations that either dangerous, expensive or impossible to run in the laboratory.

Conceptual Development- General understanding of ideas that can be used to group together objects, events, qualities that are similar in some way to make people make sense of the world.

Learner Engagement- Mobilization of learner cognitive, affective and motivational strategies to foster effective learning.

## 1.8 Thesis outline

This is a mini dissertation structured in chapters that detail all the finding generated by this study starting with the introduction where the background of the study is outlined. Other Chapters include literature review wherein the study focused on the gaps that have not been filled by other researchers in this domain, research methodology which outlined the population that was targeted in this study among

other things. The results of the study are tabled in chapter 4 and the findings are discussed lengthily in chapter 5 under discussion. The references in this study are written in line with APA requirements.

## 1.9 Concluding remarks

This study focused on exploring learners' conceptual development using computer simulation in a grade 10 science class. The study was conducted on the assumption that the use of Computer Simulation in a grade 10 science class could prompt the effective way of teaching science and encourage learners to engage in inquiry-based learning. As a result, that computer simulations have a potential to improve understanding of scientific concepts and enhance conceptual development and performance of learners. The results are therefore tabled in chapter 4 to demonstrate the findings of this study.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

Currently, most learners struggle to learn high order cognitive skills in Physical Sciences such as inquiry, this is mainly because of lack of resources to teach them properly (Harper, 2000). From this point of view, the use of computer simulations would be used to reflect the complexity of real life and be used to take learners to an environment where they would be able to conduct meaningful inquiries with the support of multimedia. Computer simulations therefore become an important tool to engage them in their own learning which in turn scaffolds their learning, hence this is one of the fundamental features of constructivist learning environment (Jonassen, 1995).

## 2.2 Engaging learners in a science class

To teach is to engage learners in learning; thus teaching consists of involving learners in the active construction of knowledge (Jenson, Lewis, & Smith, 2002). A teacher requires not only knowledge of subject matter, but knowledge of how learners learn and how to transform them into active learners (Jenson, Lewis, & Smith, 2002). When a teacher goes into a classroom, s/he prepares a lesson by setting out the objectives that s/he wants to achieve at the end of the lesson. It then becomes the responsibility of the teacher to ensure that what is intended for learners to learn has been learned. The question will be whether the teacher simply transmits the information to the learners or provides an opportunity for the learners to construct their own knowledge.

Over the last century science educators have tried repeatedly to reform science education (Fetters, Czerniak, Fish, Shawberry, 2002). Learners engage in scientific inquiry to cease being passive receptors of information. In many instances learners gain more in inquiry learning than in passive class and they develop positive attitudes toward science (Shymansky, Kyle, & Alport, 1983). The aim of teaching with CS is to transform learners from passive recipients of knowledge into active constructors of their own knowledge (Palmer, 1998).

The following section discusses how teachers teach science, learners' performance in science, learners' interest in learning science and an alternative to laboratory work.

## 2.3 How teachers teach in a science class

Do all teachers teach with an aim of transforming learners and to make them active constructors of knowledge? This question can be addressed by observing teachers. Although they always complain about lack of resources in schools that prohibit learners from performing practical work, yet there could be other avenues to conduct it. It is because of this reason that teachers do not engage learners in active learning (Sentongo, Kyakulaga & Kibirige, 2011). In many schools learners are still taught without practical work and yet they are expected to perform well in class and be creative thinkers. How teachers perceive teaching and learning and how they really teach are influenced by their understanding of the nature of science (Brickhouse, 1989). Being engaged in science teaching and learning requires individuals to be able to carry out research projects by asking questions, constructing hypotheses, predicting outcomes, designing experiments, analyzing data, and reaching conclusions (NRC, 2005). The more the teachers understand the nature of science the more they are able to help their learners to develop conceptual understanding in science (Klassen, 2006). Therefore, science teaching in schools should focus on Nature of Science and principles of enquiry, that is, the conceptual structures of scientific knowledge are changeable.

In many African countries, including South Africa, learners do not do well in Science (Howie, 2001). The Third International Mathematics and Science Study Repeat Survey (TIMMS-Rs) conducted in 2003 showed that South African learners' performance in mathematics and science was significantly poor in basic science and mathematical skills than the vast majority of other participating countries (Reddy, 2004).

## 2.4 Factors responsible for the poor performance

The poor performance may be attributed to a number of factors. A study that was done in Nigeria indicates that factors that contribute to poor performance include:

lack of motivation for most teachers, poor infrastructural facilities, inadequate textual materials, negative attitude of learners to learning, lack of teaching skills and incompetence by science teachers, as well as a lack of opportunities for professional development for science teachers (Braimoh & Okedeyi, 2001; Folaranmi, 2002; Okebukola, 1997; Olaleye, 2002; Olanrewaju, 1994). Ivowi (1995) also found that the lack of funds for equipment and materials for fruitful practical work, especially in view of large class size, in most schools was a problem.

All these factors together have a negative impact on the interest of the learner to learn science. If a learner finds it difficult to make meaning of what is learnt it may become difficult to continue learning science. In Singapore learners start to learn complex scientific concepts in primary school (Howie, 2001). They learn advanced concepts like Cell Division and Solar System in the lower grades and this makes those that do not perform well to have difficulties in learning science (Swanson & Lussier, 2001). This may lead to learners losing interest in the subject and eventually developing a negative attitude towards learning. Learners' attitude is vital in a science class. The teaching of Physical Sciences, like other science subjects, should focus on the development of scientific concepts, attitudes and skills (Khan & Iqbal, 2011).

However, teachers find it hard to help learners to learn content at the same time they are learning skills and processes required for inquiry-based learning. Also, many learners need time to adapt to a classroom situation in which they must take initiative (Holbrook & Kolodner, 2000). Crawford (2000) views the teaching of science as enquiry-based helping a learner to find answers to the questions using logic and evidence. Inquiry-based learning goes beyond asking questions, trying to figure out how to make sense of data to answer a scientific question (Crawford, 2012). Many teachers in South Africa do not understand what inquiry-based learning is all about (Hofstein & Lunetta, 2003), Learning by inquiry (NRC, 2000) poses challenges for teachers and learners (Krajcik, Mamlok & Hug, 2001). Inquiry refers to diverse ways in which *scientists* study the natural world, propose ideas, and explain and justify assertions based upon evidence derived from scientific work (Hofstein & Lunetta, 2003). Learners will only be interested in learning science once they find out that they do well if they can see that the science they are taught is of personal worth to themselves (Reiss, 2000).

## 2.5 Stimulating learners' interest in learning science through laboratory work

Many have argued that science cannot be meaningful to learners without worthwhile practical experiences in the school laboratory (Hofstein & Lunetta, 2004). Inquiry-based learning is often associated with laboratory work. Teachers use laboratory tasks to learn by doing, design experiments and investigate issues in a classroom (Ivgen, 1997). Laboratory tasks are envisaged to "provide model lessons and experiences, build relevant theory and content knowledge" (Lit & Lotan, 2013: 54-76). Laboratory activities have long had a distinctive and central role in the science curriculum and science educators have suggested that many benefits accrue from engaging learners in science laboratory activities and generate interest (Hofstein & Lunetta, 2004; Tobin 1990; Hodson, 1993; Lazarowitz & Tamir, 1994; Lunetta, 1998; Hofstein, 2004; Lunetta et al., 2007).

Many studies have been conducted to investigate the educational effectiveness of laboratory work in science education in facilitating the attainment of the cognitive, affective, and practical goals (Hofstein & Lunetta, 2003; Sentongo, Kyakulaga & Kibirige, 2011) ). There is evidence suggesting that learners see scientific experiments as enjoyable but more importantly as effective and useful in helping them understand science. Tobin (1990) suggested that meaningful learning is possible in the laboratory if learners are given opportunities to manipulate equipment and materials in order to be able to construct their knowledge of phenomena and related scientific concepts. Research suggests that while laboratory investigations offer important opportunities to connect science concepts and theories discussed in the classroom and in textbooks with real phenomena, teacher intervention to guide learners in the right direction is also important. Dupin and Joshua (1987) have reported that teachers need to integrate practical work with other metacognitive learning experiences such as "predict–explain–observe" demonstrations, in order to help build learners' conceptual development.

In many schools especially in rural areas of South Africa where learners are only taught using the traditional way learners struggle to make sense of what they are being taught and as a result they lose interest in learning science. Many rural schools in South Africa do not have access to laboratories or do not use laboratories when teaching sciences (Makgato & Mji, 2006). Laboratory work provides learners

with an opportunity to experience science by employing scientific research procedures. Thus, in order to attain meaningful learning, to understand scientific theories and their application methods, learning should be done using laboratory investigations (Kibirige & Tsamago, 2013). Moreover, engaging in practical work should encourage the development of critical thinking skills and create interest in science (Ottander & Grelsson, 2006). Tobin (1990) wrote that "Laboratory activities appeal as a way of allowing learners to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science". Knowledge construction depends on the level of conceptual understanding of science. A learner who is exposed to practical work understands how the world operates. The reality is that not all the schools have access to laboratories, even some schools that have access to laboratories, are not using them effectively (Muwanga-Zake, 2006). For instance, in Nigeria and many other African countries there are insufficient laboratory facilities, consequently, secondary school learners are taught physics using guided discovery notes, demonstrations and expository teaching approaches. These methods are highly effective in improving learners' attitudes towards physics in such under-resourced schools (Crawley & Black, 1992). However, the challenge may still emerge where a teacher wants to perform an experiment or laboratory investigations and does not have equipment to perform it. It has been found that schools that do not perform laboratory investigation register low performance rates in school exit examinations and learners quickly lose interest in Physical Sciences (Kibirige & Tsamago, 2013).

According to Raimi (2002), laboratory work in Pakistan improved learners' performance in chemistry. Similarly, Adesoji and Olatunbosun (2008) described how a chemistry workshop using laboratory investigation was adequate to enhance learners' performance in chemistry. Rural schools in South Africa have overcrowded classrooms and it is practically difficult to perform laboratory work, as a result teachers focus simply on direct transmission of information to learners (Folaranmi, 2002).

### 2.6 An alternatives to laboratory work

Research shows that learners learn better when they construct their own understanding of scientific ideas within the framework of their existing knowledge

(Bransford, Brown & Cocking, 2000). To accomplish this, learners must actively engage with the content and must be able to learn from the engagement (Osborne, Simon & Collins, 2003). When learners start to engage with the content, they start to fall in what the constructivists call "*Self-discovery learning"*. Scientific discovery learning is a highly self-directed and constructivistic form of learning (De Jong & Van Joolingen, 1998). Polman (1999) conducted a case study of a teacher who created a collaborative learning community and provided his high school learners with opportunities to "learn by doing" *authentic* science in a science classroom. The teacher was guided by constructivist pedagogy giving special attention to *collaborative visualization.* Constructivist approach can be supplemented in a number of ways, one being through CS.

Interactive CS can meet the needs of a learner where s/he can explore and build on his/her existing knowledge (Annetta, et al., 2009). Thompson, Simonson and Hargrave (1996) defined simulation as a representation or model of an event, object, or some phenomenon, on the other hand Geban, Askar, and Özcan (1992) confirmed that computers can be used in science education as teaching devices. Traditionally, computers are being used in biological investigations for collecting data, searching literature, planning experiments, and analysing data. These functions are very common in many science and biology laboratories. However, simulations are important for formulating and, improving the conceptual models that scientists and science teachers use in their practice and teaching (Geban, Askar, & Özcan, 1992). In science education a computer simulation according to Akpan and Andre (1999) is the use of the computer to simulate dynamic systems of objects in a real or imagined world.

Literature suggests that the success of CS in science education depends on how it is incorporated into the curriculum and how the teacher uses it (Sahin, 2006). CS is a supplementary tool for classroom instruction and laboratory work. Researchers studying the use of simulations in the classroom have reported overall positive findings. Literature indicates that simulations can be effective in developing content knowledge and process skills, as well as in promoting more complicated goals such as inquiry and conceptual change (Bell & Smetana, 2008).

Since the 90s, new technologies have made rich and dynamic visual representations possible on common personal computers (Annetta, et al., 2009). This visual representation gives users of educational simulations the control and flexibility to make changes and see the effects in real time (Annetta, et al., 2009). With these advances, simulations can provide learners with opportunities for rich and dynamic educational experiences as well as instantaneous feedback on the results of a virtual "experiment," (Podolesky, Perkins, & Adams, 2010).

This is seen as a possible solution to science classes with a big number of learners, and science classes that are not well resourced (Annetta, et al., 2009; Podolesky, et al., 2010). In essence, the activities that learners engage in with modern computer simulation can be quite different from those in traditional educational environments (Podolesky, et al., 2010; Van der Meij & de Jong, 2006). Computer simulation provides learners with access to questions and methods of inquiry which are well aligned with the ways scientists use experiments for exploration and discovery, (Podolesky, et al., 2010).

## 2.7 Using technology in a science class

The use of technology has been seen as a way of engaging learners to participate effectively in a science class, this has been defined by Ang and Wang (2006) as engaged learning. Engaged learning is not a new concept. It can be traced back to the earlier years of the twentieth century when Dewey (1933) argued for active and engaged learning through inquiry. Engagement is often defined as 'the mobilization of cognitive, affective and motivational strategies for interpretive transactions with text' (Bangert-Drowns & Pyke, 2001). Furthermore, Jones, Valdez, Nowakowski and Rasmussen (1994) defined engaged learning by giving the following concrete indicators:

• Engaged learners are responsible for their own learning, and find excitement and pleasure in learning,
• The tasks for engaged learning are challenging, authentic, and multidisciplinary,
• The assessment of engaged learning is performance-based and generative, and it has equitable standards that apply to all students,

• The instructional strategies for engaged learning are interactive and generative,
• The context for engaged learning is a knowledge-building learning community, collaborative and empathetic, and
• The grouping for engaged learning is heterogeneous, flexible and equitable.

