THE USE OF COMPUTER SIMULATIONS ON GRADE ELEVEN LEARNERS' PERFORMANCE IN PLANTS BIODIVERSITY, MANKWENG CIRCUIT

By

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ABSTRACT

Learners' performance largely depends on the pedagogy used. This study explored the use of Computer Simulations (CS) to teach plants biodiversity to grade eleven learners Mankweng Circuit. A randomised Solomon Four-Group design was used. Sixty-six learners from two schools equipped with computers were randomly assigned to the Experimental Group (EG), and 66 learners from two other schools without computers were the Control Group (CG). A performance pre- and post-test was used to the EG taught using CS and to the CG taught using Chalk-and-Talk Method (CTM). Also, Focus Group Discussion Interviews (FGDI) were conducted with 12 learners: six from each of the EG and the CG to collect information regarding their attitudes towards the methods used to learn biodiversity. The quantitative data were analysed using a T-test and Analysis of Variance (ANOVA), while the qualitative data were analysed thematically. The results show that the learners in the EG performed better than those in the CG (T-test; $p < 0.05$), (ANOVA; $p < 0.05$). Hypothesis one which states that learners in the EG who were taught using CS will perform better than those in the CG taught using CTM is accepted. Also, hypothesis two, which states that learners' performance in the pretest will not vary in the EG and the CG is accepted. Also, hypothesis three which states that there will be no statistically significant differences in achievements between boys and girls in the EG is established. Thus, the CS method is a useful tool to enhance learners' performance.

Keywords: *Computer simulations, PCK, TPACK, Quasi-experiment, Solomon four group design, Learner's performance*

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DECLARATION

I declare that the full dissertation, "The use of Computer Simulations on Grade Eleven learners' performance in Plants Biodiversity, Mankweng Circuit" hereby submitted to the University of Limpopo, for the degree of Master of Science in SCIENCE EDUCATION has not previously been submitted by me for a degree at this or any other University; that it is my work in design and in execution, that all materials contained herein have been duly acknowledged.

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K.B. BODIRWA (Mr) DATE

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CHAPTER 1: INTRODUCTION

1.1 Background to the study

Life Sciences courses in South Africa have significant themes in educational programs (Bolscho & Seybold, 1996). Jahnke (2011) stated that more emphasis has been on sustainable development education, which includes ecological and socio-economic factors. Biology as a Life Sciences subject explains the interaction of events in the living world, that is; the structure of the world, how the world functions, development, the existence of the living things, and how they interact with one another and with their surroundings (Okori & Jerry, 2017; Umar, 2011). Ahmed (2008) further points out that biology is an essential subject for many faculties of learning that contribute significantly to the technological development of the nation. The faculties include nursing, medicines, pharmacy, agriculture, forestry, nanotechnology, biotechnology, among others (Ahmed & Abimbola, 2011).

Biology is one of the major subjects in the secondary school curriculum in many countries, South Africa included. More learners enrol for biology in the senior secondary school certificate examination (SSCE) than for physics and chemistry. Biology is introduced to learners at secondary school level as a foundation for human development. Learners discover their talents and potential and pursue careers in Biology (the Federal Republic of Nigeria, 2009). Future scientists, engineers, technologists, and associated professionals are developed through the quality and quantity of science education taught at secondary schools. Be that it may, performance at senior secondary school level has been poor despite the prominence and attractiveness of biology among South African learners and in other countries such as Nigeria (Ahmed, 2008). The implication of this failure in education may be due to lack of science education specialists in science and technology related disciplines.

While scientific knowledge about plants has significantly increased in the last 100 years, there seems to have been a simultaneous drop in student education and interest in botany over the same period. Botany is perceived to be taught in a hypothetical and unexciting way for learners (Silva, Guimarães, & Sano., 2017). Hershey (1996) reported that the proportion of high schools offering botany classes had declined from over 50% in the early 1900s to less than 2% in the 1990s. Uno (2009) further noted that less than 1% of all learners entering college take 'botany' as their prospect major and a small number of undergraduate institutions were offering botany degrees. Wandersee and Schussler (1999), as well as Kinchin (1999), have acknowledged that grade R-12 learners have more interest in studying about animals compared to plants. It was because learners did not perceive plants as being alive in comparison to animals, and most learners found giving specific names to plants to be mainly difficult (Wandersee, & Schussler, 1999).

As it is, learning and teaching of plant science or Botany in the classroom is still a challenging task (Silva et al., 2017). Furthermore, the imbalance of interests throughout all age groups causes botanic themes to be much more challenging paralleled to animal topics. A study conducted by secondary school learners in Germany and Austria highlighted that Botany is the science subject that instigated less interest in learners (Elster, 2007; Silva et al., 2017), with such concepts as plant biodiversity or Botany still tricky for learners to grasp. As a result, many learners lack the motivation to truly engage with the learning process and have trouble determining the applicability of what they are being taught. Also, Traditional pedagogical approach "Chalk and Talk" (CTM) is still very much the custom within higher education. Learning through the teacher's guidance is still emphasized by this teacher-centred method. Learners are still required to listen to lectures and learn from them. Classrooms are still dominated by teachers' talks instead of encouraging learners' interactions and allowing them to ask questions in order to understand the lesson thoroughly. Learners memorize without having a complete understanding of the subject because most classes still involve rote learning. What matters most is to complete the curriculum and for learners to pass the tests (Adegoke, 2011; Umar, 2011). Thus, student learning is based upon extracting knowledge from lectures and note-taking. Raymond and Usherwood (2013) suggest that this style of teaching denies learners the opportunity to use their newfound knowledge to real situations, resulting in a severe delay between students' learning and applying new knowledge, and yet teachers may not know how to deal with the situation. Poor teaching methods embraced by teachers at senior secondary school level in Nigeria and South

Africa have been identified as one of the major factors leading to learners' poor performance in biology (Ahmed & Abimbola, 2011; Umar, 2011).

In particular, we acknowledged the increase across several fields in teaching literature that focused upon role-plays and computer simulations. In this sense, there seemed to be myriad authors proclaiming the reimbursements of these methods as they lead to more efficient and stimulated learning (Cobb, 2000). Simulations have become an integral part of various science curricula due to the increasing availability of computers and their linked equipment such as mobile devices and smart-boards, and because computer simulations have a wide range of applications (e.g., the PhET sims at http://phet.colorado.edu, 2011). That is the reason why simulations are top used to contribute to the improvement of learning of science. It was further suggested that the use of these computer Simulations in high school biology could further the instructional process. Learners are expected to assign a distinct number of variables when doing experiments and to make decisions several times through these simulations (Gredler, 1986). Moore and Thomas (1983) suggest that experiments can as well be performed through simulation. This approach can also be used when the apparatus needed in the laboratory is too complicated, costly or unsafe for learners, or when the experiments are time-consuming (Moore & Thomas, 1983). Reigeluth and Schwartz (1989) point out three phases in the problem-solving process when learning to use simulations, i.e., acquisition, application and assessment. Lavoie and Good (1988) further suggest that learners should also acquire necessary skills in order to work with computer simulations wherein they can alter the independent variables in order to identify the dependent variables and to set experimental conditions.

Eliminating of extraneous variables and promotion of understanding of the causal relationships between events or variables (DeJong & van Joolingen, 1988) can be performed by the use of Computer simulation as learners will only focus on the essential aspect of a process system. The simulations allow interactive engagement and immediate feedback to students. Smetana and Bell (2012) further highlight that conceptual reasoning and more in-depth understanding is promoted when learners work at their own pace and easily repeat trials. Simulation tools that are freely available over the internet, such as the

Phet collection developed by the University of Colorado (http://phet.colorado.edu/) are now well established for science teaching and learning in classrooms as computer-based technologies.

Although such computer simulations are thought to have great potential to enhance learning, they often require learners to devote substantial mental effort for processing of information. Learners' educational effectiveness also depends on various designs that are involved in the expansion of active visual learning of materials. The educational objectives, learner characteristics, content, settings and plan for curricular integration had to be considered by the simulation designers in order to regulate if the information should be represented as static visualized (image), dynamic animations (animations), or interactive dynamic visualization (simulations). Nevertheless, Höffler and Leutner (2007) revealed that dynamic visualizations are more effective than static visualisations.

On the other hand, some previous studies by Trundle and Bell (2010) and Scalise, Timms, Moorjani, Clark, Holtermann, & Irvin., (2011) reported mixed or indecisive results on the effect of simulations whether they enhance learners' learning. Trundle and Bell (2010) argued that scaffolding is essential to assist learners to develop sufficient background. Lack of enough background has the potential to overwhelm student ability and readiness to explore the phenomena. For learners to explore the phenomenon on their own fully, there should be an adequate balance between the level of guidance provided and their flexibility.

Despite the growing popularity of this method (CS), it appeared that little work was done to experience the significant impact of such method. While subconsciously many supported the belief that innovative methods of teaching could improve student learning, there was little firm evidence to support this. Computer simulations are therefore viewed as a prospective method through which to overcome our teaching challenges. There is no surprise that the National Curriculum Statement (NCS) and Curriculum Assessment Policy Statement (CAPS) for Grades R-12 encourage an active and critical approach to learn, rather than rote learning.

Science teachers are expected to have diverse knowledge to teach different topics (Shulman, 1986). The knowledge the teachers possess to teach different topics (Sickel & Friedrichsen, 2017; Deidre, 2015) and according to Shulman (1986), such knowledge is called Pedagogical Content Knowledge (PCK). Shulman (1986:9) alludes “PCK is a discrete body of knowledge that distinguishes teachers from a content specialist”, and this valuable knowledge is embodied in a teacher. PCK research focuses on the use of a range of teaching schemas, approaches, assessments and illustrations in order to improve the understanding of any subject taught. Also, Hill, Ball and Schilling (2008) reported that international policymakers and researchers regarded PCK to improve teaching and learning. In search of a better approach, technology is proposed to be added to PCK in teaching, and this is known as Technological Pedagogical Content Knowledge (TPACK).

Slough and Chamblee (2017) reported that TPACK concepts superficially represent sufficient descriptive, theoretical frameworks for executing, discussing, and researching technology in teaching and learning in all ages. From the time of the conception of TPACK, Koh, Chai and Lim (2018) and Jang (2010) indicate that several teacher information and communications technologies (ICT) professional development courses that foster teachers’ TPACK development have been updated. As it is, it appears that 21st Century learning perpetually involves the engagement of learners in collaborative work and real-world problem solving through sufficient utilization of ICT (Koh, Chai & Lim, 2018). Another means of implementing 21st Century learning in schools is to reflect how ICT-integrated learning can be designed to support such pedagogical objectives. The use of technology in the teaching and learning process has now become unavoidable as it improves the efficiency of education in parallel to the developments experienced in ICT (Yildirim & Sensoy, 2018).

The effect of Computer simulations (CS) as tenets of TPACK on learners’ performance in plant biodiversity was studied to find out how CS can be embedded in instructional support to promote learning processes. It has been postulated that CS use in the science classroom has the potential to generate higher learning outcomes in ways not previously possible (Akpan, 2001). Simulation classrooms motivate and encourage learners to learn and afford learners information-rich background wherein they work collaboratively in groups, brainstorm, and make a verdict in certain circumstances while working in a risk-free practical environment (Zulfiqar, Zhou, Asmi, & Yasin., 2018). Simulation systems require learners to follow some set of rules and roles which would give them the essence of working in the real-based scenario (Zulfiqar et al., 2018). Mawhirter and Garofalo (2016) further stated that simulation methods could be an innovative and advanced technique to increase learners' interest in learning. Also, simulation systems can also enhance learners' knowledge retention capability (Popil & Dillard-Thompson, 2015). The quantitative approach was chosen in this study because the researcher was to find out the effect of using simulations. The Solomon four-group design was utilized due to its robustness commended in previous research. The Solomon design used two experimental groups and two control groups. As Campbell and Stanley (1963) suggested, this design can efficiently maintain internal validity because it can regulate the problems arising from pretest-posttest, history, and maturation during the experimental procedure. The hypotheses explored was that learners taught using CS technique perform better than those taught using CTM and also that the CS approach is biased towards one gender.

1.2 Research problem statement

Teachers, by their training, are supposed to have PCK for specific topics in their areas of specialisation. This very knowledge distinguishes them from other knowledge and demarcates them as teachers. Sanders, Borko and Lockard (1993) state that experienced teachers have a "wealth of general pedagogical content knowledge" while Chan and Yung (2018) report that teachers' previous experiences had a bearing on their new PCK development and may also hinder this development. Furthermore, studies about pedagogy used in schools show that teachers do not use technology with their existing PCK as TPACK to improve learners' performance (Mavhunga, Kibirige, Chingonga, & Ramaboka., 2016). Teachers talk for a long time and frequently ask low-level order questions (Carlsen, 1993). They also have limited knowledge of learners' pre-conceptions and misconceptions (Hashweh, 1987) and consequently, teachers have challenges in choosing appropriate strategies when presenting the subject matter to improve learners' performance. These challenges contribute to low interest among learners, low enrolment and poor performance in subjects such as Botany. It is envisaged that incorporating technology such as computer simulations in the teaching and learning process can improve learners' interest and performance. To date, not much research on the effect of simulations on learners' performance in the developing country like South Africa has been published. This study explored the effect of using simulations on learners' performance compared to those taught using traditional approach "Chalk and Talk Method" (CTM) when teaching Plant Biodiversity.

1.3 The purpose of the study

- The purpose of this study was to explore the effect of using Computer Simulations (CS) to teach Grade eleven learners a plant biodiversity topic.

1.4 Hypotheses

The study was guided by three hypotheses and four questions

- Learners' performance in biodiversity topics will not statistically vary significantly between the EG and the CG in the pre-test even though the significance exist. Therefore, if the p-value is larger ($p > 0.05$), this would mean that the null hypothesis (H_0) is rejected.
- Learners in the experimental group (EG) who are taught by using Computer Simulation will perform better than those in the control group (CG) taught using "chalk and talk method" (CTM) after intervention. Therefore, if the p-value is small ($p \leq 0.05$), this would mean that the null hypothesis (H_0) is rejected.
- There will be no statistical significant differences in achievements between boys and girls in the EG even though it exist. Therefore, if the p-value is larger ($p > 0.05$), this would mean that the null hypothesis (H_0) is rejected.

- Learners from EG will have positive attitudes towards science, but not those from CG.

1.5 Research questions

The main research questions addressed by this research were:

a) What effect will be experienced on learners' performance when taught using Computer Simulations (CS) compared to the control group (CG) taught using CTM?
b) What performance differences will be experienced in learners pre-test scores between the EG and CG?
c) What significant difference in achievements would be experienced between boys and girls in the EG?
d) How would teaching using CS influence learners' attitudes towards learning of sciences?

1.6 Theoretical framework

The social constructivist theory of learning (Vygostky, 1978) and the Technological Pedagogic Content Knowledge (TPACK) (Mishra & Koehler, 2006; Mishra & Koehler, 2008, 2009) were used. Constructivism theory of learning states that knowledge is created when people interact with their environment and when they build on their prior knowledge or belief system. The social constructivism theory was chosen as it comprises of beliefs about how learning occurs in humans and the things that motivate learning; and about ideas on how to design content and teaching that address matters about education. This theory fits well in this study because teachers foster learning that is active, inquiry-based, cognitive, social, contextual and motivational. On the other hand, TPACK is the incorporation of technology with PCK in the teaching and learning process (Koehler, 2012; Koehler, Mishra, Kereluik, Shin, & Graham., 2014). Thus, technology can blend well with pedagogy and content knowledge in teaching. Technology also offers a conducive learning environment with tools that could facilitate collaboration and social construction of knowledge. Technology subsequently supports the social constructivist belief that people construct meaning through their interactions with one another and the environment in which they live (Koh et al., 2018). As it is, in any teaching space, each learner carries various skills, including computer-based skills, and distinctive learning styles to the learning process. Each learner could support the distinctive thinking and learning skills of another. Thus, individual preferences can be catered for using multimedia and support what can be described as constructivist pedagogy in various ways. Due to lack of apparatus for practical work in schools, and learners' challenges in the understanding of plant biodiversity topic, TPACK and Social Constructivism theories are envisaged to provide a social environment where simulations in this study can be used to teach plant biodiversity topic and further be used to supplement practical work (Samsonau, 2018).

1.7 Significance and contribution of the study

Student motivation to achieve is significant in teaching and learning. Learners' motivation could be fostered using CS as compared to passive CTM. Yildirim and Sensoy (2018) contend that the integration of CS in teaching leads to an increased level of interest in course materials. The study addressed the effect of computer simulations on learners' performances and their attitudes towards plants biodiversity when taught using CS. CS contributed to 'learners-play-to-learn' process. Learners created knowledge through playing and interacting with the environment (Mavhunga & Kibirige, 2018). CS created a conducive environment for learners to repeat the simulations many times to learn. CS contributed to other methods such as demonstrations, inquiry-based, and active learning that improve learners' performance (Dorgu, 2015). In fact, Gonczi, Maeng, & Bell (2017), stated that CS involves learners in active participation twice as much as Chalk and Talk method does.

The effect of computer use among learners is envisaged to shed light on the impact of CS on learners' achievements from a developing country like South Africa with a high learner to computer ratio. This study, therefore, is significant to researchers, teachers, and subject advisers in science education.

1.8 Limitation to the study

The findings of this study should be interpreted with caution. The study used only four classes from four high schools within the same cluster accessible to the researcher. Two served as experimental, and two served as control groups. As it is, the findings of this study cannot be generalized over the population of all the secondary schools in the province. Therefore, generalization is not advised when interpreting the results of this study. This study was conducted over a short period of time, and therefore, it would give a snapshot sight of the problem and not the complete picture in one school set-up. A maximum of four weeks was allocated to the researcher to collect data instead of the intended minimum of six weeks, including two weeks of adaptation of learners to the method. Finally, suitable CS and multimedia would be the potential limitations of the teaching methods for use in the classroom. To address this problem, the researcher made use of resources that were freely available on the Internet, downloaded and saved them through a proper program such as https://ClipGrab.org. In terms of fidelity, the present technique was comparatively high by integrating the visual and auditory senses. Nonetheless, the kinesthetic component was lacking for the reason that it was not possible for learners to use the devices or technology themselves in a lecture room. The computer simulations were made readily available online and through copying in a memory stick.

