THE USE OF OPEN DISTANCE e-LEARNING (ODeL) TO SUPPORT LIFE SCIENCES TEACHERS IN THE USE OF VISUAL MODELS TO TEACH GENETICS

by

SIFISO MOYO

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ABSTRACT

Covid-19 has brought in a lot of innovative changes in people's lives, especially in the teaching and learning of Life Sciences. Visual models have helped to improve effective teaching and learning of Life Sciences, particularly during the Covid-19 pandemic era. The world is trying its best to adjust and use modern means of teaching and learning, and South Africa is no exception.

South Africa, as a developing country is currently adopting teaching methods that integrate information technology such as the use of visual models in teaching genetics in Life Sciences. The primary purpose of the present research was to investigate the use of Open Distance e-Learning (ODeL) to support Life Sciences teachers in the use of visual models to teach genetics. This research adopted qualitative approach in five high schools in the Oliver Reginald Tambo Coastal District of the Eastern Cape in South Africa involving Grade 12 Life Sciences teachers. Employing purposively sampling technique, the study revealed that, content understanding and methods improve under the ODeL but with some limitations. Hence, the study recommend that e-learning infrastructure and visual models are needed for a successful utilisation of the ODeL especially teaching new topics like genetics.

KEYWORDS: *Electronic learning, Life Sciences, Open Distance e-Learning, Visual models, Genetics,*

DECLARATION

Title: The use of Open Distance e-Learning (ODeL) to support Life Sciences teachers in the use of visual models to teach genetics.

I, Sifiso Moyo, hereby solemnly declare that the dissertation mentioned above is my unaided sole efforts through the professional guidance of Supervisor, Prof L.E. Mnguni, except as stated in references. It is submitted in the fulfilment of the requirements for the degree of MASTER OF EDUCATION in the University of South Africa, Pretoria. It has not been submitted before for any degree or examination in this or any other university.

Sifiso Moyo :

Signed at Mthatha, South Africa on 10 May 2023

DEDICATION

This dissertation is dedicated to my God, my husband, my children and family for always giving me time to do this research through their unwavering support.

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God gave me strength when I felt like giving up, were it not for Him, I could not have reached this milestone.

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TABLE OF CONTENT

LIST OF FIGURES

CHAPTER 1

INTRODUCTION AND BACKGROUND OF CURRENT RESEARCH

1.1 Introduction

Open Distance e-Learning (ODeL), to support Life Sciences teachers in the use of visual models to teach genetics in Life Sciences, is an important phenomenon in the academic field. The pressure brought by technological advancement and innovation makes teaching Life Sciences challenging for teachers and learners (Mafenya, 2013) to address dynamic COVID-19 challenges in the classrooms and online teaching done, currently. Osharive (2015) postulates that optimum attention is paid by learners when taught through visual models as they enjoy and learn faster. It would be of good if Life Sciences teachers can positively embrace open distance e-learning by using visual models in teaching genetics. Life Sciences is a field of study that studies living things and how they function, such as biology, medicine and occasionally anthropology or sociology (Lundy & Stephens, 2015).

Open Distance e-Learning's (ODeL) acceptance as a means of teaching and learning virtually, globally, has seen numerous learners' access education. While the prevalence of Open Distance e-Learning's (ODeL) is rising as economic reasons support it and new technologies make it possible, the eruption of the unique coronavirus disease (COVID-19) pandemic has compelled many countries to embrace and accelerate open distance e-learning (Toquero, 2020). Moreover, open distance e-learning is paralleled with hybrid education in some cases. The fundamental aim for open distance education is to allow everyone access education from anywhere and anytime convenient for a person to study (Arinto, 2013). Furthermore, teaching and learning methods focus mainly on inclusive education, a relaxed learning atmosphere and learner-centeredness. Suffice to say, Open Distance e-Learning has provided learners an opportunity to learn at their own time and has allowed teachers to impart knowledge to learners whom they may never meet in real life, as well as use of flexible teaching approaches.

Fundamentally, the internet is one of the most important resources available when teaching and learning through open distance e-learning, for both teachers and learners, as well as any other people who may be involved in academic matters in whatever capacity (Laurillard, 2011).

Furthermore, digital acquisition of knowledge and imparting knowledge needs both intrinsic and extrinsic motivation of learners and teachers. Importantly too is that the internet eases communication and improves relationships that sustain training, administration, teaching as well as learning. Learners have the option to use any medium of communication such as print, video or television, tutors, audio meetings or technology-assisted support mechanisms at a convenient place and time. Despite its advantages, open distance e-learning has its downfalls when adopted in education. Marimo, Mashingaidze and Nyoni (2013) state that, among other issues, lack of face-to-face communication between educators and pupils has some psychological and emotional effect on some learners who may be slow learners and need face-to-face instruction. In addition, Makoe (2012) intimates that when some teaching and learning instruments are made free online, for purposes of education, it becomes relatively easy for educators to monitor the progress of learners. Faced with the induced closure of schools due to the deadly coronavirus disease, open distance e-learning has become the desired choice of teaching and learning in the contemporary world.

1.2 Research Problem

The use of open distance e-learning to support Life Sciences educators in visual models to teach genetics in South Africa faces challenges as some teachers lack the knowledge and skills for a technology-driven global village. There is motivation by education authorities for academic institutions to embrace new teaching and learning methods (Laurillard, 2011). According to Brindley (2014), for open distance e-learning to be successfully conducted, the use of new information communication tools, structures, and resource support, among others, is required. This enables educators and learners who are geographically distant to engage educationally. Such systems are not readily available, especially for poor or marginalized societies. Use of open distance e-learning to support Life Sciences educators in using visual models to teach genetics needs teachers to have a better comprehension of visual models and consider models' selection and design concerning teaching genetics. Some Life Sciences Educators' Content Knowledge and Pedagogical Content Knowledge on genetics literacy is poor, and this contributes to poor delivery of knowledge to learners (Lundy & Stephens, 2015). Pedagogical Content Knowledge is defined as data overlay on taught topic information, including preparation and valuations (Mwenda, et al., 2013). Moreover, educators' dearth of virtual literacy compounds imparting of knowledge processes. Virtual literacy is a collection

of abilities that enable one to select, interpret, analyse and present pictorial or graphic information (Lundy & Stephens, 2015).

According to Mnguni (2007), acquiring knowledge from visual models is a cognitive function that includes thinking, memory cues and imagining, which is how graphic mental images are created. Mnguni (2014) further indicates that visual literacy should be developed on the theoretical congestive process of visualization to give people the much-needed understanding, teaching and learning in science education. The creation of information employing visual models, therefore, poses learning difficulties for genetics learners. The use of open distance e-learning to support Life Sciences teachers in visual models to teach genetics is relatively novel. However, the unique focus of open distance e-learning for Life Sciences teachers demands empirical evidence that explores perceptions of society on such teachers and understanding of genes using visual models (Irez et al., 2018). Additionally, educators face challenges in choosing suitable visual models for a subject (Burns, 2013). Simultaneously, Lundy and Stephens (2015) observe that learners lack visualisation skills. Mnguni (2014) defines visualisation skills as an individual's ability to encode and decode information presented by external representations.

Childs and Wilson (2017) argue that learners comprehend the Nature of Science from a modelling viewpoint and how empirical modes are improved and constructed. To this end, research pertaining use of open distance e-learning to support Life Sciences teachers using visual models to teach genetics is topical. Such research may make the nexus between Nature of Science, Content Knowledge and Pedagogical Content Knowledge clearer. Teachers need support mechanisms that include having tutors on demand, study leave, access to audio conferences or computer-assisted learning. However, use of open distance e-learning to support Life Sciences teachers in using visual models to teach genetics has not been investigated much in the Oliver Reginald Tambo Coastal District. Premised on the reasons explained above, the researcher sought to explore the use of open distance e-learning to support Life Sciences teachers in using visual models to teach genetics.

1.3 Inquiry aims and objectives

To investigate the use of Open Distance e-Learning to support Life Sciences teacher in the use of visual models to teach genetics. The study's objectives were:

(i) To explore how Open Distance e-Learning could be used to support in-service Life Sciences teachers in the use of visual models to teach genetics in a Grade 12 class.

1.4 Research Questions

The research questions were grounded on the **Main research question,** which is:
What are Life Sciences teachers' perceptions of the use of ODeL to support them to use visual models in teaching genetics?

The main research question was divided into sub-research questions focusing on the following key elements:

(i) How could Open Distance e-Learning be used to support in-service Life Sciences teachers in the use of visual models to teach genetics in a Grade 12 class?

(ii) How effective is ODeL in supporting Life Sciences teachers in the use of visual models to teach genetics?

1.5 Rationale

The rationale for this study, in terms of educational policy, is that its findings could be used to inform educational policy by the South African government in ensuring that Life Sciences teachers get adequate training to teach genetics using visual models (SACE, 2010). Acquiring pre-requisite knowledge increases teacher competencies, including how a teacher imparts knowledge to learners. Furthermore, policy decisions can be made concerning provision of information and telecommunication technology, meaning everyone can buy and use this for gaining knowledge (Mashile & Matoane, 2012). Associated plans for embracing the employment of open distance e-learning at various levels include the promotion of electronic learning initiatives, the promotion of blended digital syllabi for the development of information as well as communication technology usage. (Brindley, 2014).

This research explored life sciences and the teaching of genetics through the use of visual models. The findings of this study could culminate in educators changing their teaching methods by embracing the teaching of genetics using visual models through the use of open distance e-learning. Blumberg (2016) states that learners with prior knowledge of models'

memory cues can recall approximately 57% better than those who seem not to understand models in a learning environment without having debated them before learning. Swann (2012) observed that understanding genetics concepts was complex for some students, as students had challenges comprehending the invisibility and inaccessibility of genetic theories, since genetics included a complicated structure. It may also assist in underpinning professional learning of knowledge, skills and understanding. Having better knowledge will help a teacher to find solutions to particular problems arising in a teaching and learning environment. The generation of new knowledge could help amplify intent, procedures and significance upon the introduction of new concepts or curricula as well as to add literature in the academic field. Schneeweib (2019) explains that previous studies revealed that genetics was complex due to its varying content involving multiple biological organization stages of cells, tissue, proteins as well as other organs. Cousin (2009) also posits that main genetic concepts such as meiosis, mitosis, gametes and allele gene are a challenge for learners to visualize and conceptualize.

Open distance e-learning also enhances the opportunity for teachers to learn more about genetics from universities they are affiliated with and acquire more knowledge to deliver to students in teaching genetics using visual models. To better understand the topic under study, the research had a comprehensive overview of several studies and existing theoretical and empirical research on the importance of using open distance e-learning education to support Life Sciences teachers in the use of visual models to teach genetics.

1.6 Planning of the Study and Chapter Outline

Chapter 1: This chapter introduces using open distance learning to support Life Sciences teachers in using visual models to teach genetics. The chapter also outlines the background of the problem leading to the problem statement. The aim, objectives, research questions of this study, the research hypothesis, justification, and the research organization are all outlined in this chapter.

Chapter 2: This chapter reviews relevant literature for this study globally, continentally and in South Africa. Previous studies, texts, journals, magazines, gazettes, relevant statutory instruments and many other forms of genetic teaching-related literature are reviewed to uncover issues pertinent to the research aim and objectives.

Chapter 3: Tools and data gathering methods employed in undertaking this research are outlined in this chapter. An overview is made of ways, tools, methods and procedures implemented when gathering, analyzing and presenting data pertinent to the use of open distance learning to support Life Sciences teachers in the use of visual models to teach genetics. Research philosophy, research design, type of research, triangulation methods used, study population, sampling techniques, sampling frame, sampling size, data analysis and presentation are amplified.

Chapter 4: The presentation and analysis of data collected on using open distance learning to support Life Sciences teachers in visual models to teach genetics is done. Systematic interpretation of the data collected into easily understandable forms that can be used by future users without difficulty is addressed in this chapter.

Chapter 5: This chapter discusses findings, limitations, and inquiry recommendations.

1.7 Summary of this Chapter

Chapter 1 gave detailed background information to the inquiry and explained the research problem of this current study with the research objectives. The chapter also stipulated the questions for the inquiry and rationale of the research. The importance of the inquiry is that it discussed the beneficiaries, the location of the inquiry and its limitations. The issues dealt with in this chapter were an important pre-requisite for the next chapter.

The next, Chapter 2 will explore relevant literature for the inquiry.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The earlier chapter explored the background of the research and stated why the study was conducted. In the current chapter, the researcher reviews affiliated literature on the use of open distance e-learning to support Life Sciences teachers in the use of visual models to teach genetics. An analysis of genetics literacy research cogitating knowledge level, attitude towards different controversies in genetics and studies focusing on decision-making processes occurs in this chapter.

2.1.1 Social Constructivism Theory

Researchers developed subjective meanings of experiences, and these meanings were directed towards objects or things in the world (Creswell & Poth, 2018). Nevertheless, meanings may be varied and multiple, giving rise to a research focus on interpretation, rather than specializing in a few categories or ideas. The Social Constructivist theory assumes that students construct knowledge as they explore content. Creswell et al. (2018) claim that the goal of constructivism is to subject participants to as much of the research process as possible, including problem-solving, reasoning, critical thinking, active and reflective use of knowledge and socially negotiated meanings in the context of subjective interpretations of the situation.

According to Taber (2011, p 41), the constructivist theory involves ideas about how learning occurs and facts that direct learning; this includes ideas about how curricula and instructional materials should be designed to respond best to educational needs. In addition, Taber (2011) emphasizes that the constructivist perspective can be seen as a long tradition of pedagogical thinking, but in its modern form, how people understand their experiences, and as a change in the meaning of what is around us. This term assumes that the student reaches knowledge by recognizing the meaning of what is found in the environment. Therefore, an object or event in the environment has a unique meaning for the learner to find and gain knowledge and may identify and complement the knowledge of the world (Taber, 2011). Based on Vygotsky's Zone of Proximity (ZPD), the learner's potential to develop a language depends on the support of

those around him. The most common natural situation for children of technical age is the use of visual models, primarily when teaching genetics in Life Sciences.

Figure 2.1 Shows the ZPD adapted from Taber (2011, p 41). It clearly shows that students may come to the class room knowing information from their past life, then enter into what they can know and wish to learn what they need to know for the future.

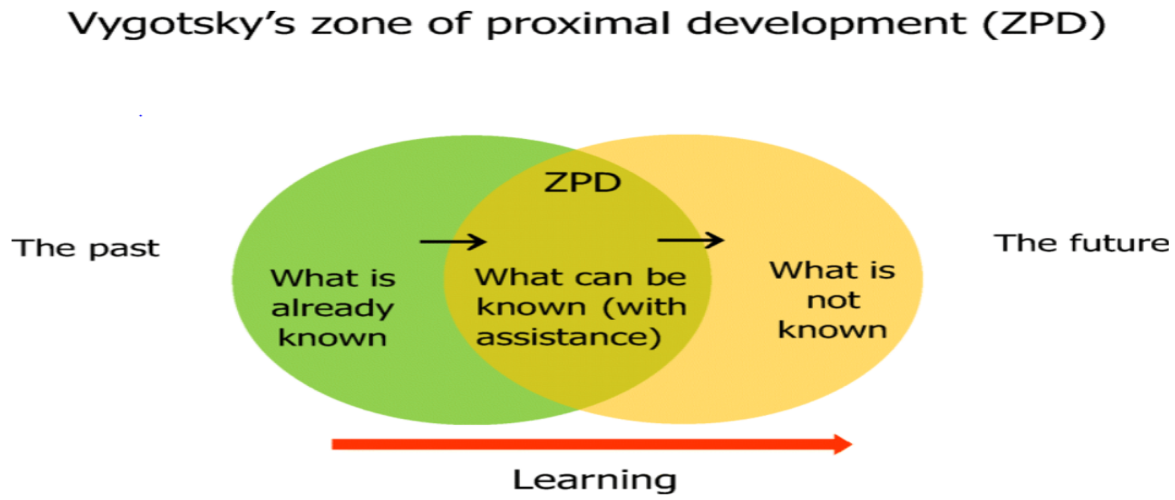

Figure: 2.1 ZPD adapted from Taber (2011, p 41) showing learning from the past to the future.

Vygotsky (1978), Keiler (2012), Yasnitsky van der Veer and Ferrari (2014) and Yasnitsky (2018) show that each function occurs twice in child development. Vygotsky argues that cognitive development cannot be understood without considering the social aspects of learning. He argues that cognitive development occurs as a result of social interactions in which children work together to solve problems. Through these interactions, children improve their cognitive abilities and acquire the ability to function intellectually on their own. In addition, cognitive development occurs when parents, teachers, or experienced peers support their children in learning (Vygotsky, 1997; Beilin, 1996; Daniels, 1996).

On the other hand, Marie (2014, p. 59) shows that the human mind is the source or origin of intentional meaning. By exploring the richness, depth and complexity of phenomena, we can gain a better understanding of what people have to do with phenomena and their social context. By clarifying how meaning is constructed, you can gain insights into the meaning conveyed, thereby gaining a better understanding of the whole. The underlying assumption is that when

they put people in their social context, they are more likely to understand the perception they have about their activities (Hussey & Hussey, 1997). The uniqueness of a given situation (context) is important for understanding and interpreting the constructed meaning (Maree, 2014, p.59).

On the other hand, social constructivism, according to the theory of Lev Vygotsky (1978), focuses on the social and historical context responsible for the building and creation of knowledge. Vygotsky (1978) emphasizes that individuals cannot leave the socio-political context in which they live, language and culture are inseparable, and inevitably build an interpretation of reality. This concept is particularly relevant in language learning as the native language and culture are used as frameworks for people to experience, communicate and understand reality (Simina & Hamel, 2005), the target language and culture. With a similar question, Felix (2005), Keiler (2012), Yasnitsky van der Veer and Ferrari (2014) and Yasnitsky (2018) have explored the cognitive and social aspects of constructivism in parallel. Knowledge is built individually but is socially transmitted (Felix 2005, p.86). At the same time, Lebow (1993, p. 45) suggests that constructivism provides a learning context that supports the need for autonomy and attribution.

Attwell (2010) examined Vygotsky's ideas related to technology-enhanced learning, especially in face-to-face learning environments. The role of the personal learning environment is a tool for providing access to more knowledgeable others, but it is one of the systems that enable students to link learning to performance through a work process using visual models. Besides captivating a wider view of artifacts, such as including information or knowledge accessed through a personal learning environment, reflection on action or performance may generate new artifacts for others to use within a zone of proximal development. Teaching Life Sciences using visual models may play a vital role in learners' academic life and help them to better understand the concept being taught. Therefore, Life Sciences teachers may need support to teach genetics in the age of electronic dynamics of COVID-19.

2.1.2 Open Distance e-Learning and Cognitive Learning Theory

Internal and external influences stimulate an individual's mental processes to augment learning, according to Cognitive Learning Theory (Clark & Mayer, 2016). When cognitive functions such as attention, observation, retrieval from long-term memory and classification fail, delays

and difficulties in learning occur (Ertmer & Newby, 1993). Theorists of cognitive learning place a premium on the acquisition of knowledge and skills, the creation of mental structures, and the processing of data and beliefs (Chunk, 2012). Learning, according to cognitivism, is an internal mental phenomenon inferred from what is said and done. Cognitivists believe that doing is the best way to learn (Aggarwal, 1994).

Furthermore, cognitivism recognizes the relevance of environmental factors in determining learning, yet teachers' explanations and demonstrations of concepts function as environmental inputs for students, according to Bower and Hilgard (1981). Learning is aided by skills, practice and accurate feedback. What students do with knowledge, namely how they pay attention to, practice with, transform, code, save, and retrieve it, is vital. Learning, according to cognitivists, occurs in the mind as a result of mental processes on the information acquired.

2.1.3 Open Distance e-Learning and Behavioural Learning Theory

Behavioural Theory is a learning theory based on the concept that all behaviour is learned through conditioning, hence it focuses on how pupils learn (Lou, 2013). Interaction with the environment is how conditioning takes place. Watson and Skinner felt that if they were given a group of infants, the way they were raised and their environment, rather than their parents or heredity, would determine how they acted (Banyard & Grayson, 2000). Furthermore, according to Nabavi (2014), behaviourists think that human acts are shaped by their responses to external stimuli and that innate or hereditary variables have very little influence on behaviour.

Behaviourism is important for teachers because it influences how students react and behave and shows that teachers can have a direct impact on their students' behaviour. Teachers can use behaviourism to understand how a student's home environment and lifestyle might affect their behaviour, allowing them to observe it objectively to help them (Lou, 2013). To put it differently, teachers feel that they will almost always have a difficult-to-manage relationship with a student in the classroom. It might be difficult to control a student's behaviour, and it can take extra effort to convince a misbehaving student to pay attention to detail. As a result, a teacher must be familiar with management tactics that will help them deal with tough students, especially for open-distance e-learning.