While the use of technology can assist to improve learner engagement in a science class, it has not been clarified on how learner engagement can improve conceptual understanding of a learner and no association between the use of technology and learner performance has been established (Taylor & Parsons, 2011). Many teachers may argue that learners may see the use of computers in class as an opportunity to play games. It is true that the majority of learners are interested in computer games, however, most striking feature of games is their ability to motivate and challenge the children (Kafai, 2001).

Research indicates that learners are more engaged in learning and have greater retention when practical work was used compared to conventional classroom instruction (Knobloch, 2005; Randel, Morris, Wetzel, & Whitehill, 1992). Many children spend much time trying to master the rules, functionalities and strategies of the computer games just because they like the challenging activities involved. With the advancement of broadband technology, online gaming has become more accessible than ever. It is common to see children gathering and gaming. Some of them even exhibit addictive behaviour towards computer game playing (Harris, 2001). Computer games that one may think are just for fun, could potentially motivate learners in learning science. New technology enables the teacher to present scientific knowledge in a way more appealing to learners than traditional textbooks.

This appeal may lead to an increased level of engagement with the content and improve the learners' understanding of abstract scientific concepts (Ang & Wang, 2006). Highly interactive, collaborative CS appeal to growing interest because of their potentials to supplement constructivist learning. Interactive learning often provides learners who have difficulties with an opportunity to gain knowledge from those who understand. CS is one of the ways that promotes interactive learning. Besides, the idea of learning by CS can be considered a modern practical based

learning methodology with some benefits that the new software technology can bring when compared to the traditional laboratory experiments, theoretical classes or the traditional teaching methodologies (Nahvi, 1996). Among the advantages of using computer simulation tools in education, the students are given the possibility of changing the parameters of a system then evaluate the results in a real time and interactive way. It permits to create a cause-effect structure of the studied concepts on the learners' mind (Nahvi, 1996).

The fact that CS simplifies reality is an indication that it permits learners to understand abstract scientific concepts by omitting or changing details, this eventually improves their conceptual understanding. Studies have suggested that one way to enhance these kinds of cognitive skills is through educational simulations (Budoff, Thormann, & Gras, 1984; Cherryholmes, 1966; Cruickshank & Tefler, 1980; Greenblat & Duke, 1975). CS are thought to increase learner participation (Boocock & Schild, 1968; Farran, 1968; Stembler, 1975), and allow low- achieving students much-needed practice in applying what they've learned to new situations in order to improve their performance (Cohen & Bradley, 1978).

Physics requires learners to continuously identify the hidden concepts, define quantities and explain underlying laws and theories using high level reasoning skills (Abdullah & Shariff, 2008). In other words, learners are involved in the process of constructing quantitative models that help them to understand the relationships and differences among scientific concepts (Abdullah & Shariff, 2008).

Trundle and Bell (2005) highlighted the effect of computer simulation on conceptual understanding. They described learners' conceptual understanding about lunar concepts before and after instruction with planetarium simulations. Results indicated that learners learned more about moon shapes and sequences, as well as causes of moon phases, by using the computer simulation than by making actual nightly observations and studying nature alone. The ability to make many more observations using the program, the ease of making and testing predictions, and the consistency and accuracy of learner measurements contributed to the dramatic improvements in learner understanding. The whole process could have taken a long time should they have decided to do night observations. In some instances it could

be an overcast that could have prevented them from seeing the moon and that by itself could have had an impact on their results.

This implies that there are as many advantages of using computer simulation. Apart from the issue of time saving, the data supplied by computer simulation gives learners clear and unambiguous information on the experiment. The process of conceptual change is an on-going challenge in science education (Bell & Smetana, 2008). Bell and Smetana (2008) indicate that CS has demonstrated the potential to facilitate the process of conceptual change by highlighting learners' misconceptions and presenting plausible scientific conceptions. In this instance conceptual change implies that there is growth of an awareness of the diversity and tenacity of learners' views of natural phenomena. Other benefits include learner enthusiasm, high engagement, and on-task behaviour while working with simulations. Effectiveness, however, varies based on design features, support measures, and sequencing of simulation activities within the curriculum (Abdullah & Shariff, 2008).

CS is not a new thing, it has existed for a long time (Stohl, 2005). As with any other educational tool, the effectiveness of CS is limited by the software used. Learners should be actively engaged in the acquisition of knowledge and be encouraged to take responsibility for their own learning; content should be placed in the context of the real world and connected to their own lives. If the use of computer simulation resembles the context that the learner is exposed to, the use of it then becomes more effective and more meaningful (Abdullah & Shariff, 2008).

## 2.8 Can computer simulation replace laboratory work?

Simulations have been around practically since the advent of computers, and researchers have been looking at classroom uses of simulations for over 20 years (Akpan and Andre, 1999). However, it has been highlighted herein that computer simulation cannot replace laboratory work, in fact research suggests that the two should be used in conjunction with each other. However, it is also suggested that learners can benefit from simulations even with a basic classroom setup of a single teacher computer connected to a projector. Computer simulation covers a lot of aspects in science education. By exposing complex concepts and abstract

phenomena, computer simulation offers the opportunity to engage learners in higher-level thinking and challenge them to struggle with new ideas. Lessons involving computer simulation should remain learner-centred and inquiry-based to ensure that learning is focused on meaningful understanding, not rote memorization (Bell & Smetana, 2008). This encourages learners to think critically and stimulate their creativeness. Conceptual understanding is also being enhanced and learners become more interested in what they learn.

Faryniarz and Lockwood (1992) reported about the effectiveness of using CS in science education and their findings about it were:

> *It allows learners to correctly solve problems related to the experiments in a linear sequence. Another advantage of computer simulated experiments is that learners deal with data in a controlled setting the data that can be obtained directly by computer and stored; and learners can change variables easily. These results lead learners to understand scientific concepts much more than conventional models.*

Simmons and Lunetta (1993) found that learning environments that incorporate meaningful and appropriate computer based learning, could stimulate the formation and development of science concepts and problem-solving skills and abilities in learners.

Advantages of CS in science education include being cheaper than laboratory experiments in terms of time and cost (Simmons & Lunetta, 1993). During experiments, learners need to wait for the results of experiment and they seem to waste their time. Also, for the laboratory experiments, equipment is expensive and that is a problem for poor schools (Jegede, Okebukola & Ajewole, 1991). For instance, generally a computer-simulated experiment can take 35 minutes but hands-on experiment can take between 120 and 180 minutes. However, CS provides learners a quicker way of understanding of concepts. While students do experiments with computer, they can receive immediate feedback (Jegede, Okebukola & Ajewole, 1991). Also, learners using CS have opportunities for reinforced practice without having the teacher to spend extra time in preparing supportive materials.

Although this seems to be effective for both teachers and learners in class, there are still some other factors that teachers need to consider when exposing learners to computer simulation. The main aim is to make learners develop a positive attitude towards the learning of science in class, but most importantly, to allow learners develop their cognitive level in learning science. Some researchers look at the use of multimedia learning to foster cognitive development in science. Jegede, Okebukola and Ajewole (1991) investigated the use of words and pictures to foster meaningful learning. They defined meaningful learning as ability to apply what was taught to new situations and highlighted the fact that during multimedia learning there is high possibility of cognitive load that teachers need to be aware of.

Meaningful learning requires that the learner engages in substantial cognitive processing during learning, but the learner's capacity for cognitive processing is severely limited. It is vital for teachers to recognize the need for multimedia instruction that is sensitive to cognitive load (Clark, 1999; Sweller, 1999; van Merriënboer, 1997).

Since learners are interested in working with computers, it is up to the teacher to make them stimulate intrinsic motivation in learners during their science lessons. Computer simulation is one way to do this. The purpose of an educational simulation being to motivate the learner to engage in problem solving, hypothesis testing, experiential learning, schema construction, and development of mental models (Winn & Snyder, 1996; Duffy & Cunningham, 1996). To facilitate learning, educational simulations rely heavily on scaffolding (Duffy & Cunningham, 1996), coaching, and feedback (Alessi & Trollip, 2001). This is just the opposite of traditional learning where learners just become passive receivers of the information. Educational simulations have a number of advantages over other instructional methodologies and media. Learners often find active participation in simulations to be more interesting, intrinsically motivating and closer to real world experiences than other learning modalities (Alessi & Trollip, 2001).

Simulations have been shown to provide learning with the result that what is learned facilitates improved performance in real-world settings (Leemkuil, et al., 2003).

Further, there is evidence to suggest that simulations may be more efficient modalities for learning in some content areas (Alessi & Trollip, 2001).

As previously indicated, simulations allow learners to experience phenomena which could be dangerous, expensive or even impossible to observe in the real world (Alessi & Trollip, 2001). For example, simulations permit the learner to stretch or compress time and space (Wilson & Cole, 1996). Because educational simulations are simplifications of real-world phenomena, they facilitate learning by omitting what would otherwise be distracting elements in a real-world situation (Alessi & Trollip, 2001). For example, if a teacher wants to talk about a vacuum, this could be simulated on the computer instead of a teacher struggling to explain what is a vacuum and what happens in a vacuum.

However, it is important that teachers understand the disadvantages of simulation such that they do not let them ruin their aims. One of the disadvantages is that simulations are often used with problem-based learning methods, they stimulate learners to immerse themselves in a problematic situation and experiment with different approaches (Heinich, et al., 1999). This type of learning may require significantly more time than other methods of instruction. Research has shown that, without appropriate coaching, scaffolding, feedback and debriefing, the learner gains little from the discovery learning, CS can facilitate the learning process if implemented accordingly (Duffy & Cunningham, 1996; Leemkuil, et al., 2003; Min, 2001; Heinich, et al., 1999). In addition, research has indicated that, in the absence of reflection and debriefing, learners tend to interact with a simulation as merely a game (Leemkuil, et al., 2003).

Some constructivists argue that educational simulations “oversimplify the complexities of real-life situations,” giving the learner an imprecise understanding of a real life problem or system (Heinich, et al.,1999). This may imply that learners take other situations for granted and they do not appreciate other phenomena that are entailed in life itself. Sometimes this means that although learning becomes safe even in situations that they could have been otherwise dangerous, learners lose the knowledge of having to avoid danger when confronted with a real situation. This is as a result of not having been confronted with that danger during experimentation.

When learning is removed from its context, the value of the knowledge and the relevance of that knowledge to the learner becomes depreciated (Duffy & Cunningham, 1996).

It is therefore vital that teachers bring to class well-designed simulation with no ambiguity and give sense to what learners need to do. A well-designed simulation can engage the learner in interaction by helping the learner predict the course and results of certain actions, understand why observed events occur, explore the effects of modifying preliminary conclusions, evaluate ideas, gain insight and stimulate critical thinking. Educational simulations can also provide the learner with "feedback throughout the learning process" (Granland, et al., 2000).

The use of simulation in a classroom is aimed at changing the negative attitude the learners may have towards studying science. Most schools use textbooks to teach science, but hands-on science curricula have become increasingly popular over the last two decades in most countries (Harlen, 2004). Hands-on science typically engages students in research activities in the classroom. Complete curricula of hands-on activities have been developed to effectively replace the use of science textbooks in elementary classroom (National Research Council, 2000). Researchers on elementary science reform emphasize the need for students to engage in scientific inquiry (Driver et al., 1994; Harlen, 2004). Engaging students in inquiry can provide a powerful learning experience where students not only learn about science content but also gain reasoning and research skills.

Critics of reforms have pointed out that the implementation of hands-on curricula can err either on the side of too much or too little guidance. Research on high school science labs shows that highly structured activities may teach learners to simply 'follow the recipe' and result in little meaningful learning of content or research methodology (National Research Council, 2005). It is therefore important for the teacher to ensure that activities motivate learners' creative thinking and challenge them to explore on the topic.

Research on the effectiveness of hands-on science curricula tends to show a positive effect for small tightly controlled studies. Studies where researchers closely

monitored the curriculum (often involving technology) have resulted in more science learning (Kracjik et al, 1998; Lehrer, Schauble, Carpenter & Penner, 2000; White & Frederiksen, 1998; Young & Lee, 2005). This clearly indicates that monitoring of the use of technology in classroom is vital to enhance learning and to achieve the learning objectives. A number of papers have linked hands-on or inquiry teaching to changes in learner attitudes (Kyle, Bonnstetter, McCloskey, & Fults, 1985; Chang & Mao, 1999). Gibson and Chase (2002) reported that inquiry activities not only led to more interest in science but that this interest persisted long after the inquiry intervention was over. If learners are more interested in science because of inquiry experiences, they may be more likely to study science in the future and persist in science classes (Gibson & Chase, 2002).