1.9 Definitions

COMPUTER SIMULATIONS: Computer simulations are computer generated, dynamic models of the real world and its processes and often represent theoretical or simplified versions of real-world components, phenomena, processes (Smetana & Bell, 2012). As such, computer simulations offer an environment for learners to explore the phenomena of the real world and better understand the science behind the phenomena. Ideally, computer simulations are flexible, dynamic and interactive and thus inquiry-based exploration, in which learners draw their conclusions about scientific concepts and ideas by altering values of different variables and observing their effect (Windschitl & Andre, 1998).

BIOLOGICAL DIVERSITY: Refers to the variety and variability among living organisms and ecological complexes in which they occur. The term biodiversity encompasses a variety of biological life at more than one scale. Biodiversity is also a variety of species of plants and animals, genes and the ecological units in which those species reside. Diversity can also be defined as several different items and their relative frequency. Fancovicova and Prokop (2010) report that human needs can be satisfied in many ways (direct and indirect) through biological diversity. For example, pharmaceutical needs and most of the world's agricultural needs.

PEDAGOGICAL CONTENT KNOWLEDGE (PCK) is an "amalgamation" of content and pedagogical knowledge. PCK takes account of an understanding of what makes the learning of subject matter easy or difficult. Learners of different ages and particular settings bring with them conceptions and preconceptions to the classroom. Therefore, PCK is of particular interest since it can help to identify the distinctive bodies of knowledge for teaching and learning. It characterizes the blending of content and pedagogy into an understanding of how specific topics, problems, or matters are systematized, symbolized, and adapted to the different abilities and interest of learners, and presented for teaching. Shulman (1987, p.8) further stated that" Pedagogical content knowledge is the group most likely to differentiate the understanding of the content specialist from that of the pedagogue."

TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPCK)

TPCK is a developing form of knowledge that goes further than all three components (content, pedagogy, and technology) (Koh et al., 2017). TPCK is the foundation of decent teaching with technology and involves an understanding of the demonstration of concepts using technologies. It also includes effective pedagogical techniques that use technologies to teach content; knowledge of what makes subject matter difficult or easy to learn and how this tool can help compensate some of the problems that learners face. Furthermore, TPCK includes learners' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to shape the current knowledge and to develop new knowledge or fortify old ones. Unfolding PCK, Marks (1990) asserts that it ‘‘signifies a class of knowledge that is dominant to teachers’ work and that would not classically be held by non-teaching subject matter specialists or by novice teachers’’ (1990, p. 9). In the case of TPCK, we can rephrase his quote to read, ‘TPCK represents a specialised knowledge that is central to teachers’ work with technology. This knowledge would not classically be held by subject matter specialists who are not technologically proficient, or by technologists and teachers who do not know much of the subject or pedagogy.

1.10 Organisation of the study

This chapter has given the background to the study and explained the use of computer simulations to facilitate learning, together with clarification of the key terminologies used in the study. Chapter two follows reviews pertinent literature on the use of CS to improve teaching and learning. Chapter three presents details on the methodology used for the study. Chapter four will present the results from the study, and finally, Chapter five will present the discussion of the study findings and after that present a brief conclusion and the recommendations.

1.11 Concluding remarks

This chapter has highlighted the background of the study and has explained the significance of the use of Computer Simulations in the classroom. Life Sciences as major science subject in South Africa, requires teachers to have PCK for specific topics for them to be able to teach effectively. Thus, the study explored the effect of using CS on learner’s performance compared to those taught using ‘Chalk and Talk Method’ when teaching Plant Biodiversity. Nonetheless, the chapter has covered the necessary sub-themes such as

the problem statement, purpose of the study, the hypotheses, research questions and theoretical framework which are key to this study. It has also provided in detailed the definitions of the terminologies used in the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter deals with the literature relevant to the use of computer simulations on grade eleven learners' performance in plants biodiversity, Mankweng Circuit. It provides an overview of how the use of computer simulations and technology as PCK can enhance teaching and learning to improve learner performance and interest in sciences. The review is focused on the use of technology to enrich teaching and to learn to supplement ordinary traditional chalk and talk teaching methods.

2.2 The teaching of plants (botany) biodiversity in schools

Biodiversity is a relatively new term which is derived from the integration of the two words "biological diversity" and was popularized in early 1985 (Benn, 2010). Benn (2010; p. 110-112) states that "Biodiversity is the variety of life on Earth, it includes all organisms, species, and populations; the genetic variation among these; and their complex assemblages of communities and ecosystems". Biodiversity also refers to the relationship between organisms and their interactions with their surroundings (Ekici & Aydin, 2007). Plant biodiversity is significant as it impacts our lives positively in many ways. It is of paramount importance that teachers and learners understand the importance of plants in the surroundings by understanding how plants function and contribute to life (Silva et al., 2017; Goodwin, 2008). Teachers should teach learners on the role plants play in life and science. They must stimulate the inquisitiveness within the learners, through involving plant biodiversity teaching and learning to the natural, everyday environment and by integrating them within teaching practice.

Life science courses in South Africa have significant themes in educational programs (Bolscho & Seybold, 1996). Jahnke (2011) stated that more emphasis has been on sustainable development education, which includes ecological and socio-economic factors. Jahnke (2011) further emphasized that a holistic approach is to be taken into consideration when teaching various aspects of biodiversity. Plants contribute more to life and biodiversity (Fancovicova & Prokop, 2010). Fancovicova and Prokop (2010) further highlighted that many times, plants are considered as less important compared to animals.

Consequently, many communities develop negative attitudes towards plants, which may lead to “plant blindness” (Wandersee & Schussler, 1999:82-86). Wandersee and Schussler (1999:82-86) further explicated plant blindness as “the inability to value and recognize the significance of plants in the environment”. This behaviour may lead to a lack of appreciation of plants as compared to animals (zoochauvinism). It is no wonder many people consider animal study (zoology) more critical than plant study (botany) because they view animals to be more critical than plants.

A lot of botanists and educators propose that learners’ interest in botany has to be carefully nurtured from an early age since learners are not as intrinsically interested in plants as compared to animals. Wandersee and Schussler (1999) have argued that this natural visual plant blindness tendency is so prevalent in humans. It could be fostered by the reasons that plants lack descriptive characteristics such as movement and a face, their uniform colour and spatial grouping, and the point that they are naturally not harmful resulting in humans dumping them from their conscious attention. Nonetheless, educational exposure to plants can increase visual attention to plants. Lindemann-Matthies (2005) in a nature study in Switzerland reported that a comparatively short educational program (averaging 17 hours of instruction) on local flora and fauna for 8 to 16-year-olds significantly improved student knowledge and appreciation of local plants. Thus, teaching about plants in prescribed education settings should be a vital component of promoting botanical interest and knowledge in learners (Strgar, 2007; Fancovicova & Prokop, 2010).

Carter (2004) reports that after the decade of the 40s in the 20th Century, the interest in Botany decreased quite a lot and held less ground in some curricula in the USA. Despite the recognition of the significance of plants for human beings, the attention in plant biology was so little that plants were seldom seen as anything other than components of decorative substances. Hence, Wandersee and Schussler (1999) still call this Botanical blindness. Within this context, there is a decline in the teaching of Botany in the classroom. Wandersee and Schussler (1999) further indicated that whereas science in schools was becoming very complicated, there were extents of research, which brought about new knowledge relating to the study of Botany.

2.3 Learners' attitudes towards sciences

Many researchers show concern that learners' attitudes are a crucial factor to be taken into consideration when attempting to understand and explain the learners' achievements in sciences (Köğce, Yıldız, Aydın, & Altındağ., 2009). There is a need, therefore, to further investigate how factors like learners' attitudes affect their learning and success in the subject as this would provide a basis for understanding some of the learners' behaviours. The current study thus investigated the influence of CS on learners' attitudes towards a science topic. Teachers must be aware of their learners' attitudes and perceptions of the subject they teach. It would help them to devise strategies for improvement in the teaching and learning of the subject (Köğce et al., 2009).

Attitudes encompass emotions, beliefs, values and behaviour. Thus, it is very significant to be mindful of the fact that learners can mainly contribute to their learning outcomes because of their beliefs and perceptions about the subject matter (Mensah et al., 2013). Beliefs and perceptions can affect the way learners think, their actions and behaviour that have many implications for teaching and learning (Mensah et al., 2013). Attitudes though not directly noticeable are secondary to the observable responses and actions, which reflect a pattern of beliefs and emotions.

Learners' attitudes towards sciences determine their ability, willingness to learn, choice of action and reaction to challenges. Attitudes determine the level of commitment, curiosity, personal effort without which one can hardly perform (Mensah et al., 2013). Negative temperaments induce trends such as fear, anxiety and stress where one resorts to other non-productive practices. These poor practices will prevent learners from experiencing the richness of sciences. Different methods that can be used to develop competencies in the subject will also be hindered. Subsequently, a student with a negative attitude towards a subject demonstrates low motivation, reduced level of participation, boredom and behavioural problems, including dodging lessons. It is apparent especially when the teacher is doing his best in presenting the lesson, but the learners seem to be isolated and remote (Furinghetti & Perkhonen, 2002).

2.4 PCK in teaching

Recent educational research reports that the quality of teaching and learning has an impact on learners' learning and motivation (Kleickmann et al., 2013). Quality teaching and learning has generally focused on teachers' content knowledge (CK) and pedagogical content knowledge (PCK) (Sickel & Friedrichsen, 2017). The content knowledge (CK) and pedagogical content knowledge (PCK) can affect teachers' instructional practices and learners' learning of sciences at schools (Baumert et al., 2010; Hill et al., 2008). Teacher knowledge is significant in enhancing learners' understanding and improves learners' progress. Success in teaching and learning can be achieved through adequate teacher education. Teacher education can provide a platform for educational transformation. However, little knowledge has been shared on how teacher education programs affect the improvement of the profession (Banks et al., 2005). Educational researchers are still faced with the challenge of assessing the teacher. Test instruments should be developed to proximally assess the area of teacher knowledge in the teaching of science subjects (Hill et al., 2008; Tatto & Senk, 2011).

Shulman (1986:9) stated that PCK "is an academic construct that represents an intriguing idea. It is an idea rooted in the belief that teaching requires considerably more than delivering subject content knowledge to learners, and that student learning is considerably more than absorbing information for later accurate regurgitation". However, PCK is not a distinct body that is the same for all teachers of a particular domain; it is a specific knowledge within teacher idiosyncrasies and significant differences that are inclined through the teaching practice. Teachers may use similar PCK's. An understanding of concepts by teachers is of necessity in a particular domain they teach. Teachers should be subject specialists so that they can be able to distinguish and expand their PCK when teaching. "This rich conceptual understanding, combined with expertise in developing, using and adapting teaching procedures, strategies and approaches for use in particular classes", is called PCK (Shulman, 1886:7-10). Shulman (1986, 1987) further explains PCK as a fusion of content knowledge and pedagogy.

Grossman (1990) claims that teachers acquire their knowledge for teaching from various sources and at the same time, they are expected to use the same knowledge gained when teaching. Given Grossman's research, Friedrichsen et al. (2009) illustrated three potential sources of subject-matter knowledge: (a) teachers' own K-12 learning experiences, (b) teacher education and professional development programs, and (c) teaching experiences. Lortie (1975) noted that professional knowledge begins to advance even before candidates enrol for teacher education, and further argued that potential teachers' beliefs and professional knowledge are significantly shaped by their own school experiences such as "apprenticeship of observation" (Lortie, 1975: 62). In the context of mathematics, Feiman-Nemser (2001) reports that the pre-training phase is thought not only to instil (often traditional) methods to teaching and learning mathematics but also to impact the development of potential teachers' understanding of mathematics.

2.5 Application of TPACK framework to classroom pedagogy

Lowther et al. (2012) observed that televisions, projectors and computer laboratories had been used in the classroom as forms of technology in the past. The uses of technology or computers have become as common as a pencil and rubber nowadays. An excellent learning environment which stimulates social interaction and learning opportunities can be provided through the use of technology in the classroom. Technology can be used by teachers to compile resources, manipulate and experience real life issues or scenarios (Kirkley & Kirkley, 2005). Teachers can use technology in multiple ways, such as lesson presentations of difficult concepts to address learners needs and giving each learner distinct attention (Becker, 2000). It means that the use of computers motivates and caters for different learning abilities. Computers update teacher's subject knowledge and enhance teaching skills; this includes search on the internet, networking with experts, colleagues and collaboration. Teachers can also use computers to present their lessons, preferably using PowerPoint through data projectors (Becker, 2000).

Researchers and educators have been trying to explore and improve the use of computers in classrooms since the emergence of microcomputers. In most universities today, computers are used in the field of science education (Sokoloff & Thornton, 1997). Computers offer various presentations and opportunities to facilitate lectures in large-scale classrooms. Furthermore, the use of computers creates conducive study environments by allowing learners to study on their own. Also, one of the most critical use areas of computers in science education is that computers allow learners to explore biology, clarifies difficult concepts related to the teaching of biology, and provide the opportunity of straightforward teaching.

These new technologies have changed the nature of the classroom or have the potential to do so (Sokoloff & Thornton, 1997). Technologies can play critical roles ranging from drawings on a blackboard and use of interactive multimedia simulations. Technologies can also be used to etchings on a clay tablet or Web-based hypertexts to the pump metaphor of the heart or the computer metaphor of the brain. Technologies have constrained and afforded a range of representations, analogies, examples, explanations, and demonstrations that can help make the subject matter more accessible to the learner (Sokoloff & Thornton, 1997).

Despite the various roles that technology can play in teaching, not all teachers have incorporated these new technologies. Sokoloff and Thornton (1997) cite some reasons for teachers not incorporating the technologies in their teaching and these include; fear of change and lack of time and support (Sokoloff & Thornton, 1997). Moreover, the fast rate of evolution of these new digital technologies inhibits them from becoming crystal clear any time soon. It leads to the fact that teachers should go beyond merely learning to use currently available tools and they also will have to acquire new procedures and skills as current technologies become out-dated (Koh et al., 2018). This is a unique context from earlier conceptualizations of teacher knowledge, whereby technologies were uniform and somewhat stable. Technology use for a pedagogy of a particular content could be expected to remain relatively fixed over time. Thus, the focus of teachers could be on the variables related to content and pedagogy and be assured that technological contexts will be stable over their career of teaching. A few years ago, this new context had foregrounded technology in ways that could not have been imagined (Koh et al., 2018). Thus, knowledge of technology becomes a significant facet of overall teacher knowledge. Of interest is that recent discussions of the role of technology knowledge seem to appeal to similar problems that Shulman identified in the early 1980s. For example, before Shulman's extensive work on PCK, knowledge of content and knowledge of pedagogy was considered isolated and independent from each other. Likewise, today, knowledge of technology is often considered to be separate from knowledge of content and pedagogy (Koh et al., 2018).

How would teachers acquire an understanding of the complex relationships among content, pedagogy, and technology? The standard approach recommends that teachers should be trained to use technology (Koh et al., 2018). Koh et al. (2018) further argued that teachers need a specialized form of professional knowledge to support ICT integration. Thus, since the outset of TPACK, many teacher ICT professional development courses were restructured to foster teachers' professional development. As it is, technology use and application are viewed as being a universally applicable skill. Basic competency with hardware and software packages use unlocks the power and potential of technology. This approach is best illustrated by the plethora of state and national technology standards that are implemented recently. The emphasis is on enhancing teachers' knowledge of current versions of hardware and software (Rogers, 2000; Mishra & Koehler, 2006). However, by faith, there is a hope that teachers will be able to successfully incorporate technology into their classrooms, demonstrating their proficiency with current software and hardware. Lankshear and Nobel (2004) pronounced this emphasis as a form of applied technocratic wisdom, a view that technology is independent and has autonomous integrity, and that to unlock its impact and power requires merely learning particular basic skills. As a result, of these initiatives by teacher educators, policymakers, and technology fanatics, we see many workshops and teacher education courses about general software tools that have application across content and pedagogical contexts (Lankshear & Nobel, 2004).

There are assumptions by this content emphasis on generic software tools that are knowing a technology automatically leads to good teaching with technology (Lankshear & Nobel, 2004). Standard methods of faculty development or teacher professional development, for example, workshops or standalone technology courses, are based on the perception that technology is independent and emphasize this rift between how and where skills are learned (e.g., workshops) and where they are to be practised (e.g., classrooms). Various scholars working in this domain agree that traditional methods of technology training for teachers such as workshops and courses, are inappropriate to produce the ‘‘deep understanding’’ that can help teachers in becoming smart users of technology for pedagogy (Koehler et al., 2007; Mishra & Koehler, 2014; Mishra, Koehler, & Zhao, 2007). This emphasis on capabilities and checklists of things that teachers need to know is intrinsically problematic for a range of reasons.

The real innovative function of computers in education depends on the novel area of Computer-Assisted-Instruction (CAI), which is the use of computer systems as learning tools. These include seminars, practice and games, simulations; discovery and problem-solving program software packages which integrate many other aspects of instruction to accommodate the different learning styles of the learners. Young (1993) reports that computer programmed lessons are now available on easy to install software, which allows the learners to interact with the computer that enhances the learning of the specific concept. The concept is then learnt and mastered as comprehensively as when a teacher does the teaching, or even much more efficiently and faster.

2.6 Simulation science classroom

There are still challenges on distinguishing between a role-play and simulation among researchers. It is because these terms are frequently used interchangeably or confused with similar methods such as ‘games’ and ‘gaming’ (Shaw, 2010). Krain and Shadle (2006) have recommended that simulations are best considered of the real environment in which learners are placed within a sensible representation of the real environment within which political or social interaction occurs.