In any teaching and learning setting, the Behavioural Learning Theory is crucial for understanding how to encourage and assist pupils (Nabavi, 2014). From a response to the correct stimulus, information is transferred from teachers to students. Teachers provide information to students as a stimulus and response element in behavioural learning, making them passive participants. Teachers also employ behaviourism to educate students on how to behave and respond to various stimuli. This must be done regularly to remind students of the behaviour that a teacher is looking for, regardless of the teacher's location or distance from the student.

The Behavioural Learning Theory emphasizes positive reinforcement. According to Lou (2013), if students are not given positive reinforcement for their responses, they would quickly abandon them since they appear to be ineffective. If students are supposed to get a sticker every time they get a distinction on a test, they are rewarded; however, if teachers stop giving that positive reinforcement, fewer students will likely be motivated to get the highest possible marks on their tests because the behaviour is no longer associated with a reward. The Behavioural Learning Theory is intricately linked to repetition and positive reward.

According to Nabavi (2014), teachers frequently try to strike the correct balance between repeating a situation and providing positive reinforcement to demonstrate to students why they should keep doing what they are doing. The importance of motivation in behavioural learning cannot be overstated. Students can be motivated by both positive and negative reinforcement. A student who is praised for a good test score, for example, is more likely to learn successfully than a learner who is not praised for a good test score. Negative reinforcement occurs when a student receives little praise, and the brain informs the student that even though he or she achieved a good grade, it is unimportant. As a result, the test information becomes irrelevant to the student. Students who receive positive reinforcement, on the other hand, see a direct link between continued performance and their response to a positive stimulus.

Drills are another type of behaviourist teaching strategy that teachers can develop and employ. Teachers can utilize drill patterns to practice skills and show pupils how behavioural learning theory uses repetition and reinforcement. Furthermore, teachers can utilize a question as a stimulus and an answer as a reaction, progressively increasing the intensity of inquiries to assist students in moving up the academic ladder. They can also benefit from guided practice.

Teachers can be personally involved in helping students work through challenges by providing reinforcement and modelling appropriate behaviour. Teachers may also conduct regular evaluations. These are significant in Behavioural Learning Theory because a teacher goes over content with students and provides positive reinforcement, supporting them in remembering what they have learned much better.

While behaviourism is a viable alternative for many teachers, it is not without problems. According to Bada and Olusegun (2015), behaviourism is more beneficial for particular learning goals, such as foreign languages and mathematics, but not for analytical and complete learning. According to Creswell (2013), behaviorisms does not encompass enough human learning and behaviour, and is not fully developed; there are many additional factors to consider when evaluating behaviour, such as mental processes, moods, social dimensions, and human emotions, as well as accounting for individuality and free will. Furthermore, behaviourism fails to account for types of learning that occur without the use of reinforcement and punishment, such as language development in children.

2.1.4 Impact of Open Distance e-Learning and Constructivism Learning Theory

People actively construct or make their knowledge, according to Constructivism Learning Theory, and reality is determined by one's experiences as a student. Students, in general, use their prior knowledge as a foundation and build on it with new information. Knowledge, according to the Constructivism Learning Theory, is merely an explanation and an assumption, not the ultimate answer to all questions. Knowledge, on the other hand, gets discarded along with the human process, and new assumptions emerge. Furthermore, knowledge is incapable of accurately summarizing the world's rules. As a result, knowledge cannot be directly applied to specific obstacles because it is necessary to analyze certain concerns based on practical circumstances. Furthermore, constructivists agree that knowledge cannot exist in a physical form or as a distinct object. Although language and signals endow knowledge with specific forms, this does not imply that all students share the same understanding of these claims, as people perceive phenomena differently. As a result, it may be argued that these perceptions are shaped by the experiences and backgrounds of individual students.

Learning, according to the Constructivism Learning Theory, is the process through which people build their cognitive structures. According to Creswell (2013), "construction" is a type

of initiative, deliberate, and self-organized recognition method. The author adds that "construction" refers to the "interaction" between the subject and the object, and that the learning process is knowledge construction. The interaction of students' old and new information completes learning as an initiative construction and generation of meanings. Pure external stimulus, according to Woods (2011), is worthless until students can code, analyze, and develop their unique understandings based on prior experiences. Learners, according to the Constructivism Learning Theory, enter the learning environment with a wealth of prior experiences. Students have strong feelings about everyday life and even universal topics. Even though students are unfamiliar with some difficulties and have no prior experience with them, they may construct unique explanations and assumptions based on prior experiences and cognitive abilities as problems arise. As a result, teaching should take prior information and experience as a starting point for new knowledge generation and expose students to new knowledge.

Teachers' roles should be transformed from initiator and indoctrinator to aid and driver for students who construct meanings on their own, according to the Constructivism Learning Theory on teachers. This indicates that teachers should create a learning environment, supervise students' learning, and serve as academic advisors to students. The Constructivism Learning Theory rejects the traditional teaching approach of using teachers as conduits for knowledge transmission and viewing the student as a passive recipient of knowledge. Teachers organize and steer the entire teaching process with innovation based on the current conditions in the new teaching mode, which is learner-centered.

Constructivism Theory has implications for basic education teaching in that it proposes new explanations for learning and teaching. Students are the subject of teaching, according to the Constructivism Theory. Teachers should provide greater humanistic care to students and foster a positive learning atmosphere. In teaching, the Constructivism Theory emphasizes initiative and interaction. Students use interactive activities to focus on exploration and cooperative learning based on prior knowledge and experiences. Students can continuously increase their cognitive abilities in this manner. Teachers can assist students in developing favourable techniques, affection, attitudes, and learning habits. All ‘these novel ideas combine to form the Constructivism Learning Theory framework, which makes a significant contribution to modern

teaching theory and teachers' teaching perspectives, as well as teachers' daily teaching activities.

The Constructivism Learning Theory is not without flaws. Contextualizing learning can impede a student's progress, among other things. This means that a student may struggle to build abstractions and transfer knowledge and abilities in new settings at first, but with practice, they will be able to do so (Bada & Olusegun, 2015). Constructivism Learning Theory is critical today, particularly considering the fatal coronavirus and the widespread use of modern technology in teaching and learning. Teachers and students must also construct and deconstruct subjectivity and objectivity of knowledge, transfer and production of knowledge in learning, teachers' supervision and students as the center, including proper application of relevant theory to basic education instruction.

Albert Bandura (1961) established the Social Learning Theory, which emphasizes the importance of observing, modelling, and mimicking others' behaviours, attitudes, and emotional reactions. Behaviours are learnt through interactions with the various socializing agents to whom one is exposed, according to the concepts of Social Learning Theory. Behaviours are either modified or eliminated as a result of these interactions (Brown, et al., 2005). Social learning theory, according to McHale, Dotterer and Ji-Yeon (2009), explores how environmental and cognitive factors interact to influence human learning and behaviour. Bandura's theories are based on core Behaviourism ideas, such as how reward and punishment influence behaviour. Bandura (1961) was not entirely satisfied with Behaviourism, claiming that it is not the only way for individuals to learn. The way people learn from others in social circumstances is a crucial insight of the Social Learning Theory. Learning does not have to come from direct experience; according to Bandura, it can also come from vicarious experience (Bandura & Walters, 1963; Bandura, 1986). Learning via seeing others and pondering what this might entail for oneself is known as vicarious learning (Brown, et al., 2005).

Bandura emphasizes the cognitive and social aspects of learning over the direct, experiential aspect. Individuals can visualize the repercussions of certain behaviours by thinking about what is going on. This means that people do not need to directly experience something to understand the repercussions of that experience because they may use their imagination and reasoning skills to figure out causes and effects. This understanding of learning as a cognitive process is

crucial, as it has far-reaching consequences for how people think about child development and all types of learning from infancy to adulthood. The Social Learning Theory does not dismiss ideas based on direct experience of the world, but it does offer a new dimension of vicarious experience that broadens the scope of what a child can learn. Learning through open distance e-learning can be justified in this context.

One of the most significant flaws of the Social Learning Theory is that its concepts were established based on children's behaviour in laboratory settings, which exacerbated the issue of demand characteristics. In some cases, the theory's premise that behaviour is always replicated may not hold, as humans may pretend in specific situations. Furthermore, human beings tend to adjust their behaviour when they are aware of being observed. To summarize, different learning theories represent different perspectives on the nature of knowledge. While learning theories provide various ways for all people to learn, including school students as they do not automatically inform teachers how to teach. Educators have to figure out how to transition from a theoretical to a practical position to implement some of the above-mentioned theories in a classroom setting. As a result, teachers have to design teaching approaches based on such learning theories based on the current situation.

2.1.4.1 Open Distance e-Learning on Implication of the Cognitive Theories of Learning to the Development of Teaching

Cognitive theories of learning have implications for the development of teaching in that teachers should organize teaching materials in such a way that the concepts in them may be easily learned and processed in the minds of students. Teachers can lead students to explore issues from various perspectives by employing several instructional strategies. Albert Bandura's observational learning theory proposes that students learn by watching others (Epstein & Sheldon, 2006). As a result, teachers must serve as role models for their students.

According to Mwenda, Gitaari, Nyaga, Muthaa and Reche (2013), current learning builds on the preceding one. As a result, before introducing new concepts, teachers should assess their students' past understanding. Teachers must give students activities and practical possibilities. This is because students learn best when they are undertaking exercises, which aid in the retention of information. Courses and subjects should be broken down into manageable chunks for students to understand. The primary flaw in Cognitive Theory is that it relates to cognitive

processes that humans cannot directly witness and mainly relies on inference (Epstein & Sheldon, 2006). As a result, the Cognitive Theory may not be scientific because what is derived from observations is subjective. Assuming that results are the consequence of invisible processes is very subjective and could lead to concerns about self-fulfilling prophecy and internal validity. Other elements that have been found to affect behaviour are ignored by cognitive theory.

2.1.4.2 Social Constructivism and Social Network Media in Life Sciences Classroom

Teachers and students argue for the use of technology for learning in the modern dynamic technologies of the fourth industrial revolution, a trend towards a constructivist approach. Incorporating technology into the Life Sciences classroom has had a significant impact. Students actively develop their knowledge and meaning from their experiences, which is at the heart of constructivism. Peter (2015) explored cognitive constructivism, social constructivism, and radical constructivism as constructivist theories. The author proposed eight principles to define constructivist teaching, emphasizing the importance of the student's engagement in knowledge acquisition through experience, puzzlement, reflection, and building.

The dynamic interplay of mind and culture, knowledge and meaning, reality and experience underpin pedagogy (Peter, 2015, p. 31). “Learning should take place in authentic, real-world settings...; learning should involve social negotiation and mediation...; content and skills should be made relevant to the student...; content and skills should be understood in the context of the student's prior knowledge...; students should be encouraged to become self-regulatory, self-mediated, and self-aware...; and teachers should serve primarily as guides and facilitators of learning, not instructors..." (Peter 2015, p. 31).

Furthermore, Peter (2015) and Itodo (2011) argue that there appears to be an alarming rate of social networking obsession among students today; this is a trend that, if not properly controlled, could negatively impact their academic, social and spiritual lives. There has been a significant movement in pedagogical methods and teaching theory in recent years, with a greater emphasis on student-centered learning. A teacher's job is to establish an environment that encourages fresh ways of thinking, sharp arguments, and rational considerations. Apart from these issues, one of the most significant tasks for today's teacher is to generate and maintain maximum potential interest in the class or the material and make the learners

inquisitive. This is difficult, given that the internet now provides access to the entire spectrum of knowledge, whilst multidimensional technology tools like Web 2.0 enable sharing across various virtual platforms. As a result, a teacher's job is to communicate with students in their language, using their resources to make the classroom environment productive and engaging. Using a visual model to teach genetics in the Life Sciences can help support teachers in making students learn more effectively.

2.2 Contextualisation of Open Distance e-Learning for this Study

Kenya has seen an increase in higher education institutions in recent decades. This might be linked to increased demand for higher education, partly due to improved knowledge of the educational benefits (Khan, 2001). Education, learning and the acquisition of new skills and knowledge, have never been more important than they are now. At both the macro and local levels, it is becoming increasingly obvious that human beings' ability to adapt will become the primary metric of success (Brindley, 2014). As a result of the rising demand, open remote electronic learning has quickly become an acknowledged and important feature of mainstream educational platforms in both developed and developing countries (UNESCO, 2002).

2.2.1 Factors Contributing to Open Distance e-Learning

Factors such as fatal coronavirus pandemic infections and family commitments, particularly among women, have fueled interest in open-distance e-learning. In comparison to men, women, particularly in underdeveloped nations, have a variety of constraints in terms of time and resources. The emergence of open distance e-learning, on the other hand, has increased humankind's opportunities and made education and training more accessible to all, as people can now study whenever they want. In today's changing environment, open-distance e-learning learning allows people to study at their speed and acquire skills for personal development while still meeting family duties (Clark & Mayer, 2016).

People must recognize that they are living in a time of extraordinary societal change. Regularly, technological, cultural, and social revolutions have influenced humanity, dramatically altering how individuals live, work and learn (Brindley, 2014). Even the most stable global social institutions, such as education, have been overwhelmed by risks such as pandemics and accelerated change. Another element that has driven social change and to a greater extent, is

that some people have turned to open distance e-learning is conflict (Mariom, Mashingaidze & Nyoni, 2013).

While the likelihood of war in wealthy countries is low, certain emerging countries experience internal conflicts as well as regional interstate warfare resulting from religious, ethnic, economic, or political conflicts, which have resulted in the closure or destruction of academic institutions. According to Mendenhal (2014), the number of refugees, homeless, or displaced individuals may dramatically expand, needing more flexible educational provision. Furthermore, there is an increasing demand for ongoing skill upgrading and retraining, and technology advancements have made it possible to teach an increasing number of disciplines remotely. The adaptability of open distance e-learning approaches is a crucial factor in their rise towards prominence as the principal mode of lifelong learning for almost everyone.

According to Toquero (2020), open distance e-learning has been mandated in various countries' education systems around the world due to the coronavirus disease's extraordinary consequences. The World Health Organization (WHO) describes coronavirus as a fatal virus known as a severe acute respiratory syndrome that causes coronavirus disease, which is currently a pandemic. Coronavirus sickness is conveyed from person to person within roughly 2 meters by respiratory droplets emitted when a virus-infected person coughs, sneezes, or talks (Demuyakor, 2020). Avoiding large events and mass gatherings, social distancing, wearing cloth face masks in public areas, and washing one's hands frequently with soap and water for at least 20 seconds or using an alcohol-based hand sanitizer containing at least 60% alcohol are all recommended precautions for avoiding coronavirus disease (World Health Organisation, 2020). As a result, academic institutions provide fertile ground for the development of coronavirus disease, as a large number of students, teaching and non-teaching staff assemble in close proximity regularly for studying, teaching and formal jobs.

Since the discovery of the coronavirus epidemic, all continents have announced or implemented compulsory school or academic institution closures, according to the United Nations Educational Scientific and Cultural Organization (2020). As a result of the broad spread of the coronavirus epidemic over the world, different jurisdictions have had to endure an unprecedented large "migration" from traditional in-class face-to-face education to virtual delivery of lessons online, despite inevitable teething problems (Sintema, 2020). Connectivity

issues, school readiness, and certain students without dependable internet access who struggled to participate in digital learning were some of the teething concerns. This disparity was observed across countries and within countries' income groups. The teething troubles were to be expected, considering the dizzying speed with which different jurisdictions required schools to relocate much, if not all, of their teaching towards online to protect students' health in the middle of the global coronavirus pandemic (United Nations Educational Scientific & Cultural Organization, 2020). Many demographics are unsure if the future of education will be virtual or face-to-face, as it was previously (Demuyakor, 2020).

2.2.2 Factor Leading to the Use of Open Distance e-Learning in Schools in Life Sciences

Some schools publish materials on their website and make more items available, but do not necessarily use online classes to open distance e-learning, to prevent loss of learning while schools are closed (United Nations Educational Scientific & Cultural Organisation, 2020). Even teachers with no prior experience with open distance e-learning were requested to create online content and teach online classes (Sintema, 2020). To encourage countries and institutions to engage in open distance e-learning in the face of coronavirus disease, the United Nations Educational Scientific and Cultural Organisation created a list of educational applications, platforms, and resources aimed at helping parents, teachers, schools, and school administrators facilitate student learning and provide social care and interaction during periods of school closure (Sintema, 2020). The majority of the UN Educational, Scientific, and Cultural Organization's solutions are free and many of them cater to many languages. While these solutions do not have the express endorsement of the United Nations Educational Scientific and Cultural Organization due to the organization's policy of not endorsing any product, service, brand or corporation, they do have a broad reach, a large user base, and proof of impact.

Although the solutions are divided into groups based on open distance e-learning requirements, the majority of them provide functionality that spans many categories. Both successes and problems in delivering teaching and learning appear to be driven by infrastructure and familiarity with technologies. Examples of resources providing psychosocial support are ClassDojo, which connects teachers with students and parents to build classroom communities; Ustad Mobile, which allows access and sharing of educational content offline, and systems with strong offline functionality; Kolibri, which is a learning application to support universal

education available in multiple languages; Zoom, which is a cloud platform for video and audio conferencing, webinars, collaboration and chat (Toquero, 2020), among many others.

Forced, unplanned and quick migration to online learning as a result of the coronavirus epidemic, with little or no training, limited bandwidth, and little preparation, may result in poor user experience unconducive to sustained growth, according to Demuyakor (2020). However, Toquero (2020) claims that due to the coronavirus epidemic, a new hybrid model of education arose with major benefits. Furthermore, the integration of information technology in education has increased, and online education will eventually become an inherent component of any school education system, according to the authors. These platforms provide open remote electronic learning throughout the learning process, although they may have drawbacks (Olcott, 2013).

Unlike in the past, when the University of South Africa was likely the only reputable institution offering open distance e-learning, universities such as the University of Stellenbosch, University of the Free State, University of Johannesburg, University of Pretoria, and the University of Witwatersrand have since adopted the use of open distance e-learning learning in enrolling for various programs such as Bachelor of Education and Bachelor of Accountancy (Mashile, Matoane Dale & Pymy, 2009). Teachers acquire knowledge and impart knowledge in such a way that students' objectives are realized (Peters & Peters, 2008).

The teaching and learning research of Peters and Peters (2008) is consistent with Dewey's (Chandakummara, 2014) belief that ideas and the development of meaning are phenomenological. Furthermore, Taylor and Medina (2013) show that students acquire knowledge in a variety of ways and styles as they progress through their academic careers, including through the use of information and communication technologies in open-distance e-learning. As a result, educators, particularly open distance e-learning Life Sciences teachers, are expected to approach their interactions with students through a different lens, as modern students' use of information and communication technologies has empowered them to the point where they may be more knowledgeable on some subject matters and have the power to control the type of information they consume.

According to Walter and Gleaves (2008), students' academic upward mobility is marked by the development of their learning skills and the adoption of new learning styles, which propels them to greater academic heights through the Virtual Learning Environment, which supports a variety of learning styles. Virtual Instructional Environments (VLEs) are internet-based platforms for delivering learning materials to students (Hansen, 2008). Valuations, student tracking, and communication tools are among the features of Virtual Learning Environment systems (Taylor & Medina, 2013). This backs up the findings of the current study, which imply that teaching and learning styles should be fluid and vary over time, as seen by the use of open distance e-learning in teaching genetics through models.

Furthermore, the current researcher was encouraged to investigate the perspectives of connectivism and navigationalism paradigms in this study by students' learning ways and styles. Visual models are things like drawings, diagrams, and flowcharts that help us teach one another, according to Walter and Gleaves (2008). This definition implies that pictorials provide exact and valuable renderings of information in solving problems in certain disciplines or phenomena during the teaching process. Since it is a graphical subject manifestation, models make understanding a specific field or phenomena of information easier.

2.3 Use of Open Distance e-Learning to Support In-Service Life Sciences Teachers in the Use of Visual Models to Teach Genetics in Grade 12 Class

Open distance e-learning is the process of acquiring knowledge in formal, informal, and non-formal settings using information and communication technology to reduce physical and psychological distance and promote involvement among students, learning sources and organizers (Olcott,2013). The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines open distance e-learning as a system of teaching and learning that has been widely adopted since the year 2020, when the world was struck by a pandemic of the coronavirus disease, forcing governments to close schools and all students to quarantine and continue learning at home. Despite the pandemic, schools were opened in stages.

The usage of electronic learning tools such as zoom meetings, electronic mails, and skype helps to bridge the physical barrier between universities and different stakeholders especially Life Sciences (Toquero, 2020). Other countries, on the other hand, are now combining remote learning with more traditional approaches such as face-to-face instruction. Blended learning is the combination of open-distance e-learning with face-to-face learning. Blended learning, also

known as hybrid learning, is a style of education that combines technology and digital media with traditional teacher-led classroom activities to give students more flexibility in customizing their learning experiences, according to Mason (2000). Information and communication technologies (ICTs) have acted as catalysts for educational transformation.