## 2.9 Attitude: Performance inhibitor

If teachers are asked, what is the most important learner characteristic associated with successful studies, they usually mention traits such as *attitude*, *motivation*, and *genuine interest* (Anders & Berg, 2005). Igwe (2002) stipulates that for teaching and learning of science to be interesting and stimulating, there has to be motivation on the part of both the teacher and the learner so as to ensure the development of positive attitude and subsequently maximum academic achievement. This study investigated how negative attitude may impact on learner conceptual development. Although this study did not concentrate on motivation, Anders and Berg (2005) have shown that when a learner develops a positive attitude towards his studies, s/he becomes motivated to study for a sufficient amount of time. Attitude as a concept is concerned with an individual way of thinking, acting and behaving. It has very serious implications for the learner, the teacher, the immediate social group with which the individual learner relates and the entire school system (Yara, 2009).
In my view, for a learner to spend much time on his/her studies gives him/her an opportunity to explore the concepts that seem to be challenging in science. Once a learner is able to focus on problem areas in science, he/she will start to understand the concepts better and that in a way develops his/her conceptual understanding.

There is a clear indication of negative attitude by learners in the study of science in many countries (Smithers & Robinson, 1988). Learners either run away from science

to other subjects and that results in few learners studying science (Dearing, 1996). The issue of attitude towards science is not completely new at all, it has been a substantive feature of the work of the science education research community for the past 30–40 years (Miller, Pardo, & Niwa, 1997). Its importance is emphasized by the mounting evidence of a decline in the interest of young people in pursuing scientific careers (Department for Education 1994; Smithers & Robinson, 1988). An exploratory study on how to teach science indicates that learners' attitudes and interests could play a substantial role in their performance (Lee & Burkam, 1996).

Learners with a positive attitude towards science are more likely to do well in the subject (Myers & Fouts, 1992). This implies that positive attitudes towards science may also lead to better performance (O'Connell, 2000). For example, learners' performance in problem solving depends on teachers' methods and attitudes towards science (Charles, et al., 1987). The use of CS in class could also be enhanced by the attitude of teachers towards the use of computers.

Studies conducted in Turkey on integration of Information and Communication Technologies (ICT) into education confirm that "computer experience" is an important factor for influencing teachers' instructional computer use (Asan, 2002; Braak, 2001; Jenson, Lewis, & Smith, 2002; Zhao & Cziko, 2001, Sahin & Thompson, 2006). According to Loyd and Gressard (1984), positive attitudes towards computers are positively correlated with teachers' extent of experience with computer technology (cited in Adesoji, 2008). If more teachers are well acquainted with the use of computers in class, the use of computer simulation will not be a challenge. Halladyna and Shanghnessy (1982) have concluded that a number of factors have been identified as related to learners' attitude to science. One of the factors they indicated was teaching methods.

Studies have revealed the influence of methods of instruction on learners' attitude towards science. Kempa and Dube (1974) worked on the influence of science instruction; the result was that attitude becomes more positive after instruction. Adesoji (2008) has established the fact that acceptable methods of instruction are capable of changing learners' attitude towards science. Wilson (1983) suggests that there is a relationship between attitude and methods of instruction also between

attitude and achievement; it is therefore possible to predict achievement from attitude scores. Yara (2009) reported the observations on teachers who teach science in a way that merely requires the learners to listen, read and regurgitate. He states that this depicts negative attitude to teaching. Several research findings have confirmed the hypothesis that teachers' attitude either towards science or towards science teaching affect their students' achievement in and attitudes towards science. Okpala (1985) found that the effect of teachers' attitude towards assessment practices on students' achievement and their attitude towards Physics was positive. Similarly, Onocha (1985) reported in one of his findings that teachers' attitudes towards science are a significant predictor of pupils' science achievement as well as their attitude.

## 2.10 Conclusion on literature review

Since creative and critical thinking is essential in a science laboratory to develop logical thinking processes (Garrison & Archer, 2000), computer simulation may prove to be a vital exercise to enhance conceptual development. According to Raimi (2002), laboratory work in Pakistan improved learners' performance in chemistry. Similarly, Adesoji and Olatunbosun (2008) described how a chemistry workshop using practical work was adequate to enhance learners' performance in chemistry.

Researchers in elementary science reform emphasise the need for learners to engage in scientific inquiry (Driver et al., 1994). Engaging learners in inquiry can provide powerful learning experiences where learners not only learn about science content but also gain research skills. Learners gain an understanding of the nature of scientific problem solving (Magnusson & Palincsar 1995). The use of technology proved to have come handy in addressing all the challenges faced by all learners regardless of their educational backgrounds. The rural schools are no longer going to be disadvantaged like in the past due to CS (Lazarowitz & Tamir, 1994). Learners learning science become highly motivated and they engage in problem solving, hypothesis testing, experiential learning, schema construction, and development of mental models (Winn & Snyder, 1996; Duffy & Cunningham, 1996). CS facilitates learning by relying heavily on scaffolding (Duffy & Cunningham, 1996), coaching, and feedback (Alessi & Trollip, 2001). The teacher is there to ensure that learners

are guided during simulation. The interesting part after all is the fact that in most cases the results are instant and the feedback is given to the learners instantly.

Knowing very well that computer simulation is based on an internal model of a real-world system or phenomena in which some elements have been simplified or omitted in order to facilitate learning, learners must be alerted all the time if such omissions have been made. Due to the simplified world learners often find active participation in simulations to be more interesting, intrinsically motivating and closer to real world experiences than other learning modalities (Alessi & Trollip, 2001). Simulations have been shown to provide transfer of learning with the result that what is learned facilitates improved performance in real-world settings (Leemkuil, et al., 2003). The improvement in performance though it is evident, the presence of the teacher is equally important because research has indicated that, in the absence of reflection and debriefing, learners tend to interact with a simulation as merely a game (Leemkuil, et al., 2003). However, if simulation is used accordingly learners can observe, explore, recreate, and receive immediate feedback about real objects, phenomena, and processes that would otherwise be too complex, time-consuming, or dangerous (Alessi & Trollip, 2001). This helps a learner in conceptual development in science.

# CHAPTER 3: RESEARCH METHODOLOGY

The study used both qualitative and quantitative approaches. Quantitative approach allows for generation of numerical data across groups of people (Neuman, 2011; Sibanda 2009). One of the main attractions of quantitative research is that the researcher can conduct the inquiry in an unbiased, objective manner (Cohen, Manion & Morrison, 2007). A pre- and post-quasi experimental research design with a non-equivalent control was used. This method was chosen because the experimental group (EG) and the control group (CG) consisted of pre-existing whole classes. Semi-structured interviews were used to complement quantitative data, since interviews offer a more complete picture of learners' thought patterns than diagnostic testing alone (Duit and Confrey 1996; Carr 1996). Furthermore qualitative approach allows the researcher to understand a situation without imposing pre-existing expectations on the setting (Mouton & Maraise, 1996).

## 3.1 Design of the study

Both quasi-experimental and phenomenological research designs were used in this study. In quantitative approach, a pre- and post-quasi-experimental design with non-equivalent CG was used. The quantitative approach helped the researcher to describe, compare or explain knowledge, attitude and performance (Cohen, Manion, & Morrison, 2007). In the treatment, the EG was taught using computer simulation (PhET), while the CG was taught without CS.

In qualitative approach, phenomenological research design was used. The phenomenon was the situation wherein learners were taught without the use of any practical activity. Semi-structured interviews were conducted before and after intervention in both groups to assess the attitude of learners towards learning Physical Sciences, since interviews offer a more complete picture of learners' thought Patterns than diagnostic testing alone (Duit and Confrey 1996; Carr 1996). This has given the researcher an opportunity to discuss with the interviewees some topics in more depth (Hancock, 2002). Learners were taught the topic of waves through computer simulation. They observed the change of wavelength when the frequency of the wave is either increased or decreased, they also observed the relationship between the amplitude of the wave and its wavelength.

## 3.2 Population

In this study, the population was Grade 10 learners who study Physical Sciences in schools with science class that do not have enough scientific resources to engage all learners effectively in performing practical work in Capricorn district of Limpopo Province of South Africa.

## 3.3 Sample

In both quantitative and qualitative approaches during data collection, purposive sampling was used. Purposive sampling is the deliberate choice of an informant due to the qualities the informant possesses (Bernard, 2002). The type of purposive sampling used in this study is criterion sampling, this involves searching for individuals who meet a certain criterion (Palys, 2008). This was selected because learners who participated in this study were taught without laboratory equipment and as such they met the criterion to be purposefully sampled. EG (school A) and CG (school B) within Capricorn district were selected based on the lack of scientific equipment in science classrooms. Both schools did not have enough classrooms as such all learners doing Physical Sciences were put in one classroom, the two schools had a total of 53 (school A) and 52 (school B) physical sciences learners respectively.

## 3.4 Instruments

A performance test was administered to both the EG and the CG before and after the intervention. Before the intervention, the performance test was multiple choice questions only, after intervention there was in addition to multiple choice answers reasons required. During the intervention, the EG was taught the topic “waves” using computer simulation (PhET). The PhET Interactive Simulation is a computer software that incorporates research-based practices on effective teaching to enhance the learning of science and mathematics concepts. The simulations are designed to be flexible so that they can be used as teaching demonstrations, labs, or homework activities. They use an intuitive, game-like environment where students can learn through scientist-like exploration within a simplified environment, where dynamic visual representations make the invisible visible, and where science ideas

are connected to real-world phenomena. In the EG, learners were taught using this software where learners observed the experiment demonstrated on a computer screen. The main computer was connected to the overhead projector to enable all learners in class to see from the big screen in front, three more computers were put on learners' tables after they arranged themselves in three groups of approximately 17 learners per group.

The teacher started by demonstrating the concept of waves on the main computer and learners used their own computers to continue with the experiment. They used their computers to observe what happens to the transverse wave when the frequency of the wave is either increased or decreased. They also checked the relationship between the amplitude and the wavelength of the transverse wave.

On the other hand, CG was taught following the traditional way. The traditional way implies that the teacher just used the information taken directly from the textbook and no experiment was done in this group. After teaching for a period of 4 weeks both (CG) and (EG) groups were tested with the original test questions re-arranged in order to minimize recognition (Roth & Roychoudhury, 2003). The questionnaire consisted of 20 multiple choice questions with four possible answers (Annexure E). Learners had to choose the most appropriate answer and provide a reason for the choice made in the second test. After the intervention five learners from (CG) and five learners from (EG) were interviewed in order to determine their attitude.

### 3.4.1 Validity

The test items in the test were assessed by four experts: a Physical Sciences head of department; and three Physical Sciences teachers from both schools where the study was undertaken. In order to ensure that the questions in the test were internally consistent, the instruments were piloted with Physical Sciences teachers who were knowledgeable about the subject and could identify errors. The content was piloted with learners of School C which is neighbouring school to School A and School B but their results did not form part of the study. The results of the pilot study did not form part of the research. Content validity index was obtained as 0.91, therefore instrument was considered valid.

The content validity index (CVI) was computed using the following formula:

CVI = *Number of items judged by both judges as right*
*Total number of items in the questionnaire*

**ble I Content Validity Index (CVI) of Survey Items**

| Item | Rater 1 | Rater 2 | Rater 3 | Rater 4 | CVI |
|---|---|---|---|---|---|
| Contemporary Skills | | | | | |
| 1 | x | x | x | x | 1.00 |
| *2* | *x* | *x* | *x* | *x* | 1.00 |
| 3 | x | x | x | 0 | 0.75 |
| 4 | x | x | x | x | 1.00 |
| 5 | x | x | 0 | x | 0.75 |
| 6 | x | 0 | x | x | 0.75 |
| 7 | x | 0 | x | x | 0.75 |
| 8 | x | x | x | x | 1.00 |
| Foundational Skills | | | | | |
| 9 | x | x | x | x | 1.00 |
| 10 | x | x | 0 | x | 0.75 |
| 11 | x | x | x | x | 1.00 |
| 12 | x | x | x | x | 1.00 |
| 13 | x | x | x | x | 1.00 |
| 14 | x | x | x | x | 1.00 |
| Intellectual capabilities | | | | | |
| 15 | x | x | x | x | 1.00 |
| 16 | x | x | x | x | 1.00 |
| 17 | x | x | 0 | x | 0.75 |
| 18 | x | x | 0 | x | 0.75 |
| 19 | x | x | x | x | 1.00 |
| 20 | x | x | x | x | 1.00 |
| **Overall** | | | | | **0.91** |

Note: X indicates items of relevance.

In order to ensure internal consistency, instruments were piloted to 10 learners with an educational background similar to that of the study groups. A Cronbach alpha coefficient (α) was computed from the results using the formula below (Cronbach 1951: 299):

$$\alpha = \left(\frac{K}{K-1}\right)\left(1 - \frac{\sum S_i^2}{S_{sum}^2}\right)$$

Where:

$K_2$ = number of components (K-Items);

$S^2_i$ = Variance of K individual items;

3.4.2 Reliability

Reliability of an instrument refers to consistency or stability of the measured score (Cohen, et. al, 2007). This study ensured the internal reliability of the questionnaire, which is the "measure of the degree of the similarity between items" of the questionnaire (Pieterson & Maree, 2007). To ensure internal reliability, the questionnaire was administered by 4 teachers who are offering the subject from Grade 10-12. $S^2_{sum}$ = variance for the sum of all items.

The Cronbach's-alpha coefficient (Cronbach, 1951) reliability was computed from the results of a pilot test of 50 learners who were not part of the study but were from similar background. The final version of the test remained on 20 items. An overall Cronbach alpha coefficient of 0.89 was obtained and this value was deemed suitable for the study since it was ≥ 0.7 (de Vos, 2010). In addition, interview schedule questions were restructured by the researcher to identify attitudes of learners after using simulations.