A simulation is a method of practical learning. Simulations are instructional settings whereby the teacher defines the worlds through which the learner can be engaged. Classroom simulations motivate students' interaction and represent real-life issues. The teacher can control the other variables to achieve the expected results post the instruction (Hertel & Millis, 2002). During simulations, learners become the test subjects; the same as doing lab experiment. The reality of the situation is experienced, and meaning is gathered from it. Innovative use of technology can be incorporated into the learning environment using simulations. Furthermore, Hertel and Millis (2002) reported that learning by real-world scenarios and problems had been supported using simulations.

According to de Jong and van Joolingen (1998), computer simulation is a package that contains a model of a system (natural or artificial; e.g., equipment) or a process. CS use has the potential to generate higher learning outcomes in the science classroom in ways not formerly possible (Akpan, 2001). A learning environment with a computer simulation has the advantages that learners can systematically discover theoretical situations in comparison with textbooks and lectures, interact with a simplified version of a processor system, change the time-scale of events, and practice tasks and solve problems in a realistic environment without difficulties (van Berkum & de Jong, 1991). Learners can discover refinement of the conceptual understanding of a phenomenon. Predictions are established by succeeding events in a simulation when the student understands how these events are produced (Windschitl & Andre, 1998).

Nowadays, research and investigations can be conducted using computer simulations in various fields of study (Samsonau, 2018). Hannel and Cuevas (2018) reviewed other possible reasons instigating teachers to use computer simulations such as effective time management, and that more time is devoted to learners instead of to the setting-up and supervision of experimental equipment. In addition to the above note, experimental variables can be changed, allowing for stating and testing hypotheses; and delivery of ways to support understanding with varying representations.

Computer simulations place a learner as an important active agent in the process of knowledge acquisition and support dependable inquiry practices such as formulating questions, hypothesis, data collection, and revision of the theory. Learners can be lead gradually through computer simulation to infer the features of the simulation's conceptual model, which may lead to changes in the learners' original concepts (de Jong & van Joolingen, 1998). Computer simulations can be powerful learning tools that actively involve learners to explore and discover concepts as it supports learning involving doing. Learning that involves doing is remembered longer than learning via listening, reading, or seeing (Yildirim & Sensoy, 2018; Akpan, 2001). Veermans, van Joolingen, and de Jong (2006), further highlight the tendency toward more learner-centeredness, which has caused this discovery learning approach to be popular as compared to teacher-centred education. Learners will have difficulties in generating and adapting hypotheses, designing experiments, interpreting data and regulating learning if there is insufficient support for the processes of discovery learning within a computer simulation (de Jong & van Joolingen, 1998). A deterioration of the efficacy of inquiry learning is led by minimization of guidance. Even when providing learning support limits the learners' possibilities of spontaneously exploring the simulation environment to a particular extent, the scaffolding it provides increases with their performance in simulation-based learning (van Berkum & de Jong, 1991).

Computer simulations are computer generated simplified representation of the real system found in the world. Computer simulation can provide theoretical understanding phenomena, and life processes (Smetana & Bell, 2012). CS provides conducive environments for learners to explore these phenomena and acquire scientific knowledge. Ideally, computer simulations are flexible, dynamic, interactive. CS support inquiry-based learning. Learners can hypothetically make judgements, observation, identify variables about scientific concepts (Windschitl & Andre, 1998). CS stimulates interaction among learners to share ideas and improve on theirs. As learners interact, they gain control and ownership of their learning. CS improves their knowledge and increases their retention capabilities (Podolefsky et al., 2013). These simulations create opportunities for learners to visualize life processes that would take too long (e.g., geological processes) or might be too dangerous or too complicated for a conventional classroom or laboratory setting (Akpan, 2001).

Computer simulation is an instruction technique that breeds actual events and processes under test conditions (Akpan, 2001). Computer simulations allow learners to deal with matters of vital concern realistically, but without terrible consequences should they make wrong choices. Simulations empower learners to understand complicated interactions of physical or social environment aspects. As systems for experimentation, simulations enable the researchers to perform unusual "dry lab" experiments or demonstrations without using erratic materials or equipment that are costly (Akpan, 2001). Also, another cost-saving feature of simulation technology is time compression. Activities that can unfold anywhere from hours to years in real time can be simulated in a few minutes.

Conversely, Wang and Reeves (2007) reported that high-quality video involving realistic graphics simulation could assist learners to understand scientific, industrial, role-playing and decision-making processes; and conveys reality into the tutorial room where the conventional practice is out of reach. Study reports by Goldberg and Otero (2003) attest that computer simulations afford learners conceptual assistance that leads to improved performance and retention of concepts learnt. Computer simulations as well encourage students to work in an active, interactive learning environment. In a study by Mkpanang (2010) on the effect of Computer-Assisted-Instruction (CAI) with exercise and practice, it was witnessed that those trained with CAI performed considerably better than those taught with traditional chalk and talk method.

Zacharia and Anderson (2003), reported that with the help of well-developed simulations, many science subjects which are challenging to teach and transfer could be made simpler and more evident. As it is, biology courses are becoming fun and immersive. It affects learners' thoughts about biology and their courage significantly. Many computer simulations prepared nowadays allow the student to learn biology concepts and let them have manual skills in virtual environments that can only be acquired in real laboratories. Many researchers have shown that they are more successful in courses run through these simulations (Zacharia & Anderson, 2003).

2.7 Computer simulation and laboratory activities

Computers can be used to perform some laboratory experiments which are challenging to make or hard for learners to understand in a real laboratory. Computers can be used to collect data in experiments as aids in the laboratory, and this data can be displayed and analysed simultaneously. Numerous studies focused on using simulations as a means of preparing learners for laboratory activities. In a study by Martinez-Jimenez, Pontes-Pedrajas, Polo, and Climent-Bellido (2003), an experiment on the extraction of caffeine from tea was performed by learners in both the control and experimental groups. To the experimental group, a pre-laboratory simulation program was introduced. After that, student performance was assessed for 1) experimenting, 2) laboratory report quality, 3) experiment problem solving and 4) results of a test written. It was then discovered that using the preparatory simulation led to a better comprehension of the methods and fundamental concepts used in their laboratory work. The learners with the most significant learning difficulties benefitted most from using the pre-laboratory program. Furthermore, in a study by Baltzis and Koukias (2009), learners taking a subject on analogue electronics were motivated to complete a circuit simulation task individually before performing a laboratory experiment in groups. An overall improvement of academic performance led by this intervention increased learners' passion in the course.

Winberg and Berg (2007) also conducted another study on pre-laboratory exercises as they considered the questions that learners ask their teachers during the laboratory exercise as a sign for cognitive focus and took the spontaneous use of chemistry knowledge when interviewing them as an indicator of the usability of knowledge. The outcomes of their experiments reveal that introducing laboratory work with a preparatory computer simulation foster to learners asking more theoretical questions during laboratory work and presenting more chemistry facts while being interviewed. It was further concluded that preparatory exercises assisted learners to integrate their theoretical, conceptual knowledge into representations, and can allow room for reflection, but may also have contributed to learners' understanding of their laboratory work. In the same manner, Limniou, Papadopoulos, Giannakoudakis, Roberts, and Otto (2007) indicate that substituting part of a laboratory session on the topic of viscosity with a cooperative pre-lab simulation exercise can increase content knowledge.

In a different setting, Dalgarno, Bishop, Adlong, and Bedgood (2009) compared the ability of a 3-dimensional Virtual Laboratory (VL) and a Real Laboratory (RL) to work as a device for familiarizing learners with the longitudinal structure of a laboratory and the apparatus and equipment it contains. After that, the VL-group explored the simulation, and the RL-group had been engaged on a tour of the actual laboratory, all learners were tested on their retention of the laboratory outline and their familiarity with apparatus. It was, therefore, concluded by the researchers that the Virtual Laboratory was an effective instrument for familiarization with the laboratory background.

2.8 The recent views on technology use in teaching and learning

Coomes and Debard (2004) said that student of nowadays and professionals at entry level are from the generation known as “millennial”, born from 1982-2002. It is further noted that this generation is the biggest in American history and is exceedingly skilled in technology use and innovation. Howe and Nadler (2010) highlights that the way this generation reads, learns, processes information and solves problems has fundamentally been altered since this generation grew up with technology and digital media. They further stated that not only are today university learners more likely to be exposed to technology at younger ages, but they are using the internet and devices frequently and at a higher rate.

Even though there is an increase in innovations and technological developments, access to a computer is still a concern. Universities and colleges expecting technological eloquence and seamless incorporation into the classroom must also acknowledge that there are still learners with poor skills and exposure. Furthermore, Jone, Johnson-Yale, Millermaier, and Pérez (2009) report that learners who had computers during their adolescence stage are more likely to interact with peers on the internet and commonly more conversant in using computer technologies on campuses.

In a study by Goergina and Olson (2007), faculty perception and perceptions of post-secondary school education institutions were identified. The majority of the respondents acknowledged that teaching using technology enhance space and expressed better use in email correspondence and browsing through the web, but still lack the skill to teach using social media. They further allude that in order to sustain technology platforms that are appropriate and envisaged for the skill of students, the faculty member must be trained so they can possess necessary skills to manage this system efficiently (Goergina & Olson, 2007). Also, Goergina and Olson (2007) noted that some faculties condemn the development of a digital learning environment for stressing on information delivery instead of learning. However, this perception of achievement of information technology at increasing and positively augmenting student learning is unlikely to be shared by students. Conversely, Nelson Laird and Kuh (2005) reported that there appeared to be a strong positive correlation between the use of technology for educational purposes and involvement in educational practices such as active and cooperative learning and student-faculty interaction.

Nonetheless, there is no uncertainty that technology has transformed the educational setting in subtle as well as profound ways. In addition to administrative and programmatic uses such as student retention, recruitment and, parent-teacher communication, technology impact can also be seen in the classroom directly. Digedu (2014), in his 2014 survey of 620 K-12 teachers in the US, reported that 90% of respondents stated that they and their learners used technology in class. On the other hand, there is still room for growth, even though technology has made its way into many classrooms. As it is, the majority of teachers in the US indicated a craving to make more use of instructional technology (Digedu, 2014). Moreover, there seems to be a necessity to increase the methods in which it is used. On the contrary, there is the undiscovered potential of the use of technology in second and foreign language (L2) classrooms (Healey, Hanson-Smith, Hubbard, Ioannou-Georgiou, Kessler, & Ware., 2011).

In a study of almost 1,300 US language educators, it was reported that technology was seldom used to engage learners in culture learning and interpersonal communication (American Council on the Teaching of Foreign Languages, 2013). Although this could be an area where computer-assisted language learning (CALL) could offer unique opportunities. Educators play a vital role in recognizing these unique opportunities for CALL. They are “the prerequisite around which successful online learning events rotate” (Guichon & Hauck, 2011, p. 188). Hubbard (2008) continues to say that teachers considerably shape the outcomes of CALL through their teaching, scaffolding, feedback and responses to teachable instants. It is particularly challenging that CALL teacher education overall is still not wholly adequate and operative with teachers acting as such “pivotal players” (Hubbard, 2008, p. 176). Many in-service programs nowadays focus on the use of CALL when training, (American Council on the Teaching of Foreign Languages, 2011) but forget also to prepare educators to productively integrate this CALL into their teaching practices (Healey et al., 2011; Hubbard, 2008). Eventually, teachers overall have expressed a desire for more and better professional development opportunities in the area of technology (Beaven et al., 2010; Digedu, 2014; Kessler, 2006).

2.9 The use of technology in teaching and learning in South African context

The South African Department of Basic Education Action Plan to 2019 report acknowledged that technology integration in teaching and learning in South Africa (SA) has not yet progressed as anticipated (Padayachee, 2017). Padayachee (2017) further reported that the inactive progress in the integration was a result of the differences in expectations between the government and teacher practices. Meanwhile, Vandeyar (2015) reported that several studies reported on the challenges involved in technology integration in schools. However, Vandeyar (2015) further argues that less has been reported on practical applications and enforcement of the Technology education policy. Teacher training on technology integration can be very efficient in improving teacher skills and knowledge in the enforcement of technology in teaching. Knowledge gaps between theory and practice can be filled through a sufficient understanding of ICT integration in the classroom (Vandeyar, 2015). Du Plessis and Webb (2012) also reports that the available South African guidelines on the use of ICT provide insufficient information and how schools and teachers are supposed to integrate ICT in teaching and learning practices. Studies that consider the comprehensive actual usage of ICT are lacking (du Plessis and Webb, 2012).

Ojo and Adu (2018) reported that in 2010, the South Africa population was probably 48 million people, but the number of people who used the internet was about three million. Only 64 % of South Africans had access to and use of the internet, and this is a relatively small percentage as compared to 72 per cent of Americans. The DoE in a White Paper on e-Education reports a significant increase of 20 per cent in the use of ICT in Africa. These percentage increases fostered the SA government during the year 2012 to organize a review of all government policies on the use of ICT in teaching and learning. Different NGO's contributed significantly to the integration of ICT in teaching and learning during the review. Post the review, the DoE (2015) reported significant progress in the implementation of ICT in teaching across all the nine provinces. Amongst all the provinces, the Western Cape, Northern Cape, and Gauteng showed better developments while other provinces are still improving.

South African schools received a significant amount of funds to build ICT infrastructure. Simultaneously, business leaders affirm the significance of assisting learners to become dynamic members of a world economy and develop 21st-century skills (International Society for Technology in Education, 2008; Partnership for 21st Century Skills, 2010). However, there are still low uptake levels of ICT integration by the teachers. These low-level uptakes are influenced by the fact that there are no professional development activities for the teachers at schools. Teachers need to develop their digital fluency in order for them to fuse ICT in their teaching. The reality is that both in-service and pre-service teachers are faced with the challenge of this new emerging ICT tools and devices. Teachers are somehow discouraged by the use of these ICT tools and devices. Cuban (200), further says that South African school oversold and underused these devices. According to Dlamini and Mbatha (2018) in the study of Buckenmeyer (2010), noted that "the challenge is not getting appropriate technology into classrooms, but getting those in classrooms prepared to use those technologies, and facilitating greater willingness to incorporate changing technologies as they emerge" (p. 27). Kalogiannakis (2010) suggested that the integration of ICT should be obligatory in the 21st century as a teaching and learning method. He further suggested that there should always be a connection between ICT funding and educational needs, otherwise, service providers will take advantage of schools and regulate ICT funding. Nonetheless, there should be processes and policies in schools that support and regulate the use of ICT funds in teaching (Dlamini & Mbatha, 2018).

2.10 Concluding Remarks

Despite the significance of technological learning in CAPS, educators hardly use technology to teach Biological Sciences in Mankweng circuit. Teachers point out many factors preventing them from using the technology learning approach. These include lack of background training in the use of dynamic learning approaches; lack of organised materials for use in the class; the fear that learners may use this technological device for other things rather than educational matters; fear of losing time to cover the content and lack of confidence in trying new techniques. As a result, this study aimed at exploring the effect of computer simulations on grade 11 learners' performance on plant biodiversity as one of the complex topics that teachers rarely teach. In the computer simulation defined above, designers had to consider the educational objectives, content, learner characteristics, educational settings, and plans for curricular integration.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The purpose of this chapter is to thoroughly explain the research approach, plan, sampling procedures, data collection and data analysis technique used. A suitable research design should be chosen to answer the research questions. The study investigated the effect of computer simulations on Grade 11 learners' performance in plant biodiversity in selected schools in the Mankweng circuit, Capricorn district in Limpopo province. The data in the study was collected using Randomized Solomon Four-Group Design by Cambell and Stanly (1963) a while teacher made a test on biodiversity was used for pre-test and post-tests in a quasi-experimental design.

For simplicity of reference, the research questions addressed in this study are herewith reiterated:

a) Will there be any effect on learners' performance when teaching using Computer Simulations (CS) than those in the control group (CG) taught using traditional Talk and Chalk method?
b) Are there differences in performance in the pre-test scores between learners in EG and CG?
c) Will there be any significant differences in achievements between boys and girls in the EG and CG?
d) How would teaching using CS influence learners' attitudes towards learning of sciences?

3.2 Research approach

In this study, a quasi-experimental mixed method was used. Therefore, both qualitative and quantitative approaches were followed (Burns & Grove, 1993). Quantitative research was chosen because of its numerical representation and manipulation of observations to define and explain the occurrences that those observations echo. Quantitative research is formal research that examines the relationship between the variables (Burns & Grove, 1993). It is commonly used in a wide range of natural and social sciences, including physics, biology, psychology, sociology. Conversely, according to Cohen (1980), quantitative research is defined as social research that employs experiential methods and empirical reports. He states that an empirical statement is defined as a clear statement about what “is” the case in the “real world” rather than what “ought” to be the case. Typically, empirical statements are expressed in numerical expressions; another factor in quantitative research is that empirical assessments are practical. Empirical evaluations are defined as a form that seeks to define the degree to which a particular program fulfils or does not fulfil a specific standard or norm. Therefore, the researcher would like to establish how the use of computer simulations on Grade 11 learners enhances performance using plant biodiversity topic. A qualitative approach was chosen because it allows the researcher to understand the situation without imposing pre-existing expectations on the setting and capturing of the in-depth views of the learners’ attitude. Qualitative research approach is most appropriate for making meaning as well as for studying inherently subjective experiences, perceptions and aspirations (Lankshear & Knobel, 2004:68). I focused on making meaning from narratives and descriptions of students’ experiences, thus exploring the multiple realities that existed in their perceptions of the world (McMillan & Schumacher, 2006:253). Reality is a personal, subjective and often socially constructed phenomenon (Freebody, 2003:56). Therefore, semi-structured interviews were used to complement the quantitative data.