In order to prevent the spread of misunderstandings, terminology must be used correctly when teaching genetics. Genetics is challenging for students to study because of its obscurity and the intricacy of Genetic phenomena (Brindley, 2014). A meaningful understanding of genetics requires a conceptual framework that is both pertinent and understandable and that has been developed through pedagogical activities. According to Blumberg (2016) the constructivist viewpoint maintains that learning always builds upon and cooperates with existing cognitive abstract resources. Novice life sciences teachers learn how to teach a variety of scientific subjects, but often run into problems with instruction like careful selection and application of effective pedagogical tools. Lack of fundamental resources needed to improve the teaching and learning of topics like genetics further exacerbates the emphasized instructional problem. Given these useful considerations, the focus of this study was on the use of open distance e-learning (ODeL) to support Life Sciences teachers in the use of visual models to teach genetics in South African schools.

2.4. Teaching and Learning and Use of Open Distance e-Learning in a Life Sciences Classroom During COVID-19

COVID-19 has influenced a new era of electronic learning and education. Teachers in the Life Sciences must be well-supported and motivated to use visual models to teach genetics so that students like and understand the material. In a classroom, teaching and learning are a collaborative effort including both teachers and students. Due to the nature of the subject domain, the teaching and learning process in scientific classes is more rigorous (Kober, 2015). More specifically, Kober (2015) asserts that constant instructional reflection is critical for student success in science. Teachers, according to Obiekwe and Chinwe (2012), require their students to learn. As a result of this desire, teachers are presented with a dilemma: they want to reach all their students with the same teaching strategy. Nasri, Yusof, Ramasamy and Halim (2010) suggest that in the scientific classroom, teachers use drilling tactics to improve learning. Ebert-May, Derting, Henkel, et al. (2015) agree with Nasri et al. (2010) that life sciences education should aim to provide students with first-hand experience of scientific inquiry

processes and assist in the building of conceptual knowledge through learner-centered activities. Nasri et al. (2010) believes that if teachers in the Life Sciences are positively supported in teaching genetics, learners may learn better electronically through the use of visual representations. In learner-centered techniques, the building of knowledge is more essential than the acquisition of factual knowledge.

COVID-19 has witnessed teaching and learning of any topic being altered in today's dynamic technological world, and teachers in the Life Sciences need to be supported at all times to stay on top of electronic learning. In a learning scenario, cognitive theories may allow teachers and students to be constructors of their knowledge. Students benefit from cognitive learning because it keeps them current and helps them attain targeted positive learning outcomes. According to Driver, Asoko, Leach, and Scot (1994), cognitive learning leads to the organized storage of knowledge in the students' schema, referred to as *cognitive structure*. In the Life Sciences classroom, the intended form of instruction may allow students to construct knowledge more successfully. As a result, the primary responsibility of teachers in the Life Sciences classroom may be to foster knowledge construction.

According to Vygotsky (1978), learning construction takes place in a social setting, and using visual models may assist teachers and students be active participants in the classroom (Toven-Lindsey, Rhoads & Lozano, 2015). Teachers in the life sciences need electronic help to teach genetics so that students in their care can create and organize their learning as teachers develop the social environment of the students. Open distance e-learning has been bolstered in academic circles in response to various governments' demands for "nonstop teaching and learning" to achieve Sustainable Development Goal #4, which emphasizes the importance of quality education in imparting the necessary skills for all sectors of the economy and increasing labour productivity (Toquero, 2020). An extended interruption in education that disengages students from the learning process may have the unintended consequence of undoing learning gains (Demuyakor, 2020). Furthermore, governments have been forced to engage in open distance e-learning to comply with Articles 28 and 29 of the Conventions on the Rights of the Child, which clearly state that every child has the right to education; education must develop each child's personality, talents, and abilities to their full potential (Sintema, 2020).

2.4.1 Advantages and Disadvantages of Open Distance e-Learning in Life Sciences

Many South African residents, in particular, and the global community in general, have identified open distance e-learning as a system that can boost academic uptake and training skills (National Plan for Higher Education Report, 2001). In the 1800s, distance education was created to overcome challenges that commonly accompanied classroom-based teaching and learning (Deepwell & Malik, 2008). Open distance e-learning has been boosted by modern information technology, virtually eliminating barriers, and increasing mobility to higher education. Most institutions that chose open distance teaching as a delivery modality did so to meet the social mission of promoting and expanding access to education.

The desire to provide higher education as a public utility drove the establishment of distance education institutions (De Villiers, 2005). According to Olcott (2013), open distance e-learning is one of the most important equalizers of virtual and inclusive education access. In recent years, historically disadvantaged students' access to education has risen dramatically, with distance education accounting for about a third of all higher education enrolments in South Africa (Ncube, Dube & Ngulube, 2014). In truth, open-distance e-learning has turned higher education into a mass-education system (Olakuhin & Singh, 2013).

While distance education has been praised for expanding access to higher education, it has also been chastised for producing low student output (Briendly, 2014). It is pointless to have access to higher education if you do not succeed. As a result, in the Republic of South Africa, open remote electronic learning institutions should provide possibilities for reasonable prospects of success while also giving access (Makoe, 2012). For this to happen, the Council for Higher Education's quality assurance mechanisms must provide increased access to study, which must be reinforced by improved country and organizational planning and program design support systems for underprepared school leavers (SACE, 2010).

2.4.2 Use of Open Distance e-Leaning in Teaching Genetics in Life Sciences

The use of Open Distance e-Leaning in Teaching Genetics in Life Sciences is essential. Despite the importance of genetics, according to Macqueen (2008), some Life Sciences teachers have difficulty understanding basic genetic structures, let alone delivering lessons on controversial

topics such as organic farming or parents ordering genetically perfect children, as well as genetic testing. Genetics is the study of heredity and how traits and qualities are passed down through generations (Swann, 2012). According to Macqueen (2008), Life Sciences educators may be effective genetics educators. On the other hand, according to Matthew (2011), some instructors are hesitant to include genetics literacy in their deliverables. Failure to completely appreciate genetics literacy, curricular limits and lack of time and money are all possible reasons for such behaviours (Cebesoy & Tekkaya, 2012).

According to Walker and Gleaves (2008), Life Sciences teachers do not appear to be equipped to convey genetics literacy successfully and efficiently to a variety of students. The ability of Life Sciences teachers to carry out practical genetics literacy during lessons is reliant on their ideas, viewpoints, values, and personal concerns. Teachers' beliefs and behaviors have a cascading effect on students' empirical thinking and belief in their ability to understand genetics via models (Sheperd, 2013). Obtaining information through visual models, according to Mnguni (2014), is a cognitive function that incorporates thinking, remembering cues and imagining how graphic mental representations are generated and beliefs followed. Learning difficulties for genetics students arise because of the creation of information using visual models.

Turner et al. (2016) also found that individuals or societal socialization agents such as friends, family and other institutions such as clubs influence individual students' or groups' attitudes regarding specific genomics literacy issues. The Department of Education's lack of support for open distance e-learning Life Sciences for in-service teachers, in which principals do not allow such teachers to have study time or other resources such as electronic equipment, hampered the development of teaching and learning genetics using visual models (Makoe, 2012).

2.5 Global, African and South African Perspectives on the Use of Open Distance e-Learning in Life Sciences

The Global Perspective on open distance e-learning in the Life Sciences is discussed in the section below.

2.5.1 Global Perspective on Open Distance e-Learning in Life Sciences

Although the use of open distance e-learning to support Life Sciences teachers in the use of visual models to teach genetics in South Africa and other countries is new, open distance e-learning Life Sciences teachers' unique focus necessitates empirical evidence that explores societal perceptions of such teachers and understanding of genes using visual models (Mahile & Matoane, 2012). Some empirical evidence includes the finding that the majority of the subject matter focuses on theory rather than investigations, as well as analyses that are more valuable than institution-based evaluations (Makoe, 2012). The implication is that teachers spend most of their time with pupils conveying empirical information rather than conducting empirical experiments, quantity measuring, or making forecasts (Marimo, Mashingaidze & Nyoni, 2013). When teachers fail to instill empirical skills, the curriculum will fall short of its intended goals and objectives (Makoe, 2012). As a result, students are unable to use inductive reasoning to reach logical conclusions about issues in the social world around them.

Although significant research has been done on using visual models to teach and comprehend genetics, using open distance e-learning to support Life Sciences Teachers in using visual models to teach genetics remains a major problem (Woods, 2011). The open distance e-learning wave has influenced all countries, regardless of their economy, population size, age group, or inequities, according to ODeL global trends. The United Nations Scientific and Cultural Organization urged countries to improve open distance e-learning by conducting cross-cutting exercises promoting accessibility to high-quality distance education tools that reflect regional, social, and economic needs at its General Conference in 2001. (Chandrakumara, 2014).

2.5.2 African Perspective on Open Distance e-Learning

Many African students received various qualifications through open distance e-learning providers in Europe and North America before the introduction of distance learning providers in Africa (Marimo, Mashingaidze & Nyoni, 2013). The University of South Africa, which has been offering correspondence courses since 1946, is one of the first distance education universities to develop on the African continent (University of South Africa website, 2021). The success of the University of South Africa has prompted the formation of more open distance e-learning institutions across Africa.

Open universities in Nigeria, Tanzania, and Zimbabwe, as well as Kenya's Delivery of Open, Distance and e-Learning, began as providers of residential programs but have since expanded to include open distance e-learning (Juma, 2003). A growing number of higher education institutions in Africa are utilizing open-distance e-learning methodologies (Mashile & Matoane, 2012). While the majority of current distance education initiatives on the continent have been used to improve the quality of basic education (Association for the Development of Education in Africa 1999), some countries are taking bold steps to implement internet-based and satellite-linked distance educational programs in specific courses. The African Virtual University, for example, used to offer programs in both Francophone and Anglophone Africa but has since shifted its focus from providing distance learning directly to students, providing training to staff in institutions that offer open distance e-learning programmers.

2.5.2.1 Challenges of Open Distance e-Learning in Africa

In Africa, the challenges of open distance e-learning are being addressed, albeit slowly. Various countries are making efforts to guarantee that open distance e-learning implementation strategies are in place to solve the challenge of expanding access to education and increasing participation to achieve inclusive education. Electronic learning, both open distance e-learning, is rapidly being viewed as a cost-effective educational delivery paradigm that does not sacrifice quality. Furthermore, in Africa, where resources are sparse and education provision is inadequate, open-distance e-learning is seen as a realistic and cost-effective way to extend provision without investing in costly infrastructure (Pityana, 2009).

While open distance e-learning has the potential to provide inclusive and uninterrupted education, several challenges must be overcome before it can be completely implemented in Africa. Open distance e-learning is hampered by several technological limitations. Outside of big cities, infrastructure is still lacking. Such a lack of connectivity outside of large capital cities could pose a challenge in developing a national distance education plan. Another issue with open distance e-learning is the absence of qualified teachers or specialists to help with implementation. According to research conducted in Zimbabwe by the Zimbabwe Open University in 2010, the majority of lecturers enabling open remote learning (about 97.5 percent) lack online teaching expertise, while being familiar with the traditional teaching and learning techniques (Mpofu, et al., 2012).

Teaching staff must be properly trained in using remote education as a delivery mode to make effective use of open-distance e-learning technologies (Briendley, 2014). According to Marimo, Mashingaidze and Nyoni (2013), there are just a few African countries that have qualified teachers who can confidently transmit knowledge to online learners. This offers a significant obstacle to the continent's long-term open-distance e-learning. According to a study conducted by the National Education Association in the United States, teaching staff members' top concern regarding open distance e-learning was that they would have to do more work for the same salary, which is a reasonable issue. According to the National Education Association (2000), most teaching staff members spend more time on distance learning courses than on regular courses, and 84% of teachers do not receive any workload reduction. Similarly, 63% of distance teaching staff members do not earn any additional pay for their distance courses (Education Association, 2000).

Another difficulty is lack of well-defined national open distance e-learning policies in most African countries. To create a foundation for the growth of open distance e-learning, policies are required. Except for South Africa, few African countries have clearly defined national policies to steer the development of remote education in open-distance e-learning delivery. Lack of such policies is a significant impediment to the growth of remote education. For example, when it comes to student support services, there are obstacles, as indicated by research conducted in Botswana, which found that the main challenge facing open remote learning teachers was limited student assistance (Sikwibele & Mungoo, 2009). This can be remedied, however, through mediation and the establishment of numerous relationships and connections between the university and the student. The main source of assistance for students is a solid relationship with individual teachers (Macintyre & Macdonald, 2011). This might be aided by the availability of internet connectivity, which remains one of Africa's primary issues, particularly in rural areas.

In Sub-Saharan Africa, the knowledge divides between the North and the South is prominent (Laurillard, 2011). Open distance e-learning has mostly been employed in Sub-Saharan Africa to provide access to basic education and maintain and improve quality in the traditional education system, particularly through in-service teacher training (United Nations Educational, Scientific & Cultural Organisation, 2003). Countries in the South are increasingly attempting to implement open-distance e-learning platforms to increase access to education and training.

Kenya, as a Sub-Saharan African country, has seen the benefits of open-distance e-learning. As a result, it is critical for Kenya's educational planning to realistically analyze the potential presented by the new style of learning within the context of national development goals in general and educational policies.

The Act of Parliament of 1966, which established the Board of Adult Education, was the first Kenyan government policy to handle open-distance e-learning in higher education (Juma, 2003). However, since independence, many commissions and reports have emphasized open distance e-learning as an alternate way of delivery. Sessional Paper No. 1 of 2005 (Republic of Kenya, 2005) supports the construction of an open university and the use of open distance e-learning technology in human resource development at all levels. In the country, open distance e-learning has been practiced at all levels of education and given by a variety of institutions, each with its own set of institutional policies (Juma, 2003). In January 2006, Kenya established a National Information and Communication Technology Policy (Farrel, 2007). This policy intends to ensure the availability of open remote electronic services that are accessible, efficient, dependable, and inexpensive. The government will support the use of open distance e-learning in schools, colleges, universities, and other educational institutions to improve the quality of teaching and learning, according to the relevant objective in this section on information technology.

Related strategies, according to Farrell (2007), include promoting the development of electronic learning resources, facilitating public-private partnerships to mobilize resources to support electronic learning initiatives, developing an integrated electronic learning curriculum to support open distance e-learning, and promoting distance education and virtual institutions, particularly in higher education and training. Similarly, the Ministry of Education's Kenya Education Sector Support Program, launched in 2005, placed high priority on integrating information and communication technologies into the teaching and learning process (Juma, 2003). The policy aims to highlight the current state of open distance e-learning in Kenya, as well as various problems preventing it from reaching its full potential.

2.5.2.2 South African Perspective on Open Distance e-Learning

According to the University of South Africa's website, the university has been offering correspondence courses since 1946, making it one of the first distance education universities in Africa and the globe (University of South Africa website, 20 March 2021). The success of the University of South Africa has prompted the formation of other open remote e-learning providers around Africa, including open universities in Nigeria, Tanzania, and Zimbabwe (Marimo, Mashingaidze & Nyoni, 2013).

According to Weimer (2010), textbooks in a formal classroom setting without the use of models are a popular method of teaching genetics. This has been hypothesized to be due to science teachers' lack of understanding of employment, while use of visual models is restricted (Siemens, 2008). Weimer (2010) adds fuel to the fire by claiming that scientific teachers' interpretations of visual models are limited and variable. Students, on the other hand, sharpen their understanding of the Life Sciences from a modeling approach, as to how empirical models are developed and produced, according to Childs and Wilson (2017). As a result, model research is an essential area for clarifying the link between the L Science and content knowledge.

The University of South Africa was the first institution in the Republic of South Africa to offer tertiary remote learning, which has subsequently evolved open distance e-learning (University of South Africa website, 20 March 2021). Many primary contact institutions have developed and launched open distance e-learning programs, frequently in specialty fields geared at specific markets, both locally and globally, to assist in-service teachers in furthering their education without having to attend planned classroom lectures (Makoe, 2013). In-service Teacher Training Programs (Muzaffar & Rahim, 2011) are designed to stimulate and maintain the expert acquisition of knowledge and skills of already qualified and teaching educators for them to hone their understanding of novel teaching methods, information, and understand the government's new thinking and curriculum restructuring. Use of visual representations in teaching genetics is included in the new curriculum. The rapid advancement of information and communication technology has aided everyone in their pursuit of higher academic success. The Department of Higher Education canvassed and ensured that growth in the system based on public funding was targeted towards national expansion of use of open distance e-learning

to support Life Sciences teachers in the use of visual models to teach genetics and aligned with the Medium-Term Expenditure Framework in encouraging and supporting learning through the use of open distance e-learning (Mashile & Matoane, 2012).

In the subject of science education, there are visual models such as diagrams and drawings that have been used for a long time and are now being utilized more frequently (Blumberg, 2016). Due to the complicated nature of the subject and instructors, as well as the learners' limited genetics literacy, Life Sciences teachers utilize visual techniques to teach genetics. According to literature, new students struggle with concepts like c*loning* and *gene therapy* (Schouborn & Anderson, 2006). The researcher believes that the use of visual models by open distance e-learning Life Sciences teachers have received little attention, hence this study's attempts to investigate this phenomenon. Based on the foregoing, this study aimed to explore the use of open distance e-learning to assist Life Sciences Teachers in the Oliver Reginald Tambo Coastal District in using visual models to teach genetics.

2.6 Effect of the Use of Open Distance e-Learning to Support Life Sciences Teachers on Teacher Effectiveness and Preparedness

This section discusses effect of the use of Open Distance e-Learning to support Life Sciences teachers on teacher effectiveness and preparedness.

2.6.1 Impact of Open Distance e-Learning to Teacher Development in Life Sciences

Open Distance e-Learning has a significant impact on teacher development (Hlengwa, Chimbo & Buckley, 2018). Teachers must adapt to varied students' requirements by adjusting to changing pedagogical approaches, education regulations, and educational reform activities to succeed in increasingly demanding school situations. As a result, teachers require ongoing assistance through a variety of professional development options to expand their material and pedagogical knowledge as well as their teaching abilities. Studies on school-based training programs, as well as training programs planned and conducted at teacher training colleges or as a result of teacher development, show that such training is typically inefficient in improving individual and organizational performance (Clarke & Hollingsworth, 2002, Glazer & Hannafin, 2006). Teachers' capacity to implement new teaching approaches appears to be unaffected by traditional and popular approaches to Teacher Professional Development.

Traditional approaches to Teacher Professional Development in support of teachers' ongoing learning, on the other hand, appear to fail at times, necessitating the need for workplace teacher development (Mouza, 2002).

Simultaneously, the Internet's rapid expansion as a potential course delivery platform provides a strong incentive for academic institutions to establish electronic learning programs for education staff employees using both on-line and hybrid techniques (Harasim, 2000). Electronic learning is widely acknowledged in the modern world, not only as a popular alternative to traditional face-to-face education, but also as a tool for lifelong learning. As a result, the traditional educational system appears ineffective in meeting the teachers' increased professional development needs. Virtual Campuses are gaining traction as a means of achieving high-quality teacher professional development (Fominykh, Paoslova-Fotand & Muzorov, 2008).

A virtual campus, sometimes known as an electronic campus, refers to a college or university's online services, in which college work is performed partially or entirely online, often with the help of an instructor, professor, or teaching assistant (Joshua et al., 2016). Teachers might strategically place themselves in relation to others in such situations. It can be deduced that the Internet has aided in the development of individual knowledge and abilities, as well as improving collaboration among the academic fraternity around the world, to combat feelings of isolation common in the education community (Laurillarad, 2011). As a result, teacher trainers are needed to construct web-based learning programs that will break down barriers between individual teacher-ship and offer activities for collaborative Teacher Professional Development (Fominykh, Paoslova-Fotand & Muzorov, 2008). It is also important that teachers develop 21st century skills that include critical thinking, collaboration and innovation, among others. Makgato and Mji (2006) suggest in their study findings that bad teaching methods have a direct impact on students' performance in science disciplines. These ineffective teaching methods are a product of the apartheid regime's conviction that teachers teach the way they were taught because, even when they utilize various teaching methods, when faced with a challenge, they teach the way they were taught (Makgato & Mji, 2006). Lundy and Stephens (2015) urge that educators take refresher courses provided, to assimilate alternative strategies and learn new teaching methods.

Muzah (2011) agrees with Makgato and Mji (2006) that certain scientific teachers' teaching techniques confine science instruction to exam and test preparation rather than boosting the learner's ability to explore ideas through hands-on activities. According to Muzah (2011), science learning is still done through parrot learning, which makes the topic dull. According to Joshua et al. (2016), teachers are passive when teaching, which means they do not encourage students to extract information from their surroundings and empirical facts. Muzah (2011) suggested that science be made more practical so that students may apply it to their everyday lives. Alternatively, Mwenda et al. (2013) discovered that demonstrations were the most regularly used teaching methods, followed by class discussions. Despite the adoption of these approaches, students still performed poorly. Low teaching methods do not appear to be a factor in poor performance or teachers' lack of content expertise, according to such data. Makgato and Mji's (2006) viewpoint is similar to that of Mwenda et al. (2013), who believe that frequent seminars should be held to provide teachers with a variety of teaching methodologies.