## 3.5 Data Collection

Both the EG and the CG were given a pre-test to determine their knowledge before the study. The EG was taught using CS and the CG was taught using the traditional method (Roth & Roychoudhury, 2003). Both groups were taught for four weeks during the second quarter of the 2015 academic year. They both worked on three sets of tasks. Thereafter, a post-test was administered to both groups. This post-test

was the same as the pre-test they had completed previously. The only noticeable difference was that questions in post-test were re-arranged to minimise recognition. Learners in the EG observed the nature of different types of waves on the screen of a computer and tried to predict what would happen to the wavelength of the wave when the frequency of the wave was increased or decreased. They also predicted what would happen to the wavelength of the wave when the amplitude of the wave was increased or decreased. During all these observations learners were asked to write their own hypothesis. Here are three sample tasks from “Waves” that were used and characterised CS activities:

1) Learners established the relationship between the frequency and wavelength of a wave. They hypothesised what would happen to the wavelength of a wave when the frequency was reduced or when the frequency was increased;

2) They also established how an increase or a decrease in the frequency of wave affect the amplitude of a transverse wave; and

3) They established how constructive and destructive interferences occur.

Thereafter, they were required to demonstrate the movement of a transverse wave on the screen of a computer and observe what happened when a wave was oscillated. For the CG, these concepts were explained to learners and no CS was performed. In order to reduce any harm done by omitting the CG from using CS, the whole class was taught using CS after the study was completed.

For qualitative data, interview schedules consisted of three questions:

1) How did you enjoy Physical Sciences lessons?

2) How did teaching Physical Sciences through computer simulation assist you in developing interest in the subject; and

3) How much time do you spend studying physical science after the lesson?

These questions were designed by the researcher and checked for face validity by two science teachers. Thereafter, they were piloted to six learners to determine their suitability. Interviews were conducted with eight learners of similar background (labelled 1-8), 4 from the CG and 4 from the EG (2 Females and 2 Males per group)

in order to determine their attitudes. Each learner was interviewed for a maximum of 20 minutes and the interviews were audio-recorded.

### 3.6 Data Analysis

Descriptive (mean and standard deviations) and inferential tests (T-test, Analysis of covariance- ANCOVA and independent-sample t-test) were utilised from SPSS version 22. The differences between the EG and the CG for the pre- and post-tests were analysed using a T-test ($p < 0.05$). ANCOVA was used to determine the impact of the CS after four weeks of teaching using a pre-test as a covariate. An independent-samples t-test was used to compare girls and boys performance in the EG after three weeks of teaching. In addition, responses from semi- structured interviews from the two groups (EG, CG) were analysed thematically to identify learners' attitudes towards science. Audio recorded data were transcribed verbatim and transcripts were analysed using open, axial and selective coding (de Vos, 2010). During open coding transcripts were read sentence by sentence to determine key ideas followed by axial coding where key ideas were re-arranged to form subthemes. Lastly, during selective coding subthemes were compared to the purpose of the study in order to generate main themes (de Vos, 2010).

### 3.7 Delimitations

The major limitation of quasi-experimental design is that the researcher cannot manipulate the independent variable or randomize his/her subjects (Levy & Ellis, 2011; Gaarder, 2010). This problem, however, can be resolved to some extent by using procedures that give the researcher some measure of control in his/her investigation. For this purpose, the independent sample t-test was used to check the effects of extraneous factors when comparing the outcomes of science learning of the boys and girls in EG after intervention. The research only focused on two schools that were chosen as the experiment and control groups in Capricorn District of Limpopo, South Africa. The study cannot be used to generalise due to the size of the sample. However, the study can be used as a foundation for more research.

## 3.8 Ethical consideration

Before data were collected, I sought permission from the university research management team, the Turfloop Research Ethics Committee (TREC). This was to prove that my research was legitimate and was known by the university. The participation was voluntary. The participants were informed that they were under no obligation to participate in the study and that their decision not to participate would bear no negative consequences. Since participants in the study were Grade 10 learners, they were provided with a consent form that their parents signed to allow their children to participate in the study.

Besides the parental consent, the participants were told that they could withdraw at any time and if they did, their material would not form part of the findings in the study. Participants were fully informed of what they are expected to do through the use of the information sheet that they were provided with. The information sheet, on the university letterhead indicated to the participants that it had official clearance. The information sheet included the details of the researcher, the name of the university that the researcher attends, the name of the supervisor and the reason for the doing the research at their school among others. The information sheet also indicated that the participants would remain anonymous and that their responses would be kept confidential. In the case of coding, participants' identities were withheld and symbols were used instead of names. It was stated on the consent form and information sheet that the interviews would be audio-recorded and participants were not allowed to edit the recording.

The audio-record was not erased after it had been transcribed and the participants were informed about this act. The raw material of the research would be kept intact for a period of 5 years. I ensured that any decision made by the participants was respected at all times and no harm occurred to all participants.

Apart from learners and parents, permission was sought, from other stakeholders of the school that included, District officers of the Department of Education, school principals, and school governing bodies (SGBs). I disclosed to the schools the aim of the research and how it would benefit them.

## 3.9 Concluding remarks

All learners who participated in this study completed the activity. No learner had withdrawn from the study during which it was carried out. All the ethical considerations have been adhered to in the whole duration of this study.

# Chapter 4: RESULTS

## 4.1 Observational results

Learners were very excited when they were first introduced to computer simulations. They seemed to be wary of working on the computer but realising that they could still observe some of the experiments performed on a computer it was something fascinating for them. They were curious about the experiments which they could not perform in their own laboratory but seeing them performed on a computer. When the teacher demonstrated some simulations, they were totally attracted, attentive and interested to learn more.

## 4.2 Overall results

The overall results reveal that the EG outperformed the CG. The results of the pre-test for the EG performance (mean 9.40 ± 2.83 SD) and the results for the CG (mean 7.12 ± 1.92 SD) did not differ significantly (T-test: -0.35, $p > 0.05$). After teaching for four weeks, the EG performance (mean 11.28 ± 3.9 SD) was again compared to that of the CG (mean 7.92 ± 2.67 SD) and there were significant differences between the two groups (T-test: 0.52, $p < 0.05$). An effect size of 0.84 and a Cohen *d* of 0.41 were calculated for the EG. The performance results attained by the girls from the EG (mean 10.22 ± 2.3 SD) were higher than of the CG counterparts (mean 7.28 1± 1.89 SD), (Table 1) and were also better than those of the boys from the CG (mean 8.64 ± 3.38 SD).

Table **4-1:** T-test results of EG and EC before and after (*Significant at $p < 0.05$)

| **Paired Samples Correlations** | | | | |
|---|---|---|---|---|
| | | N | Correlation | Sig. |
| EXPERIMENTAL | Experiment Group Pre-Test & Experiment Group Post-Test | 53 | .524 | .000 |
| CONTROL | Control Group Pre-Test & Control Group Post-Test | 52 | -.035 | .807 |

Table **4-2** ANCOVA summary results of EG and CG before and after
(** Significant at $p < 0.01$)

| *Source* | *SS* | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|---|
| Pre-test | 24.58 1 | 24.57 | 4.23 | 0.06 | 0.01 |
| Post-test | 36.41 1 | 36.41 | 6.27 | | |
| *Error | 273.02 | 47 | 5.81 | | |
| Total | 3845.00 | 49 | | | |

Using pooled data for boys and girls per group, the summary of ANCOVA shows that there were no significant differences between the two groups during the pre-test ($p > 0.05$). However, the results of the post-test indicate that there is a significant difference between the two groups ($p < 0.05$). This suggests that learners using CS improved their understanding of Physical Sciences. Thus, CS reinforced critical thinking and logical reasoning in the topic waves. While the performance of girls from both the EG and the CG did not differ in the pre-test results, results for girls from the EG differed significantly from those of the CG ($U = 35.50$, $p < 0.05$) after four weeks of teaching. The results show that learners from the EG (taught using CS) had positive attitudes towards Waves but not those learners from the CG (taught without CS).

**Table 4-3** t-test results for girls and boys performance after intervention

**Independent Sample Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|---|---|---|
| | | F | sig | t | df | Sig (2-tailed) | Mean Difference | std.Error Difference | Lower | Upper |
| EG, (Boys & Girls) | Eq.variance assumed | 1.419 | 0.239 | -0.08 | 51 | 0.937 | -0.20714 | 2.60207 | -5.43101 | 5.01673 |
| | Eq.variance not assumed | | | -0.08 | 43.253 | 0.938 | -0.20714 | 2.64960 | -5.54966 | 5.13538 |

(*Significant at $p < 0.05$)

An independent-samples t-test was conducted to compare girls and boys performance in the EG after intervention. The results show that there was no significant difference in the scores for girls (M=54.60, SD=10.93) and boys (M=54.39, SD=7.90), t (51) =-0.08, p=0.9 after intervention. These results suggest that the performance of learners in the EG did not depend on gender. Therefore, the results show that CS did not discriminate between girls and boys in the EG.

From semi-structured interviews, three themes were identified and these are: 1) lack of enjoyment; 2) lack of interest in science; and 3) takes time to understand science.

**Themes for the control group are stated below:**

**Theme 1** Enjoyment

As the first question stipulated, the researcher wanted to know how learners enjoyed Physical Sciences lessons. In response to this question, all learners from the CG stated that they did not enjoy science at all. They even said that they think it was a big mistake for them to take Physical Sciences as one of their subjects since they are struggling to cope with the work. They indicated that, they thought they would perform practical work like other learners from their neighbouring schools, but lack of resources from their school prohibits them from exploring experiments. They claimed that the teacher read directly from the textbook and that made it difficult for them to

comprehend the work as such even when they read by themselves, they still could not make sense of it. Below are a few specific direct quotes from a few learners:

*Learner 1: "I do not enjoy learning physical sciences because it is very hard to understand"*

*Learner 3:* Echoed what learner 1 said by stating that

*"I do not like physical sciences; I don't even know why I chose it because it is really difficult for me. No matter how much effort I put to the subject I still fail it".*

*Learner 4*: echoed learner three by stating that,

*"I sleep in a physical sciences class because there is nothing that captures my attention."*

*Learner 5:* "I thought Physical science was a practical subject, since we don't do any practical work I'm not enjoying it.

**Theme 2** *Interest in the subject*

On the second question that sought to assess the interest of learners in Physical Sciences as a subject, learners from the CG indicated that they found nothing interesting about science. However, they agreed that everything in their lives revolved around science but they still couldn't relate science to their daily living. They felt science was tiresome and did not provoke interest and this impacted on their performance because they never passed the subject. Below are a few specific direct quotes from a few learners:

*Learner 1:*

*"I was told that science gives clarity to everything happening around us, but I have never seen anything to suggest it."*

*Learner 3:*

*"I hate physical science, I have never passed the test and it does not seem like I will ever pass it."*

*Learner 4*: echoed learner three by stating that,

*"I have no desire to continue with physical sciences. I have had enough. I work hard and fail and because of that I hate the subject. Whenever I try to understand I become even more confused".*

*Learner 5:*

"*I realised that physical science is not for people like me, maybe I'm not gifted enough to study science. I think I'm about to quit the subject."*

**Theme 3** *Understanding*

On the last question that asked learners about how much time did they spend studying Physical Science after the lesson, it appeared that they had a different approach to this. Some learners from the CG differed on the amount of time they spent on the subject. Some spent small amounts of time or they didn't even bother to give time to the subject at all. Their reason was, they were struggling so it became pointless for them to spend time on something they did not understand. Some indicated that they spent too much time on the subject but that did not yield any results. They saw the study of science as time consuming. Below are a few specific direct quotes from a few learners:

*Learner 1: "Physical sciences subject is time consuming. If I want to understand the content I have to spend a lot of time. I may not even pass it. I mean, it seems impossible to cover all the content in a given time."*

*Learner 3: "No matter how much time I spend on this subject, I just can't understand it."*

*Learner 4*: *"I gave myself enough time to understand physical science; I think I had lost a lot of it without gaining anything."*

*Learner 5: "I can't spend time on something I do not understand; I will waste time for other subject. I realised that physical science needs geniuses."*

**Themes for the Experimental Group are stated below:**

**Theme 1** *Enjoyment*

All four learners from the EG had positive attitudes judging from their responses they provided to the questions. As the first question stipulated, the researcher wanted to know how learners enjoyed Physical Sciences lessons. In response to this question, all learners from the EG stated that they really enjoyed the Physical Sciences lessons. Below are a few specific direct quotes from a few learners:

*Learner 2:* Stating that it was his first time that he enjoyed such a learning task because he loved the game-like environment. He stated having liked computers and never thought they could be used to enhance science learning.

*Learner 7:* "If all subjects were taught the way we have been taught science, then I would not have any reason to bunk the class."