3.3 Research design

A Randomized Solomon Four-Group Design by (Cambell & Stanly, 1963) was used. This design was chosen due to its robustness recommended in previous research, and since it limits many issues concerning internal validity and external validity that can negatively affect the study. It also allows comprehensive control of variables by the researcher to ensure that the pre-test does not influence the results. The presence of pre-test sensitization inhibits generality of results from the pre-tested sample to an un-pretested population (Bracht & Glass, 1968; Huck & Sandler, 1973). Furthermore, this design allows us to control the simultaneous effects between pre-test scores and post-test scores, and to remove the measurement errors through repeated trials. The design can also permit increased generalizability as compared to other experimental designs, since the four elements of the design, are paralleled (Campbell & Stanley, 1963; Cook & Campbell, 1979). The paralleled elements control for the potential effects of a pre-test on learners' after the performance and determine both the main effects and interactions of testing. Also, suppose the pre-test hints the learners, post-test scores will be higher for both pre-test groups than the groups that did not take the pre-test. If there is an interaction between the pre-test and the experimental treatment, so that the pre-test offers benefit to those learners who receive only the treatment, the pre-test-treatment-post-test group will have higher post-test scores as compared to the treatment post-test group (Abraham & Cracolice, 1994; Campbell & Stanley, 1963; Cook & Campbell, 1979).

Conversely, the investigation of variables, as well as interaction effects, is permitted through this design. As shown in Table 1 below, the Solomon design has two experimental groups and two control groups. Therefore, the current study used two, EG which were taught using computer simulations (CS) and two CG which were taught using traditional chalk and talk method (CTM). The two extra control groups of Solomon Four Design served to reduce the influence of confounding variables such as age group, location where the study is conducted, i.e all learners comes from the same environment with average age of 16 years, and extraneous factors such as learners intelligence, prior knowledge and language used. The test was piloted and T-test was performed on pretested learners.

Table 1: Solomon Randomized Four- Group Design (x-intervention & -Not pre-tested & intervention)

Randomised Group	**Pre-tested**	**X, intervention & -, No intervention**	**Post-tested**
EG_1	O_1	X	O_2
CG_1	O_3	-	O_4
EG_2	-	X	O_5
CG_2	-	-	O_6

3.4 Research population and study sample

The targeted population was Life Sciences learners from the secondary schools in the Capricorn District in Mankweng Circuit. Schools were purposively (Creswell, 2013) selected based on the availability of computers that would be used for teaching science using simulations and control group were selected because those learners came from similar environments and had similar understanding of content regarding plant biodiversity. The sample of this study involved 132 grade 11 Life Sciences learners (males and females) from four schools selected in Mankweng circuit. There were 66 leaners from EG and 66 learners from CG. The ages ranged from 15 to 17 years, with an average of 16 years. Meanwhile, two intact classes were randomly assigned to Experimental Groups (EG) and two intact classes were assigned to Control Groups (CG).

3.5 Instruments

Performance pre- and post-tests, as well as Focus Group Discussion Interviews (FGDI) schedule (Appendix E), were used for data collection. The interview questions were checked for face validity by two lecturers and three educators teaching Life Sciences in the selected schools, and the recommended changes were addressed before the data collection commenced. In order to make sure that the test questions were internally consistent, the instrument was piloted with relevant stakeholders who gave enough and accurate information. Learners were interviewed for 30 minutes, and interviews were audio recorded. The learners permitted consent and their parents since face to face interviews require utterance meanwhile their utterance is to be recorded (Duit & Confrey, 1996).

3.6 Data collection

3.6.1 Quantitative pre-post tests

EG1 and CG1 were pre- and post-tested. The learners' pre-post test scores were used as independent performance variables. EG2 and CG2 only did a post-test. Thus, a pre-test was omitted because the subjects already were exposed to the treatment. The scores were performed out of 80 marks (see Appendix G). The collection of data took approximately 4-5 weeks. It was done because the researcher sought to guard against the maturation and history of the data (Campbell & Stanly, 1963). The EG was taught using CS to influence specific outcomes which would assist the researcher to assess the impact of the treatment on learners' achievements. Due to a shortage of computers in the schools, four to five learners were assigned to one computer to access at their opportune time after classes. The study used computer simulation to teach. The researcher conducted the simulation classes under the supervision of the professor from the University who is well trained on the use of simulations. The professor is trained on PhET interactive simulation package. Although there was about 30 teachers who were trained on PhET and certified by the university, Department of Maths Science and Technology but they were just assisting in assembling and disciplining of the learners in their schools. The training conducted only took a 5 days (week) . These simulations targeted plants biodiversity topic in grade 11 syllabus. The learners observed objects as if they were real objects in three dimensions. Learners were able to repeat the simulations many times to learn. Learners were given opportunity to handle the ICT tools as they learn. Some learners copied the simulations to their memory stick for revision purposes as they were very exciting to them. Thus, CS contributed to ‘learners-play-to-learn’ process.

3.6.2 Focus Group Discussion Interviews (FGDI)

Interviewing is very significant when certain information, such as perceptions, feelings, beliefs, and opinions, cannot be directly observed (Merriam, 2001). Also, Focus Group Discussion Interviews (FGDI) with 12 participants divided into two groups of 6 participants per group were used to collect the views of learner’s attitudes towards sciences before and after teaching. A total of four sessions were held, and the interview ended when there was no new information gained from the participants. Learners’ were interviewed for 30 minutes, and interviews were audio-recorded (Duit & Confrey, 1996). The questions were set beforehand as a guide to the researcher during the interview session (Wildavsky, & Hammer, 2018). Learners were very enthusiastic and excited, more especially those who were taught using simulations than those who were taught using Chalk and Talk Method. Learners in the EG would talk continuously as they were explaining their experiences on the use of CS. Their interest in learning Life Sciences showed to have improved as compared to their counterparts. Otherwise, The excitement may have increased their desire to do more and hence achieve more. Learners were not given time to acclimatize themselves with the use of computers for teaching and learning. So, some of them could have been using the computers for the first time and they might have been carried away by the fact that they have access to the computers not necessary that they were learning from Simulations. Thus, learning in this case could have been passive learning or unintended learning. Leaners from the CG were not afforded enough time for revision; suppose a period of four days was allocated for them some would have performed better. The use of CS was helpful in ensuring that the syllabus was completed within 3 weeks and learners were able to revise through re-playing the simulation which helped them to internalize and retain the knowledge gained

For qualitative data, an interviews schedule consisting of the following five questions was administered on the experimental group:

1) How did you enjoy plant biodiversity lessons using computer simulations as compared to the traditional teaching method?
2) How did teaching plant biodiversity using computer simulations assist you in growing knowledge and interest in the subject; and
3) How much time did you spend studying plant biodiversity before and after the lessons using computer simulations?
4) How do you want to be taught in a plant biodiversity class?
5) Did you perform plant biodiversity practical work in the class before?

For the control group, an interviews schedule consisting of the following five questions was administered on the experimental group

1) How did you enjoy plant biodiversity lessons taught using Chalk and Talk Method?
2) How did teaching plant biodiversity using Chalk and Talk Method assist you in growing knowledge and interest in the subject; and
3) How much time did you spend studying plant biodiversity?
4) How do you want to be taught a plant biodiversity topic in classroom?
5) Did you perform a plant biodiversity practical work in the classroom before?

3.7 Data analysis

The Statistical Package for Social Scientist (SPSS) Software version 17 was used to analyse data (Garth, 2008). Descriptive (mean, standard deviations) and inferential (T-

Test, Analysis of Variance) and Cohen's d statistics were used to analyse data. The descriptive analysis provided information about how the distribution is from the mean. Qualitative data were analysed thematically (Struass & Corbin, 1998). During qualitative data analysis, learners' interviews were recorded and then later replayed by the researcher to extract the emerging themes. Data were transcribed, and the codes generated. Finally, qualitative data were analysed thematically. Similar and related codes formed sub-themes and sub-themes were grouped to form main themes.

3.7.1 T-test

The T-test was used to measure the statistical difference between two groups at $p<0.05$ that is: Firstly, whether the means of the two groups (O_1 and O_3) pre-test were statistically different from each other and to establish whether that learners in the two groups were at the same level of understanding and knowledge of concepts before the intervention.

Secondly, the T-test was used to measure the statistical difference between two experimental groups (O_2 and O_5) to determine the effect that the pre-test had upon treatment.

Thirdly, the T-test also was performed to measure whether the means of the EG groups (O_4 and O_6) post-test were statistically different from each other and to indicate whether the pre-test itself affected behaviour.

Fourthly, the comparison between the groups (O_5 and O_6) post-tests results was performed to determine the effect of pre-testing.

Fifthly, the T-test was calculated between pre-test O_3 results and O_6 post-test results to establish if any external factors could have caused a temporal distortion.

Lastly, the T-test was used to determine the differences between boys and girls post- test scores of the EG (pre-tested O_1 and not pre-tested O_5) and CG (pre-tested O_3 and not pre-tested O_6).

3.7.2 Analysis of Variance (ANOVA)

Campbell and Stanley (1963) pointed out, the initial phase of analysis is to determine whether evidence of pre-test sensitization exists in the outcome. The test for this is a 2 x

2 between-groups analysis of variance (ANOVA) on the four post-test scores and is indicated in Table 2 below.

Table 2: A 2 x 2 ANOVA Solomon four post-test scores

GROUP	**PRE-TESTED**	**NOT PRE-TESTED**	**COMPARISONS**
EG	**O_2 (A)**	**O_5 (C)**	**(A and C)**
CG	**O_4 (B)**	**O_6 (D)**	**(A and D)**
TOTAL COMPARISONS	**(A and B)**	**(C and D)**	

This is further described using a flowchart summarising the recommended sequence of testing and decision presented in Figure 2 below when using Randomised Solomon Four-Group Design (Campbell & Stanley, 1963; Huck & Sandler, 1973). The ANOVA is a statistical tool designed to analyse meaningful statistical differences between and within more than two groups or in different groups of data. In the present study, the ANOVA was used to investigate the differences between the three sets of data: the results of the distributions of the pre-tests (O_1 + O_3) with the distribution of post-test results for the control distribution (O_4 + O_6) and the experimental distribution (O_2 + O_5). The null hypothesis (H_0) states that there is no difference between the different sets of data. The alternate hypothesis (H_1) states that there is a statistically significant difference between the three sets of data. This ANOVA analysis was done using the SPSS software tool to obtain the output.

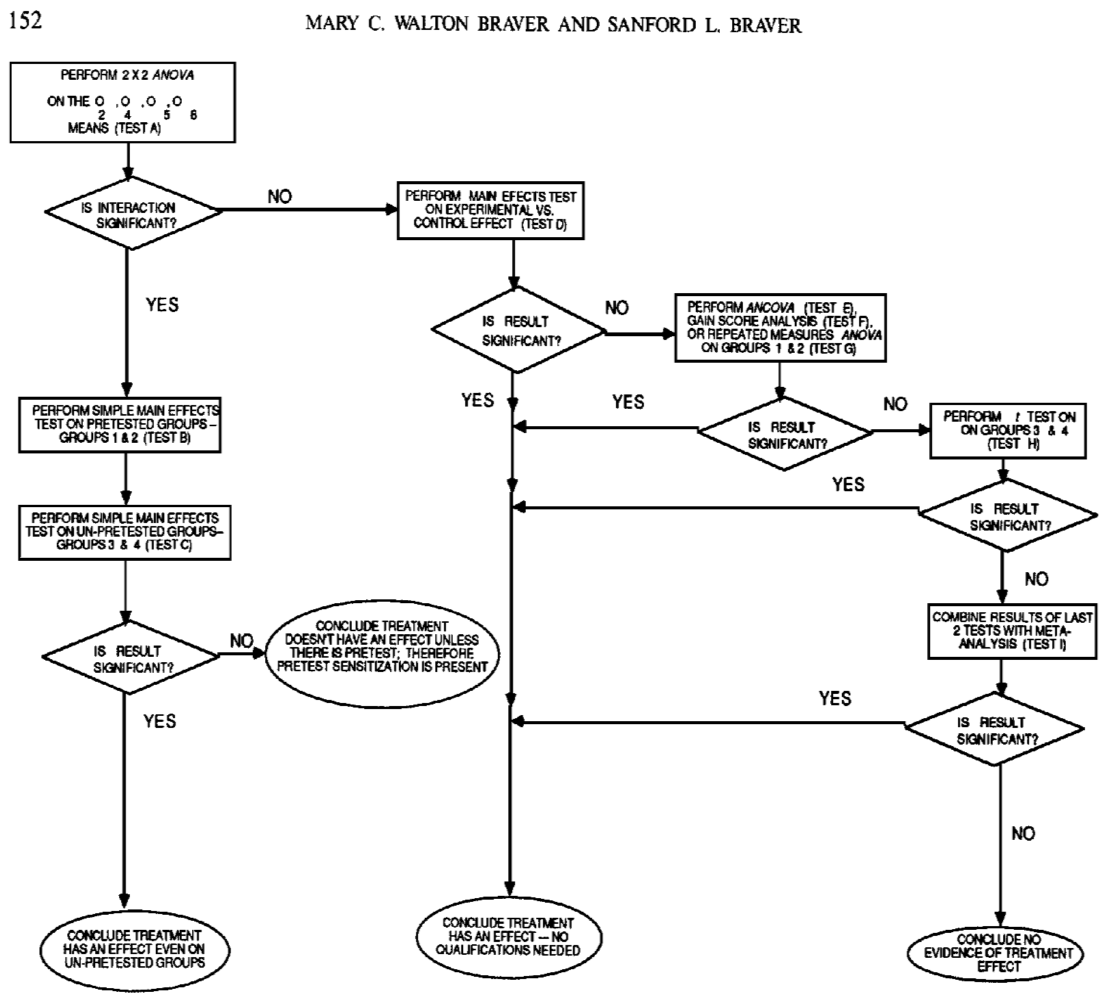

Figure 1: Flowchart summarizing the recommended sequence of testing and decision (Campbell & Stanley, 1963; Huck & Sandler, 1973)

3.7.3 Cohen's d

In order to measure gain between the two groups after the intervention, Cohen's d was performed. Although statistical tests of significance tell us the likelihood that experimental results differ from chance expectations, effect-size quantities tell us the relative size of the experimental treatment. They tell us the size of the experimental effect. Effect sizes are especially important because they allow us to compare the size of experimental treatments from one experiment to another. Although percentage improvements can be used to equate experimental treatments to control treatments, such calculations are often challenging to interpret and are almost always impossible to use in cognitive assessments across experimental paradigms. Cohen's d has two advantages over other effect-size measurements. First, its growing popularity is making it the standard. Thus, its calculation enables immediate comparison to increasingly more significant numbers of published studies. Second, Cohen's (2013) recommend that effect sizes of .20 are small, .50 are medium, and .80 are large enables us to compare an experiment's effect-size results to known benchmarks (Rosnow & Rosenthal, 1996). An effect size is a difference between two means (e.g., treatment minus control) divided by the standard deviation of the two conditions. It is the division by the standard deviation that enables us to compare effect sizes across experiments.

$$d = \frac{\overline{x}_t - \overline{x}_c}{s_{pooled}} \qquad \textit{equation 1}$$

d = Cohen's **d** effect size
x = mean (average of treatment or comparison conditions)
s = standard deviation
Subscripts: **t** refers to the treatment condition and **c** refers to the comparison condition (or control condition).

3.7.4 Homogeneity of data

It is often significant to establish if a set of data is homogeneous before any statistical technique is applied to it. Homogeneous data are drawn from a distinct population. It means that all peripheral processes that could affect the data must be kept constant for the whole duration of the sample. In-homogeneities may be caused when non-natural changes affect the statistical properties of the observations through time. Transforming data is performed is essential to distribute data usually. Therefore, simple homogeneity test was performed using T-test on pretest scores between EG1 and CG1 to see the mean distribution (Flores, Lillo., & Romo, 2018).

3.7.5 Interviews

The learners' interviews were recorded and then later replayed by the researcher to extract the emerging themes. Data were transcribed, and the codes generated. Finally, qualitative data were analysed thematically. Similar and related codes formed sub-themes and sub-themes were grouped to form main themes (Struass & Corbin, 1998).

3.8 Quality criteria

The methods for data collection, which was used in this study, are pre and post-test. Pre-post: validation that is content validity was done. The content was given to relevant authorities for scrutiny.

3.8.1 Reliability

A pilot study was conducted in this study as the researcher sought to establish the strength of the research and to make any adjustment to the instrument. In order to make sure that the test questions were internally consistent, the instrument was piloted with relevant stakeholders who gave enough and accurate information. The Cronbach's alpha coefficient (ά) of reliability was computed from the results of a pilot test collected.

$$(\acute{\alpha}) = \left(\frac{k}{k-1}\right)\left(1 - \frac{\Sigma S_{\mathrm{i}}^{2}}{S^{2} sum}\right)$$

K=number of components (K-Items or testlets)

S_{i}^{2}= variance of K individual items;

S_{sum}^{2}= variance for the sum of all items

The Cronbach Alpha coefficient was 0.85, which is acceptable because it is above 0.7 cut-off line (Nunnally, 1994, Muijs, & Reynolds, 2011).