2.6.2 Impact of Coronavirus in Life Sciences Teachers' Education on Open Distance e-Learning

According to Toquero (2020), globally open distance e-learning has been enforced on various countries' education systems by the unprecedented effects of the coronavirus diseases. When a person infected with the coronavirus sneezes, coughs or talks, respiratory droplets are generated and transfer the disease from person to person within roughly 2 meters (Demuyakor, 2020).

2.6.2.1 Life Sciences Teacher Support on Open Distance e-Learning

All teachers receive help because they require opportunities to grow as professionals and enhance their work regularly. In-service assistance programs focused on teachers' desire to improve their teaching skills can have a significant impact on student learning. According to Makgato and Mji (2006), such programs are most effective when linked to teacher evaluation and needs, are ongoing, interactive, school-based and collaborative. Teachers with some in-service training tend to teach more effectively than those who have not, but programs are offered in a variety of methods by different institutions in different nations (Muzah, 2011). In-service teachers receive support in the form of continuing professional development, which allows them to improve their topic knowledge as well as their pedagogical and other abilities.

Governments and development partners, as well as schools, may provide school-based continuing professional development programs.

A variety of entities, including schools, may provide online or distance learning programs (Mwenda et al., 2013). Workshops, meetings, and other short courses, according to Brindly (2014), are perhaps the most prevalent modalities for providing professional development opportunities, though not necessarily the most effective. Mentoring programs and professional learning communities are two further types of support for in-service teachers. To become a good teacher, you must first have the knowledge, skills and disposition necessary to improve student achievement. Support programs based on teacher needs include those recognized through teacher evaluation systems or by the teacher's observations of the professional development they require.

Workshops or seminars that provide ongoing teacher support or continuous professional development are less effective than programs that provide ongoing support (Muza, 2011). Ongoing teacher support programs, such as principal or head teacher coaching and mentoring, expert teachers, or instructional coaches, help instructors master specific teaching approaches and are more effective than one-time workshops or meetings. When coaches observe teachers, model useful instructional strategies, and provide feedback to teachers as they practice them, so coaching and mentoring are most effective (Obiekwe & Chinwe, 2012). Many programs are delivered through more traditional pedagogical modalities, such as lectures, but programs are more effective when teachers actively participate by implementing innovative approaches and strategies (Thorpe, 2001).

Furthermore, if teachers are involved in learning how to employ new and improved teaching approaches, they are more inclined to implement them. Providing only educational materials has not proved to be particularly successful since these focus on the teaching and learning process. School-based support programs are the most effective; however, they must be evaluated and maintained to assure quality. Teachers' individual needs, such as subject knowledge and classroom management skills are addressed in effective programs; therefore, monitoring and assessment are essential. Lesson study programs, in which teachers prepare, teach and evaluate lessons in groups, can help with this. These programs work because they take place in specific school settings and focus on areas where the school needs to improve.

One of the most effective programs for teacher support is collaborative support. Teachers, as well as administrators and community members, can collaborate. Teachers might benefit from opportunities to exchange their expertise, resources, and lesson ideas to tackle difficulties in their classrooms (Ball et al., 2008). In addition, Chux et al. (2013) note that forming professional learning communities within a school is a frequent collaborative method. Teachers gather in a safe and non-evaluative environment as a professional learning community to debate educational readings, address a problem through instructional practice, or share classroom management skills. According to Basson and Kriek (2012), strong professional learning communities can promote school culture, student learning and the adoption of a learner-centered pedagogy. Bringing together topic area teachers from several schools' fosters collaboration among teachers who may be the only ones teaching that subject at their school. The cognitive and emotional processes that teachers must engage in to become culturally responsive are referred to as the personal component (Ruche, 2013). Material, techniques and activities that form the foundation of instruction are included in the instructional dimension. All three elements are crucial in assessing the success of culturally responsive pedagogy because they interact considerably in the teaching and learning process. Teachers can act based on personal and instructional dimensions. This should hint at methods in which professors might become content curators and provide recommendations so that students are not overburdened with lectures, lesson plans and assignments. This guide includes simple ideas for teachers in the United States of America, Uganda, and France, among other places, to adapt content from remote learning modules to local needs (LeBard, 2019).

Teachers' professional development can be aided by technical upskilling and getting the relevant technology and tools. Since remote teaching involves a combination of technological and pedagogical abilities, this is essential. It is vital to learn how to combine multiple modes of delivery, such as online, offline, and blended learning, to successfully promote learning. The administration must develop peer support programs to enhance connectivity and assist teachers in making the shift to remote teaching. According to Siemans (2008), volunteer teachers in Korea are paired with colleagues who have requested technical support to help design online sessions and offer guidance on how to adapt in-person content for a remote audience. In a similar vein, Estonia has established an educational technology hotline for teachers to call with technology-related questions. The Ministry of Education and Higher Education in Lebanon educated teachers to use online collaboration technology to improve classes and share information. Teachers in the United Kingdom, Canada, and Mexico have all developed similar

courses and webinars, while Sintema is looking for funding to support open-distance e-learning (2020).

Funding is required to increase teacher capacity through structured pre-and in-service teacher training programs. Teacher support can include things like diversifying and inventing teacher training strategies like virtual coaching, as well as developing regular follow-up plans to reinforce skills learned from both remote teachers and students. Such help is more necessary in the aftermath of the coronavirus outbreak. Teachers are given instructional DVDs and other resources to supplement the coaching they get. According to Sadler and Zeidler, rural instructors in Cambodia and India get video lessons that show the teaching of culturally relevant, curricula-aligned content utilizing student cantered pedagogy (2005). According to the findings of LeBard's (2019) study on teacher support, 80% of teachers believe that open distance e-learning may be successful if provided with enough support. This is a model lesson for teachers to follow. Using interactive radio education, similar efforts have been repeated around the world.

Life Sciences teachers' support is given to them in different forms like having subject coordinators visit teachers in their teaching environments and advising them on how to conduct lessons on certain seemingly difficult genetics topics. According to LeBard (2019), Life Sciences teachers can be assisted with virtual laboratories when the real experience is not possible due to restrictions on access to equipment, costs or time. Virtual laboratories can help students learn more effectively, and students have utilized virtual labs for molecular biology research, including fast breeding virtual fruit flies when examining how traits are inherited and simulating vast numbers of organisms for population genetics, according to Sintema (2020). These tools enable students to collect vast amounts of data and conduct experiments that would be impossible in real life. Life Sciences teachers are also supported through funding for upskilling in their fields. The Department of Higher Education and Training opens distance e-learning teachers to attend workshops from time to time at various workshops and are given various teaching materials which they use to upgrade themselves. Materials include demonstration movies and flash discs containing information that they can utilize for instructional reasons, according to SACE (2010). Teachers in the Life Sciences are also permitted by their administrators to take time off to write exams or attend classes.

Findings from the experiences of Life Sciences teachers in the United States of America, Uganda and France revealed that among other issues, Life Sciences teachers diligently perform

their duties when given adequate support from both administration and peers (LeBard, 2019). However, Life Sciences teachers' assistance was hampered by factors such as a shortage of resources due to inadequate funding and school principals who, at times, refused to provide teachers time off to complete their studies, among other things. Existing information had a substantial beneficial impact on this study since data polished the researcher's awareness of obstacles faced by other researchers and afforded the researcher strategies for navigating similar challenges or improving on such studies.

Dale and Pymy (2009) buttress this when they posit that acquisition of knowledge and imparting of knowledge by educators is such that learners' aspirations are fulfilled (Peters & Peters, 2008). Peters and Peter's (2008) research on teaching and learning is in line with Dewey's thoughts (Chandakummara, 2014) that ideas and the creation of meaning are manifested phenomenological. Furthermore, Taylor and Medina (2013) found that as learners' progress through the academic system, they use a variety of methods and styles to acquire knowledge, including the use of information and communication technology in open-distance e-learning. As a result, educators, particularly open distance e-learning Life Sciences teachers, are expected to approach their interaction with students through a different lens, as modern students' use of information and communication technologies has empowered them to the point where they may be more knowledgeable on some subject matters and have the power to control the type of information they consume at their leisure.

Walter and Gleaves (2008) point out that students' upward mobility academically sees them developing their learning skills and embracing new learning styles which propel them to greater academic heights, especially through the Virtual Learning Environment, which in essence supports a variety of learning styles. Virtual Learning Environments are systems for delivering learning material to students through the use of the internet (Hansen, 2008). Virtual Learning Environment systems include valuations, student tracking and communication tools, among others (Taylor & Medina, 2013). This supports the current researcher's study which suggests that teaching and learning styles should be fluid and change over time, hence the use of open distance e-learning in the teaching of genetics using models. Furthermore, the current researcher was motivated to investigate the perspectives of connectivism and navigationalism paradigms in this study due to students' learning ways and styles.

2.6.2.2 Visual Models

Visual models are tools of teaching and learning such as flowcharts, pictures, diagrams and animation which are important in science education. Mnguni (2007) intimates that visual models can be effective and useful when selected and designed properly and used accordingly. The author articulates that models can sometimes create challenges for teachers and students if the teacher fails to select the models properly. Mnguni, Schonborn and Anderson (2016) warn that the effectiveness of visual models as teaching and learning instruments can be hindered if both the teacher and students do not have important pre-requisite skills fundamental in both the selection and employment of visual models.

2.7 Effectiveness of Open Distance e-Learning in Supporting Life Sciences Teachers on the Use of Visual Models to Teach Genetics

Visual models such as numerous media variety, among others, increases the probability for students to learn more, retain better what they learn and improve their performance on skills they are expected to develop (Bryson, 2013). Moreover, Merchant, Goetz, Cifuentes, Keeney-Kennicutt and Davis (2014) postulate that students understand and retain better when they have been shown or taught some objects that associate with the content. Dunn and Dunn (2014) add to the effectiveness of visual models by stating that educational experts have recognized that certain learners struggle with reading comprehension because they cannot interpret words.

Dunn and Dunn (2014) discovered that while there are a variety of techniques for teaching word-reading abilities, few of them include systematic procedures that aid mastery, fluency and skill retention for struggling readers. Students who struggle in the acquisition of skills need specific interventions to increase their science knowledge, so visual models are a necessary tool in the teaching and learning process. Interventions using visual models should be ongoing and occur early in the learning process to ease the cognitive load on the learners' comprehension of science his or her level for the next grade level.

Using visual models, such as authentic materials, which include print, video and audio materials, learners could increase their science genetics vocabulary retention based on their vocabulary to improve their speaking, writing, listening, and reading skills. According to Lundy and Stephens (2015), students are more motivated to complete assignments and

activities that contain certain items they are familiar with and appear to require less work because they are confident in their ability to do such projects.

2.7.1 Different Types of Visual Models Used in Imparting Knowledge to Learners Using Visual Models to Learn Genetics

Different types of visual models such as visual models, physical models and conceptual models and statistical and mathematical models are used in imparting knowledge to students, depending on the nature of the subject taught (Mnguni, 2007). This study reviewed literature on the use of open distance e-learning to support Life Sciences teachers in the use of visual models to teach genetics. Visual models are utilized as amplifying teaching aids because they play an important role in assisting professors in communicating life science basics to students. In comparison to text alone, visual models are crucial teaching tools because they help learners understand a phenomenon in both content and reality, to some extent, especially if the visual models are properly selected and deployed (Mayer, 2001). As a result, when it comes to learning scientific concepts, teachers must be very careful in their model selection and design.

The study of genetic phenomena is made possible by biological systems known as genetic models. The additive model (AM), the dominant model (DM), and the recessive model (RM) are typically the three genetic models of genes (RM) ((Irez et al., 2018). The additive model presupposes that the relationship between the trait effect and the number of minor alleles is linear. A dominant model is a genetic paradigm in which dominant alleles are presumed. According to the dominant paradigm, either one or two copies of the minor allele are needed to have an equal effect on the trait. In terms of genetics, the term recessive describes the connection between an observed trait and the two inherited forms of a gene associated with that feature (Stephens (2015). Each gene has two alleles that an individual receives from each parent (Childs & Wilson, 2017). Model organisms will be chosen because they are simple to maintain and reproduce in a lab setting, have quick generation times, or can produce mutants that can be used to investigate features or diseases. Insights into biological systems at the cell, tissue, organ and system level can be gained through model organisms.

2.7.2 Open Distance e-Learning and Design of Visual Models

According to Turner, Brownhill and Wilson (2016), there is a need to be thoughtful when designing, selecting and employing visual models for science teaching and learning. This is

important because some visual models can provide learners with erroneous material and are badly designed to the extent that learners may find it difficult to comprehend the whole concept (Schönborn & Anderson, 2006). As a result, teachers must consider students' social, emotional, and cognitive perspectives when choosing and constructing a visual model. Visual models should grab a learner's attention and encourage them to desire to learn more about a phenomenon without incurring additional fees, especially in Open Distance e-Learning if the content is accessed online. According to Bozdogan (2011), well-chosen and constructed visual models aid students in visualizing a subject or topic through images, diagrams and graphs.

2.8 The Theoretical Framework for this Study

The theoretical framework of an inquiry is the structure that can hold or support a theory of a research study (Creswell, 2018). The theoretical framework introduces and describes the theory that explains why a research problem under study exists. This academically positions their studies. Moreover, the theoretical framework serves as the focus of research and is linked to the research problem under study. Therefore, it guides a researcher’s choice of research design and data analysis plan (Adom, Hussein & Agyem, 2018). A research project can benefit from a theoretical framework in several ways. It shows how a researcher defines his or her research philosophically, epistemologically, methodologically, and analytically. Grant and Osanloo (2014), Adom, Hussein and Agyem (2018) and Ravitch and Carl (2016) agree that the theoretical framework serves as a guide for researchers when it comes to situating and contextualizing formal theories in their research.

Consideration of the phenomenon under research and the presumptions that are consistent with the phenomenon is the first stage in developing a theoretical framework. The researched event is a part of the phenomena. There are numerous options, such as group organization, instructional strategy or pupil learning. An analyst makes predictions about how the phenomenon will be affected, impacted, transformed, or portrayed. In the end, a theoretical framework only fits the researcher's hypothesis regarding a phenomenon. The identification of a theoretical framework can be demonstrated by an example of how a researcher's contemplation on the phenomena and acceptance of assumptions can do.

2.8.1 Theoretical Framework for this Study

This part discusses the theoretical framework of this study:

2.8.1.1 The Interaction Equivalency Theorem

The prevalence of distance learning is rising as economic reasons support the Interaction Equivalency Theorem and new technologies make it possible (Creswell, 2018). By its two theses, being the meaningful learning can be maintained as long as one of three forms of interactions student to content, student to teacher or student to student is present at a high level. The Interaction Equivalency Theorem offers suggestions for effective online course design (Saunders et al, 2019). The quality of learning can be maintained even if the other two types of these are only supplied in the bare minimum or not at all. High volumes of interactions that span several different types are likely to result in more enjoyable learning opportunities. These experiences may, however, be less effective due to their expense and design time requirements. Because it tackles social interactional limits, this theory appeals to businesses looking to improve and diversify their online program offerings. Online students frequently reject the notion that various forms of engagement are interchangeable or equivalent (Rubin and Babbie, 2017).). Perceptions may, however, differ from real actions and results. It has long been acknowledged that interactions with a teacher, peers or content are crucial to any course. Both students and teachers have cited their value in online courses (Osharive, 2015). Online interactions have been linked to higher satisfaction levels, better course grades and fewer course dropouts (Blumberg, 2016).

It takes a lot of work to design and construct the learner-to-content (LC) interactions version of the course because the material had to be self-explanatory to make up for the absence of social interactions (Schneeweib (2019). Teachers make an effort to anticipate all the questions that students might have as they progress through the course and to respond to them. Reading texts that have integrated audio, photos and hyperlinks encourage student to content interactions (Mashile & Matoane, 2012). Students must respond to activities in a clear, observable manner. A poll that lets students see the group's comments, three podcasts with transcripts, multiple choice quizzes with automatic feedback and a personal wiki that students can only use to record their reflections were among the resources. There may not be any other

embedded communication tools besides the general discussion forum. A teachers' job is to keep an eye on students' progress without getting involved themselves. Teachers could use the open discussion forum to address concerns and define tasks as needed.

2.8.1.2 Constructivism Theory

The study's theoretical foundation is based on social constructivism, namely social interaction theory (Vygotsky, 1986; Piaget, 1968). Life Sciences visual models are particularly suited to support a Social Constructivist approach to task design for this current study because electronic visual models expand options for interaction with teachers, which is critical in teaching. In this work, Vygotsky's (1978) theory is crucial in offering insight into the usage of electronic visual models in Life Sciences to teach genetics. Natural communication, according to Vygotsky's social constructivism theory, is the best approach to learning a language. The roots of the study are based on social constructivism, namely social interaction theory (Vygotsky, 1986; Piaget, 1968). Even though electronic visual models extend choices for engagement with teachers, which is crucial in teaching, Life Sciences visual models are particularly well suited to support a Social Constructivist approach to task design for this current study. Vygotsky's (1978) theory is critical in this work since it provides insight into the use of electronic visual models in the Life Sciences to teach genetics. According to Vygotsky's social constructivism theory, natural dialogue is the greatest way to acquire a language.

Mamba (2012) claims that a critical component of constructivism's progressive learning view is appropriately examining learners' errors and analyzing whether learners' misconceptions have been rectified. Furthermore, Resnick (1982) contends that visual models in the Life Sciences may constitute active knowledge in construction, implying the presence of erroneous learning rather than the lack of learning. "In social constructivism," Creswell et al. (2018, p. 24) write, "individuals seek a knowledge of the world in which they live and work." They interpret their experiences in terms of subjective meanings directed towards specific objects or things." For this study, the researcher used the Social Constructivists theory, which is based on the aforementioned.

2.8.1.3 Application of Theoretical Framework for the Present Research

Life Sciences teachers were employed as an intervention approach in the Life Sciences classroom for this study. Dewey (1938), a proponent of experiential learning, is a good fit for constructivism. According to Dewey (1978), students must experience, feel, and sense real-world concepts and ideas and relate them to their prior knowledge and schemata to construct meaning, so using the electronic visual model by Life Sciences teachers may be an added benefit to support teachers. Taber (2011, p. 42) emphasizes the importance of comprehending that human beings are never completely tabula rasa: a blank slate on which anything can be written. By the time a person is born, he or she has already been influenced by the outcomes of millions of events. Students cannot just memorize, absorb, or duplicate pre-packaged ideas; instead, they must actively engage in personal experimenting to create their versions. In constructivist thinking, there are two major schools of thought. Based on the work of Jean Piaget (1968; 1970; 1972), cognitive constructivism addresses the mental processes involved in an individual's knowledge production. Piaget's grand ambition (his 'genetic epistemology') was to figure out how people might learn about the world, given their starting place (in effect a single cell containing only genetic information from the parents). Piaget believed that (i) the baby could not construct formal, abstract knowledge of the world and that it could act in the world intelligently because it could use sensory-motor experience to model the world and then modify that model in light of new information; and (ii) that through an interactive process, it was possible to transfer through qualitatively different levels of understanding, acting in the world according to expectations, and comparing those actions (Taber, 2011). The researcher used the Social Constructivism theoretical framework to guide this study. The questionnaire was used as one of the data collecting instruments which were designed to detect the impact of the animation used as an instructional medium for learners with different learning styles. Semi-structured interviews, questionnaires and zoom in were used to track the use of visual models in teaching genetics in Life Sciences.

2.9 Impact of Open Distance e-Learning on Genetics Literacy

Bowling et al. (2008) defines genetics literacy as having enough understanding of genetics to make informed decisions about one's health and successfully engage in discussions about genetics issues. According to Jennings (2004), having sufficient knowledge of genetics and comprehending the importance of genetics is insufficient for genetics literacy. Genetically literate individuals, according to Jennings (2004), should be able to make judgments about health-related concerns based on their genetic knowledge. McInerney (2002) emphasized the

necessity of acquiring an awareness of basic technological principles and genetic notions in his definition. He also mentioned how important it is to consider ethical, legal, and societal considerations when making decisions. The important function of genetics literacy, as mentioned in the above definitions, is to build an understanding of genetics and genetics-related issues, as well as technology-related concerns, and to use that knowledge to make informed decisions with ethical, legal, and social implications. Since the terms "understanding in genetics," "understanding in technology," and "making informed decisions" were explicitly defined in genetics literacy definitions, biotechnology, and socio-scientific concerns research merged with genetics literacy research. Villegas (Villegas, 1991). While biotechnology and socio-scientific issues research focused on contentious issues arising from technological advancements such as genetic modification of crops and animals, cloning, genetic testing, and stem cell research, socio-scientific issues research focused on informed decision-making and reasoning processes.