*Learner 8: "I can't' wait to get to my science class each day I go to school, I really enjoy doing science and observing experiments on the computer."*

*Learner 6: "I used to sleep in a science class but not anymore, I enjoy every moment."*

**Theme 2** *Interest in the subject*

On the second question that sought to assess the interest of learners on waves as a topic, learners from the EG indicated that they found it highly interesting. They indicated that they could not comprehend the concept of waves, now they understand how waves occur and they were able to explain the types of waves. Below are a few specific direct quotes from a few learners:

*Learner 2: "I became more interested in science more especially to the concept of waves because of the CS it made me realize what real science is all about and the observations helped me relate to what I read in the textbook."*

Learner 7: *"I find waves to be more fascinating especially when we do experiments on the computer; I enjoy working with a computer too."*

*Learner 8: "I always want to know more about the world we live in and science makes it easier for me to understand."*

*Learner 6: "I can't believe science is about the practical work, even without resources, the CS does wonders for us."*

**Theme 3** *Understanding*

On the last question that asked learners about how much time did they spend studying Physical Sciences after the lesson, they showed that they spent much time because they loved the subject therefore they always wanted to know more. Some

indicated that they were no longer spending as much time as they did before they used CS. Below are a few specific direct quotes from a few learners:

*Learner 2: "I used to read many times without understanding, but after CS I could understand content after reading once. I now understand the concept of waves more clearly than ever before because of CS. I was happy to perform an experiment in my school despite lack of resources because of CS."*

*Learner 7: "I spend lesser time on my books these days because the observations that I got from CS, they help me relate to what I read in the text book about waves."*

*Learner 8: "After the CS actually you do not need much time to read the content because the content is right in your mind. That is to say, when I learn using CS I understand content much quicker and better than ever before."*

*Learner 6: "I spend more time because of the love I have for the subject, each time I study there is something that tells me to study more. I enjoy the time I spend studying waves in physical sciences.*

### 4.3 Concluding remarks

The learners who were taught through computer simulations became very active in the learning process as they could relate the learning tasks to what they had been doing on a computer. They were able to tackle the tasks that were not only authentic but rather challenging for them. They were completely engaged and actively participating in class, they were not passive information receivers any more.

The learners who were taught through traditional teaching found it hard to participate actively in the learning process. They were struggling to deal with their tasks and they seemed to have lost interest in the learning of Physical Sciences.

# CHAPTER 5: DISCUSSION

## 5.1 Introduction

The aim of this study was to explore learner conceptual development using computer simulation in a Grade 10 science class. A pre-test was given to both groups (EG and CG) and the results show that there was no significant difference in performance of learners from both groups (T-test, $p > 0.05$), suggesting that learners in the two groups had similar understanding of concepts before instruction. However, in the post-test, the EG performed better than the CG and the differences were significant (T-test, $p < 0.05$). An effect size of 0.84 was obtained, suggesting large positive effects for the EG and Cohen d of 0.41 obtained was greater than (> 0.35), suggesting a large gain (Cohen 1988) for the EG. Therefore the objectives of the study are met.

The fact that simulations cannot replace laboratory work must be considered, ideally, both simulations and hands-on practical work can be used in conjunction with each other. The combination of simulations and laboratory offers advantages in time so that the laboratory portion can be reduced and learners using the simulations have a slightly better knowledge of the practical aspects directly related to laboratory work (Kennepohl, 2001). Raimi's (2002) study in Pakistan found that laboratory work positively affects learners' performance in Physical Sciences. Furthermore, Adesoji and Olatunbosun (2008) argued that learners tend to understand and recall what they see more than what they hear and this improves their performance. The results indicate that EG performance improved more than the CG, as a result of the opportunity to observe and interact with what happened during CS. This result hence enforces the fact that CS provides learners with an opportunity to view and being able to conceptualise what they observed.

After four weeks of teaching, there was a significant difference in performance of boys and girls in the EG ($p < 0.05$) when compared to those in the CG. These results are not surprising because it has been recently reported that strategies focusing on learners are successful in narrowing the achievement gap between boys and girls in Physical Sciences in high schools (Baker, 2013; Michael, 2013). In addition, learners benefit through engagement with concepts especially when they do practical work

through “interactions, hands-on activities, and application in science” (Hampden-Thompson & Bennett, 2013). In case of computer simulation, an interaction among learners themselves still exists. Learners continue to engage with each other and with the concepts during the lesson.
In schools where laboratories are not available, CS can help to provide practical work that could have been provided by the use of laboratory. This suggests that it is possible to use a computer simulated experiment in place of a laboratory experience in the teaching of most science concepts (Choi & Gennaro, 1987).

Traditional teaching used in the CG did not make learners enjoy Physical Sciences and their attitudes, after teaching using traditional approach, were negative towards the subject. This might have been due to the expository approach being too abstract in science classes. It is no wonder learners spent a lot of time to understand science content. Conversely, computer simulation is potentially useful for simulating labs that are impractical, expensive, impossible, or sometimes too dangerous to run (Slotta, 2002). Simulations can contribute to conceptual change, provide open-ended experiences, and provide tools for scientific inquiry and problem solving.

Computer simulation improves understanding of science concepts and this ultimately improves the quality of science education. Learners who were taught through CS claimed to have spent less time to understand science content when they were interviewed; it also saved time that could have been wasted by setting up apparatus during the lessons and this allowed much time to be used on the experiment; they enjoyed science lessons and developed a desire to continue studying Physical Sciences in future. In a situation where they indicated having spent much time, this is understandable due to the attraction they now have on the subject due to an interest caused by the level of their understanding of the subject. Thus, their attitudes formed a vital part of learning science and developed traits such as positive attitudes, motivation, and genuine interest in studying science. The findings are in agreement with Dalgety et al. (2003) and Covington (2000) regarding the importance of attitudes and motivation in science, respectively. Dwyer and Lopez (2001) also talked about learners being motivated when they experience realistic problems and arriving at realistic solutions in a relatively short time period.

Considering learners' reasoning during the post-test, the EG developed a clear conceptual understanding of scientific procedures but not those from the CG. The conceptual understanding exhibited by the EG is in agreement with Slotta (2002), who indicated that learners may benefit from CS that allows them learn from each other and also make them develop autonomous learning.

The development of positive attitudes has been reported in cognitive, behavioural and affective domains (Ajzen, 2005). In this study, semi-structured interviews were intended to uncover the affective domain by seeking learners' emotional feelings regarding Physical Science (Rajecki, 1990). Learners from EG were positive while learners from the CG exhibited negative attitudes towards Physical Sciences. These findings clearly indicate that tasks given during CS appealed to emotions and raised contextual issues and were not restricted to availability of resources unlike in the traditional teaching method. Although it may seem like much time was spent on experiments in CS classes, learners reported that they enjoyed the teaching approach and it made them understand concepts much better than traditional approach. This is why some learners suggested that it took them a shorter time to read and understand the concepts. Learners from EG clearly explained confidently the concepts of waves and this proved that their conceptual understanding had improved.

## 5.2 Conclusion

In conclusion, learners who were taught through computer simulation were happy with the way they understood the concepts. Computer simulation allowed the learners to gain a better knowledge of science concepts. The learners were "highly motivated", and it was evident when they showed an improvement in their performance. This justifies that computer simulations have the potential to enhance the way teachers teach and learners learn. They allow teachers to bring even the most abstract concepts to life for learners and incorporate otherwise impossible or impractical experiences into daily instructions.

The main conclusions after finishing the project, related on conceptual development were:

- CS improves motivation and performance;
- CS can help to get a scientific literacy of the learners; and
- CS is most effective when integrated with guided inquiry activities which encourage learners to explore scientific concepts.

The study is encouraging teachers from poor schools that do not have resources to use computer simulation when teaching science in Grade 10. This makes it possible for learners to explore the world that they could not otherwise have explored because of their background. Learners will be engaged in inquiry, further develop their knowledge and conceptual understanding of the content, gain meaningful practice with scientific process skills, and confront their misconceptions. On the other hand, this study is bridging the gap between learners learning in different ways from the same class, by improving every learner's conceptual development. CS indeed provides good quality practical work done in a safe environment that engages learners and it helps them to develop important skills. It makes them understand the process of scientific investigation, and develop their understanding of concepts.

## 5.3 Recommendations

The aim of this study was to explore learner conceptual development using CS in a Grade 10 science class. The objectives were to establish whether the visualization of phenomena through CS can contribute to learner's conceptual development in science, establish whether learner performance in the test increases when learners are taught through interactive CS and identify learners' attitudes after using CS in a science class. From the results it shows that if learners were to develop conceptual understanding of science concepts, teachers need to integrate CS in their day-to-day teaching. As a result, their performance and attitude towards Physical Sciences improves. CS may be used as supplementary tools for classroom instruction and not be used to replace physical laboratory. CS solves the problem of lack of space in schools, allowing learners to perform an experiment in a classroom and make a teacher not worried about the space to put away the equipment.

Other limitation of this study is time allocated for practical work at secondary school. Times allocated for the practical work could be increased beyond one hour and maybe allow teachers use more time in practical work demonstrated on their computers than to teach directly from their textbooks. Some limitations of this study is the small sample (N = 105) and the gender imbalance. Thus, findings from this study cannot be applied to the rest of the province and indeed the country, but they add to a growing body of literature of CS and its effect on attitude and performance. Nevertheless, the study has far reaching implications in learning science regarding exploring learner conceptual development using computer simulation in Grade 10 Science class. Therefore, more studies are recommended. Also studies using subjects other than science can use simulation to confirm or refute the findings.

## References


Abdullah, S., & Shariff, A. (2008). The effect of Iquiry-Based Computer Simulation with Cooperative Learning on Scientific Thinking and Conceptual Understanding of Gas Laws. *Eurasia Journal of Mathematics, Science & Technology Education, 2008, 4(4),387-398.*

Adesoji, F. A. (2008). Managing students' attitude towards Science through Problem –Solving Instructional Strategy. *Department of Teacher Education, University of Ibadan, Ibadan, Nigeria.*

Akpan, J. P., & Andre, T. (1999). The effect of a prior dissection simulation on middle school students' dissection performance and understanding of the anatomy and morphology of the frog. *Journal of Science Education and Technology*, 8, 107-121. Retrieved December 10, 2013 from http://ipsapp008.kluweronline.com/content/getfile/4947/1/2/fulltext.pdf

Ajzen, I. (2005). *Attitudes, Personality and Behavior (* 2nd Ed.) Maidenhead: Open University Press.

Alessi S. M., & Trollip, S. R. (2001). *Multimedia for learning: Methods and development* (3rd Ed.). (pp 214, 254-257). Boston: Allyn & Bacon.

Annetta, L. A., Holmes, S.Y., & Cheng, M., Minogue, J. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Elsevier, 53(1), 74 – 85.*

Asan, A. (2002). Preservice teachers use of technology to create instructional materials: A school-college partnership. *Journal of Information Technology for Teacher Education, 11*(2), 217–232.

Baker, D. (2013). What works: Using curriculum and pedagogy to increase girls' interest and participation in science. *Theory Into Practice*, 52, 14–20.

Bangert-Drowns, R. L., & Pyke, C. (2001). A taxonomy of student engagement with educational software: An exploration of literate thinking with electronic text. *Journal of Educational Computing Research, 24*(3), 213-234.

Bell, R.L., & Smetana, L. (2008). Using computer simulations to enhance science teaching and learning. In R.L.Bell, J. Gess-Newsome, & J. Luft (Eds.), *Technology in the secondary science classroom*. Arlington, VA: NSTA Press.

Bernard, H. R. (2002). *Research Methods in Anthropology: Qualitative and quantitative methods*, ( 3rd Ed.) Calfornia, Walnut Creek, California.

Braak, J.V. (2001). Individual characteristics influencing teachers' class use of computers. *Journal of Educational Computing Research, 25*(2), 141–157.

Braimoh, D. S., & Okedeyi, A. S. (2001). Direction of professional development for classroom teachers in effective science, technology and mathematics teaching: Matters arising. *Lagos Journal of Science Education,* 5, 33-37.

Bransford, J., Brown, A., Cocking, R. (2000) (Eds.). *How People Learn: Brain, Mind, Experience, and School* (National Academy Press, Washington, DC).

Brickhouse, N. W. (1989). The teaching of the philosophy of science in secondary classrooms: case studies of teachers' personal theories. *International Journal of Science Education*, 11(4), 437-449.

Bookcock, S., & Schild, E. (Eds.) (1968). *Simulation games in learning*. Beverly Hills, CA: Sage.

Budoff, M., Thormann, J., & Gras, A. (1984). *Microcomputers and special education*. Cambridge, MA: Brookline

Carr, M. (1996). Interviews about instances and interviews about events. In: DF Treagust, R Duit, & B. J. Fraser (Eds.): *Improving Teaching and Learning in Science and Mathematics (pp.44-53).* New York: Teachers College Press.

Chandra, S., Theng, Y., O. Lwin, M., & Foo, S. (2009). Examining the role of cognitive absorption for information sharing in virtual worlds. *Conference Papers — International Communication Association*, 1-33.

Chang, C., & Mao, S. (1999) Comparison of Taiwan Science Students' Outcomes with Inquiry-Group versus Traditional Instruction. *Journal of Educational Research*, 92(6), 340-46.

Charles R., Lester, F., & O'Daffer, P. (1987). *How to Evaluate Progress in Problem Solving*. Palo Alto California Dale Saymour.

Cherryholmes, C. H. (1966). Some current research on effectiveness of educational simulations: Implications for alternative strategies. *American Behavioral Scien- tist,* 10, 4-7.

Choi, B. S., & Gennaro, E. (1987). The effectiveness of using computer simulated experiments on junior high students' understanding of the volume displacement concept. *Journal of Research In Science Teaching,* 24, 539-552.

Clark, R. C. (1999). *Developing technical training* (2nd Ed.). Washington, DC: International Society for Performance Improvement.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education (6th Ed.).* New York: Routledge.

Covington, M. V. (2000). Goal theory, motivation, and school achievement: An integrative review. *Annual Review of Psychology*, 51, 171-200.

Crawford, B. A. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Reseach in Science Teaching, 37(9),* 916-937.

Crawley, F., & Black, C. (1992). Casual modelling of secondary science students' intentions to enrol in physics. *Journal of Research in Science Teaching,* 9, 585-599.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika,* 16, 297–334.

Cruickshank, D., & Tefler, R. (1980). Classroom games and simulations. *Theory Into Practice*, 19, 75-80.