3.8.2 Validity (internal and external)

According to Crooks (2001), validity is an integrated evaluative judgement caused by the empirical evidence and theoretical rationales on the test scores. All the instruments used in this study were subjected to content and face validity, as judged by my supervisor. As an expert in the field of science education, he went through the research instruments and checked through the grammar, wording and the structure of the instruments (face and content validity). After that assessing the Items in the test for their adequacy and appropriateness, content validity index (CVI) was computed using the formula below and results computed in Table 3.1 below The CVI of 0.75 was established in this study.

$$CVI = \frac{\textit{number of items judged by both judges as right}}{\textit{total number of items in the questionnaire}}$$

Table 3.1: Content validity index table

Questions	Rater 1	Rater 2	Rater 3	Rater 4	*CVI*
1	4	4	3	3	0.75
2	4	4	4	1	0.75
3	4	4	4	3	0.80
4	4	4	4	2	0.75
5	4	4	4	2	0.75
6	4	4	2	3	0.75
7	4	4	2	3	0.75
8	4	4	3	3	0.75
9	4	4	4	2	0.75
10	4	4	3	2	0.75
11	4	4	2	3	0.75
12	4	4	4	3	0.80
13	4	4	4	3	0.80
14	4	4	2	3	0.75
15	4	4	2	3	0.75
16	4	4	3	2	0.75
17	4	4	3	2	0.75
18	4	4	2	3	0.75
19	4	4	2	2	0.65
20	4	4	2	2	0.65
21	4	3	3	2	0.65
22	4	3	3	2	0.65
23	4	4	2	2	0.65
24	4	4	2	3	0.75
25	4	4	2	3	0.75
26	4	3	2	3	0.65
27	4	4	2	3	0.75
28	4	3	4	3	0.75
29	4	4	4	3	0.80
30	3	4	4	2	0.75
31	4	4	2	3	0.75

32	**4**	**4**	**3**	**3**	**0.75**
33	**4**	**4**	**3**	**2**	**0.75**
34	**4**	**4**	**2**	**2**	**0.65**
35	**4**	**4**	**2**	**2**	**0.65**
36	**4**	**4**	**2**	**3**	**0.75**
37	**4**	**4**	**2**	**3**	**0.75**
					0.75

Internal validity threats as recorded by Creswell (2013) have been identified in this study and are displayed in the Table 3.2 below.

Table 3.2: internal validity table

Type of threat	**Description of threat**	**Action**
Selection of participants	Brighter learners may be selected and can influence the outcome.	participants were randomly selected
Diffusion of treatment	Communication between the control and experimental groups can influence outcomes.	The two groups were kept as separate as possible during the collection of data.
Instrumentation	Varying the instrument a (pretest and Post-test), may impact the scores on the outcome.	The same instrument was used by the researcher to avoid negative or unintended outcomes

3.8.3 External validity

The following **external validity** threats have been identified in this study as possible threat and are displayed in table 3.3 below

Table 3.3: Table representing external validity threats

Type of threat	**Description of threat**	**Action**
Setting and interaction	Participants setting in this experiment can make it difficult for the researcher to	Additional experiments should be conducted in other settings to see if the

	generalize to individuals in other settings.	same results manifest as in the initial setting.
History of the study	The results of an experimentation are time-bound, therefore the results to past or future situations research cannot be generalized.	The study may be replicated at later times or done within a reasonable time frame.

Ethical issues/considerations

3.8.4 Permission

Permission to carry out the study was given from the Turfloop Research Ethics Committee (TREC) prior its commencement.

3.8.5 Informed consent

The researcher informed the interviewees that participation was voluntary and that they were free to withdraw from participation at any time if they did not feel comfortable. The interviewees were asked to sign a consent form (Appendix C) and assent form (Appendix B) to show that they agreed to partake in the study and that they had been given details information about their participation in the study. The participants were within adolescent age ranges 15 to 17 with an average of 16 years. Therefore, a letter for permission to participate in the study was sent to the parents and guardians of participants (Appendix D).

3.8.6 Protection from harm and benefits of the study

The researcher protected the identities of the participants. Their privacy also was protected through anonymity. The use of computers in a classroom has the potential to increase learners' interest in biology. Also, learner truancy and poor participation were insignificant in this study. Thus, the probability and magnitude of harm or discomfort anticipated in the research were no higher in and of themselves from those ordinarily encountered in daily life or during the performance of routine physical or psychological examination or tests. As it is, the researcher together with the gatekeepers; principals and circuit managers, subject teachers included, encouraged the learners to participate in the study to ensure that all learners participated and do not miss lessons. Learners who by chance, happened to miss a lesson attended revision classes. Also, learners who were taught using traditional talk and chalk method were given opportunity as-well to learn through simulations at the end of the research as part of revision work.

3.8.7 Fair participation

Both girls and boys were allowed to participate in the study. Women were not inappropriately excluded from research solely based on gender or sex. children, and individuals with cognitive impairments or intellectual disabilities also were not inappropriately excluded from research by them cannot decide whether or not to participate in particular research initiatives.

3.8.8 Confidentiality and anonymity

Participants’ confidentiality and anonymity was taken into consideration. The participants’ real names were not mentioned in the study, and the information they provided was only used for research or study purposes. The researcher informed the participants before they agreed to participate in the study. The anonymity of individuals or school/ or organizations participating in the research was also ensured (Kvale, 1996). Therefore, educators used pseudo-names to protect their identities and schools were referred to as groups 1,2,3. 4

3.8.9 Respect and discountenance

Researchers took the participants' understanding of themselves seriously and avoided representations that could diminish their legitimate rights. The researcher prioritised the respect for the dignity of research participants. Participants had the right to withdraw from participating at any level of the study without any penalty, and they also had the right to be informed about the study (Capron, 1989).

3.9 Concluding remarks

In this study, a quasi-experimental mixed method was used. Also, a Solomon Four Group Design was also used due to its robustness in limiting many issues concerning validity of the study and that it can also allow comprehensive control of variables. To complement the quantitative data, the learners' were interviewed and recorded. Data from the interviews were transcribed, and the codes generated. Finally, qualitative data were analysed thematically. When CS were used in teaching, learners showed to be very enthusiastic and excited for learning than those taught using Chalk and talk method. Consent to participate in the study was signed by the parents and learners.

The study unfolded well, and all learners who participated in this study completed the activity. Conversely, all the ethical considerations were observed in the entire duration of the study.

CHAPTER 4: RESULTS OF THE STUDY

4.1 Introduction

The previous chapter described the research approach, plan, sampling procedures, data collection and data management. In this chapter, the techniques for data analysis using Solomon Four-Group designs are presented.

4.2 Homogeneity of group before treatment

The study was conducted on four groups: two control groups and two experimental groups. However, learners' prior knowledge and level of achievements were assessed from the pre-test. In this case, only two groups, group A (experimental) and group B (control) were pre-tested, and an independent T-test was performed to assure the equal entry knowledge of both groups and results are shown in Table 4 below; Figure 2.

Table 4: T-test results for pre-test for both experimental A and control B groups.

Group Statistics						
	Group	N	Mean	Std. Deviation	Std. Error Mean	Significance*
Pre-test	A	34	14.0698	3.78213	.57677	.205
	B	34	12.9412	4.90480	.84117	

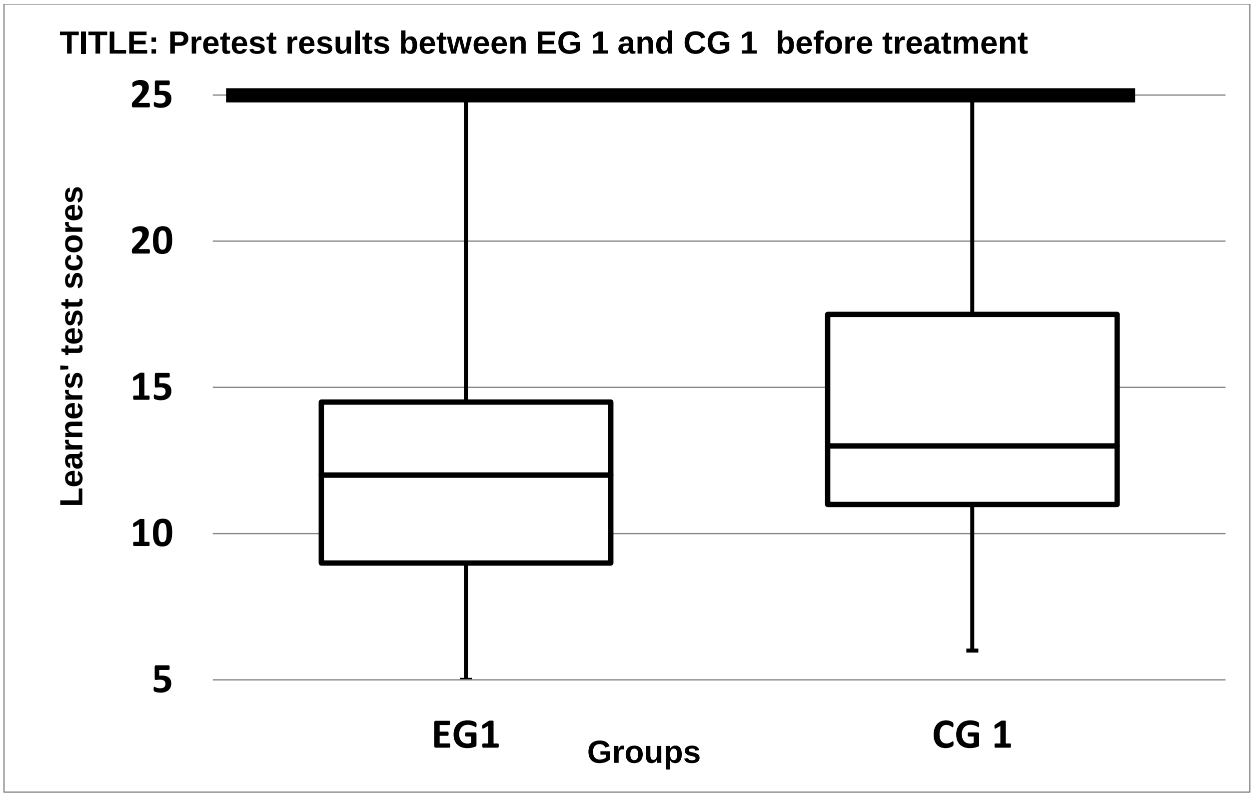

Figure 2: mean pooled score (Mean±SD) of EG and CG before treatment. Bar line indicates significant scores of EG and CG (T-test, *p* ≤ 0.05)

The results of the pre-test for both EG performance (mean 14.06±3.78 SD) and the results for the CG (mean 12.94±4.90 SD) did not differ significantly and Levene's Test for Equality of Variances t (75) = 1.140, *p* > 0.05). The variation is indeed not statistically significant even though it exists. It means that initially, the teaching method did not affect learners' achievements hence there is no differences in scores. Both the EG and CG were taught in the same way. Thus, this larger *p*-value (*p* > 0.05) indicates weak evidence against the null hypothesis (H_0), so the null hypothesis is rejected. However, after teaching for three weeks, EG performance (mean 38.53±11.19 SD) was again compared to that of the CG performance (mean 22.32± 6.87 SD) and there were significant differences between the two groups and Levene's Test for Equality of Variances t (66) = 7.198, p ≤ 0.05) table 5 below. Thus, this small *p*-value (*p* ≤ 0.05) indicates strong evidence against the null hypothesis (H_0), so the null hypothesis is rejected. There was generally an improvement with EG and CG after treatment or intervention. The mean (38.5; table 5) of the EG was found to be higher than the mean (22.3; table 5) of the CG. Furthermore, there was more variation on learners performance with the EG (S.D 11.19) and CG (S.D 6.87). The high standard deviation of the EG means that, learners within the group have data values that are more variable unlike the CG with lower standard deviation value. Basically, this large standard deviation (SD) of the EG means that the values in a statistical data set are farther away from the mean whereas small SD values in CG means that the data set is close to the mean. Thus, results of post-test revealed that EG performed better than CG as can be seen in Table 5; Figure 3.

Table 5: T-test results for post-test for both experimental group A and control B.

Source	group	Mean Difference	Std. deviation	F	Sig.	t	df	Sig (2-tailed)
Post-test	EG -A	38.5294	11.1931	7.20	0.009	7.19	66	0.000
	CG- B	22.3235	6.8787					

Note: this is a T-test results for pretested groups (EG-A and CG B), means used to measure gain

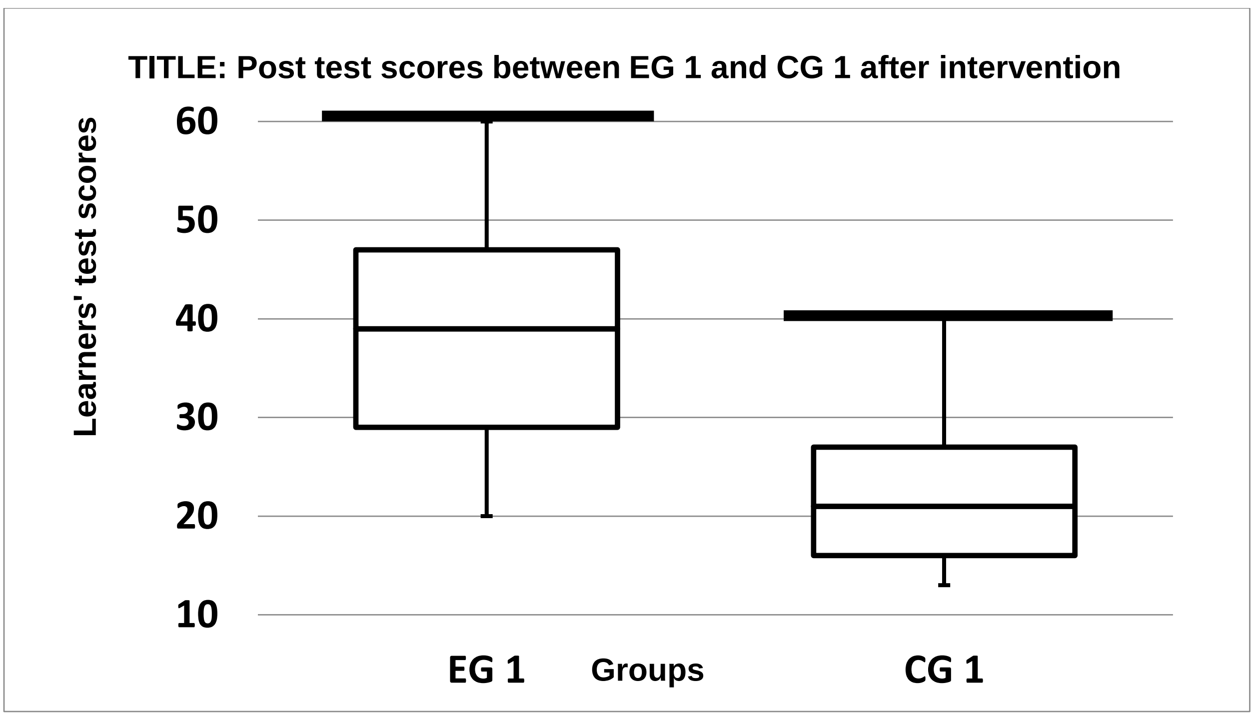

Figure 3: Mean pooled score (mean±SD) of EG and CG after treatment. Bar line indicates significant scores of EG and CG (T-test, p<0.05)

Table 6:Gain between EG and CG after intervention

Cohen's d for EG and CG			
Group	**PRE-TEST (Mean$\pm$SD)**	**POST-TEST (Mean$\pm$SD)**	**Cohen *d***
CG	12.94$\pm$4.90	22.32$\pm$6.87	1.60
EG	14.07$\pm$3.78	38.53$\pm$11.19	2.02

Table 6 shows again between EG and CG after the intervention. An effect size of 2.02 and Cohen's d of 2.02 was calculated for the EG group. It indicates a huge effect. The means are very different. Also, the effect size of 1.6 and Cohen's d of 1.61 was calculated for the CG. It also indicates a very large effect on CG. However, the effect size difference between the EG and CG was found to be 0.42, which signifies that there was medium effect on EG (treatment) as compared to the CG (not- treated). Table 7 below shows the summary results of the EG and CG groups before and after the intervention.

Table 7: T-test summary results of EG groups and CG groups before and after (*Significance at $p \leq 0.05$).

Group	source	F	Sig.	T	df	Mean Difference	SD
A vs B	pretest	1.635	.205	1.140	75	1.12859	6.8787
A vs B	posttest	7.198	.009	7.193	66	16.2059	11.1931

The significant comparison results of the pre-test for both EG and CG were found to be (sig. 0.205), thus ($p > 0.05$). This results show a non-significant difference between the two groups Table 7 above. Thus, this larger p-value ($p > 0.05$) indicates weak evidence against the null hypothesis (H_0), so the null hypothesis is rejected. However, for post-test results, EG and CG show a significant difference after intervention with (mean 16.21±11.19, $p \leq 0.05$). Thus, this small p-value ($p \leq 0.05$) indicates strong evidence against the null hypothesis (H_0), so the null hypothesis is rejected. It means that initially, the teaching method did not affect learners' achievements. After teaching for three weeks, there were significant differences between the two groups. There was a vast improvement with EG after treatment or intervention. The mean of the EG is higher than the mean of the CG.

As Campbell and Stanley (1963) pointed out, the initial phase of Solomon four-group design analysis is to determine whether evidence of pretest sensitization exists, that is, whether X affect O only when a pretest measure is administered. If this were the case, O2 would be higher than O4, but O5 would not be higher than O6. The test for this is a 2 x 2 between-groups analysis of variance (ANOVA) on the four posttest scores, as indicated in Table 8 below. The factors are treatment (yes vs no) and pretest (yes or no). Evidence demonstrating pretest sensitization is detected by the interaction (referred to as TEST A).

Table 8: A 2 x 2 Analysis of Post-test Scores

Pretest	Treatment (X) Yes	No
yes	O_2	O_4
No	O_5	O_6

Note O=outcome measure

The ANOVA table below gives F statistics (F (1.127) = 0.868, p>0.005; (F (1.127) = 76.532, p<0.005 and (F (1.127)= 0.073, p>0.005, for pretest, group and pretest*group, respectively. These rows inform us whether our independent variables (the "Pretest" and "Group" rows) and their interaction (the "Pretest*Group" row) have a statistically significant effect on the dependent variable. From the Descriptive Statistics Table 9, it can be seen that there was no significant interaction on the pre-tested groups EG (O_2) and CG (O_4) at $p > 0.05$. There is also no significant interaction between pretest*groups at ($p > 0.05$). However, there is a significant interaction between groups at ($p \leq 0.05$). This pattern is obvious when looking at the plot, Figure 4 below.