2.9.1 Open Distance e-Learning Studies Focusing on Genetics Knowledge and Attitudes Towards Genetics in Life Sciences

A wide range of studies has been conducted with various focus groups, including the general public, students, pre-service and in-service teachers, and open distance e-learning. Students' content knowledge in genetics, as well as their attitudes toward various issues in genetics, such as genetically modified foods and genetic modifications in organisms (Wynne, Stewart, & Passmore, 2001), gene therapy and specific applications of gene therapy such as somatic and germ line gene therapy (Lewis, Leach, & Wood-Robinson, 2000b), use of genetic data, and general attitudes toward biotechnology (Sturgis, et al., 20), have long been investigated. Furthermore, the investigations investigated the relationship between genetics content knowledge and attitudes regarding various genetics concerns.

2.9.2 Students' Understanding of Genetics and Attitudes Towards Issues in Genetics Literacy

Lewis and Wood-Robinson (2000) assessed the knowledge and understanding of genetics concepts among English students aged 14 to 16 to better understand students' grasp of genetics ideas. According to the findings of the study, students lacked basic knowledge of genetics, such as chromosomes, genes, and cell structure. Only 11% correctly identified the location of genes, even though a large majority of 73 percent were able to specify some properties of genes. Half of the students did not realize that genetic information may be found in all living things, and most of them could not tell the difference between meiosis and mitosis.

Furthermore, students were unfamiliar with the concept of "alleles." Only 3% correctly identified alleles and their roles in genes and distinct types of genes, for example. The research also found that students had differing viewpoints on chromosomes and genes. For example, 25% of them thought genes were bigger than chromosomes, and just 10% of them correctly identified where chromosomes were in organisms. The conclusion is that students' lack of understanding of genetics was caused by a misunderstanding of the terminology used in genes, uncertainty, and lack of information about genetics, and such students had less interest in the subject.

Marino, Mashingaidze and Nyoni (2013) proposed that the secondary school Life Sciences curriculum be changed to include fundamental genetics information and educate people on how to evaluate scientific information or evidence through lessons. It was observed that open-distance e-learning students found it even harder to understand genetics compared to students who were exposed to more teaching models (Lewis & Kattmann, 2004). Furthermore, Venville, Gribble and Donovan (2005) discovered that students' difficulties stemmed from genetics language, which they perceived open and as complex and containing many unfamiliar terms, mathematical expressions used in genetics, distinguishing meiosis from mitosis, and insufficient time for understanding genetics, despite the use of teaching models.

2.9.3 Pre-Service and in-Service Teachers' Understanding of Genetics and Attitudes Towards Issues in Genetics Literacy

Donovan (2016) studied four science teachers' implementations of socio-scientific issues to open distance e-learning open students as well as in their classrooms and explored their motivation to teach socio-scientific issues by conducting a series of semi-structured interviews with each teacher and through classroom observations. They looked at how teachers handled socio-scientific topics such as their interest in them, their worries, and how they implemented socio-scientific themes into their classes. Environmental issues such as pollution, global warming and endangered species were identified through interviews and observations, as were biotechnology-related issues such as cloning, stem cell research, and genetically modified foods and power plant challenges. All teachers' implementations, according to the researchers, were heavily impacted by their views, values, philosophies, and personal concerns. Teachers' motivation to teach learners about socio-scientific concerns varied depending on their Pedagogical Content Knowledge. Two of the teachers in their study created their own teaching goals, which influenced their students' decision-making abilities and attitudes toward socio-scientific concerns.

Donovan (2016) investigated science teachers' implementation of socio-scientific issues and the factors that influence these. Dawson (2011) studied experienced Life Sciences teachers' teaching strategies in the reproduction unit, focusing on socio-scientific issues such as genetic diseases, embryo testing, and genetic engineering, as well as Mendelian patterns of inheritance and the use of visual models to teach genetics. In addition, the researcher looked into how the students' attitudes toward science were changed by the learning activities used. The study included a variety of data-gathering approaches, including participant observation, teacher interviews, questionnaires, and personal reflection journals. When dealing with socio-scientific concerns, the teacher used group work, whole group discussion, cooperative learning, and student-centered learning. The findings suggested that a teacher's views on socio-scientific topics may have an impact on pupils' attitudes. The researcher concluded that the teacher's views on the goal of socio-scientific topics mattered. Students' reasoning and argumentation skills increase more when teachers directly explain the importance of socio-scientific issues in genetics. She emphasized the importance of instructors' views, understanding and skills in the development of pupils' decision-making abilities.

Law and Lee (2004) investigated how pre-service science teachers in Korea dealt with socio-scientific concerns, as well as the importance of character and values in this process. Using visual models, the program addressed socio-scientific concerns such as nuclear power generation, climate change and embryonic stem cell research. Audio typing of small group conversations of each scenario, as well as pre-service teachers' self-reflections, were acquired and analyzed in terms of pre-service teachers' personalities and values. Participants' reactions to various socio-scientific concerns were influenced by their character and value considerations, according to the researchers.

In the case of stem cell research, the impact of moral consideration was particularly noticeable. When coping with a stem cell research scenario, the participants faced problems rooted in their personal views and religious convictions. Another key finding was that even pre-service teachers were motivated by ethical and moral issues and had a high level of faith in science and technology. The researchers believe that programs concentrating on socio-scientific concerns can help pre-service teachers improve their thinking and decision-making skills.

Some researchers investigated the role of content knowledge in making informed decisions, as the above-mentioned studies stressed the importance of factors such as teachers' ideas, beliefs, values, philosophies, and personal concerns, as well as moral and religious perspectives' influence on their decisions. Van der Zande et al. (2011) evaluated the content knowledge needed to teach genetic testing using visual representations in such a study.

The researchers interviewed 9 (nine) experienced Life Sciences teachers with an average of more than 20 years of teaching experience in both open distance e-learning and classroom environments, as well as 12 stakeholders, including four clients, two physicians, one clinical geneticist, one genetic counsellor, and medical ethicists. Semi-structured interviews with instructors, semi-structured interviews with various stakeholders, and referents on ethical, legal, and societal elements of genetic testing were utilized to collect data. Overall, the findings demonstrated that subject knowledge is required for effective genetic testing training. However, in addition to the principles covered in the existing curriculum, experts believe that new concepts such as multifactorial and polygenic disorders are required.

Furthermore, ethical, legal, and social features and traits such as uncertainty, complexity, probability, and morality have been identified as critical components in effective teaching. Some features, such as informed consent and solidarity, were also added by the researchers. In both genetic screening and euthanasia scenarios, similar patterns were identified. Students made various ethical judgements in response to various events. They, for example, talked about the relevance of people's choices and rights, as well as the role of religious values in prenatal genetic testing, abortion, and euthanasia scenarios. Students' ethical actions are influenced by their ideas of personal choices, individual rights, and values, as well as their theological worldviews, according to the research findings.

Studies on scientific teachers' teaching impressions and challenges in teaching controversial themes in genetics contexts, as well as other possible characteristics influencing their teaching, such as gender, teaching experience, or self-perceived importance, were reviewed in another area. According to Ratheesweri (2018), Australian Secondary Life Sciences teachers' difficulties were investigated while teaching two specific biotechnology units that focused on deoxyribonucleic acid, proteins, mutations, genetic manipulations, and the role of biotechnology in daily life, including ethical issues.

Other research backed up the challenges experienced by Australian Life Sciences teachers. For example, Lazarowitz and Bloch (2005) used interviews and visual models to investigate 30 Israeli high school open distance e-learning biology teachers' awareness of societal issues such as values, moral, ethical, and legal issues when teaching genetics, genetic engineering, and molecular genetics. The data was evaluated based on teaching experience, gender, and religious affiliation. When teaching genetics, most teachers tended to cover Mendelian genetics such as Mendel principles, sex determination, hereditary illness, and blood types. Only three teachers taught societal issues in their classes. Overall, the findings revealed biology teachers' lack of awareness of societal challenges related to molecular biology and genetic engineering, including bioethical, social, and political issues. While the perspectives of biology teachers were not dissimilar, experienced professors were keener to impart societal issues to their students, regardless of religious faith or gender. Teachers opted not to address societal issues in their courses, preferring instead to prepare their learners for matriculation examinations, according to the researchers, which is comparable to Cebesoy and Tekkaya's findings (2012).

Bayrhuber (2016) found no differences between male and female teachers' attitudes and implementation of problematic problems based on gender or religion, while Sadler and Zeidler (2005) discovered disparities between male and female teachers' perspectives and implementation of controversial issues. All female professors agreed that incorporating socio-scientific concerns into science classrooms was a good concept, but only half of them did so. Five of the eight male teachers who took part in the study were undecided and hesitant about the importance and implementation of these concerns, showing that females were more eager to do so than their male counterparts. Furthermore, all teachers in the study agreed that it is critical to incorporate ethical themes into science classes and teach students about ethical issues. Even science teachers understood the importance of contentious problems in science classes, as teachers' Content Knowledge prevented them from including ethical dilemmas in their genetics lessons. Furthermore, open distance e-learning high school and middle school teachers had differing views on how socio-scientific issues should be implemented. High school teachers, for example, preferred to concentrate on content knowledge in the curriculum while preparing their students for admission exams.

Turner, Brownhill, and Wilson (2016) interviewed 9 Dutch biology teachers about how to teach genetic testing, considering pedagogical content such as students' learning processes, subject matter such as curriculum knowledge, morals such as controversial issues and their ethical and interpersonal aspects, and a teacher's ability to create a positive learning environment. They observed five teachers' sessions and discovered that science teachers engaged in a variety of learning and teaching activities when teaching genetic testing in the pedagogical content area. Experienced teachers used more problem-based tasks in their lessons. The studies discussed above were undertaken in a variety of locations and circumstances, ranging from stem cell research to cloning.

Various factors such as religious, cultural, and personal factors (Law & Lee, 2004), beliefs (Dawson, 2011), content knowledge (van der Zande, et al., 2012), ethical, legal, and social factors (van der Zande, et al., 2012), ethical, legal, and social factors (van der Zande, et al., 2012), ethical, legal, and social factors (van der Zande, et al., 2012), (van der Zande et al, 2012). Overall, the examined studies offered empirical evidence that numerous factors influence teachers' decision-making processes. Furthermore, the investigations looked into how life sciences teachers coped with a variety of challenges in the classroom. While various research found that Life Sciences teachers recognized the importance of such issues, Sadler et al (2006) found that several issues hampered successful implementation of these issues in other studies.

Overall, the reviewed research studies have emphasized the need of looking at a variety of elements that influence teachers' decision-making processes, as well as some background qualities that may influence science teachers' implementation in a variety of situations. As a result, a study examining both the variables that impact life sciences teachers' decision-making as well as the interaction between life sciences teachers' background characteristics, genetics literacy level, attitudes toward genetics literacy difficulties and teaching perspectives is required. As a result, this study investigated the impact of factors like gender, teaching experience, content knowledge, self-perceived interest, and self-perceived importance in genetics, as well as the relationship between background characteristics, genetics literacy levels, and attitudes toward genetics literacy, as well as teaching perceptions. Furthermore, it used a multi-layer viewpoint to try to explain elements that influenced participants' decision-making processes that had been identified in prior studies and to analyze the overall role of these factors.

2.9.4 Studies Focusing on Teachers' Perceptions of Teaching Issues in Genetics Literacy and Self-Efficacy Beliefs Regarding Genetics Literacy

This section contains studies on pre-service and in-service teachers' opinions of teaching about genetics literacy concerns, as well as their self-efficacy in teaching ideas about genetics literacy. Czerniak and Schriver (1994) used a Likert scale questionnaire to investigate pre-service teachers' self-efficacy beliefs and related their pedagogical teaching practices to their self-efficacy ratings over two years. Data were obtained from a total of 25 pre-service teachers in the first year of the study using an open-ended and journal-style questionnaire after determining the first and second years on how to learn about their teaching practices. Both groups of teachers employed a variety of teaching tactics, including discussions, experiments, games, and hands-on activities, according to the findings. Low efficacious teachers, on the other hand, favored teaching from textbooks and used lecturing and demonstrations while teaching, whereas highly efficacious teachers used student-centred activities such as simulations and small group discussions. Overall, high-effective teachers were more enthusiastic to assist their students in learning life sciences and were more aware of their strengths and weaknesses. They were also keen to implement student-centred activities and selected teaching tactics to aid their kids in their sciences learning. Low efficacious teachers, on the other hand, were concerned about their ability to teach life sciences effectively. They highlighted other reasons that contributed to their failure.

Researchers concluded that self-efficacy is important in improving students' scientific learning since self-efficacious teachers frequently used effective teaching tactics to help their students grasp scientific ideas. According to the researchers, life sciences teachers should be aware of the self-efficacy concept since it influences students' beliefs and behaviour in life sciences. Peters (1998) looked at the relationship between teaching efficacy beliefs and the number of alternative conceptions held by pre-service elementary teachers. A total of 619 pre-service teachers were polled as part of a survey that looked at both efficacy views and alternative perceptions about life sciences education. The findings demonstrated that highly efficacious pre-service teachers were more educated in the life sciences ideas assessed by the inventory, but there was no link found between the number of alternative conceptions and science teaching efficacy views. Certain misconceptions about life sciences, such as "planets can only be seen through a telescope" or "dinosaurs lived alongside cavemen," were found to be linked to low scientific teaching efficacy beliefs.

Alternative notions generate hurdles in the learning process, according to the researchers, and pupils with these alternative misunderstandings struggled to acquire scientific knowledge, resulting in low self-efficacy views. The researchers proposed that pre-service science teachers should focus on alternate conceptions as well as misconceptions among students, which could help them develop their self-efficacy beliefs about teaching science. Ratheesweri (2018) investigated the role of varying lengths of in-service teacher training programs in boosting teachers' self-efficacy in a separate study. The findings showed that 2- and 3-week programs were more effective in raising the self-efficacy levels of teachers who scored below average.

In-service training programs were found to be more effective in boosting low efficacious teachers' efficacy scores, according to the study. The researchers emphasized the impact of in-service training programs in boosting teachers' self-efficacy beliefs because they predicted teachers' efficacy to be directly related to students' outcomes.

Cebesoy and Tekkaya (2012) used a science concept test and Science Teaching Efficacy Beliefs to investigate Turkish senior pre-service science teachers' grasp of science ideas and teaching self-efficacy beliefs regarding science. Pre-service teachers correctly answered less than half of the questions, showing that PSTs had a limited understanding of science topics and the teaching of genetics using visual models. In addition, errors in basic scientific principles were exposed. For example, 89 percent of students answered that "plants only breathe at night," whereas 11 percent said that "respiration in plants occurs in the leaves." Pre-service teachers scored well in the Efficacy Beliefs results when it came to self-efficacy beliefs and outcome expectations. For example, a large majority, 86 percent, said they were confident in their ability to effectively teach science ideas to their students, and PSIs welcomed students' questions during class.

The researchers also investigated the link between self-efficacy views, the number of courses taken, and scientific conceptual comprehension. The finding suggests that completing more courses and having a good conceptual understanding of science improved pre-service teachers' personal teaching efficacy beliefs in science. In comparison, there was no difference in outcome expectancy scores when it came to the number of courses completed and scientific conceptual comprehension. The researchers concluded that even scientific teachers had great confidence in their abilities to teach science successfully but lacked a solid comprehension of the subject. Rather than adding more courses to university science teacher education programs, the researchers propose that current courses focus on alternative pre-service teacher conceptions and solutions before pre-service teachers begin their careers.

To summarize, studies on pre-service teachers' and life sciences teachers' teaching perspectives and self-efficacy beliefs looked at a variety of topics. While previous studies identified characteristics of high and low efficacious teachers (Czerniak & Schriver, 1994), they revealed that high efficacious teachers tended to use a variety of student-centered activities to enhance their students' life sciences learning, such as simulations or small group discussions. In addition, Peters' (1998) research indicated that teachers with low efficacy had more alternative misconceptions.

The findings of Tekkaya et. al (2002) investigation in a Turkish context backed up this conclusion. Furthermore, extracurricular activities and school types such as public, private, or open, as well as distance electronic learning, were found to improve teachers' self-efficacy beliefs. Gender was not shown to relate to teachers' self-efficacy views, according to Borgerding, Sadler and Koroly (2013). Most students emphasized the importance of high school subjects like method courses and in-service training programs in boosting pre-service teachers' self-efficacy views, which was a frequent finding.

2.9.5 Using Open Distance e-Learning to Mitigate Loss of Learning

Many countries turned to online learning to make up for lost time in continuing education while schools were closed due to coronavirus sickness. Some countries put resources on their websites and made more learning items, online classes, and radio lessons and delivered packages available, while others resorted to radio lessons and delivered packages (Toquero, 2020). Other countries, such as Spain and South Africa, have encouraged professors to create online curricula and provide online classes. Infrastructure and familiarity with online tools appeared to be driving success and challenges in delivering learning in developed countries, as some schools were not prepared for such a phenomenon. China, for example, was successfully offering open distance e-learning, whereas Vietnam and Mongolia, both of which had low internet, mobile telephony, or television penetration, were finding it difficult to reach all learners equally (Demuyakor, 2020). To say the least, many governments struggled to ensure that education services were equally accessible to all people, including those with disabilities.

Some African countries like Zimbabwe, Kenya, Rwanda, South Africa, Senegal and Botswana started preparing for sustained open-distance e-learning soon after their governments ordered lockdowns because of the coronavirus disease as there was reasonable school connectivity, especially in urban centres and growth points (Toquero, 2020). Some institutions gave students devices such as tablets to take home for continued education. In most countries, however, students had access to personal mobile devices and optimized accessible solutions to such devices were the main emphasis. Although there seemed adequate online content available even from open sources, a significant challenge for many countries was to arrange pedagogical material easily accessible and structured in such a way that students could recognize and easily comprehend it.

Consequently, some were compelled to partner with development partners like non-governmental organizations to provide readymade open distance e-learning content as some of these organizations like the United Nations Educational Scientific and Cultural Organisation and the United Nations International Children's Emergency Fund were better prepared for such an eventuality (Sintema, 2020).

2.9.6 Open Distance e-Learning and Influence of the Internet

Swann et al. (2012) showed that academic trends are constantly changing due to a variety of reasons such as new information and communication technologies, student choices due to post-modernism and economic conditions, among others. Such forces of change compelled both academic and political leadership to have a diverse focus on sustainable curriculum development. This parodic shift in the imparting of knowledge called for authorities to have a changed mindset and interrogate future evaluations of teaching and learning (Chandakummara, 2016). More so, Deepwell and Malik (2008) revealed that contemporary academic practices must fully consider sustainable education systems for future generations. A contemporary learning system is open distance e-learning which is new for Life Sciences teachers who teach genetics using visual models (Blumberg, 2016).

This further shows that in making academic structures to morally embrace critical difficulties of globalization and prevent loss of bio-cultural diversity among others, various governments have not been sitting on their laurels and continuing with the old ways of imparting and the acquisition of knowledge. Subject integration in imparting and acquisition of knowledge through open distance e-learning as well as access to education for all from anyone's comfort zone and being motivated by good government policies enable the global village to tackle complex matters. The open distance e-learning system may be a placebo to such challenges (Demetriou et al., 2012). These further points out there is no shadow of doubt that robust global open distance e-learning systems will witness access to education for all in their own time and comfort zones (Buckly et al, 2008).

Schneeweib (2019) reveals that the use of open distance e-learning to support Life Sciences teachers in visual models to teach genetics is being experimented on at a slow pace due to poor understanding of genetics by both teachers and students or mere negative attitudes. Hansen (2008) points out that teaching genetics through open distance e-learning using visual models has changed in many ways the understanding of genetics immensely.

Wilson (2016) also reveals that teaching was primarily by teachers interacting with learners in person in tutorial rooms and was traditionally accepted as the best method of instruction. However, some learners have found such instructional practice boring and ineffective in understanding genetics. Similarly, it reveals open distance e-learning teachers in their quest to have learners understand genetics, teachers need multiple assessments aligned with their learning goals (Lindeman & Pelegri 2008). To measure learning and understanding of conceptual difficulties, teachers use various visual models (Turner, et al., 2016). Swann et al (2012) agree that at an age where almost all information is readily found online, it is of paramount importance that open distance e-learning is fully utilized as learners attend lessons at their own pace and space. Use of ODeL in this time and age makes teaching and use of visual models in understanding genetics relatively easy. Teachers need to improve on how best they can deliver lessons in a virtual class, and this calls for more training teachers.

In South Africa, open distance e-learning at an institution like the University of South Africa is fundamentally important for pre-service and in-service teacher academic progress. This is premised on the argument that the apartheid regime marginalized many teachers from realizing their potential in the teaching field. It is also important to note that various open distance e-learning establishments in South Africa and continentally employ different state-of-the-art new technologies mixed with old technologies to enable the distribution of learning material evenly to open distance e-learning (Mbatha, 2014). Use of new technologies in open distance e-learning has facilitated easy interaction of teachers and students as well as fast exchange of information as well as the use of clearer visual models like pictorial items.

Open distance e-learning Life Sciences teachers can use visual models in teaching genetics. Demetriou et al. (2012) add that models are critical implements for both the teacher and student to have a clearer comprehension of teaching and the learning process. Therefore, this calls for the planning and implementation of models at both the teaching and learning levels. Demetriou et. al (2012) research on teaching and learning observed that information technology and the internet were likely to motivate prospective students to simultaneously uptake learning at their own time and place and understand other non-academic matters as they navigate through their lives (Wilson, 2016). Through the Theory of Navigationalism, researchers recognize that the interceding function of the educator is important in the making and imparting of knowledge (Wilson, 2013).