Dalgety, J., Coll, R. K., & Jones, A. (2003). Development of chemistry attitudes and experiences questionnaire (CAEQ). *Journal of Research in Science Teaching*, 40, 649-668.

Dearing, R. (1996). *Review of Qualifications for 16–19 year olds* (London: Schools Curriculum and Assessment Authority).

De Jong, T., & van Joolingen W. R. (1998). Scientific Discovery with computer Simulations of Conceptual Domains. University of Twente, The Netherlands.

Department of Education documents, (2005). *National Curriculum Statement Grades 10-12 Subject Assessment Guidelines Physical Sciences.* Pretoria: Department of Education documents.

Department of Education documents, (2007). *National Curriculum Statement Grades 10-12 Subject Assessment Guidelines Physical Sciences.* Pretoria: Department of Education documents.

De Vos, A. S, Strydom, H., Fouche, C. B., & Delport, C. S. L. (2002). *Research at grassroots. For Social sciences and Human service professions. (*2nd Ed.). Pretoria: van Schaik.

Dewey, J. (1933). *How we think: a restatement of the relation of reflective thinking to the educative process*. Lexington, Mass: D.C. Health.

Dix, S. (2003). *Looking beyond the statistics: the Internet in the lives of the Emerging Black Market. A Research Paper presented to the SAMRA 2003 conference. http://www.webcheck.Archive.htm.*

Driver, R., Osoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23* (7), 5-12.

Driver, R. (1995). Constructivist approaches to science teaching. In L. P. Steffe & J. Gale (Eds.), *Constructivism in education* (pp. 385–400). Hillsdale, NJ, Lawrence Erlbaum.

Duffy, T., & Cunningham, D. (1996). Constructivism: Implications for the Design and Delivery of Instruction. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology*. New York: Simon & Schuster.

Duit, R., Confrey, J. (1996). *Reorganizing the curriculum and teaching to improve learning in science and mathematics*. In: DF Treagust, R Duit, BJ Fraser (Eds.), *ImprovingTeaching and Learning in Science and Mathematics*. New York: Teachers College Press, pp. 79–93.

Dupin, J. J., & Joshua, S. (1987). Analogies and 'modeling analogies' in teaching: Some examples in basic electricity. *Science Education*, 73(2), 791–806.

Dwyer, W. M., & Lopez, V. E. (2001). Simulations in the learning cycle: a case study involving Exploring the Nardoo. National Educational Computing Conference, "Building on the Future", Chicago, IL.

Farran, D. (1968). *Competition and learning for underachievers*. In S. Boocock & E. Schild (Eds.), *Simulation games in learning* (pp. 191-204). Beverly Hills, CA: Sage.

Faryniarz, J., V. & Lockwood, L. G. (1992). Effectiveness of microcomputer simulations in stimulating environmental problem solving by community college students. *Journal of Research in Science Teaching*, 29(5), p:455.

Felder, R. & Prince, M. (2007). The Many Faces of Inductive Teaching and Learning. *Journal of College Science Teaching, 36(5), 14 – 20.*

*Fetters, M. K., Czerniak, C. M., Fish, L., Shawberry, J. (2002).* Confronting challenging, and changing teachers' beliefs: implications from a local systemic change professional development program*. Journal of Science Teacher Education 12(2):101–130.*

Folaranmi, B. A. (2002). The teaching of sciences in our schools: What hope do we have for the future, bright or bleak? *Journal of Science and Movement Education,* 4, 132-142.

Gaarder, M. M. (2010). Experimental and quasi-experimental designs. *International Initiative for Impact Evaluation.*

Garrison, D. R., & Archer, W., (2000). *A Transactional Perspective on Teaching and Learning: A Framework for Adult and Higher Education*. Oxford, UK: Pergamon.

Geban, O., Askar, P., and Özkan, I. (1992). Effects of computer simulations and problemsolving approaches on high school students. *Journal of Educational Research*, 86(1), 5-10.

Gibson, H. L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science education. *Science Education, 86*(5), 693-705.

Gilbert, J. (2007). Catching the Knowledge Wave: Redefining knowledge for the post-industrial age. *Canadian Education Association*, *47*(3), 4-8.

Gitlin, T. (2001). Media unlimited: How the torrent of images and sounds overwhelms our lives. New York, NY: Metropolitan Books.

Granland R., Bergland, E., & Eriksson, H. (2000). Designing web-based simulation for learning. *Future Generation Computer Systems*, 17, 171-185.

Greenblat, C., & Duke, R. (1975). Gaming simulation: Rationale, design, and application. New York: Halsted.

Halladyna, T. & Shanghnessy, J. (1982). Attitudes towards science: A qualitative synthesis. *Journal of Research in Science Teaching*, 66 4: 547-563.

Hampden-Thompson, G., & Bennett, J. (2013). Science teaching and Learning activities and students' engagement in science. *International Journal of Science Education*, 35(8): 1325–1343.

Hancock, B. (2002). Trent Focus for Research and Development in Primary Health care. An introduction to qualitative research. Division of General Practice, University of Nottingham.

Harlen, W. (2004) Evaluating Inquiry-Based Science Developments, National Academy of Science, available online http://www.nsrconline.org/pdf/NAS_paper_eval_inquiry_science.pdf

Harper, B., Squires, D. & McDougall, A. (2000). Constructivist simulations in the multimedia age. Journal of Educational Multimedia and Hypermedia, 9, 115-130.

Harris, J. (2001). *The effects of computer games on young children: A review of the research*. http://www.homeoffice gov.uk/rds/pdfs/occ72-ompgames.pdf [Viewed 1 March, 2006].

Heinich, R., Molenda, M., Russell, J., & Smaldino, S. (1999). *Instructional Media and Technologies for Learning*. (6th Ed.). ( pp.14-15, 21, 213-214, 290-291, 319-324). Upper Saddle River, NJ: Prentice-Hall.

Hodson, D. (1993). Re-thinking old ways: Towards a more critical approach to practical work in school science. *Studies in Science Education*, 22, 85–142.

Hofstein, A. & Lunetta, V. N. (2003). The Laboratory in science education: foundations for the twenty-first century. National Association for Research in Science Teaching.

Hofstein A. & Lunetta V. N., (2004), The laboratory in science education: foundation for the 21st century, *Science Education*, **88**, 28-54.

Holbrook, J., & Kolodner, J. L. (2000). Scaffolding the Development of an Inquiry-Based (Science) Classroom. In B. Fishman & S. O'Connor-Divelbiss (Eds.), *Fourth International Conference of the Learning Sciences* (pp. 221-227). Mahwah, NJ: Erlbaum.

Howie, S. J. (2001). *Third International Mathematics and Science Study Repeat (TIMSS-R)*. Pretoria: Human Sciences Research Council.

Howie, S. J. (2003). Language and other background factors affecting secondary pupils' performance in Mathematics in South Africa . *African Journal of Research in SMT Education, 7*, 1-20.

Hug, B., Krajcik, J. S. & Marx, R. W. (2005). Using Innovative Learning Technologies to Promote Learning and Engagement in an Urban Science Classroom. *Urban Education, 40, 446 – 472.*

Igwe, I. O. (2002). Relative effects of Framing and Team assisted instructional Strategies on students' learning outcomes in selected difficult chemistry concepts. Unpublished Ph.D Thesis University of Ibadan, Ibadan.

Ivgen, R. (1997). *Biological Researches Guide*. Istanbul: Milli Egitim Press.

Ivowi, U. M. O. (1995). *Secondary science education Nigeria.* Paper presented at the UNESCO workshop on Planning Secondary Science Education. Magaliesburg, South Africa.

Jegede, O., J., Okebukola, P., A., and Ajewole, G., A. (1991). Computers and the learning of biological concepts: attitudes and achievement of Nigerian students. *Science Education*, 75(6), 701-706.

Jenson, J., Lewis, B., & Smith, R. (2002). No one way: Working models for teachers' professional development. *Journal of Technology and Teacher Education.* 10(4), 481–496.

Jonassen, D. H. (1995). Computers as cognitive tools: Learning with technology, not from technology. Journal of Computing in Higher Education, 6 (2), 40-73.

Jones, B., Valdez, G., Nowakowski, J., & Rasmussen, C. (1994). *Designing Learning and Technology for Educational Reform*. Oak Brook, IL: North Central Regional Educational Laboratory.

Kafai, Y. (2001). *The Educational Potential of Electronic Games: from games-to-teach to games-to learn*. Retrieved March1, 2006, from http://culturalpolicy.uchicago.edu/conf2001/papers/kafai.html

Kempa, R. F., & Dube, G.E. (1974). Science interest and attitude traits in students subsequent to the study of chemistry at the ordinary level of the G.C.E. *Journal of Research in Science Teaching*, II(4), 361-370.

Kennepohl, D. (2001). Using computer simulations to supplement teaching laboratories in chemistry for distance delivery. *Journal of Distance Education,* 16(2), 58-65.

Khan, M., & Iqbal, M.Z. (2011). Effect of Inquiry Lab Teaching Method on the Development of Scientific Skills Through the Teaching of Biology in Pakistan*. Language in India,* 11(1), 169-178.

Kibirige, I., & Tsamago, H. (2012). Learners' Performance in Physical Science Using Laboratory Investigations. *University of Limpopo, Department of Mathematics, Science and Technology Education*

*Klassen, S. (2006).* A theoretical framework for contextual Science teaching, *Interchange,* 37*(1–2), 31–62.*

Knobloch, B. (2005). Reap the benefits of games and simulations in the classroom. *The Agricultural Education Magazine,* 78(2), 21-23.

Krajcik J., Mamlok R. & Hug B., (2001), Modern content and the enterprise of science: science education in the 20th century. In: L. Corno (Ed.). *Education across a century: the centennial volume (*pp. 205-238). Chicago, Illinois: National Society for the Study of Education (NSSE).

Kyle, W.C., Bonnstetter, R. J., McCloskey, J., & Fults, B. A. (1985). What research says: Science through discovery: Students Love It. *Science & Children*, *25* (7), 39-40.

Lazarowitz, R., & Tamir, P. (1994). Research on using laboratory instruction in science. In: DL Gabel (Ed.), *Handbook of Research on Science Teaching and Learning (pp. 94-128).* New York, Macmillan.

Lee, V., & Burkam, D. (1996). Gender differences in middle grade science achievement: Subject domain, ability level and course emphasis. *Science Education,* 80(6): 613-650.

Leemkuil, H., de Jong, T., de Hoog, R., & Christoph, N. (March, 2003). KM QUEST: A collaborative Internet-based simulation game. *Simulation & Gaming*, *31*(1), 89-111.

Lehrer, R., Schauble, L., Carpenter, S., & Penner, D. (2000). The inter-related development of inscriptions and conceptual understanding. In P. Cobb & E. Yackel & K. McClain (Eds.), *Symbolizing, mathematizing, and communicating: Perspectives on discourse, tools, and instructional design*. Mahwah, NJ: Lawrence Erlbaum Associates.

Levy, Y., & Ellis, T. J. (2011). A Guide for Novice Researchers on Experimental and Quasi-Experimental Studies in Information Systems Research. *Interdisciplinary Journal of Information, Knowledge, and Management, 6*, 151-161.

Lit, I.W., Lotan, R. (2013). A balancing act: Dilemmas of implementing a high- stakes performance assessment. *The New Educator*, 9: 54–76.

Loyd, H., and P. Gressard. (1984). Reliability and factorial validity of computer attitude scales. *Educational and Psychological Management.* 44, 501-505.

Lunetta V. N., (1998). The school science laboratory: historical perspectives and centres for contemporary teaching, . In P. Fensham (Ed.). *Developments and dilemmas in science education* (pp 169-188), London, Falmer Press.

Lunette, V. N., & Hofstein, A. (1981). Simulations in science education. *Science Education*, 65, 243-252.

Lunetta V. N., Hofstein A., & Clough M., (2007)**.** Learning and teaching in the school science laboratory: an analysis of research, theory, and practice, In N, Lederman. and S. Abel (Eds,), *Handbook of research on science education.* (pp. 393-441), Mahwah, NJ: Lawrence Erlbaum.

Magnusson, S.J, Palincsar, A. (1995). The learning environment as a site of science education reform. *Theory into Practice*, 34(1), 43-50.

Makgato, M., & Mji, A. (2006). Factors associated with high school learners' performance: A spotlight on mathematics and physical science. *Africa Education Review, 4(1), 89 – 103.*

Malcom, S. H. (2010), *How to Reach out to Girls, their Famalies and Communoties to support involvementin Inquiry-BasedScience. Presented at the IBSE for Girls/Primary Connections Workshop, held on 11-13 May 2010 at Pretoria, South Africa.*

Michael, C. W. (2013). Learning Strategies and Their Relationships to Academic Performance of High School Students in Hong Kong. Educ Psychol. From <http:// dx.doi.org/ 10.1080 /01443410. 2013. 794493 > (Retrieved on May 30, 2013).

Miller, J. D., Pardo, R., & Niwa, F. (1997). *Public perceptions of science and technology: a comparative study of the European Union, the United States, Japan, and Canada* (Bilbao: BBVFoundation).

Min, R. (2001). Designing dynamical learning environments for simulation: Micro-worlds applets on the World Wide Web. 6th Proceedings of EARLI, SIG, June 27-29**,** 2002, Erfurt, Germany.

Mouton, J., & Maraise, H.C. (1996). *Basic Concepts in the Methodology of the Social Sciences.* Pretoria: Human Sciences Research Council.