Table 9: A table of Tests of Between Subjects Effects ANOVA results analysis

Tests of Between-Subjects Effects

Dependent Variable: post-test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	7678.642[a]	3	2559.547	25.799	.000
Intercept	124581.972	1	124581.972	1255.713	.000
pretest	86.113	1	86.113	.868	.353
group	7592.861	1	7592.861	76.532	.000
pretest * group	**7.209**	**1**	**7.209**	**.073**	**.788**
Error	12599.938	127	99.212		
Total	144378.000	131			
Corrected Total	20278.580	130			

a. R Squared = .379 (Adjusted R Squared = .364)

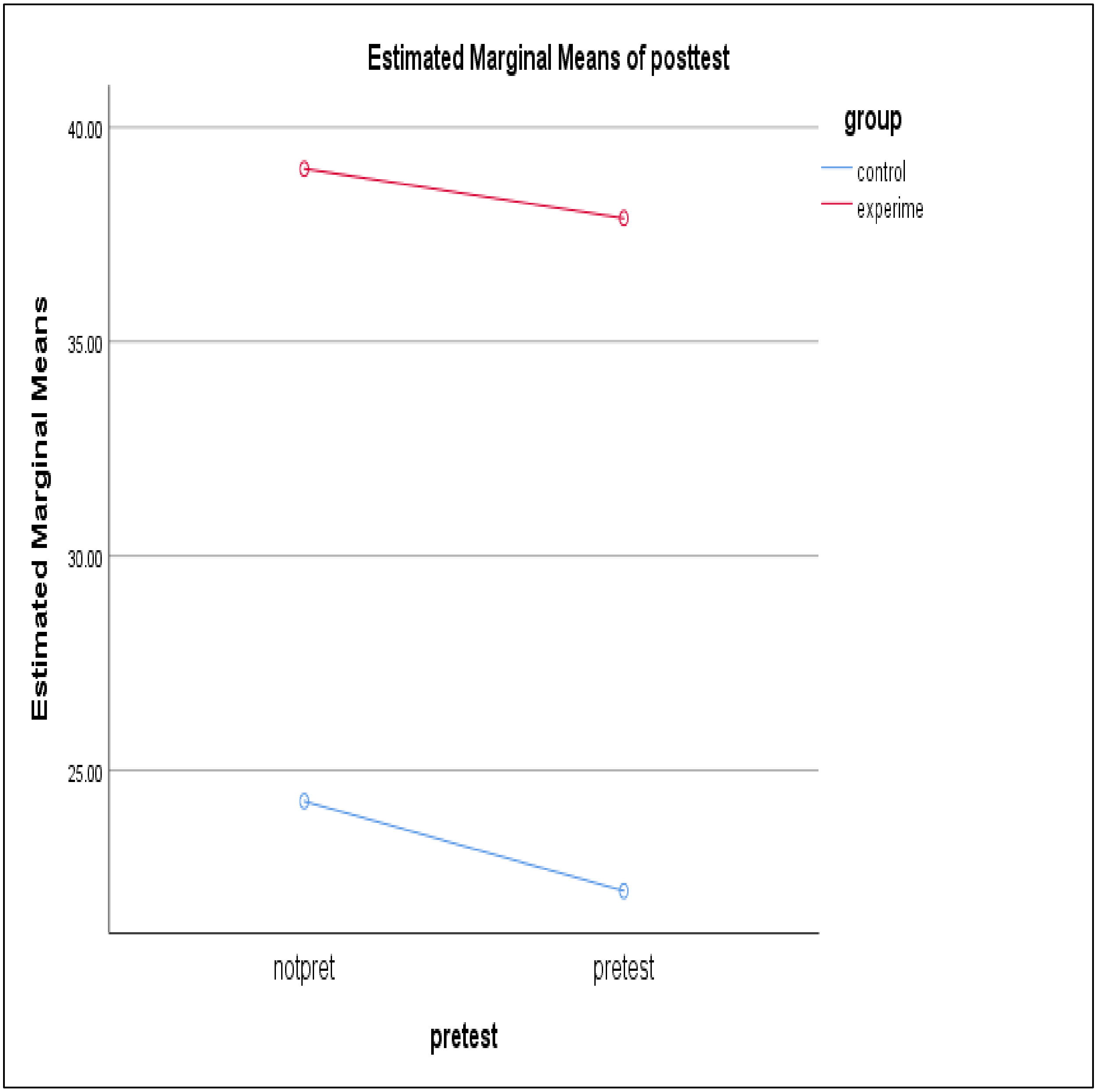

Figure 4: A plot showing the differences in scores for control and experiment groups pretested and not pretested

Since the lines representing the groups in the plot show differences in scores for pre-tested and not pre-tested groups, this implies that there is no interaction effect between groups and post-test scores. The lines are approximately parallel since there was no interaction. If the interaction is not significant, Cambell and Stanley (1963) suggested that the test for main effects for treatment (test D) should be performed. The results for main effects for treatment are represented in Table 10.

Table 10: Table 10: Table representing main effect test on experiment vs control.

Tests of Between-Subjects Effects					
Dependent Variable: post-test					
groups	**7592.861**	**1**	**7592.861**	**76.532**	**.000**
pretested	**86.113**	**1**	**86.113**	**.868**	**.353**
groups * pretested	7.209	1	7.209	.073	.788
Error	12599.938	127	99.212		
Total	144378.000	131			
Corrected Total	20278.580	130			
a. R Squared = .379 (Adjusted R Squared = .364)					

For now, the part of the output we need to be concerned about is the part with the box around it in table 10 above. It describes the tests for the main effects of groups (EG vs CG) and the effect of a pre-test. Looking under the “Sig.” column, we see that the main effect of the pre-test is not significant (p = .353), but the main effect of groups (EG vs CG) is significant (*p* ≤ .000). In this case, we report that the results of the main effect of student pre-test on post-test was not significant (F(1,127) = .868, p = .353) but the main effect of groups on post-test was significant. This means that learners in the EG who were taught using computer simulations received higher scores than learners in the CG who were taught using the traditional method, (F,(1,127) = 76.532, *p* ≤ .000). The interaction above shows a significant interaction. Therefore, treatment has an effect and no qualification needed (Cambell & Stanley, 1963). It is because test D disregards the pre-test information available for groups 1 and 2, data that typically increase power substantially. Table 11 below highlights the results for the independent T-test between males and females on the post-test results.

Table 11: Table 11: Independent T-test between males and females (EG) on the post test results

Test	Gender	n	Mean	SD	F	Sig.	t	df	Sig. (2-tailed)	Mean Diff
Post test	Male	27	39.63	11.5	0.21	0.65	0.39	52	0.697	1.26
	Female	27	38.67	12.1						

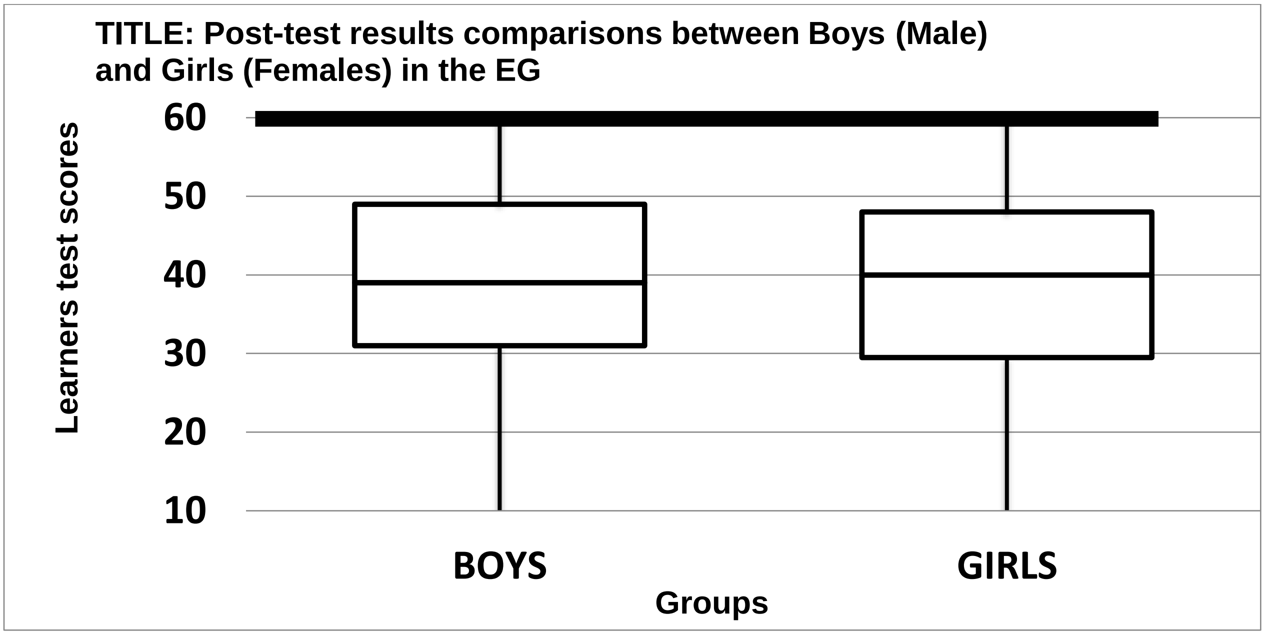

Figure 5: mean pooled score (Mean ± SD) of (male and female) EG after treatment. Bar line indicates significant scores of male and females (both EG and CG); (T-test, p ≤ 0.05).

An independent T-test was performed to prove that there was no statistically significant difference in achievements between male and female in the EG on the post-test results, Table 11, Figure 5. It was found that there was no statistically significant difference at t (52) = (0.392); $p > 0.05$ with the mean pooled score for male (39.63±11.52) and female (38.67±12.08). Therefore, if the p-value is larger ($p > 0.05$), this would mean that the null hypothesis (H_0) is rejected.

It can, therefore, be concluded that both boys and girls learned the same way when using simulation in teaching, and the null hypothesis is rejected. Table 12 below further shows the results of independent T-test between male and females in the CG on the post-test scores.

Table 12: Independent T-test between male and female (CG) on the post test results

Test	Gender	n	Mean	SD	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference
Post test	Male	31.	23.58	7.50	.064	.801	.153	60	.879	.029
	Female	31	23.29	7.49						

Furthermore, an independent T-test was also performed between male and females in the CG post test results to justify the significant differences; Table 12 further. It was found that there were no statistically significant differences at t (60) = (0.153); p >0.05 with the mean pooled score for male (23.58±7.50) and female (23.29±7.49). Therefore, if the p-value is larger (p > 0.05), this would mean that the null hypothesis (H_0) is rejected. It can, therefore, be concluded that both boys and girls learnt the same way when using traditional teaching. It is, however, evident that both male and female improved in scores when both methods were used but with the EG with more gain in the score at a mean score of ±39 than CG at mean score of ±24; Figure 6 below. There was a difference in the mean score of approximately 15 points which is a vast difference which affirms the rejection of the null hypothesis.

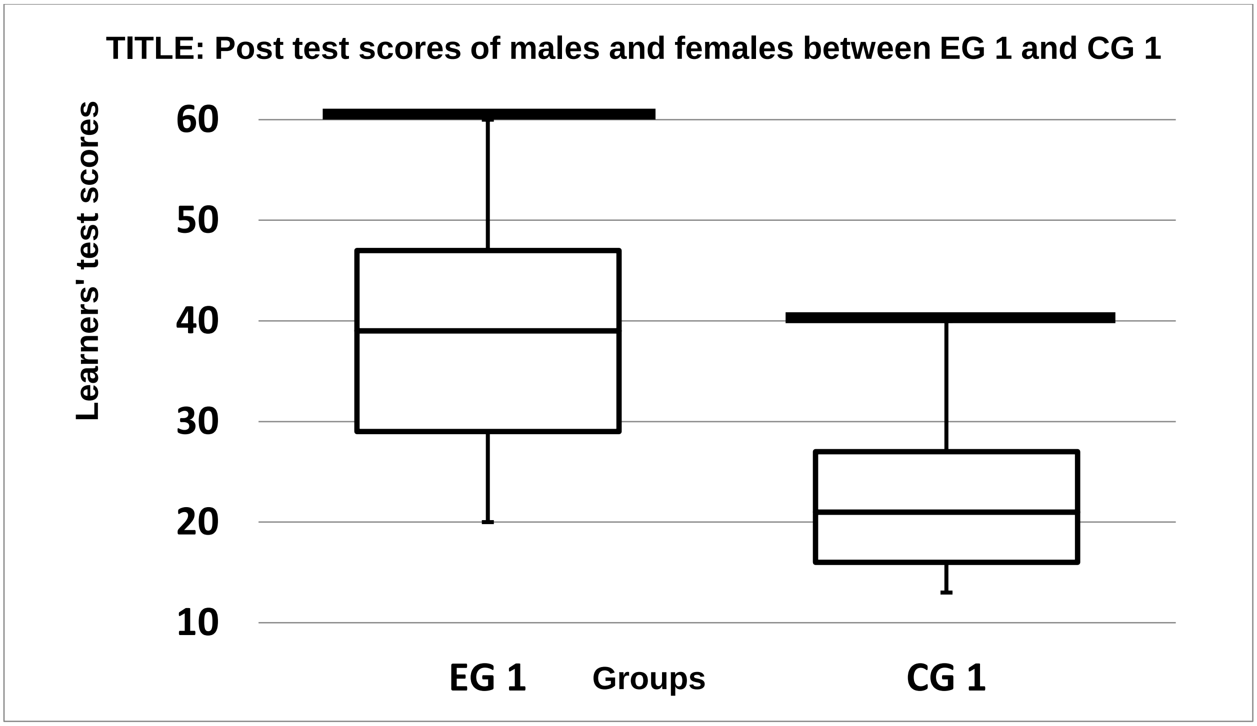

Figure 6: mean pooled score (Mean±SD) of (male and female) EG and (male & female) CG after treatment. Bar line indicates significant scores of male and females (both EG and CG); (T-test, $p<0.05$).

4.3 Qualitative (observational) results

Learners in the experimental group were pleased and jubilant when they were first introduced to computer simulations. At first, they seemed to have underestimated the method, but later when it was continually used, they realized that the method was far much better than the traditional method they were used to. The Learners' attitude and concentration levels on simulation lessons increased day by day, and the lessons became fascinating to them. Learners were interested to learn more, and some requested that the simulations be stored in their memory sticks for later use. What fascinated them most was that simulation freed their imagination as they saw real images appear on the screen, and they could now identify them in their surroundings. Experiments were real to them. It is, however, contrary results for the CG who were taught using traditional teaching. The learners' attitude depended more on the energy the teacher possessed. The curriculum was not finished on time due to the learners' lack of understanding of subject matter.

Learners took much time to understand the subject matter, and that would cause a delay in completion of the curriculum.

The learners' interviews recorded were later replayed by the researcher to extract the emerging themes. Data was then transcribed into codes. Similar and related codes formed sub-themes and sub-themes were grouped to form main themes. Thus, the following themes were extracted and coded when using FGDI namely: 1) interest in learning, 2) Acquisition of knowledge and 3) finishing tasks in time. Each theme is presented below using the learners' narratives.

THEME 1: Interest in learning

The main excerpts describing learners' attitude and interest consisted of the words such as; boring, no fun, easily forgettable, difficult. Direct quotes from learners' responses are presented below:

FGDI 1: From CG "learning life sciences in not interesting, the subject is boring".
FGDI 2: From CG also shared the same sentiment with the learner one as she stated that "Life sciences is not interesting because it is easy to forget."
FGDI 4: From EG, "I now found life sciences interesting since we learnt plant biodiversity using simulations

FGDI 3: From EG "the subject is boring. We study for a pass only, and it is not even funny."
FGDI 3: From CG "the subject is interesting. We study with excitement to watch the simulation as if they were real live objects."
FGDI 2: From CG "the topic is amazing to watch on the screen, Actually it is fun to us."

Learners in CG lacked the enthusiasm to learn life sciences as it was boring, and it is not fun. On-contrary, learners from EG found learning using CS very interesting. This could mean that the use of CS can enhance learner interest and improves learner academic performance. Learners' attitude could be another factor in determining their learner's achievements in the tests.

THEME 2: Acquisition of knowledge

In asking question 2, the researcher sought to determine the impact or effect of computer simulations on learners' comprehension of the content knowledge. Learners, mostly in the EG group, indicated that the lessons were engaging and they could still remember what they have learnt using simulations. This assertion is depicted when learners were able to share information among themselves even after lesson presentation. The other reason was that the simulation was repeated and accessible for learners who could not immediately understand or who needed to revise on their own. However, learners in the CG group had problems remembering what has been taught.

FGDI 1: From EG noted, "I now found life sciences interesting, I was able to remember everything we learned in class using CS."

FGDI 2: From CG, "We easily forget what we have been taught, and we are not even able to share the knowledge."

THEME 3: Finishing tasks in time

For the EG, it was also appealing that this simulation covers much scope within short space-time. So, it was easy to finish the scope on time and later do a revision. While on the other hand, CG learners were devastated that they could not finish the scope on time and always lagged. This could mean that learner academic success in the CG is much dependent on the teacher. If the teacher is not at school due to some reason, then learners would not learn anything during that time. Also, it is also unlikely that the teacher would revise the content with the learners. Thus, more time is needed for learners to study and understand and to cover the scope. When learners were asked to comment on the strategy used in teaching, the following directs quotes from FGDI are presented here below:

FGDI 4: from EG reported that, "I now enjoy life science lessons and I now spend more time studying life sciences"

FGDI 3: from CG indicated that, "we don't cover syllabus and is not easy for us when are about to write examinations."