2.10 Consolidation of the Argument

The previous chapter introduced the research topic and discussed a set of research questions. This current reviewed literature on the contextualization of open distance e-learning, teaching, and learning in electronically Life Sciences classrooms and further discusses the global, African, and South African perspectives on open distance e-learning in Life Sciences and the impact of Open Distance e-Learning on teacher development in Life Sciences. A detailed account of the impact of coronavirus in Life Sciences teachers' education on open distance e-learning, Life Sciences teacher support on open distance e-learning and visual models on open distance e-learning were discussed. Furthermore, open distance e-learning impacts of visual models on learners, open distance e-learning on educational theories importance and impact of open, distance electronic learning and types of visual models were discussed while open distance e-learning and the influence of the internet were discussed in detail. More so, a detailed account of the importance of a theoretical framework was discussed with emphasis on Social Constructivism and Social Network Media in Life Sciences Classroom.

The next, Chapter 3 will discuss the research design and methodology for this current study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

Tools and data gathering methods employed in undertaking this research are outlined in Chapter 3. This discusses tools, methods and procedures implemented when gathering, analyzing and presenting data pertinent to the use of open distance e-learning to support Life Sciences Teachers in the use of visual models to teach genetics. Research philosophy, research design, type of research, triangulation methods used, study population, sampling techniques, sampling frame, sampling size, data analysis and presentation are also discussed in this chapter.

3.2 Overview of Methodology

Research methodology is an explicit logical way employed to classify, opt for, develop and evaluate data around a phenomenon under study so that a researcher can weigh the entirety of a study's reliability and other parameters. Optionally, a researcher can employ qualitative, quantitative, and mixed methods depending on the phenomenon being investigated (David & Sutton, 2004). It can be inferred that a researcher must be meticulous in the selection of the type of methodology to use as a study's progress may be stalled due to the poor selection of a methodology (Leedy & Ormrod, 2010).

3.3 Research Paradigm

A research paradigm refers to opinions and activities which help a researcher logically see how a study unfolds (Creswell & Poth, 2018). A researcher's beliefs are grounded on ontological, epistemological, and axiological assumptions. Ontological assumptions refer to the nature of reality, which may be subjective (Woods, 2011). Ontological assumptions refer to whether the sample is a true representative of the population and whether the sampling technique chosen is the best for most population samples. Epistemological assumptions speak of the relationship between a researcher and that which is being researched. Consequently, the distance between a researcher and the researched is reduced as the researcher collaborates with the participant, depending on the environment. Epistemologically, the research assumes that the study environment is conducive and that the target population will cooperate throughout the study. Axiology speaks of values and beliefs (Okeke, 2015). Axiological assumptions are value-laden

as personal biases are inevitable in research (Goduka, 2012). The researcher remained focused on the study's aim in order not to be influenced by any beliefs and the study adopted an interpretivism paradigm.

3.3.1 Interpretivism

Woods (2011), postulates that interpretivism enables a researcher to examine a research problem from various angles since it enables the researcher to experience the world through the participants' eyes. Interpretivists are concerned in the relativist or subjective realities present in each research issue from an ontological perspective (Creswell, 2018). The subjective epistemology is the epistemological position of interpretivism.

Regarding how people comprehend phenomena, the interpretive paradigm places an emphasis on social context (Rahman, 2017) and human complexity (Saunders et al, 2019). The world is not viewed objectively by Interpretivists as people create their own realities and develop their own worlds. According to the interpretive approach, meanings are created by people when they interact with the world they are interpreting (Creswell, 2018). These realities must be comprehended to understand the world. The Interpretivists emphasizes the significance of participant subjectivity as a component of this process and seeks to develop a profound understanding of the social phenomenon under study. Participants in the study describe their experiences and beliefs in their own words. Suffice to say the interpretivism paradigm assisted the researcher to answer research questions and to engage with participants well.

3.3.2 Philosophical Assumptions

Creswell and Poth (2018, p.326) define philosophical assumptions as, stances taken by the researcher that provide direction for the study such as the researcher's view of reality (ontology), how the researcher knows reality (epistemology), the value-stance taken by the inquiry (axiology) and the procedures in the study (methodology). These assumptions, in turn, are often applied in research through the use of theories (or, as we call them, interpretive frameworks). Denzin and Lincoln (2011, p.12) state philosophy means the use of abstract ideas and beliefs that inform research. Philosophical assumptions are typically the first ideas in developing a study which helps to place philosophy and theory into perspective in the research

process. The researchers bring to the inquiry their personal history, views of themselves and others, and ethical and political issues.

Furthermore, the researcher brings to the inquiry certain theories, paradigms**,** and perspectives, a "basic set of beliefs that guides action" (Guba and Lincoln, 2012, p. 17). Huff (2009) states that philosophical assumptions shape how we formulate our problem and research questions to the study and seek information to answer those questions. These beliefs are called paradigms (Lincoln, Lynham and Guba, 2011; Mertens, 2010); philosophical assumptions, epistemologies, and ontologies, methodologies and alternative knowledge claims (Creswell, 2015).

Figure. 3.1: below shows the beliefs about:

a) Ontology - the nature of reality;
b) Epistemology - what counts as knowledge and how knowledge claims are justified?
c) Axiology - the role of values in research; and
d) Methodology - the process of research.

Figure: 3.1 below shows philosophical assumptions on ontology, epistemology, axiology and methodology by Denzin and Lincoln (2011).

Assumption	*Questions*	*Characteristics*	*Implications for Practice (Examples)*
Ontological	What is the nature of reality?	Reality is multiple as seen through many views	Researcher reports different perspectives as themes develop in the findings
Epistemological	What counts as knowledge? How are knowledge claims justified? What is the relationship between the researcher and that being researched?	Subjective evidence from participants; researcher attempts to lessen distance between himself or herself and that being researched	Researcher relies on quotes as evidence from the participant; collaborates, spends time in field with participants, and becomes an "insider"
Axiological	What is the role of values?	Researcher acknowledges that research is value-laden and that biases are present	Researcher openly discusses values that shape the narrative and includes his or her own interpretation in conjunction with the interpretations of participants
Methodological	What is the process of research? What is the language of research?	Researcher uses inductive logic, studies the topic within its context, and uses an emerging design	Researcher works with particulars (details) before generalizations, describes in detail the context of the study, and continually revises questions from experiences in the field

Figure: 3.1 Philosophical Assumptions Adopted from Denzin and Lincoln (2011).

Creswell (2015, p.6) uses the term "worldview" to describe the "general orientation about the world and the nature of the research that the researcher holds". He points out that this encompasses "what others have called" paradigms, epistemology, ontology and methodology. The philosophical assumption adopted in this study is closely social constructivist worldview. In a social constructivist worldview, the objective of research "is to rely as much as possible on the participants' view of the situation being studied," (Creswell 2015, p.9). The meaning inherent in a particular situation is commonly determined through interaction with other persons. In this worldview, the generation of meaning is invariably social and results from "interaction with a human community". The researcher found the use of Open Distance e-

Learning to support Life Sciences teachers in the use of visual model to teach genetics very closely linked to the social constructivist view of the world.

3.3.3 Ontological Assumptions

Ontology is defined by Creswell and Poth (2018, p.325) as "a philosophical assumption about the nature of reality. It addresses this question: When is something real? The answer provided is that something real in qualitative research when constructed in the minds of the actors involved in the situation. Thus, reality is not "out there" apart from the mind of actors (Guba and Lincoln, 1988). Ontology is concerned with the nature of reality and what there is need to know about the world. Key ontological questions concern whether or not there is social reality that exists independently of human conceptions and interpretations and, closely related to this, whether there is shared social reality or only multiple, context-specific ones (Ritchie, Lewis, Nicholls and Ormston, 2013).

Ontology is the reality of the nature of social beings (Scotland, 2012). An ontological understanding points to reality as inter-subjective and is constructed on understandings and meanings developed on the social and observational levels (Mertens, 2014; Leah, 2018). In terms of ontology, reality cannot exist in a single form but in multiple realities (Mertens, 2014). This means that reality is seen through and becomes relevant in an individual's eyes within a particular case (Pizam and Mansfeld, 2009). Thus, in this study, reality may be referred to as the expression of what happens in the day-to-day teaching of learners in Life Sciences (Goduka, 2012).

Ontology may be defined as a researcher's view of reality. This refers to the consideration of the form and nature of reality: Ontology answers a question of what reality is. If 'real' world is assumed, then consideration is given to whether 'real' existence and 'real' action is admissible. Ontology, therefore, considers the relationship between real existence and real action (Nyamayedenga, 2018). According to Mack (2010) and Nyamayedenga (2018), ontological assumptions of interpretivism imply that social reality is interpreted differently by different people from different cultural contexts.

Ontology contracts with the connection that exists between shared and natural entities (Bryman, 2008; Nyamayedenga, 2018). Also, Nyamayedenga (2018) claim that ontology, which is linked to constructivism, is about participants' awareness and activities. Ontology,

therefore, holds two positions, namely, objectivism and constructivism. In this study, the researcher took a social constructivist ontological posture which aligned with an interpretivist paradigm. This assisted the researcher to understand how participants created their knowledge about the use of WhatsApp in their day-to-day lives. This position is in contrast with objectivism which assumes that researchers have no influence on a social phenomenon under study (Nyamayedanga 2018). As such, it rejects the notion that an objective reality, that can be known, exists (Nyamayedenga, 2018).

A constructivist ontology embraces the notion that researchers guided by the interpretivist and the constructivist paradigms comprehend the world by interpretations of what they observe. In this study, these interpretations were focused on how participants may be influenced by the use of Open Distance e-Learning to support Life Sciences teachers in the use of visual models to teach genetics.

According to Nyamayedenga (2018), ontology deals with questions about what exists in the real world, how it is acted out and how others respond to it. Constructivist ontology believes that reality is socially constructed and exists in multiple mental constructions dependent on time and context and may be in conflict with each other (Mertens, 2010; 2014; Nyamayedenga, 2018).

As the researcher collected data in this study, the researcher took cognisance of the fact that participants from the OR Tambo Coastal District in the Eastern Cape may respond to the interview questions and questionnaires through different instructional methods, depending on their contextual understanding. Although the researcher believed that the use of Open Distance e-Learning supports Life Sciences teachers in the use of visual model to teach genetics were expected to have a full understanding of how to structure their teaching and learning, the researcher understood that learners view reality in diverse ways. As a result, the researcher entered participants' classrooms with pure consideration that Open Distance e-Learning supports Life Sciences teachers in the use of visual model to teach genetics. Teachers and learners may vary from school to school and from learner to learner since their realities are subjective and may not be the same (Mertens 2014; Nyamayedenga, 2018). Therefore, the researcher tried to comprehend participants' multiple social constructions of meaning and knowledge.

3.3.4 Epistemological Assumptions

Creswell and Poth (2018. p.324) define epistemological assumption as "a qualitative research which addresses the relationship between the researcher and that being studied as interrelated, not independent". More so, epistemology is concerned with ways of knowing and learning about the world and focuses on issues such as how we can learn about reality and what forms the basis of our knowledge (Ritchie, Lewis, Nicholls and Ormston, 2013). Epistemology is seen as the researcher's view of how knowledge is acquired. It refers to considering the nature of the relationship between the knower and the known: What it means to claim that something exists and so it must be known; how to know something. If reality is assumed, then the knower must be objective and detached in order to discover that reality and know how things really work (Nkonki, 2009). Epistemology allows for the most advantageous ways to study humankind and social reality (Battacharjea, 2012). As a result, the researcher aimed to gain an understanding of the of Open Distance e-Learning to support Life Sciences teachers in the use of visual models to teach genetics through participants' points of view (Scotland, 2012; Nieuwenhuis, 2016).

Epistemological considerations require researchers to reveal the issue of how the social world should be studied and whether a scientific approach is the right approach to adopt (Bryman, 2012; Nyamayedenga, 2018). More so, Nyamayedenga (2018) view epistemological issues as assumptions that answer questions such as what things exist in the world, how we can know certain things and what can be regarded as genuine knowledge. Epistemology considerations influence how researchers interpret knowledge, whether knowledge exists, and how it connects to human beliefs and cultural values. This study was aligned with the belief that teachers construct their own knowledge from what they use through their day-to-day understanding of life, which may influence and may have an impact in their lives. The use of Open Distance e-Learning to support Life Sciences teachers may be viewed as a day-to-day life style.

The epistemological belief of interpretivism is that participants and researchers are constructors of new knowledge; therefore, the researcher ensured that she created a relationship with the participants through the interview questions which were held in conducive environment to understand their context (Thomas, 2009; 2013; Nyamayedenga, 2018). The researcher embraced the view that participants were individuals with feelings, understandings and prior

knowledge of their life understanding within their learning environment that they had full control over.

3.3.5 Axiological Assumptions

Okeke (2015, p.24) states that "axiological assumption relates to values, value judgements and ethics. Positivist axiology stipulates that observable facts are distinct from personal ideas and values. Thus, the positivist researcher is enjoined by axiology to keep personal values out of the study. This, the positivist will accomplish by entirely omitting statements about values from a written report, using impersonal language, and reporting the facts, arguing closely from the evidence gathered in the study. On the other hand, interpretivists consider it ambitious to claim that a researcher can be impartial, objective, and neutral. Axiological assumption characterizes qualitative research. How does the researcher implement this assumption in practice? In a qualitative study, the inquirers admit the value-laden nature of the study and actively report their values and biases as well as the value-laden nature of information gathered from the field. We say that they "position themselves" in a study. In an interpretive biography, for example, the researcher's presence is apparent in the text, and the author admits that stories voiced represent an interpretation and presentation of the author as much as the subject of the study (Denzin and Lincoln, 2011)

3.4 Different Research Methodologies

Different research methodologies include quantitative, qualitative and mixed methods (Creswell, 2013). According to Mamba (2012), research methods complement each other, especially where there are emergent issues. In this study, the researcher adopted a qualitative approach.

3.4.1 Qualitative Research Approach

Rahman (2017) refers to qualitative research as a discipline of finding important meaning in society and not outside the community. Creswell (2018) explains that qualitative research, *inter alia*, presumes the approval of a precise set of morals and is characterized by beliefs that the portions of a phenomenon are intricately intertwined, so the nexus cannot be easily defined. The qualitative research approach requires that a researcher be a participant in the research to understand what participants say or do (Woods, 2011). Qualitative research methods' power

varies in many ways. For this current study, the researcher used qualitative research to gather rich data in an effective and efficient method (Corbin & Strauss, 2014). I preferred this design so participants would not be limited to points on concrete questions but answer emergent issues that arose for more detailed information on the matter being investigated. Additionally, when a researcher uses qualitative research methods, one can construct a novel theory premised on the study's findings (Cohen, Manion & Morrison, 2018). Generating a new theory is one key component of qualitative research methods which is not found in other research methods like quantitative research methods (Corbin & Strauss, 2014).

Drawbacks of the qualitative research method include self-bias which compromises the quality of study results (Cohen, Manion & Morrison, 2018). Moreover, qualitative research may be expensive as a researcher may engage participants more times than intended in search of the truth since qualitative truth is subjective (Creswell, 2018). Suffice it to say, the use of the qualitative method was appropriate for this study. Questionnaires and interviews were used for data gathering in this study for the qualitative research approach.

Creswell (2014) claims that qualitative research is an exploratory technique that emphasizes words rather than quantitative in data collection and analysis. The main stresses of the qualitative research methodology are to view the world through the eyes of the examinees, to describe and take into account the context, to emphasize the process rather than just the results, to be adaptable, and to develop concepts and theories as outcomes of the research process (Bryman, 2017). As observed by Opie (2004), in a qualitative research methodology data are gathered more in a verbal and visual than in a numeric form. When analysing the gathered data, statistical procedures are also not used, but instead predominantly qualitative analysis, the essence of which is searching for codes in the analysed materials (Bryman, 2017). Charmaz (2006) asserts that the coding process forms the main part of the qualitative analysis of the material. According to Bryman (2017), a qualitative analysis of the data should begin with identifying the coding units, then selecting the relevant phenomenon recordings based on our assessment and analyzing the traits of these phenomena. Creswell (2014) claims that qualitative research is an exploratory technique that emphasizes words rather than quantitative in data collection and analysis. The main stresses of the qualitative research methodology are to view the world through the eyes of the examinees, to describe and take into account the context, to emphasize the process rather than just the results, to be

adaptable, and to develop concepts and theories as outcomes of the research process (Bryman, 2017

3.4.2 Quantitative Research Approach

The quantitative research approach stresses concrete amounts and the use of mathematical analysis for a study (Ranjit, 2014). Key categories of quantitative research include descriptive, correlational, causal-comparative, and experimental research (Woods, 2011). Gathered data when using a quantitative research approach can be generalized in a study (Creswell, 2018).

3.4.3 Mixed Research Approach

The mixed research approach integrates components of qualitative and quantitative data gathering as well as data scrutiny in a particular study (McMillan & Schumacher, 2010). Johnson, Onwuegbuzie and Turner (2007) in Mpeta (2013) indicate that the mixed-method approach offers better comprehension of a research problem. The mixed method approach also increases the correctness of gathered data compared to the use of a single research method (Creswell, 2018). Ivankova (2006) in Shorten and Smith (2017) postulates that a mixed methods approach needs a focused mixing of methods in gathering and analysis of data as well as its interpretation.

3.5 Research Design and Justification

Research design and justification are essential elements of a study as the components guide a study's direction (Islamia 2016). It can be opined that when a research design is penned out correctly, its implementation may not be difficult as a researcher can answer research questions (Woods, 2011). Creswell (2018) posits that a research design enables a researcher to have some contingency in case of emergent cases in the process of data gathering. The researcher adopted a phenomenological qualitative design as well as a case study. In gathering data, the researcher conducted interviews and used electronic mail and telephonic tools. Any emergent issues for the qualitative data were considered as part of the study (Saunders et al, 2019). Woods (2011) put forward, for example, that among a subset of mixed method research design, sequential mixed design is extensively used in research, this concurs with Hanson, Petska, Creswell and Creswell (2005). The researcher used the phenomenological method design.

Phenomenological studies examine human experiences through descriptions provided by participants (Rahman, 2017). These experiences are called lived experiences. The objective of phenomenological studies is to define the meaning that experiences hold for each subject. In phenomenological research, participants are asked to describe their experiences as they perceive them. They may write about their experiences, but the information is generally obtained through interviews. To understand the lived experience from the vantage point of the subject, the researcher must consider her or his own beliefs and feeling. The researcher must first identify what she or he expects to discover and then deliberately put aside these ideas; this process is called bracketing. Only when the researcher puts aside her or his ideas about the phenomenon is it possible to see the experience from the eyes of the person who has lived the experience.

Phenomenological research would ask a question such as, “What is it like for a mother to live with a teenage child who is dying of cancer?” The researcher might perceive that she, herself, would feel very hopeless and frightened. These feelings would need to be identified and then put aside to listen to what the mother is saying about how she is living through this experience. This mother may have discovered an important reason for living, whereas previously she had not felt needed anymore by her teenage child (Wood, 2011).

The justification of phenomenological studies is grounded on observations that help in interaction among respondents, as the respondents depend on the comments, perceptions, views, opinions, and ideas of people (Rahman, 2017). Moreover, phenomenological studies involve respondents more than in a structured survey as it uses dynamic processes such as interviews and group discussions. The opportunity to probe allows a researcher to determine more than just initial responses and rationales (Saunders et al, 2019). Observation, recording and interpretation of non-verbal communication, play an integral role during interviews and discussions. Furthermore, phenomenological studies also help to overcome self-consciousness that can prevent impulsive reactions and responses. Suffice it to say, the qualitative research method is specifically designed to uncover a target audience’s behaviour and its connection to a particular topic or issue. It uses in-depth analysis of small groups of people for building theories. The results of qualitative research are not predictive, but descriptive. The researcher was able to answer research questions using this approach.

The researcher adopted a case study design as well. A case study is a qualitative research method that uses a variety of data collection techniques to provide a thorough evaluation of a particular occurrence (Woods, 2011). A case is a single element of a study that might be either a person or an organization. A community or a collection of people can also be a case. Nonetheless, there are times when researchers conduct multiple case studies to provide better support for their conclusions following comparison. The statement stated by Creswell (2018) that the term "case study" might apply to more than one case study of many cases supports the observations. Small is defined by Corbin and Strauss (2014) as a study's total cases being no more than four or five. The preservation of a study's credibility, transferability, confidentiality, and trustworthiness in research is ensured by focusing on small figures. Cohen, Manion, and Morrison (2018) point out that only a total of 40 to 50 people can be considered to be separate cases. With the use of diverse data sources and several perspectives, a qualitative case study is a research methodology that aids in the analysis of a phenomenon within a specific context and reveals the phenomenon's many dimensions (Rahman, 2017). Case studies are one of the methods that are widely utilized in qualitative research (Kumar, 2014). The lack of well-structured and fully defined protocols, however, means that it still does not hold a legitimate position as a social science research strategy. As a result, inexperienced researchers who intend to use this methodology frequently become perplexed about what a case study actually is and how it differs from other kinds of qualitative research methodologies (Saunders et al, 2019).