Muwanga-Zake, J. W. F. (2006). Evaluation of Educational Computer Programmes as a Change Agent in Science Classrooms. *Australian Journal of Educational Technology, 24(4), 374 – 386.*

*Myers, R. E., Fouts, J. T. (1992).* A cluster analysis of high school science classroom environments and attitude toward science*. Journal of Research in Science Teaching, 29, 929-937.*

*Nahvi, M. (1996). "Dynamics of Student-computer Interaction in a Simulation Environment: Reflections on curricular issues".* In: Proceedings of Frontiers in Education.

*National Research Council, (2000). National science education standards, National Academy Press: Washington, D.C.*

*National Research Council (NRC) (2005). America's lab report: investigations in high school science. National Academy Press, Washington, DC.*

Neuman, W. L. (2011). *Social Research Methods: Quantitative and qualitative Approaches Sixth Edition.* USA: Pearson International Edition.

O'Connell, S. (2000). *Introduction to Problem Solving: Strategies for the Elementary Maths Classroom*. Portsmouth, N.H: Heinemann.

Okebukola, P. A. O. (1997). The state of science education in Nigeria. *Science Teachers Association of Nigeria Bulletin,* 14(21), 8-10.

Okpala, N. P. (1985). Teacher attitudinal variables in instructional assessment practices as correlates of learning outcomes in Physics. Unpublished Ph.D Thesis, University of Ibadan, Ibadan.

Olaleye, E. O. (2002). New training and teaching technologies: Issues, problems and prospects for teacher education programme in Nigeria. *Journal of Science and Movement Education,* 4, 38-49.

Olanrewaju, A. O. (1994). *New Approaches to the teaching of integrated science*. Ibadan: Alafas Nigeria Company.

Onocha, C.O. (1985). Patterns of Relationships between Home and School Factors and Pupils' learning outcomes in Bendel Primary Science Project. Unpublished Ph.D Thesis. University of Ibadan, Ibadan.

Osborne, J. F., Simon, S., & Collins, S. (2003). Attitudes towards Science: A Review of the Literature and its Implications. *International Journal of Science Education*, 25(9), 1049–1079.

Ottander, C., & Grelsson, G. (2006). Laboratory work: The teachers' perspective. *Journal of Biology Education*, 40(3): 113–118.

Palmer, P.J. (1998). *Exploring the inner landscape of a teacher's* life. In *The courage to teach:* Jossey-Bass.

Palys, T. (2008). Purposive Sampling. In Lisa M. Given (Ed.). *The Sage Encyclopedia of Qualitative Research Methods (pp697-698)*. Thousand Oaks, CA: Sage.

Perkins, K., & Parson, R. (2012). PhET Interactive Simulations: Using Research-Based Simulations to Transform Undergraduate Chemistry Education #1226321 Organization:University of Colorado at Boulder.

Piaget, J. P. (1952). The origins of intelligence in children. New York. International Universities Press.

Pieterson, J., & Maree, K. (2007). Standardisation of a questionnaire. In K. Maree, *First Steps in Research* (pp. 214-223). Pretoria: Van Schaik Publishers.

Podolesky, N. S., Perkins, K. K., Adams, W. K. (2010). *Department of Physics, University of Colorado at Boulder, Boulder, Colorado 80309-0390,* USA.

Polman, J. L. (1999). *Designing project-based science: Connecting learners through guided inquiry.* New York: Teachers College Press.

Project Tomorrow. (2010). Unleashing the Future: Educators “Speak Up” about the use of Emerging Technologies for Learning. Speak Up 2009 National Findings. Teachers, Aspiring Teachers & Administrators, May 2010. Retrieved February 2013 fromwww.tomorrow.org/speakup/ Thousand Oaks, CA: Sage.

Raimi, S. M. (2002). *Problem-solving Techniques and Laboratory Skills as Supplements to Laboratory Teaching in Senior Secondary School Students' Learning of Volumetric Analysis*. PhD Thesis, Unpublished. University of Ibadan, Ibadan.

Rajecki, D. W. (1990). *Attitudes.* 2nd Edition. Massachusetts: Sinauer Associates Inc.

Randel, J., Morris, B., Wetzel, C., & Whitehill, B. (1992). The effectiveness of games for educational purposes: A review of the research. *Simulation and Gaming*, 25, 261-276.

Reddy, V. (2004). TIMSS media briefing, Human Sciences Research Council, 14 December, Pretoria.

Reiss, M. J. (2000) *Understanding Science Lessons: Five Years of Science Teaching.* Buckingham. Open University Press.

Roth, W. M., & Roychoudhury. A. (1993). The development of science process skills in authentic context. *Journal of Research in Science Teaching*, 30, 127-152.

Sahin, I., & A. Thompson (2006). "Using Rogers' Theory to Interpret Instructional Computer Use by COE Faculty." *Journal of Research on Technology in Education*, 39(1), 81-104.

Sahin,S. (2006). Computer Simulations in Science Education: Implications for Distance Education. *Turkish Online Journal of Distance Education-TOJDE July 2006 ISSN 1302-6488 Volume: 7 Number: 4 Article: 12.*

Sentongo, J., Kyakulaga, R., & Kibirige, I. (2012). *The effect of Using Computer Simulations in Teaching Chemical Bonding: Experiences with Ugandan Learners. Makerere University, Department of Science and Technology Education (DOSATE), Kampala, Uganda.*

Shami, P. A. (2001). Science Curriculum for the Primary School National Institute of Science and Technical Education. Islamabad: Ministry of Education, Govt. of Pakistan.

Shymansky, J. A., Kyle, W. C., & Alport, J. M. (1983). The effects of new science curricula on student performance. *Journal of Research in Science Teaching*, 20(5), 387-404.

Sibanda, N. (2009). Quantitative research – Victoria University of Wellington. Retrieved January 30, 2013, from www.voctoria.ac.nz/ postgradlife/

Simmons, P., E., & Lunetta, V., N. (1993). Problem-solving behaviors during a genetics computer simulations: beyond the expert/novice dichotomy. *Journal of Research in Science Teaching*, 30(2), 153-173.

Slotta, J. (2002). Designing the web-based inquiry science environment (wise). *Educational Technology*, 15-20.

Smithers, A. and Robinson, P. (1988). *The growth of mixed A-levels* (Manchester: Department of Education, University of Manchester).

Stembler, W. (1975). Cognitive effects of a programmed simulation. Simulation & Games, 6, 392-403.

Stohl, H. (2005). Probability in teacher education and development. In G. Jones (Ed.), *Exploring Probability in School: Challenges for Teaching and Learning*, (pp. 345-366). Dordrecht, Netherlands: Kluwer Academic Publishers.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. London: Sage.

Swanson, H., & Lussier, C. (2001). A selective synthesis of the experimental literature on dynamic assessment. *Review of Educational Research,* 71(2), 321-363.

Sweller, J. (1999). *Instructional design in technical areas*. Camberwell, Australia: ACER Press.

Taylor, L., & Parsons, J. (2011). Improving Student Engagement. *Current Issues in Education*, *14(1)*, 1-33.

Thompson, A., Simonson, M., & Hargrave, C. (1996). Educational technology: A review of the research (2nd Ed.). Washington, DC: Association for Educational Communications and Technology.

Thurlow, C., Lengel, L., & Tomic, A. (2004). *Computer mediated communication: Social interaction and the Internet*. London: Sage.

Tobin K.G., (1990), Research on science laboratory activities; in pursuit of better questions and answers to improve learning, *School Science and Mathematics*, 90, 403-418.

Trundle, K. C., & Bell, R. L. (2005). The use of a computer simulation to promote scientific conceptions of moon phases. A paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Dallas, TX.

Van der Meij, J., & de Jong, T. (2006). Supporting students' learning with multiple representations in a dynamic simulation-based environment.

Van Merriënboer, J. J. G. (1997). *Training complex cognitive skills.* Englewood Cliffs, NJ: Educational Technology Press.

White, B., & Frederiksen, J. (1998). Inquiry, Modeling, and Metacognition: Making Science Accessible to All Students. *Cognition and Instruction*, 16(*1*), p.3-118.

Wilson, V. L. (1983). A Metal-Analysis of the Relationship Between Science and Achievement and Science Attitude: Kindergarten Through College. *Journal of Research in Science Teaching*, 20(9), 839-885.

Wilson, B. & Cole, P. (1996). Cognitive teaching models. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology*. New York: Simon & Schuster.

Winn, W., & Synder, D. (1996). Cognitive perspectives in psychology. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology*. New York: Simon & Schuster.

Xulu, N. (2012). *Exploration of use of the Science resource centre by Physical Sciences Teachers*. Durban: Unpublished Masters thesis, University of Kwazulu-Natal.

Yara, P. O. (2009). Relationship between Teachers' attitude and Student Academic Achievement in Mathematics in Some Selected Senior Secondary Schools in Southwestern Nigeria. *European Journal of Social Sciences, 11(3), 364-369.*

Young, B. J., & Lee S. K., (2005). The effects of a kit-based science curriculum and intensive science professional development on elementary student science achievement. *Journal of Science Education and Technology*, 14(5/6), 471-481,

Zhao, Y., & Cziko, G. A. (2001). Teacher adoption of technology: A Perceptual-control-theory perspective. *Technology and Teacher Education* 9(1), 5–30.

# Appendices

**ANNEXURE A**

Enquiries: Tsamago H.E
Contact: 0722329497
E-mail: hoditsamago@rocketmail.com
Department Of Education
Private Bag X9489
Polokwane
0700

P.O Box 2777
Koloti
0709

Re: Request for permission to conduct research

1. The above matter bears reference.
2. I am requesting permission to conduct a study in the secondary schools within Capricorn District, Bahlaloga circuit during the third term of 2014. The participants are leaners studying Physical Sciences in Grade 10 in two schools.
3. The purpose of the study is to:
    - Establish whether the visualization of phenomena through computer simulation can contribute to learner's conceptual development in science.
    - Establish whether learner performance in the test increases when leaners are taught through interactive computer simulations.
    - Identify learners' attitudes after using computer simulations in a science classroom
4. The positive impact of this study will help learners develop positive attitude towards the learning of science, and perform practical work with limited resources.
5. The study will not bear any financial implications for the Limpopo Department of Education, and it will not in any way disrupt the academic programs at the schools.
6. Hoping for your positive response.

Yours faithfully
Tsamago H.E

**ANNEXURE B**

Enquiries: Tsamago H.E
Contact: 0722329497
E-mail: hoditsamago@rocketmail.com

P.O Box 2777
Koloti
0709

The Principal

Re: Application to conduct a study at your school

1. The above matter bears reference.
2. I am requesting permission to conduct a study at your school during the third term of 2014. The participants will be leaners studying Physical Sciences in a Grade 10 class.
3. The purpose of the study is to:
    - Establish whether the visualization of phenomena through computer simulation can contribute to learner's conceptual development in science.
    - Establish whether learner performance in the test increases when leaners are taught through interactive computer simulations.
    - Identify learners' attitudes after using computer simulations in a science classroom
4. The positive impact of this study will help learners develop positive attitude towards the learning of science, and perform practical work with limited resources.
5. The study will not bear any financial implications for the school, and it will not in any way disrupt the academic program at the school.
6. Hoping for your positive response.

Yours faithfully
Tsamago H.E

**ANNEXURE C**

***(A letter to the Parent or Guardian)***

Enquiries: Tsamago H.E
Contact: 0722329497
E-mail: hoditsamago@rocketmail.com

P.O Box 2777
Koloti
0709

Dear Parent or Guardian:

I am a student at the University of Limpopo in the faculty of humanities in the department of Mathematics, Science and Technology. I am conducting a study on **Exploring learner conceptual development using computer simulation in a Grade 10 Science class**. I request permission for your child to participate in the study.

Participation in this study is voluntary. Your decision whether or not to allow your child to participate will not affect the services normally provided to your child by the school. Your child's participation in this study will not lead to the loss of any benefits to which he or she is otherwise entitled. Your child is free to refuse to participate even if is granted permission. If your child agrees to participate, he or she is free to end participation at any time. You and your child are not waiving any legal claims, rights, or remedies because of your child's participation in this research study.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means deletion of identifiers; crude report categories and micro-aggregation (that is, the construction of 'average persons' from data on individuals and the release of these data, rather than data on individuals). There shall be a tape recording to capture the information and it will be subsequently kept in a safe place for a period of five years.

Yours faithfully

Tsamago H.E

Please indicate whether or not you wish to allow your child to participate in this study. Sign both copies and keep one for your records.

I,_____ (grant/do not grant) permission for my child to participate in *Tsamago HE's* study on **Exploring learner conceptual development using computer simulation in a Grade 10 Science class**.

| | |
|---|---|
| _____ | _____ |
| Parent/Guardian's signature | Date |
| _____ | _____ |
| Printed Name of Child | Date |

## ANNEXURE D

### INTERVIEW SCHEDULE FOR LEARNERS BEFORE INTERVENTION

1. What is your attitude towards the learning of science?
2. Do you perform practical work in class?
3. What makes you enjoy learning science in a class?
4. How do you want to be taught in a science class?

### INTERVIEW SCHEDULE FOR LEARNERS AFTER INTERVENTION

1. How did the use of computer simulation improve your understanding of science concepts?
2. Does the use of computer simulation in class motivate you to learn science?
3. How is your attitude towards the learning of science using computer simulation?