These comments show that learners from EG were excited about the use of CS and were able to cover the scope with confidence. The excitement may have increased their desire to do more and hence achieve more. This could also mean that CS supported interaction among the learners. Furthermore, Ragasa (2010) said that computer simulation assisted teaching and learning can be more efficient than CTM methods to increase academic success in science classrooms. In addition, when using computer simulations for teaching and learning, learners are treated differently when compared to the traditional chalk-and-talk classrooms. As a result, learners take responsibility for their learning, which occurs through involvement. Ragasa (2010) further concluded that, learners take consideration of self-assessment and focus on features that contribute to attaining meaningful results

While CS using four to five learners per one computer increased learners' achievements, it is not clear as to how many learners per computer are needed before the effects are nullified. The effects of many learners to one computer was not investigated but may be of interest to researches. Also, a comparative study of the use of CS between the developed countries and developing countries need further studies.

4.4 Conclusion

The results from the statistical analysis show that the learners from the EG group who were taught using CS performed much better than learners in the CG group. A significant gain in scores is evident among the two groups. However, more significant achievements are reported on the EG. The influence of gender on learners' achievements was not significant. The EG group learners reflected a more positive attitude to learning Life Sciences than their counterparts in the CG.

CHAPTER 5: DISCUSSION

5.1 Introduction

The study explored the effect of using Computer Simulations (CS) to teach Grade eleven learners a plants biodiversity topic, in Mankweng Circuit. Before the execution of the study, a pre-test was administered to both groups, EG (group A) and CG (group B) as indicated in the Solomon Four-Group Design. Subsequently, the results from the pre-test showed that there was no significant difference in the performance of learners from both groups (T-test, $p > 0.05$; Table 4), signifying that learners in the two groups were on the same level of understanding and knowledge of concepts before intervention since they come from the same background. From these results, the null (Hypothesis two) that states that 'learners' performance will not vary in the EG and the CG in the pre-test was accepted.

Nonetheless, in the post-test, Table 5; Figure 2, the mean score of the EG (mean 38.53±11.19 SD) is higher than that of the CG (mean 22.32± 6.87 SD) with a Levene's Test for Equality of Variances; ($t(66) = 7.198$, $p <0.05$). This shows that learners in the EG performed better than learners in CG. Equally, the post-test scores in this study did not show any interaction between the pre-test and the instructional intervention. If there were practice effects by the pre-test, the post-test performance by groups receiving the pre-test would be higher. In addition, the ANOVA (Table 9 in the results) show that, there was no significant interaction on the pre-test group at ($p=0.788$). The significant difference between the performance of the EG compared to CG imply that Hypothesis one which states that 'learners in the experimental group (EG) who are taught by using CS will perform better than those in the control group (CG) taught using "chalk and talk method" (CTM) after intervention is accepted. The social constructivism theoretical framework is also accepted because these results mean that learning was active, enquiry based, cognitive, social, and motivational. On the other hand, technology blended well with pedagogy and content knowledge in teaching using CS. Technology also offered a conducive learning environment with tools that facilitated collaboration and social construction of knowledge.

These results agree with the findings of Mihindo et al. (2017) conducted on the effect of computer-based simulations teaching approach on learners' achievement in chemistry. The study showed that there was a statistically significant difference in the achievement of learners who were taught using CS teaching approach compared to those taught using traditional teaching method CTM. The study findings further agree with the findings of Popil and Dillard-Thompson (2015), who reported that simulations enhanced learners' performance. Furthermore, Ragasa (2010) showed that computer simulation assisted teaching and learning was more efficient than CTM methods to increase academic success in science classrooms. In computer simulation teaching, learners are treated differently when compared to the traditional chalk-and-talk classrooms: learners took responsibility for their learning, which occurs through involvement; learners take consideration of self-assessment and focus on features that contribute to attaining meaningful results. Learners were always engaged in activities and were able to make predictions and make hypotheses. Gonczi et al (2017), reported that CS teaching method involves learners twice as effectively as CTM does. Learners can replay the simulations and get more committed than in CTM. The commitment eventually results in high performance in comparison to CTM (MacManaway, 1970).

On the other hand, a combination of CS and direct teaching yield excellent performance. For instance, In his study, Ragasa (2010), and Zulfiqar et al. (2018) showed that a combination of computer-assisted instruction and collaborative work improved learning. Conversely, Kiboss and Ogunniyi (2005) explored that the mean improvements of the learners in the CS were significantly higher than those of their counterparts without CS.

Furthermore, Wanjala (2007) and Nkemakolam et al. (2018) reported that learners learning with computer-based instruction (CBI) in cooperative groups achieved better than those learning individually. The verdicts of this study correspond with the findings of other studies in regards to the use of computer simulations in teaching and learning. Furthermore, Hykle (2011) investigated the relationships between gender and science content achievement and discovered that computer-assisted instruction for science teaching had greater success. While Feyzioglu (2009) stated that the use of a computer-based instructional program that engages the learners more vigorously in the learning process frequently results in advanced academic accomplishments than those that put them in an inactive role.

Also, Yildirim and Sensoy (2018) concluded that there was a significant increase in the attitude levels of the learners in the EG and were preserved for months even after the execution of the study. However, in contrary Hannel and Cuevas (2018) reported a non-significant difference in achievements between CTM method and the computer-based simulation method. Hannel and Cuevas (2018) found that CG and EG both had academic gain. As it is, various research studies have concluded that labs with virtual manipulations are as efficient as labs with hands-on physical manipulations (Hannel & Cuevas, 2018; Chen, Chang, Lai, & Tsai, 2014). Their studies endorsed that no execution method was more effective than the other. Be that as it may, teachers by virtue of their training are supposed to have PCK for specific topics in their areas of specialisation. This very knowledge distinguishes them from other knowledges and demarcates them as teachers. Sanders, Borko and Lockard (1993) state that experienced teachers should have a“*wealth of general pedagogical content knowledge*” and use it when teaching.

5.2 CS on gender differences in achievement

The T-test results in Table 11, Figure 5, show no significant difference in the mean scores between female and male learners in EG. The T-test results were calculated at t (52) = (0.392); p >0.05 with the mean pooled score for male (39.63±11.52) and female (38.67±12.08). Similarly, an independent T-test was also performed between male and females in the CG post test results to further justify the significance differences; Table 12, Figure 6. It was found that there were no statistically significant differences at t (60) = (0.153); p >0.05 with the mean pooled score for male (23.58±7.50) and female (23.29±7.49). It can, therefore, be concluded that both boys and girls learned the same way when taught using computer simulation in and the null hypothesis is rejected.

Other studies have conveyed findings that coincide with the results of this study. The studies by Nkemakolam et al. (2018) and Mihido et al. (2017) that studied the effect of gender on computer-based simulation on chemistry problem solving did not find any major differences between male and female high school learners performing stoichiometric chemistry problems. They ascribed the increase in student accomplishment in computer-based science activities. They were rendering to report by Fraser and Walberg (2005) new technologies improved students' performance and motivation. On that note, simulations, microcomputer based-laboratories and databases are said to be vital for assisting mastery of science concepts and science process skills, especially in science education. Similarly, Fraser and Walberg (2005) reported that new technologies improved the students' performance and motivation. Thus, simulations, microcomputer based-laboratories and databases are said to be vital for assisting mastery of science concepts and science process skills especially in science education.

In addition, Table 6 in the results showed a significant gain for both EG and CG after the intervention. The EG group showed a significant gain in effect size of 2.02 and Cohen's d of 2.02 while CG showed a significant gain in effect size of 1.6 and Cohen's d of 1.61. However, the effect size difference between the EG and CG was found to be 0.42, which signifies that there was the medium effect on EG (treatment) as compared to the CG (not-treated). There was generally an improvement with EG and CG after treatment or intervention. These performance results concur with some previous studies, which also reported unsatisfying results on the use of simulations to enhance learners' learning (Trundle & Bell, 2010; Scalise et al., 2011). Scholars found that traditional methods were just as efficient as Computer simulations whereas CS alone is insufficient in helping learners to understand more difficult ideas since these more-complex CS time and again require greater interactivity, which can potentially devastate learners (Adams et al., 2008; Podolefsky et al., 2010a). As a result, scaffolding is crucial to help learners develop enough contextual knowledge so that they are not burdened but are adequately armed and ready to discover the content they are learning (Khan, 2011; Schneps et al., 2014).

Whereas, in their study, Smetana and Bell (2012) reported that, like in any other educational technique, the effectiveness of Computer simulations is reliant upon the methods in which they are used. They further recommended that computer simulations are most effective when they (1) are used as complementary tools; (2) integrate high-quality support systems; (3) inspire student reflection; and (4) support cognitive dissension. Simulations can help enrich learners with opportunities to experience phenomena and to understand difficult concepts (Bell & Trundle, 2008).

The constituent of learning is dependable on the goals of the learner and teacher. It, therefore, suggests that a blended learning approach practised in a classroom can help learners to understand the subject matter (Bliwise, 2005). These results designate that even mediated experience of these interactive, computer-based tasks via blending them into a large class, face to face teaching can support learner understanding. In support of the above note, Davis and Bostrom (1992) and Psotka et al., (1993) reported that how computer-based tasks can advance understanding by visual learning appears to be one means by which the present use of technology assisted learning. The benefit of computer-based simulations is that they can mainly show the process in action visually rather than expecting learners to imagine the process (e.g., taking a random sample). Different approaches to teaching and learning that were used in the past can be enhanced by the technology that was used. As such, the use of technology in teaching and learning can be anticipated to benefit those learners who find it challenging to learn from a traditional talking; lecture slides only. How technology use broke up the classroom traditions may also benefit learning since it divided the lecture into smaller, more controllable amounts of information.

Scaffolding, as pronounced by Wood, Bruner, and Ross (1976), comprises fundamentally of the teacher controlling those elements of the activities that are initially beyond the learner's capability, thus allowing the learner to concentrate upon and perform only those features that are within his range of competence. In our days, the definition of scaffolding has extended to include a wide-ranging of formal systems, including conversational strategies (e.g., guiding questions), curriculum design (e.g., direct instructions for learners), and components of computer software (Pea, 2004; Quintana, et al., 2004; Tabak, 2004).

Consequently, the findings of the study have demonstrated that the CS technique was useful and might be one solution to the complications that teachers often encounter with traditional teaching methods. The findings demonstrated that CS teaching had an effect that led to an enhancement of performance in the subject as compared to CTM. CS has a constructive and significant influence on the understanding of plant biodiversity or Biology concepts were better understood in the EG than in the CG. When learners integrate the use of computers in their learning, they learn how to think about what their study is all about, and how to connect ideas from various sources by constructing on what they know, and so the computer is an expansion of the thinking and making processes (Goldman-Segall & Maxwell, 2003). Therefore, this study gives support to the fact that the achievement of learners in Biology could be significantly improved if they are exposed to CS teaching approach. This denotes that the use of CS teaching approach if enriched will reduce memorization learning and can be used to stress on learner-centred activities. The use of CS will stimulate meaningful learning between learners and raise their levels of performance in Biology courses.

It can, therefore, be concluded that CS enhanced learner performance in plant biodiversity and the following comments on the hypothesis are made:

- ❖ Hypotheses one which states that “learners’ performance in the pretest will not vary in the EG and the CG” is accepted.
- ❖ Also, the hypothesis two which states that learners in the EG who were taught using CS will perform better than those in the CG taught using CTM is accepted.
- ❖ In addition, the hypothesis three which states that “there will be no statistically significant differences in achievements between boys and girls in the EG” is established.
- ❖ Finally, the hypothesis four which states that “learners from EG will have positive attitudes towards science, but not those from CG” is also established.

5.3 Conclusion and recommendations

Computer-based simulation can be effective at enhancing learners’ understanding. A higher achievement was found when using computer simulation lessons than the traditional “chalk and talk method” (CTM). There is a more significant effect size for the simulation group, which reinforces that probability. The suggestions of our results and our recommendations are the following:

(1) The use of CS model has several advantages, in terms of its potential to promote higher-level thinking in the acquisition of knowledge, interest and acceleration of time when doing tasks as demonstrated in this study.

(2) Traditional CTM should not be over-ruled since they are similarly effective, although with a small gain in effect size.

(3) The influence of gender on learners’ achievements in plant biodiversity topic was not significant.

(4) Further study is recommended on teachers’ attitude and understanding of the use of computer simulations in the science classroom to influence the learners' overall development because teachers' attitudes may hamper learners’ understanding of content.

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APPENDIX A: PERMISSION LETTER

PERMISSION LETTER

UNIVERSITY OF LIMPOPO

Turfloop Campus
Department of Mathematics, Science and Technology
Private Bag X 1106
Sovenga
0727

Limpopo Department of Education
Private Bag X9489
Polokwane
0700

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN YOUR SECONDARY SCHOOL AT MAMABOLO CIRCUIT AT CAPRICORN DISTRICT

DEAR SIR/MADAM.

The above matter has reference. I Kgashane Bethuel Bodirwa, Masters student at University of Limpopo Turfloop Campus, hereby request the permission to conduct a research study within your District at Mamabolo circuit.

I'm doing a research titled: "The effect of using simulations on learners' performance in plant biodiversity"

This study is therefore significant to researchers, colleagues, beginning teachers who struggle to use conducive teaching strategies like simulations.

Patiently waiting for your response

Email address: kgashanebodirwa@gmail.com

Yours sincerely,

Bodirwa KB

Signature……………………………………… Date…………………………………….

APPENDIX B: ASSENT FORM

Project Title: The use of computer simulations on grade eleven learners' performance in plants biodiversity, Mankweng circuit

Investigator: BODIRWA KB

We are doing a research study about the use of computer simulations in plant biodiversity topic in grade eleven. A research study is a way to learn more about people. If you decide that you want to be part of this study, you will be asked to:

1. Attend the lessons as per school time-table or as scheduled by both the school and the researcher and this may take duration of 3-4 weeks, at least 4 hours a week.
2. There are some things about this study you should know. You will be taught using computer simulation which is different from the usual way of teaching i.e. traditional talk and chalk method.
3. You may be given a pre-test before administering the lessons to determine how much you have learned on the topic in the previous grades and a post-test after effective teaching. The tests results will be used in the study to make conclusions about the study.
4. Your raw marks will be statistical analysed to see how much you have gained after the intervention, and your test marks will be presented to you once marked. However, the test marks will not be used for promotion or continuous assessment purposes by your school.
5. Not everyone who takes part in this study will benefit. A benefit means that something good happens to you. We think these benefits might be improvement in knowledge and achievement, skills in using computers, cooperative learning.
6. When we are finished with this study we will write a report about what was learned. This report will not include your name or that you were in the study.

N.B. You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too. Your parents know about the study too.

If you decide you want to be in this study, please sign your name.

I, ________________________________, want to be in this research study.

____________________________________ ______

(Sign your name here) (Date)

APPENDIX C: INFORMED CONSENT FORM

INFORMED CONSENT FORM

Project title: The use of computer simulations on grade eleven learners' performance in plants biodiversity, Mankweng circuit

Project leader: BODIRWA KB

I, …………………………hereby voluntarily consent to participate in the following project: "The use of computer simulations on grade eleven learners' performance in plants biodiversity, Mankweng circuit."

I understand that:

1. My responses will be treated with confidentiality and only be used for the purpose of the research.
2. No harm will be posed to me.
3. The research project aim has been explained to me.
4. I do not have to respond to any question that I do not wish to answer for any reason.
5. Access to the records that pertain to my participation in the study will be restricted to persons directly involved in the research.
6. Any questions that I may have regarding the research, or related matters, will be answered by the researcher.
7. Participation in this research is entirely voluntary and I can withdraw my participation at any stage.
8. I understood the information regarding my participation in the study and I agree to participate.

Signature of interviewee **Signature of witness**

_____________________ ___________________

Signature of interviewer

____

Signed at_______________________ on this ____ day of ____________20_____

APPENDIX D: (A letter to the parent/ guardian)

Enquiries: BODIRWA KB

Email: kgashanebodirwa@gmail.com

P O Box 1530
Sovenga
0727

Dear Sir/Madam

REQUEST FOR YOUR PERMISSION TO ALLOW YOUR CHILD TO PARTICIPATE IN RESEARCH

- The above matter has reference
- We are doing a research study about the use of computer simulations in plant biodiversity topic in grade eleven. This research topic is aligned with the department of education grade 11 biology pacesetter and/or syllabus and that it has no harm to your children in some-way, in fact, it will help your child to develop better skills in using computers and will therefore enhance their understanding and improve their academic achievements. A research study is a way to learn more about people. If you allow your child to be part of this study, he/she will be asked to:

1. Attend the lessons as per school time table or as scheduled by both the school and the researcher and this may take duration of 3-4 weeks, at least 4 hours a week.
2. Your child will be taught using computer simulation which is different from the usual way of teaching i.e. traditional talk and chalk method.
3. You child may be given a pre-test before administering the lessons to determine how much he/she has learned on the topic in the previous grades and a post-test after effective teaching. The tests results will be used in the study to make conclusions about the study.
4. Your child's test marks will be presented to him/her once marked. However the test marks will not be used for promotion or continuous assessment purposes by the school.
5. When we are finished with this study we will write a report about what was learned. This report will not include your child's name or that he/she was part of the in study.

If you assent or give permission to your child to be in this study, please sign your name.

I, ________________________________, permit my child to be in this research study.

__________________________________ ______

(Sign your name here) (Date)

APPENDIX D: (A letter to the parent/ guardian) TRANSLATED VERSION

Enquiries: BODIRWA KB

P O Box 1530

Sovenga

0727

Email: kgashanebodirwa@gmail.com

Motswadi yo a Hlomphegago

TUMELELO YA GO DUMELELA NGWANA WA LENA GO KGATHA TEMA MO DINYAKIŠIŠONG TSE

Ke le moithuti Univesiting ya Limpopo go lefapha la humanities lekaleng la mathematics, Science and Technology, re kgopela tumelelo ya ngwana wa lena go tsea karolo mo dinyakišišong tša hlogo taba ye: The use of computer simulations in plant biodiversity topic in grade 11. Hlogo tabe ye e sepelelana le lenaneo thuto la department ya education naga ka bophara. Gomme, dinyakišišo tše ga dina kotsi mo bophelong goba maikutlong a ngwana wa lena. Dithuto tše di na le bokgoni bya go oketša tsebo mgwaneng ya lena, go mo fahloša gore a tšwelelele dithutong, le gore a kgone go šoma le bana ba banngwe gabotse. Tumelelo ya lena e dumelelana le tše letalago:

1. Ngwana wa lena o tla tsenela dithuto tše go ya leka lenaneo la sekolo, goba lenaneo leo le tla byakantšwego, nako ye e ka bago dibeke tše tharo goya go tše nne, iri tše nne (4) mo bekeng.