3.6 Population and Sampling

This section discusses the population and sampling for this current study.

3.6.1 Population

Population is explained by Simon and Goes (2012) as a group of persons or objects with similar features. Similar features of a population allow a researcher to make conclusions on investigations being conducted as data and any other parameters of interest can be collected and scrutinized (Alvi, 2016). In agreeing with Simon and Goes (2012), Babbie (2007) defines a population as individuals with some acumen of some sort needed for a study. Litchman, (2011) and McMillan and Schumacher (2012) buttress the definitions alluded to by indicating that a population consists of individuals or groups with identifiable common characteristics.

Life Sciences teachers teaching Grade 12 students in OR Tambo Coastal District in the Eastern Cape Province of South Africa were selected for the study.

3.6.2 Sampling

Sampling is a procedure for choosing participants from a target population for a study (Gerrish & Lacey, 2010). Sampling is essential in a study as it enables a researcher to deal with a portion of the population, manage budgetary constraints as well as reduce errors (Field, 2007). Three male participants and two female participants with open-distance e-learning backgrounds were chosen for the inquiry.

3.6.3 Purposive Sampling

Purposive sampling is defined by Creswell (2018) as a form of non-probability sampling wherein researchers depend on personal conclusions while selecting a portion of the populace to be research participants. Purposive sampling comprises choosing of participants with some background in the research (Lodico, Spaulding & Voegtle, 2010).

Three male participants and two female participants with open distance e-learning backgrounds were chosen for the study. The choice of purposive sampling was informed by the research's objective to explore the effects of open distance e-learning to support Life Sciences teachers in the use of visual models to teach genetics in a Grade 12 class in Oliver Reginald Tambo Coastal District. Therefore, participants were viewed as knowledgeable in the area being studied. A small sample size was considered adequate for the study, as observed by Mangan (2019) and Saunders (2012) who postulate that a minimum sample size of about 5 to 25 for semi-structured interviews is adequate.

3.7 Data Collection Procedure

The data collection procedure refers to logical and scientific data gathering (Ranjit, 2014). During the collection of data from participants, the researcher first conducted a pilot study and created a good relationship with the participants. During the pilot study, the researcher explained all ethical considerations in English and used the local language where further clarity was required. Participants were also informed that the study was for academic purposes only.

Due to the coronavirus pandemic protocol adherence, the researcher further engaged participants by using her mobile telephone or electronic mail.

As pre-arranged, the researcher-initiated cell phone conversations when gathering data from participants. The researcher re-introduced herself to all participants using her name after which greetings were exchanged. Having selected an appropriate research instrument, the researcher asked questions to participants based on the research instrument. The researcher managed the interview purpose and gave each participant 30 minutes to answer questions, and participants were allowed to ask questions for clarity. When questions on the research instrument were exhausted, the researcher terminated conversations with participants.

3.7.1 Data Collection Instruments

Data collection tools employed in this inquiry included telephonic interviews and questionnaires. The use of the two instruments enabled the researcher to triangulate data. Easily understood language was employed in the construction of these tools so participants do not struggle when answering questions. The researcher, in adhering to research requirements, asked a single question per phenomenon, and participants were given the right to ask questions where there were doubts. Questions were asked for clarification only.

3.7.2 Telephonic Interviews

Telephonic interviews were essential for data gathering due to the eruption of the coronavirus, and national coronavirus protocols had to be followed. Telephonic interviews do not offset the budget so much and also save time as information is exchanged instantly (Cohen, Manion & Morrison, 2018). Furthermore, using telephonic interviews cuts travel costs, food and accommodation in some instances (Woods, 2011). However, telephonic interviews have drawbacks as the interviewer is unable to view the facial expressions of a participant. Facial expressions help in understanding how a participant may be affected by the subject matter emotionally or psychologically (Bada & Olusegun, 2015). The researcher faced difficulties in conducting interviews using a mobile telephone due to poor connectivity. However, on some days, connectivity was good. Literature review, however, shows that telephonic interviews are important where some areas cannot be reached physically due to shocks like cyclones (UNESCO, 2017).

The researcher personally carried out interviews following her instrument layout. Telephone interviews had scheduled dates and times for each participant. The researcher thus initiated calls and confirmed connectivity as well as the clearness of the audio after interviews were carried out. A questionnaire, according to Creswell (2013), is a data-gathering instrument about a particular phenomenon of interest (Cohen, Manion & Morrison, 2018). The questionnaire was made up of a list of open-ended questions (Woods, 2011) and closed questions. The questionnaire also included unambiguous instructions and spaces for answers or administrative details related to the research. The study employed exploratory questionnaires for data gathering from participants (Corbin & Strauss, 2014). A total of 8 open-ended questions were asked, and the researcher self-administered questionnaires to exclude bias, among other issues.

Questionnaire advantages are that a questionnaire can gather data from large demographics using minimum budgetary costs as questionnaires may also be administered through the internet or telephonically (Woods, 2011). However, questionnaire disadvantages include poor response rates at times since a researcher cannot compel participants to complete a questionnaire (Creswell, 2013). In this study, the researcher depended on questionnaires that were returned by participants.

3.8 Trustworthiness of Research

Trustworthiness of research implies the examination of the logical process employed for reaching essential elements of trustworthiness (Dahlia, Remler & Van (2014). Fundamental elements of trustworthiness are *inter alia*, constancy, believability, and conformability of data. The researcher had to double-check her gathered data for authenticity, and this gave credence to the study. To ensure that trustworthiness was achieved, the researcher requested all participants to check gathered data with her to be assured of the gathered data's authenticity (Wood, 2011).

Credibility is seen as an essential component of trustworthiness. Credibility, as an important component of trustworthiness, is often used to establish the genuineness of a research's findings (Dahlia, Remler & Van, 2014). The researcher had to employ the member-checking method in a bid to achieve trustworthiness. The member-checking method is a procedure

whereby a researcher shares field notes with participants. In so doing, a researcher allowed participants to double-check the authenticity of gathered data.

3.9 Clearance and Permission to Conduct a Study

Clearance and permission to conduct a study are important before any study is carried out as such permission gives credence to a study. Creswell (2018) states that before conducting the study, one should gain local access permission. Permission to conduct research was granted by the Eastern Cape Department of Education, which targeted high schools and gatekeepers. The researcher personally administered the requests to carry out a study.

3.9.1 Ethical Considerations

Ethics refers to what is wrong or right. As such, it is important for a researcher to adhere to principles of human rights and astute conduct in all phases of a study, and even well after.

3.9.2 Confidentiality

Confidentiality is defined by Woods (2011) as the safeguarding of data. This implies that good rapport is established between a researcher and those being researched to establish trust. Furthermore, safeguarding data ensures that there are no litigations during and after the end of the study (Henning, Rensburg & Smith, 2011). McMillan and Schumacher (2006) indicate that a researcher must protect data, including that of participants. The researcher ensured that data was safeguarded using codes and pseudonyms and that gathered data was only accessible to participants and herself. Any data released for public consumption would also have been authorized by participants.

3.9. 3 Right of Participation

Right of participation implies that a participant has an option to participate or not participate in a study (Creswell, 2018). The right to participation was explained to all participants in English and the local language. Importantly, the researcher explained that optionally, participants had the right to stop participating in the inquiry whenever they felt like it. The researcher also explained that participation was voluntary, and there were no rewards or monetary incentives for participation.

3.9.4 Informed Consent

Informed consent calls for a researcher to educate all participants regarding their role in a study (Woods, 2011). The researcher made all efforts possible to ensure that participants were supplied with all relevant information about how the study was going to unfold, and the study's objectives and informed them that the study was purely academic (Bruce, 2016). Every participant must understand and sign a consent sheet (Ranjit, 2014). Every participant was given a participant information sheet written in simple language and where there were doubts, issues were ironed out immediately by engaging the participants and reaching amicable solutions.

3.9.5 Anonymity

Anonymity means that the identity of anything remains unknown (Ranjit, 2014). The researcher made use of codes to ensure that participants' identities were not associated with the study or target area. Besides, the researcher ensured that data was safeguarded by securing all data in a locked cupboard. Any data stored in the mobile cellular telephone was only accessible to the researcher as she was the only one who knew the mobile cellular telephone's access code.

3.9.6 Violation of Privacy

Privacy is a component of individual concealment (Bruce, 2015; Maree, 2014). The researcher explained to participants that all gathered data or information related to the study would be treated with the uttermost confidentiality. Furthermore, no information was going to be made public without the participants' consent. The researcher also explained to participants that the participants were at liberty not to answer any questions that participants were not comfortable with. In summing up the aspects of privacy, the researcher informed the participants that all their rights were going to be respected.

3.10 Summary of the Chapter

This chapter presented detailed information about the methodology employed, and the research paradigm and justified the choice of qualitative research for this current study. This chapter further gave an outline of population and sampling and gave a detailed account of data

collection instruments, discussed validity, reliability and trustworthiness. Ethical consideration was detailed in this chapter.

The next, Chapter 4 will present findings and data analysis.

CHAPTER 4

RESULTS PRESENTATION

4.1 Introduction

The present research investigated the use of open distance e-learning to support Life Sciences teachers in the use of visual models to teach genetics. In this chapter, the results are presented, as developed from both quantitative and qualitative data analyses. These results strive to answer the research questions, detailed in Chapter 1 as:

4.2 Main Research Question

What are Life Sciences teachers' perceptions of the use of ODeL to support them to use visual models in teaching genetics? The main research question was divided into sub-research questions as:

(i) How could open distance e-learning be used to support Life Sciences teachers in the use of visual models to teach genetics?

(ii) How effective is ODeL in supporting Life Sciences teachers in the use of visual models to teach genetics?

(iii) What is the effect of the use of open distance e-learning to support Life Sciences teachers on teacher effectiveness and preparedness?

The present research engaged a qualitative method of which according to Holliday (2007) assets that qualitative research puts emphasise upon exploring and understanding the meaning individuals or group ascribe to a social or human problem. Denzin and Lincoln (2005) describe this approach as gaining perspective of issues from investigating them in their own specific context and the meaning that individuals bring to them. The emphasis of qualitative research is on drawing meaning from participant's experiences and opinions.

To answer the set research question (i) from Chapter 1, this study presents the data below.

4.3 Biographic information of participants

This section discusses data collection done for this study.

4.4 Participant Perceptions on Fitness to Use ODeL for Teaching Life Sciences

The fitness of the ODeL for teaching of life Sciences, according to the participants it is fit. They agreed that for its to remain relevant Life Sciences must be experienced in life of the students. A participants stated that, "*In Life Sciences, as the subject suggests Life Sciences learners need to relate what they learn in class to the environment and the society because some of the things they learn, they find them, they are really in society.* In addition, a participant said, "*as long as it is done effectively in such a way that learners understand the concept being taught".* Its fitness was more relevant in the COVID19 period since classes were interrupted and the only alternative to curtail the situation was the use of online classes in the form of Open Distance e-Learning. To affirm this, a report from a participant was that *"as we are faced with this pandemic disease COVID-19, immediately when you introduce them to electronic learning it will be very easy, and learning will continue without any hustles and less spreading of the disease. For learners to understand a variety of teaching methods to be used*". However, it could be emphasized that this means of teaching and learning has got a limitation in terms of practicals. Participant has this to say, "*theory can be taught using electronic ways, but not the practical part".* This was a confirmation of the fact that ODeL was the most fit alternative for progressive learning.

4.4.1 Teacher Views on the Use of ODeL for Improving Teachers' Content Understanding

The question with regards ODeL for the improvement of teachers' content understanding, all the respondents expressed their agreement on its usefulness. It was stressed that; it encourages active involvement of teachers since much responsibility is on the individual teacher for the acquisition of the content of life sciences. To illustrate the view on this content understanding, one of the participants has this to say "*the use of different mode of learning like e-learning is very good since the teachers have basic knowledge and are further exposed to the content to deepened it".* To affirm this view another participant indicated that, ". *I strongly agree with the question, it's an extension of actual learning from classrooms to home. Learning becomes a continuous and every minute process which makes it an advantage not to forget the process."*

It could be said that content understanding of teachers can be improved with the use of ODeL in the teaching of Life Sciences.

4.4.2 ODeL Improves Teaching Methods

In an answer to the improvement of teaching methods using ODeL, the participants indicated that it is useful as it varies the various ways students acquire knowledge. It integrates the environment in the learning process that enhances the relevance and the meaningfulness of the teaching. To illuminate in these views one of the participants presented that "*There are some which give learners room to discover their methods of learning. They can develop their methods from the environment home to classrooms.* However, some of the participants emphasized that it may not completely suit every condition since Life Sciences also involves experiment and practical activities aside the traditional methods like questions and answers. A participant expressed that "*I think this approach is okay although teachers vary in teaching. Others use experiments, questions and answers and explaining and that different teaching techniques and methods are used by different teachers which may not be suitable for ODeL.* To this end, it could be said that although ODeL can improve and vary teaching methods, it is limited to practical and experimental lessons.

4.5 Effect of Use of ODeL in Supporting Life Sciences Teachers' Effectiveness and Preparedness

4.5.1 Responses on ODeL Resources Improving Content Understanding

Concerning the ODeL resources improvement of content understanding, it was revealed that, the resources can encourage the improvement of content understanding as indicated by the participants. This is exemplified by a participant's statement as "*I will use ODeL to understand the content which will enable me give the content of reality".* In addition, it was stressed that e-learning is supportive as it makes teachers becomes abreast with the current issues of the subject, Life Sciences. In an agreement with the statement, another participant stated that "*although teachers already know, in this era, there is nothing wrong with going digital and checking on the web to improve, see the latest information that will help to improve the content of the subject*". It can be concluded that, e-learning resources are useful in the enrichment of the Life Sciences content understanding.

4.5.2 ODeL Resources Improve Teaching Methods

In response to the statement on e-learning resources improvement of teaching methods, participants expressed their agreement that it enables them to remain relevance in terms of the teaching techniques and methods of the subject in question. For instances a participant stated that, "*due to the changes in times, it is advisable to use new teaching methods than the old traditional teaching methods*." Again, to reinforce this view, another participant said "*You realize that in classrooms we are limited to textbooks, so in using ODeL, the internet, there are many sources we use online. Thus, we move away from the traditional way of teaching using the textbooks only*". On this note, ODeL has become more relevant not just an alternative method of teaching but improves the existing methods of teaching.

4.5.3 Skills to Use ODeL Resources for Teaching Life Sciences

With regards to the possession of necessary skills to the use of ODeL resources in the teaching of Life Sciences, some of the participants indicated that they were equipped with the skills whiles others expressed their inadequacy of these needed skills. A report from a participant is that "*I have the necessary skills because I have improved myself on the use of the internet and the use of computers.* On the side of the participant who was less skilled in ODeL resources stated that *"It is still work in progress. I can't say I'm very much skilled in using modern resources*." It could be concluded that while some are equipped with necessary skills in dealing with ODeL resources, others are less equipped, and they are still struggling in the use of these resources.

4.5.4 Availability of Technology Necessary to Use ODeL Resources in Life Sciences

It was revealed that, some of the participants have the technological resources and therefore making use of them while others expressed lack of those resources to facilitate their usage and enhance teaching of the subject. A participant reported with regards to availability of the resources by saying "*90 percent of learners, the current learners now have cell phones, they have smartphones and also we are provided with laptops so I can connect all of my learners through my laptop and the learning can take place. We use YouTube, Facebook and other sources besides, the zoom method".* However, a participant said *"I don't have all the technology, all I have is my computer and my tablet". "I need more",* in response to the

availability of resources. To this extend, it can be said that, while some teachers have the technological resources available for ODeL others do not have.

4.5.5 Sufficiency of Time to Use ODeL Resources when Teaching Life Sciences

Concerning time and its sufficiency, the participants reported that, although the time was sufficient, network also interfered with teaching in the use of the various resources. A report from a participant is that "*time is more than sufficient because it can happen at any time. It is unlike in class where you know that it's between 9:00 to 10:00 for Life Sciences meaning it can happen at any time".* Another participant's experience is that *"network is a problem".* It can be said that, although teaching and learning using ODeL encourage meaningful usage of time, network can have an obstructing effect on the process.

4.5.6 Teachers' Level of Preparedness when Teaching Grade 12 Students Genetics

The question on their preparedness in the teaching of genetics, all the teachers reported that they are always prepared before the lessons. In line with this, a participant stated that, "*Yes, before going for a lesson, I always make sure that my preparation book is ready and I have thoroughly planned for my lessons".* In addition, "*it is a requirement that a teacher should prepare before going to class".* In an emphasis to the need for preparedness, another one stated that "*Yes, l always gives genetics problems before I go to class and have my answers ready with me and l prepare enough question papers to supply my students.* In addition, the participant said, "*knowledge is a continuous process, we need to prepare since you can never know, you can't say you know everything, so you need to prepare".* From these reports, the conclusion is that they prepare before delivery of their lessons which therefore explains that preparation is a prerequisite for a successful lesson especially genetics.

4.5.7 Level of Students' Understanding of Genetics in Grade 12

With regards to the students understanding of genetics, some of the participants reported positively on the understanding of students on genetics while other indicated that the topic is challenging resulting from it abstract nature. On the students understanding, it was stated that "*Yes, this is because after teaching the concept, students write exercises and tests and on average, they pass" report from a participant.* Accordingly, the report from another

participant says, "*Yes, they do understand it better because since I am not the only teacher for Life Sciences even if l am facing problems on the topic, I always get help.* While some reported on better understanding of the topic when students are taught, others reported that genetics remains a challenging topic which pose some difficulties when being taught. A participant stated that *"Not all of them, as the topic of genetics is challenging, from my experience l have realized that the topic is too abstract for them, and they are starting genetics for the first time in Grade 12.* To this extend it be concluded that, there is some degree of understanding from the students on the topic, but the topic remains a challenge due to its abstract nature.

4.5.8 Experiences of Using Visual Models in Teaching Genetics in Grade 12

On the use of visual models in teaching genetics the report was that they are useful in simplifying the understand of the topic. In an illustration of this reality the participant said "*Yes, when I was introducing the topic genetics to learners, I used an overhead projector as well as a chart of models for the students to see.* This implies that using these models they enable reduce the lesson from abstract to semi concrete state and ease their understanding on the topic. Another participant affirms that *"Yes, especially when I am introducing the topic like types of variation. I have used the learners themselves; the complexion of their family members, height, ability to roll their tongue and size of their fingers".* Visual models are not just important but necessary in the teaching of the topic, genetics for its better understanding.

4.5.9 Relevance of Visual Models to Teach Genetics in Grade 12

The relevant of visual model to teach genetics in grade 12 was reported that, since they can see models or pictures and other teaching aids they quicken their understanding of the topic especially genetics. Statements from a participant in an affirmation of this reality is, "*That is a no-brainer, using visual aids assists learners to understand better. It is the best way to go. My learner understands better when I use visual materials than when I just explain abstract concepts. Every teacher who wants to be a good teacher must use visual aids.*" To agree with these statements, a participant said "*"Yes, since l used that method, it improved my grade 12 results. Learners learn easier by seeing. If they see a concept they quickly understand, and they can analyze*". These presentations indicate the absolute relevance of visual models to bridging the gap from abstract to reality and for better understanding by the students on the topic of genetics.

4.5.10 Availability of any Visual Models to Teach Genetics at School

The question on availability of visual models in the teaching of genetics revealed that almost all the participants have a number of them with exception of one school where it was reported that models were lacking. A participant indicated in an answer to the question, *"Yes, my school does have quite a number of these visual models and not for genetics only but other areas as well*." Besides, another participant said, "*Yes, we have some contents sent to us teachers. We at times use PowerPoint to show these learners. At the same time, our grade 12 learners have tablets with loaded content.* This indicates that, they integrate information communication and technology in their teaching to creating better understanding of the topic. However, one participant reported on lack of such models and tools in their school by simply saying "*We don't have."* The revelation here is that most schools have some of the models while few do not have. Again, even those who claimed they have some of the visual aids they are not mainly for genetics but for other Life Sciences topics.

4.5.11 Effect of COVID-19 on Teaching of Life Sciences

Participants responds to the effect of COVID19 on the teaching and learning of Life Sciences was that it negatively affected the teaching process on the greater scale. The purpose of this question way to establish the role ODeL plays as a way forward to the teaching and learning of the subject. The negative effect to the COVID19 is affirmed by a participant saying "*The actual content coverage is not attained in all the grades, especially, grades Grade 10 and 11 as well as Natural Sciences in Grade 8 and 9.* In addition it was reported that*, most practical experiments are usually done in groups and were restricted due to social distancing that needed to be observed*." In summary, the effect of COVID19 was felt massively ranging from time factor, incompleteness of content, the relevance of group work just to mention a few as a practical oriented subject.