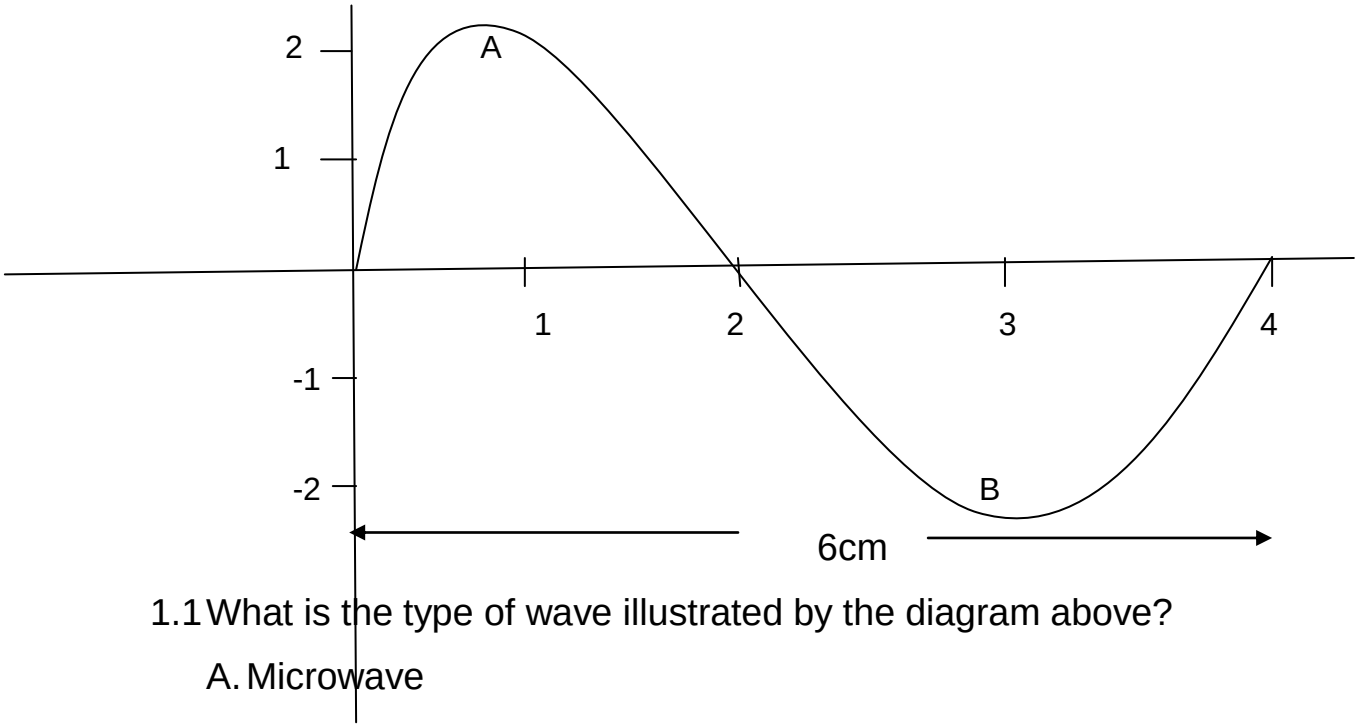
**ANNEXURE E**

PHYSICAL SCIENCE GRADE 10 PERFORMANCE TEST 1

MULTIPLE-CHOICE QUESTIONS

The diagram below is not drawn according to scale, it illustrates the type of wave of a certain frequency. Refer to the wave to answer some questions

Each question has only ONE correct answer. Write only the letter (A-D) next to the number.




1.1 What is the type of wave illustrated by the diagram above?

A. Microwave

B. Transverse wave

C. Longitudinal wave

D. Medium wave

1.2 What is the wavelength of this wave?

A. 3 cm

B. 2 cm

C. 6 cm

D. 12 cm

1.3 What is the amplitude of the wave?

A. 2 cm

B. 4 cm

C. 6 cm

D. 3 cm

1.4 How many waves are illustrated in the diagram?

A. 4

B. 3

C. 2

D. 1

1.5 When the frequency of the wave increases, the amplitude…

A. Increases

B. Decreases

C. Stay the same

D. Decreases and then increases.

1.6. The increase in frequency will result in….

A. Increase in the number of waves

B. A decrease in the number of waves

C. Doubling wavelength

D. Tripling wavelength

1.7 Period of a wave refers to…

A. The number of complete vibrations per second

B. Time taken to form a wave

C. Time taken for a complete wave

D. Frequency of a wave

1.8 When a crest of one wave coincides with a crest of another wave it results in a bigger crest…

A. destructive interference

B. cancellation

C. constructive interference

D. amplitude

1.9 What is the velocity of the above wave?

A. $0.2m.s^{-1}$

B. $0.0015m.s^{-1}$

C. $0.015m.s^{-1}$

D. $0.001m.s^{-1}$

1.10 An increase in the frequency of wave means the pitch of sound…

A. Decreases

B. Remains the same

C. Increases

D. Fluctuates

1.11 The frequency of this wave is…

A. 0.0009Hz

B. 0.008Hz

C. 0.12Hz

D. 0.016Hz

1.12 What is the relationship between frequency and wavelength of a wave?

A. Frequency is directly proportional to the wavelength

B. Frequency and wavelength do not have a relationship.

C. Frequency is inversely proportional to wavelength

D. Frequency of a wave does not affect the wavelength

1.13 How long does it take for a complete wave to form?

A. 2s

B. 3s

C. 1.3s

D. 4s

1.14 The quality of sound is attributed to…

A. Amplitude of a wave

B. Speed of a wave

C. Waveform

D. Period

1.15 A dolphin emits an ultrasonic wave with frequency of 0.15 MHZ. The speed of the ultrasonic wave in water is 1500m.s$^{-1}$. What is the wavelength of this wave?

A. 0.1 mm

B. 10 cm

C. 100 m

D. 1 cm

1.16 Position **A** on the graph represents…

A. Trough

B. Wave

C. Point in phase

D. Crest

1.17 Position **B** on the graph represents…

A. Crest

B. Point in phase

C. Wave

D. Trough

1.18 The amplitude and the frequency of a sound wave are both increased. How are the loudness and the pitch of the sound affected?

| | Loudness | Pitch |
|---|---|---|
| A. | Increased | raised |
| B. | Increased | unchanged |
| C. | Increased | lowered |
| D. | Decreased | raised |

1.19 What points are considered points in phase?

A. Points that move perfectly in step with each other

B. Points those are close to one another

C. Points that are closely parked

D. Points on crest and trough

1.20 Low amplitude represents a…

A. High sound

B. Low sound

C. No sound

D. Quality sound

2 x 20 = 40

_____END_____END_____

**ANNEXURE C**

***(A letter to the Parent or Guardian)***

Enquiries: Tsamago H.E P.O Box 2777
Contact: 0722329497 Koloti
E-mail: hoditsamago@rocketmail.com 0709

Motswadi yo a hlomphegago:

Ke moithuti Universiting ya Limpopo go lefapha la humanities ka lekaleng la Mathematics, Science and Technology. Ke swaragane le go phetha dinyakišišo go hlogo ya gore **Exploring learner conceptual development using computer simulation in a Grade 10 Science class**. Ka go reialo ke be ke kgopela tumelelo ya gore le dumelele ngwana wa lena go kgatha tema mo dinyakišišong tše.

Ngwana o kgatha tema ka boithaopo. Sephetho sa go kgatha tema ga ngwana se ka se ame go rutwa ga gagwe ka phaphošing. Ngwana le yena o na le maloka a go dumela goba go gana go kgatha tema mo dinyakišišong tše lege a filwe tumelelo gotšwa ka gae. Motswadi goba ngwana ga ana tšhutšhumetšo ya semolao goba maloka lege e ka ba tefo ya ge ngwana a kgatha tema mo dinyakišišong tše.

Tshedimušo efe goba efe gotšwa mo dinyakišišong ya go amana le ngwana e tla ba khupamarama ntle lege go bile le tumelelo ya gore e ka phatlalatšwa. Tshedimušo e tla hlathwa go ya ka ditshwantšhišo le mafapha ao a ka go go dirišwa go e boloka e ka se šumišwe go hlatha mokgatha tema. Go tlaba le segatiša mantšu go boloka tshedimušo yeo etlago dula sebaka sa go lekana mengwaga ye mehlano (5).

Yours faithfully

Tsamago H.E

Laetša ga eba o ka rata ge ngwana wa gago a ka kgatha tema mo dinyakišišong tše. Tsikitla mongwalo wa gago go matlakala a ka bobedi gomme o beye le lengwe bjalo ka bohlatse.

Nna,_____ (dumelela/gana) gore ngwana a kgathe tema mo dinyakišišong tša morena *Tsamago HE go* **Exploring learner conceptual development using computer simulation in a Grade 10 Science class**

| | |
|---|---|
| _____ | _____ |
| Motsikitlo wa motswadi | Letšatši kgwedi |
| _____ | _____ |
| Leina la ngwana | Letšatši kgwedi |

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

**TURFLOOP RESEARCH ETHICS COMMITTEECLEARANCE CERTIFICATE**

| | |
|---|---|
| **MEETING:** | 28 January 2015 |
| **PROJECT NUMBER:** | TREC/07/2015: PG |
| **PROJECT:** | |
| **Title:** | Exploring learner conceptual development using computer simulation in a Grade 10 Science class |
| **Researcher:** | Mr HE Tsamago |
| **Supervisor:** | Prof I Kibirige – University of Limpopo |
| **Co-Supervisor:** | N/A |
| **Department:** | Mathematics, Science and Technology Education |
| **School:** | Education |
| **Degree:** | Masters in Science Education |

**PROF TAB MASHEGO**
**CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE**

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031.**

**Note:**
i) Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.
ii) The budget for the research will be considered separately from the protocol.
**PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.**

Finding solutions for Africa

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

Private Bag X 9711
POLOKWANE
0700
Tel: 015 285 7300
Fax: 015 285 7499

**CAPRICORN POLOKWANE DISTRICT**
**CONFIDENTIAL**

Enq : Mphaphuli AJ
Tel No.: 015 285 7410
Email : MphaphuliAJ@edu.limpopo.gov.za

**To :** **Tsamago HE**
P. O. Box 2777
Koloti
0709

**SUBJECT: PERMISSION TO CONDUCT RESEARCH IN POLOKWANE DISTRICT, BAHLALOGA CIRCUIT.**

**Title: Exploring learners' conceptual development using computer simulation in a Grade 10 Science class**

1. The above matter refers.
2. The Department wishes to inform you that your request to conduct a research has been approved.
3. The following conditions should be considered

3.1 The research should not have any financial implication for Limpopo Department of Education.

3.2 Arrangements should be made with both the circuit offices and school concerned.

3.3 The conduct of research should not anyhow disrupt the academic programs at schools.

3.4 The research should not be conducted during the time examinations especially the fourth term.

3.5 During the study, the research ethics should be practiced, in particular the principle voluntary participation (the people involved should be respected).

3.6 Upon completion of research study, the researcher shall share the final product of the research with Department.

4. Furthermore you are expected to produce this letter at schools/offices where you intend conduct your research as evidence that you are permitted to conduct the research.
5. The department appreciates the contribution that you wish to make and wish you success in your research.

**Best wishes**

**MR MOTHEMANE KD**
**ACTING DISTRICT DIRECTOR**

04/03/2015
**DATE**

LIMPOPO PROVINCE
DEPARTMENT OF EDUCATION
POLOKWANE DISTRICT OFFICE
DEM OFFICE
2015 -03- 04
PRIVATE BAG X9711
POLOKWANE, 0700
KGORO YA THUTO LIMPOPO PROVINCE

**SUBJECT: PERMISSION TO CONDUCT RESEARCH IN POLOKWANE DISTRICT, BAHLALOGA CIRCUIT.**

# MAMOLEMANE SECONDARY SCHOOL

**POSTAL ADDRESS**
P O Box 2777
Koloti
0709

**Enquiries:**
The Principal
**Contact-no: 079 924 0009**

**E-MAIL ADDRESS**
mamolemane@yahoo.com
**District:**
Capricorn District Bahlaloga Circuit
EMIS-NO: 0922220613

**Date: 5 March 2015**

TO WHOM IT MAY CONCERN

This letter serves as a proof that Mr Tsamago HE is given permission at our school to conduct research for his study towards Masters in Science Education which he studies at the University of Limpopo as per his request. We are therefore hoping that the project will be beneficial to both him and the school.

We are humbled by the fact that our school has been considered to be part of the project.

We would like to thank him in advance.

Yours faithfully

.....
(Principal)

DEPARTMENT OF EDUCATION
MAMOLEMANE SECONDARY SCHOOL
P.O. BOX 2777 KOLOTI 0709
2015 -03- 08
EMIS: 0922220613
BAHLALOGA CIRCUIT CAPRICORN DISTRICT
LIMPOPO PROVINCE

# MOSHUBABA SENIOR SECONDARY SCHOOL


CAPRICORN DISTRICT

EMIS NO: 0922221015
ENQ: Mr. Mokoena H.J.
☎ :0829495257

BAHLALOGA CIRCUIT

PRIVATE BAG X22
KOLOTI
0709
05 MARCH 2015


TO WHOM IT MAY CONCERN

I Mokoena M.J. ( The principal ) of the above mentioned school, hereby grant Mr. Tsamago H.E permission to contact research project for his degree in Masters in Science Education at our school.

We are hoping to benefit from his findings and also trust that they will help us deal with any challenge we may encounter at the school.

DEPARTMENT OF EDUCATION
MOSHUBABA
SECONDARY SCHOOL
2015 -03- 05
PRIVATE BAG X22, KOLOTI 0709
LIMPOPO PROVINCE

Your faithfully

Principal