2. Ngwana wa lena o tla rutwa ka computa e se bego mokgwa wa ka mehla wa thuto.

3. Ngwana wa lena o tla ngwala molekwana pele ga dithuto go lekola gore o ithutile go fihla kae mengwageng ya go feta, molekwana o mongwe mafelelong a dithuto go laetša gore o ithutile byang.

4. Meputso kamoka e tla fiwa ngwana wa lena efela e ka se šome hlatlošong ya ngwana.

5. Mafelelong a dithuto byale ka monyakišiši, rephoto e tla ngwala go akaretša tshepidišo ya dinyakišišo tšeo.

6. Ngwana wa lena ona le maloka a go kgaotša dithuto nako efe kappa efe ntle le tefo goba go gobošwa.

Ge le dumelelana le tše kamoka, go dumelela ngwna wa lena go kgatha tema, ka kgopelo saenang kgopelo ye.

Nna, ________________________________, ke dumelela ngwana waka go kgatha tema mo dithutong tše.

__________________________________ ______

(Leina) (Tšatši kgwedi)

APPENDIX E: INTERVIEW SCHEDULE

For qualitative data, an interviews schedule consisting of the following five questions was administered on the experimental group:

6) How did you enjoy plant biodiversity lessons using computer simulations as compared to the traditional teaching method?
7) How did teaching plant biodiversity using computer simulations assist you in growing knowledge and interest in the subject; and
8) How much time did you spend studying plant biodiversity before and after the lessons using computer simulations?
9) How do you want to be taught a plant biodiversity topic classroom?
10) Did you perform plant biodiversity practical work in the class before?

For the control group, an interviews schedule consisting of the following five questions was administered:

6) How did you enjoy plant biodiversity lessons taught using Chalk and Talk Method?
7) How did teaching plant biodiversity using Chalk and Talk Method assist you in growing knowledge and interest in the subject; and
8) How much time did you spend studying plant biodiversity?
9) How do you want to be taught a plant biodiversity topic in classroom?
10) Did you perform plant biodiversity practical work in the class before?

APPENDIX F: BIODIVERSITY LESSON PLAN

Biodiversity Lesson Plan

TOPIC: THE EFFECT OF USING COMPUTER SIMULATIONS ON GRADE ELEVEN LEARNERS' PERFORMANCE IN PLANTS BIODIVERSITY

Teacher: BODIRWA KB **GRADE: 11** **DATE: JAN –FEB 2018**

AZ Science Standards:	*Strand 1: Diversity, change and continuity,* *Specific aim 1: Specific Aim 1 involves knowing, understanding, and making meaning of sciences, thereby enabling learners to make many connections between the ideas and concepts.Evaluate how the process of natural ecosystems affect and are affected by humans* *Strand 3: Environmental Studies (Population Ecology and Human Impact);* *Specific aim 2: Learners must be able to plan and carry out investigations as well as solve problems that require some practical ability. This ability is underpinned by an attitude of curiosity and an interest in wanting to find out how the natural world and living things in it work.* *Specific aim 3: The third aim of Life Sciences is to enable learners to understand that school science can be relevant to their lives outside of the school and that it enriches their lives.* *Identify the relationships among organisms within populations, communities, ecosystems, and biomes.* *Learners must be able to describe how organisms are influenced by a particular combination of biotic (living) and abiotic (non-living) factors in an environment.* *RST 9-10.RST.1. Cite specific textual evidence to support analysis of science and technical texts, attending to precise details of explanations or descriptions*
Enduring Understandings/ Essential Questions:	Biodiversity (the variety of life on Earth): All Ecosystems contain a variety of life that is interdependent. / How does human behavior affect biodiversity? How does decreased/increased biodiversity disturb life on Earth? How are people dependent on biodiversity?
Content Objective:	*Learners will learn how biodiversity is defined, why it is important, and what how it is impacted by human behavior.*
Language Objective:	Learners will define and give example of words relevant to the study of Biodiversity

Vocabulary	**Materials**
Biodiversity, habitat, ecosystem, niche, endemic, old world, evolution, organisms, exotic, species, extinction, sustain	*Pre-test with vocab and matching definitions. Computer simulations on "*Biodiversity" using PhET: Expressions of Life- *Introduction to Biodiversity.*
Seasonality	January –February 2018
Reflection	

Anticipatory Set:
Ask learners to write a response to the following questions
How do you define biodiversity, and how do you depend on it in your daily life?

Think-Pair-Share
Have learners share and compare answers with their neighbors and reflect on how they were similar/different, then add to their answers.

Choose students randomly to share their answers – write a list of ideas on the board
Activity/Investigation:
Pretest: Have learners take the Biodiversity "Words and Concepts" pre-test to self-assess prior knowledge.

Introduce Biodiversity concepts with the Power Point presentation
(and/or computer simulation "Biodiversity: Expressions of Life") using PhET.

Have learners finish matching terms and answering questions on pre-test after listening to lecture and or computer simulations. Check answers as a class.

Have class further research the question, "Why is Biodiversity important and how do we depend it?"
Ask learners to research, discuss, and write a page summarizing all or some of the following points:

- Give some examples of the variety of biologically diverse forms of life that exist on Earth.
- Name some of the diverse types of habitats in which life exists.
- How do humans depend on other life-forms? Give some specific examples.
- What are some of the reasons that increasing numbers of species are becoming extinct?
- What are some of the solutions to the problem of biodiversity loss?

Make a list of your sources, and support your claims with evidence;

Closure:
Work together to construct a collaborative explanation of what students understand about biodiversity based on new information they've learned. Record this explanation and save it until the end of the unit. At that time you will develop another explanation and compare the two. Tell

learners that in this project they will be learning the tools and methods scientists use to study biodiversity, such as observing, measuring, collecting, classifying, recording and analyzing data, and communicating findings to each other. With these skills, they will study an outdoor site (at their school or a chosen field site, or both) in great detail, looking primarily at arthropods and plants, but also birds and reptiles and mammals when possible. The goal is to participate in citizen science and contribute quality observations to a project called *iNaturalist,* as well as present their findings to the class.

Biodiversity Words and Concepts: From the list below, select the right word for the following definitions:

Biodiversity	niche	evolution	species
Habitat	endemic	organism	extinction
Ecosystem	Old World	exotic	sustain

________________ The way of life of a species within its ecosystem
________________ A natural system made up of a community of living things and the physical environment where they live.
________________ A non-native.
________________ The process by which organisms become different from generation to generation.
________________ The physical place where an organism lives.
________________ A species which is native to a certain area and lives only there.
________________ A group/population of similar organisms that can interbreed to produce fertile offspring (unless they reproduce a sexually)
_________________ The variety of organisms and ecosystems.
_________________ To keep in existence, to maintain.
_________________ The disappearance of a species, either locally or total (global).

What are the three main causes for the loss of biodiversity?
1. __________________________2. _____________________3. ___________________
Give three benefits of biodiversity
1. __________________________2. ______________________3. __________________

APPENDIX G: PRE-POST TEST

PRE-POST-TEST

QUESTION 1

Choose the correct answer by writing only the letter next to the question number in the ANSWER BOOK. E.g. 1.1 A

1.1 Which two features do angiosperms have that other plants do not?

A. Flowers and fruit

B. Leaves and fruit

C. Flowers and seeds

D. Fruit and seed.

1.2 ________ is a capsular structure that produces spores.

A. Sporophyte

B. Filament

C. Ovary

D. Sporangium

1.3 Which one of the following is not involved in sexual reproduction?

A. Gametes

B. Mitosis

C. Zygote

D. Meiosis

1.4 Which of the following are products of meiosis?

A. Male and female gametes.

B. Different types of pollen.

C. Microspores and megaspores.

D. Diploid spores

1.5 Gymnosperms are hetero-sporous because they

A. Produce male gametes only

B. Have different types of pollen.

C. Produce microspores and megaspores.

D. Produce haploid and diploid spores. 5x2 **(10)**

1.6. Write down the correct biological term for each of the following descriptions. Write only the term next to the question number (1.6.1 to 1.6.5)

1.6.1 A unique feature in plants is that they undergo an ___________ during their life cycle. (1)

1.6.2 The asexual generation in moss plants is called the __________and it is diploid (2n). (1)

1.6.3 Spores are haploid structures produced during the process called________ (1)

1.6.4 Bryophytes are group of plants that differs from other groups because they don't have __________. (1)

1.6.5 Vascular tissue in plants is composed of xylem and ________.(1) (5x1) **(5)**

QUESTION 2

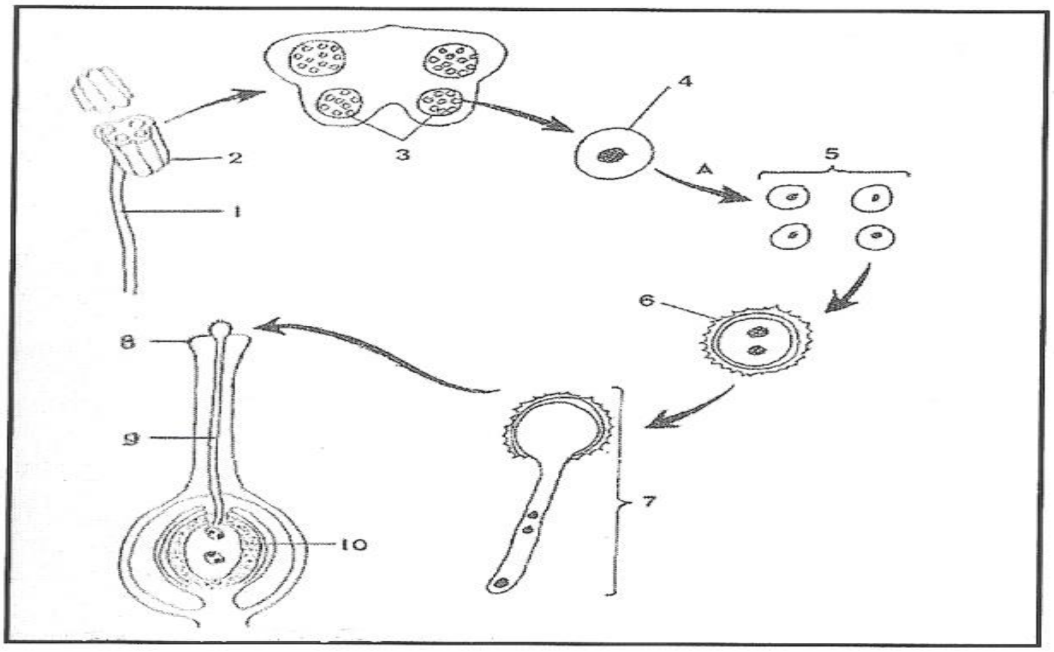
Match the items in column A with the ones in column B by choosing ONLY one correct response as in the example. 2.1 A (Sporophyte)

	Column A	Column B
2.1	The sexual generation as it produces gametes or sex cells (n).	A. Gametophyte B. sporophyte
2.2	a plant body that is not differentiated into stem and leaves and lacks true roots and vascular system.	A. Thallus B. Fern
2.3	Roots like structures that are found on mosses, ferns and some algae.	A. Rhizome B. Rhizoids
2.4	The surface or material from which an organism lives.	A. Substrate B. Soil
2.5	A group of similar or dissimilar cells having a common origin and cooperating with one another to a set of similar functions.	A. Tissue B. Organ

(5x2) **(10)**

QUESTION 3

Study the diagrams below and answer the questions that follow. For questions 3.1 to 3.4, use the figure below to answer the questions.



3.1 Write down the differences between fertilisation and pollination. (2)

3.2 Write down the names of the parts labelled 1, 2, 3, 8 and 10. (5)

3.3 Write down the **two ways** in which Angiosperms differ from Gymnosperms? (2)

3.4 Write down the function of phloem and xylem cells? (2)

3.5 Distinguish between self-pollination and cross pollination (2)

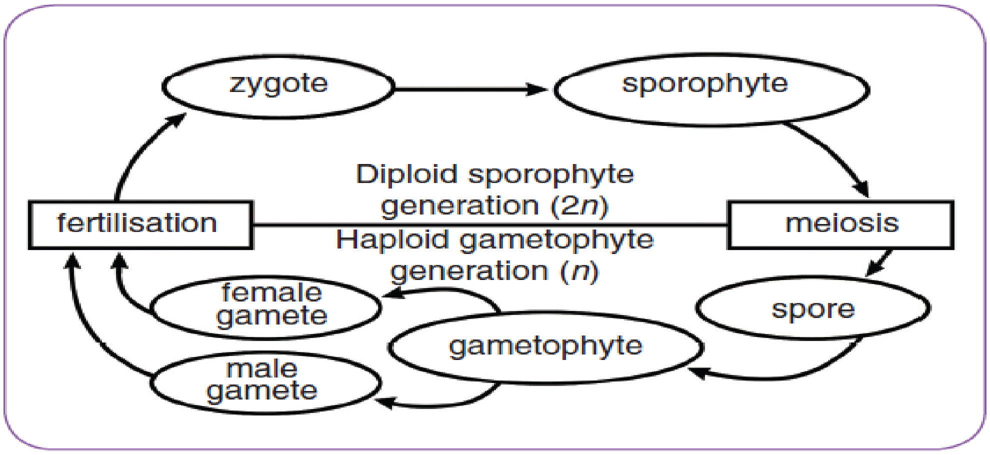
3.7 Sexual reproduction in angiosperms follows four steps. Write them down (4)

3.8 List and write down at least two examples of pollinating agents (2)

[19]

QUESTION 4

The diagram below shows the generalised alternation of generations in plants. For questions 4 a-d, use the figure below to answer the questions.



4.1 If the sporophyte generation of a plant has 36 chromosomes, how many chromosomes would there be in

a) The gametophyte

b) Spores

c) Zygote

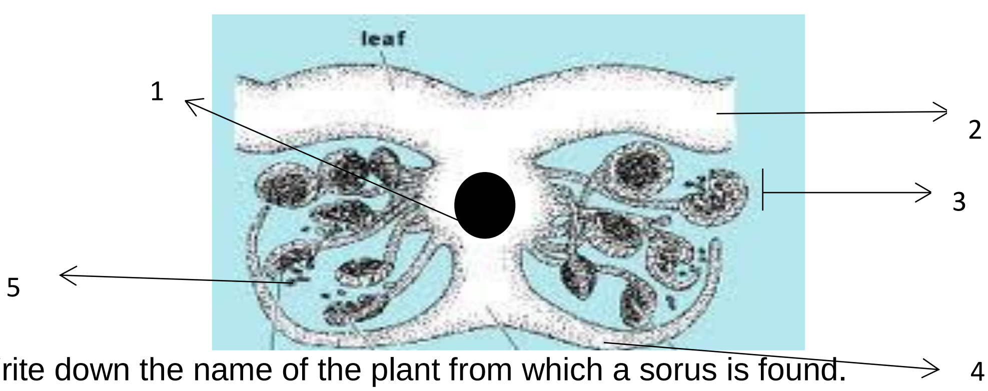
d) Gametes

(4)

4.2 The zygote and spores which one contains diploid cells? Give a reason to your answer (2) **[6]**

QUESTION 5

The diagram below represents a sorus from pteridophyte plants. Study the diagram and answer the questions from (a) to (f).



5.1) Write down the name of the plant from which a sorus is found. (2)

5.2) Identify and write down the parts numbered 1 to 5. (5)

5.3) Write down the function of parts numbered (i) 3 and (ii) 5? (4)

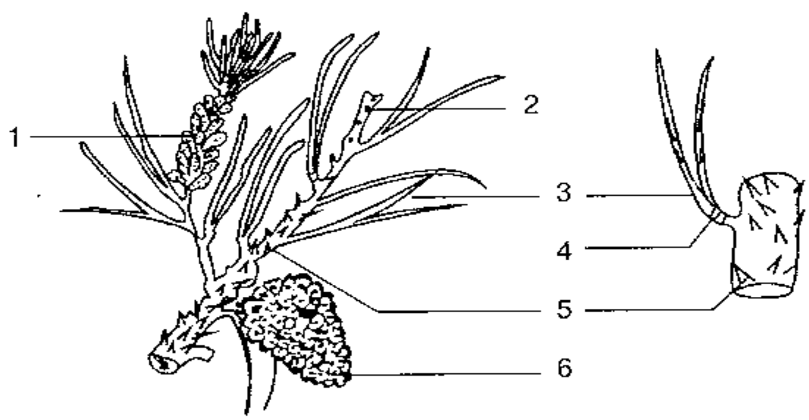
5.4) Is this the sporophyte or gametophyte generation? Write down your choice and reasons for your choice (4)

5.5) Write down the meaning of the term 'haploid'. (2)

5.6) Write down the number of a haploid structure. (2) **[19]**

QUESTION 6

The diagram shows a branch of a *Pinus* sp Plant



a) Identify and write down the names of the parts numbered 4 and 5. (2)

b) Write down the number of the part in which:

i. Microspores are produced; (1)

ii. Seed is produced; (1)

iii. Photosynthesis takes place; and (1)

iv. Unlimited growth can take place. (1)

c) Write down the average life-span of the part numbered 4? (1)

d) Write down and explain why female cones are so well reinforced and often armed with ferocious looking spikes. (2)

e) Write down the two adaptations that help conifer needles survive the winter season? (2) **[11]**

TOTAL [80 marks]