4.5.12 The Challenges of Teaching Life Sciences Online During COVID19

Concerning the challenges of teaching Life Sciences online during COVID 19, it was reported that there were problems which impeded the delivery of lessons. In an affirmation to this result a participant said, "*The protocols of this pandemic are such that there must be no gatherings, no sharing utensils including papers, pens without sanitizing". Again, another participant*

reechoed the statement in the previous question in respond to this question by saying, most practical activities are usually done in groups but social distancing restricted". According to some of the participants some lessons were being conducted online as an alternative means of lesson delivery. This was said by a participant, "This has compelled visual meetings or teleconference kind of communication. Digital use of IT has taken everything by storm everywhere due to COVID-19". Finally, it can be said that, as a practical subject, the sharing of tools, working in groups, continues sanitization, the limited of students at a time were some of the problems encountered as dictated by COVID19 protocols.

4.6 Summary of this Chapter

This chapter focus is on the analysis of the data collected from the participants. The purpose of this analysis was to examine the use of open distance e-learning (ODeL) in the support of life sciences teachers using visual models in the teaching of genetics. Because genetics is a new topic introduced only in the grade 12 but it is assumed as an abstract topic. The findings of this study revealed that, the content understanding, and methods of teaching are improved with the use of ODeL, the methods, however, could further be explored more since its limited in terms of practical's. It was concluded that e-learning resources were useful in the enrichment of Life Sciences as other teachers remained less equipped with the necessary skills, others were struggling with the associated inadequate e-learning resources. The study also revealed that, teachers acknowledged lesson preparation as a key for a successful lesson on genetics, moreover, understanding is enriched with the use of visual models. Findings indicate that, COVID19 obviously interrupted teaching of Life Sciences. The introduction of ODeL as an alternative to reduce the effects of various COVID19 protocols was useful, however, practical lessons were massively affected.

The next, Chapter 5 will discuss findings in detail, limitations and recommendations of the study and incorporates the reviewed literature in Chapter 2 of this study.

CHAPTER 5

DISCUSSION OF RESULTS AND CONCLUSION

5.1 Introduction

Chapter 5 consists of the discussion of results, recommendations, and conclusion of this study. Discussion of the results is also guided by the research topic and focuses on how the research questions allow the emergence of new knowledge. The results are discussed through the lens of two theories that guided the present research. The core inquiry question of the research required understanding of the use of open distance e-learning to support Life Sciences teachers in visual models to teach genetics. The results that emerged from this study indicate that ODeL Life Sciences teachers need support to use a visual model to teach genetics.

5.2 Discussion of Biographic Research Findings

The main research question of the present research reads: The use of Open Distance e-Learning to support Life Sciences teachers to teach genetics using visual models. The results that emerged from this study indicates that the content understanding, and methods of teaching are improved with the use of ODeL, however, the methods could further be explored more since its limited in terms of practical's. Furthermore, the study concluded that e-learning resources were useful in the enrichment of Life Sciences as other teachers remained less equipped with the necessary skills while others were struggling with the inadequate e-learning resources.
It was concluded that e-learning resources were useful in the enrichment of Life Sciences as that contributes in students understanding. Findings indicate that, COVID19 affected the teaching of Life Sciences. The introduction of ODeL as an alternative to reduce the effects of various COVID19 protocols was useful, although, practical lessons were massively affected.

5.3 Findings that Support Literature

Results found from the data collecting instruments namely interviews and questionnaire indicate that ODeL is very effective and usefulness as it improves the teachers' content understanding and encourages their active involvement since much responsibility is on the individual teacher for the acquisition of the content of life sciences. On the improvement of teaching methods using ODeL, the participants indicated that it is useful as it varies the various ways students acquire knowledge. It integrates the environment in the learning process that

enhances the relevance and the meaningfulness of the teaching. Cohen and Arieli (2011) and Merriam (2009). The relevant of visual model to teach genetics in grade 12 was reported that, since they can see models or pictures and other teaching aids they quicken their understanding of the topic especially genetics. According to Bozdogan (2011), well-chosen and constructed visual models should grab a learner's attention and encourage them to desire to learn more about a phenomenon without incurring additional fees, especially in Open Distance e-Learning if the content is accessed online. These presentations show the absolute importance of visual models to bridging the gap from abstract to reality and for better understanding by the students on the topic of genetics.

There are different ways through which information about ODeL can reach people. In this study, participants learnt about ODeL through workshops, professional development studies, colleagues, and the Internet. All teachers, however, indicated that the textbooks they used also provided such information. The Social Constructivist Theory assumes that information is created by human beings in the processing of comprehending their phenomenology (Driscoll, 2000). Creswell et al. (2018) postulate that the aim of the Social Constructivist Theory is to have a deeper understanding of the subjective truth. Vygotsky (1978), Keiler (2012), Yasnitsky van der Veer and Ferrari (2014) and Yasnitsky (2018) indicate that children's development is defined on the social level as well as on the individual level. Vygotsky (1978) firmly believes that children's cognitive development cannot be easily understood outside scholarship.

Furthermore, according to Vygotsky (1997), Beilin (1996) and Daniels, (1996), social interaction is a bedrock for children to hone their cognitive development skills. Participants' views were sought on how COVID-19 affected the teaching and learning of Life Sciences. All participants responded that COVID-19 negatively affected teaching and learning in schools. According to Demuyakor (2020), the forced, unforeseen, and hurried change from face-to-face to digital learning with insufficient resources is, to a large extent, attributed to the poor performance of learners. Contrary to observations, Toquero (2020) argues that a new hybrid model of education has emerged as a result of the coronavirus disease, with significant benefits. The author further posits that the integration of information technology in education will be accelerated, and that online education will eventually become an integral component of any academic system. These platforms sustain open distance e-learning through the learning

process even though they may come with a disadvantage that in some quarters, quality is said to be compromised (Olcott, 2013).

In using open distance e-learning to ensure that teaching and learning were not discontinued during the COVID-19 period, some schools used the internet and made available more products but did not have online classes (United Nations Educational Scientific & Cultural Organisation, 2020). Even teachers who were unfamiliar with open distance e-learning learning were asked to prepare online content and offer online classes (Sintema, 2020).
The United Nations Educational Scientific and Cultural Organization, in encouraging countries and institutions to engage in open distance electronic acquisition of knowledge midst of coronavirus disease, produced a list although without explicit endorsement of various digital tools to ensure that no student was left behind despite some countries' lack of resources (Sintema, 2020). This is consistent with unrelated literature which posits that factors such as the deadly novel coronavirus pandemic diseases and family commitments, especially among women, have led to an increasing interest in open distance e-learning. The United Nations Educational Scientific and Cultural Organization (2020) indicates that due to archaic traditions, values and norms, some females were less capacitated to provide necessary resources in some countries. The introduction of open distance e-learning, has, however, widened opportunities for humankind and helped all and sundry to learn at their convenience while performing other duties in the changing world (Clark & Mayer, 2016).

Most participants were of the view that visual models can help improve teaching and learning during the COVID-19 pandemic. The COVID-19 pandemic has seen new dawn on electronic learning and teaching. Life Sciences teachers need to be highly supported and motivated to teach genetics using visual models so that learners may enjoy and grasp the concepts taught. Teaching and learning in a classroom is a process that requires the participation of both teachers and learners. The teaching and learning process in science classrooms is more demanding because of the nature of the subject domain (Kober, 2015). Human beings must recognize that communities are living in an age of unprecedented societal change. Technological, cultural and social upheavals have impacted humanity with regularity, radically changing the way people live, work and learn (Brindley, 2014). Risks such as pandemics and accelerating change have overtaken even the most stable global social institutions, including education.

Participants were also required to rate perceived teachers' knowledge to teach genetics. It emerged that a minority of the teachers considered themselves as having sufficient knowledge in teaching genetics while the majority felt they had adequate knowledge; one female participant said she had gained adequate knowledge in teaching genetics as she was pursuing an Honours Degree in Life Sciences to hone herself on the subject matter. This is consistent with Macqueen (2008) who states that despite genetics' importance, it is evident that other than the principled and right quandaries concerning the use of information and communication technologies in genetics, some Life Sciences teachers face challenges in comprehending fundamental genetics structures, not to mention delivering lessons on some contentious topics like organ farming or ordering of genetically perfect children by parents as well as genetic testing.

Genetics refer to the study of heredity and how qualities and characteristics are passed on (Swann, 2012). Macqueen (2008) states that Life Sciences educators may be good deliverers of genetics academics. Matthew (2011) differs from that perspective as he states that some educators seem not uncomfortable with including genetics literacy in their deliverables. Reasons proffered for such actions may include failure to fully comprehend genetics literacy, curricular restrictions as well as lack of time and resources (Cebesoy & Tekkaya, 2012).

The study also sought teachers' effectiveness and preparedness when teaching using ODeL. All participants viewed ODeL as having a positive effect on improving teachers' pedagogical content understanding. Similar findings emerged in the qualitative section when the majority view was that ODeL improves the efficiency as technology is not bound in classrooms. This is supported by Mnguni (2007) who intimates that visual models can be effective and useful when models are selected and designed properly and used accordingly. The author further articulates that the models can sometimes create challenges for teachers and students if the teacher fails to select the models properly. Mnguni, Schonborn and Anderson (2016) warn that the effectiveness of visual models as teaching and learning instruments is hindered if teachers and learners do not have important fundamental pre-requisite skills, especially in both the selection and employment of visual models.

A consistent trend of participant agreement also emerged when participants responded to the use of ODeL for teaching Life Sciences. This showed similar views in qualitative findings. For instance, one participant said, "*I think this approach is okay although teachers vary in teaching.*

Others use experiments, questions and answers and explanations". Another participant echoed, "*the fact that we are all different and we have different teaching techniques. Some teachers ought to use other methods of teaching."* This is consistent with Borgerding, Sadler and Koroly (2013) whose study revealed that some teachers are innovative and use different teaching approaches using visual models depending on the prevailing situation including learners' understanding of basic concepts of genetics.

Furthermore, to support qualitative, all participants agreed, but two participants associated the use of ODeL with improving imagination. This is in line with findings by Walker and Gleaves (2008) revealing that Life Sciences educators seem not to be geared to impart genetics literacy matters efficiently and effectively to different students. How Life Sciences teachers carry out practical matters of genetics literacy during lessons is based on philosophies, views, morals as well as individual worries. Beliefs and actions by educators have a ripple or domino effect on the learners' empirical thinking and belief in the comprehension of teaching genetics using models (Sheperd, 2013). According to Mnguni (2014), acquiring knowledge from visual models is a cognitive function that includes thinking, memory cues as well as imagining how graphic mental images are created and beliefs followed. The creation of information employing visual models poses learning difficulties for genetics learners.

5.4 Findings that Contradict Literature

Most participants indicated that they needed to be supported for ODeL in their teaching subjects and had very positive views on visual models being supported by the Department of Education in the teaching of genetics in Life Sciences. This contradicts the revelation by Turner et al. (2016) that individuals or societal socialization agents such as peers, family and other institutions like clubs influence individual students or group behaviour towards various matters in genetics literacy. It is, therefore, prudent to opine that students' understanding of genetics issues including their habit of being swayed to some extent by social agents, make genetics literacy fundamental. Besides, lack of support for Life Sciences teachers in open distance e-learning by the Department of Education, whereby principals of such teachers did not allow teachers to have study time and other resources like electronic equipment, hampers the development of teaching and learning genetics using visual models (Makoe, 2012).

This finding contradicts Brindly (2014) who points out that in-service training of teachers does not always produce the desired results. Instead, some teachers may upskill themselves in their

own time and present their new qualifications to management (Muza, 2011). However, Obiekwe and Chinwe (2012) insist that for teachers to upskill themselves, they need institutional support as resources are scarce, especially in developing countries.

5.5 Findings not Supported by Literature

Regarding the possibility of visual models being used for self-learning by Life Sciences learners, 60% of the participants positively agreed whereas 40 % were uncertain. In the qualitative section, there were mixed feelings about ODeL as a resource that improves understanding of teaching or learning content. As such, while participants were all knowledgeable about ODeL, to various extents, they were not agreeing uniformly on ODeL as a resource for improved teaching and learning. It also emerged that not all participants had very good skills to use ODeL resources for teaching as some were knowledgeable while others were learning on the ground. As such, all participants had the experience of using visual models in teaching genetics in Grade 12.

Most participants felt that the technology necessary to use ODeL resources in Life Sciences was available in schools as most learners owned cell phones. There was little mention of other school support resources such as infrastructure. This reality brings in the view of participants that it is important to utilize the resources available to improve learning. Considering that such resources are a form of home support to enhance school resources for better technological learning during this Fourth Industrial Revolution drive, schools should embrace the use of cell phones for learning. This is a digital age era, so use of visual models to teach genetics in Grade 12 was viewed as relevant and beneficial to learners.

The study also found that some participants felt there was sufficient time to use ODeL resources when teaching Life Sciences while others were not convinced. The contradictions on the issue of time are expected and based on individual experiences when using ODeL for teaching. When it came to teachers' level of preparedness when teaching Grade 12 learners genetics, I asked teachers if they were always prepared when going to class to teach genetics. All of them said they were mostly prepared when going to teach.

The level of learners' understanding of genetics in Grade 12 was not consistent among schools. There were varied responses to this statement. While other participants agreed, two participants

responded negatively, one of them said, "*Not all of them, as the topic of genetics is challenging*," while another participant indicated, "*Not all of them, from my experience I have realized that the topic is too abstract for them, and they are starting genetics for the first time in Grade 12. For fast learners, it will be easy for them to catch the concept. For the average learners, it becomes a problem, especially a format in which we give the genetic process even though they eventually catch it*." To elicit school support, I asked participants if there were any visual models to assist them when teaching genetics in Life Sciences. Responses were varied as it emerged that two other participants had almost the same models while one participant said the school had not provided any support. This exposes the differences in terms of resources in schools to support teaching.

5.6 Recommendations

The recommendations below are premised on the findings of the research.

5.6.1 Implementation by Relevant Stakeholders

Given the findings made, the study makes the following recommendations for implementation by relevant stakeholders:

Recommendation 1: More workshops should be conducted on ODeL because very few teachers know of it. As a result, there is a need for workshops on how to operate computers and address the content gap there. This should enable more exposure for teachers to current ways of teaching.

Recommendation 2: The Department of Education should support schools with visual models to enhance learners' understanding of genetics because most learners do not have a good background in the subject. This should be a good way to start enhancing the current education system.

Recommendation 3: Most classrooms are overcrowded, and that is another challenge that should be addressed. This has been a challenge for many years whereby a classroom can have more than 60 learners instead of the government recommendations of 40. This makes teaching and learning difficult.

5.6.2 Further Research Recommendations

a) A similar study may be conducted across many schools in the province to check if findings of this study may be generalized. The sample was small for this inquiry, so results cannot be generalized.
b) A larger study may be conducted within the country to check for differences in the approach to teaching Life Sciences, especially genetics. This will allow comparisons in teaching of the subjects between schools as they perform differently.
c) Instead of focusing on teachers only, it is also important to explore what students say about learning Life Sciences through ODeL. This should help to bring in learners' perceptions.

5.7 Conclusions

The study makes the following conclusions based on the findings and in line with the recommendations:

Firstly, ODeL is an attractive option mainly for mature learners as it is flexible since learners' study at their convenience. The study's findings revealed that genetics, as a subject, seems to be difficult for educators and students. The use of ODeL to support Life Science teachers in visual models to teach genetics is important.

Secondly, teaching of genetics using visual models is increasing, globally, as models make comprehending a certain field or phenomenon of information relatively lighter as it is a graphical subject manifestation. Models are pictorial and positive aids that reflect key concepts as well as mutations in a procedure. This infers that, in the teaching process, pictorials offer precise and valuable depictions of desirable information in solving difficulties in certain fields or phenomena.

The study concludes that ODeL Life Sciences teachers gained more knowledge and skills on the use of visual models to teach genetics although they felt that there was need for upgrading their skills. Furthermore, ODeL Life Sciences teachers felt they needed more support in terms

of training resources as well as time. ODeL Life Sciences teachers intimated that a number of challenges inhibit their development, and these needed to be addressed for better results. Lastly, the study concludes that there is need for more policies to be crafted to support ODeL Life Sciences teachers as currently, teachers are impacted negatively in their efforts due to inadequate support necessary for effective teaching and learning.

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APPENDIX A: PERMISSION LETTER FROM THE PROVINCE

Province of the
EASTERN CAPE
EDUCATION

CORPORATE PLANNING MONITORING POLICY AND RESEARCH COORDINATION
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
Private Bag X0032 • Bhisho • 5605 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)40 608 4537/4773 • Fax: +27 (0)86 742 4942 • Website: www.ecdoe.gov.za

Enquiries: B Pamla Email: babalwa.pamla@ecdoe.gov.za Date: 26 June 2020

Mrs. Sifiso Moyo

Mhlanganisweni Senior Secondary School

P.O. Box 110

Port St Johns

5120

Dear Mrs. Moyo

PERMISSION TO UNDERTAKE A MASTERS' RESEARCH: THE USE OF OPEN DISTANCE LEARNING (ODL) TO SUPPORT LIFE SCIENCE TEACHERS IN THE USE OF VISUAL MODELS TO TEACH GENETICS

1. Your application to conduct the above-mentioned research involving 5 Senior Secondary schools in the OR Tambo District of the Eastern Cape Department of Education (ECDoE) is hereby approved based on the following conditions:

    a. there will be no financial implications for the Department;

    b. institutions and respondents must not be identifiable in any way from the results of the investigation;

    c. no minors will participate;

    d. it is not going to interrupt educators' time and task;

    e. the research may not be conducted during official contact time;

    f. no physical contact with educators and learners, only virtual means of communication should be used and that should be arranged and agreed upon in writing with the Principal and the affected teacher/s;

    g. you present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the Cluster and District Directors before any research is undertaken at any institutions within that particular district;

    h. you will make all the arrangements concerning your research;

APPENDIX B: ETHICAL CLEARANCE CERTIFICATE

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2019/11/13

Ref: **2019/11/13/48282863/13/AM**
Name: Mrs S Moyo
Student No.: 48282863

Dear Mrs S Moyo

Decision: Approved

Researcher(s): Name: Mrs S Moyo
E-mail address: fiemoyo12@gmail.com
Telephone: +27732707180

Supervisor(s): Name: Prof L Mnguni
E-mail address: mngunle@unisa.ac.za
Telephone: 0124294614

Title of research:

THE USE OF OPEN DISTANCE E-LEARNING (ODL) TO SUPPORT LIFE SCIENCE TEACHERS IN THE USE OF VISUAL MODELS TO TEACH GENETICS

Qualification: MEd in Natural Science Education

Research Ethics Committee Recommendations:

None

Yours sincerely,

Name of the Chair: Prof AT Motlhabane

E-mail: motlhat@unisa.ac.za

Tel: (012) 429-2840

APPENDIX C: LANGUAGE EDITING CERTIFICATE

23 Elfin Glen Road, Nahoon Valley, East London, 5200, masharose0@gmail.com, 0827708892

Professional EDITORS Group

To whom it may concern:

This document certifies that the research document whose title appears below has been edited for proper English language, grammar, punctuation, spelling and overall style by Rose Masha, a member of the Professional Editors' Group whose qualifications are listed in the footer of this certificate.

Title:

THE USE OF OPEN DISTANCE e-LEARNING (ODeL) TO SUPPORT LIFE SCIENCES TEACHERS IN THE USE OF VISUAL MODELS TO TEACH GENETICS

Author:

SIFISO MOYO

Date Edited:

11 September 2022

Signed

Dr. Rose Masha

B. Library & Inf. Sc.; HDE; Hons. ELT; M. Phil. Hyll.; PhD Ed.

APPENDIX D: CONSENT LETTER TO TEACHERS

P. O Box 110

Port St Johns

5120

25 February 2021

Sir/ Madam

REFERENCE: SIFISO MOYO, STUDENT NUMBER 48282863 AT UNIVERSITY OF SOUTH AFRICA (UNISA). REQUEST FOR PERMISSION TO CONDUCT AN ACADEMIC RESEACH IN YOUR SCHOOL.

RESEARCH TITLE: THE USE OF OPEN DISTANCE E-LEARNING (ODeL) TO SUPPORT LIFE SCIENCES TEACHERS IN THE USE OF VISUAL MODELS TO TEACH GENETICS

I hereby, request you to take part as one of the participants in my academic research. I am doing an academic research on the topic **THE USE OF OPEN DISTANCE E-LEARNING (ODeL) TO SUPPORT LIFE SCIENCES TEACHERS IN THE USE OF VISUAL MODELS TO TEACH GENETICS,** which will be used for academic purposes only. Kindly be informed that the information you give me will be treated with high confidentiality. You will be free to withdraw from supporting this research at any stage of the research as long as you feel like.

The aim of this study is to investigate the use of Open Distance E-Learning to support Life Sciences teachers in the use of visual models to teach genetics. In this study, there are no foreseeable risks. Your school has been selected because the school falls under Oliver Reginald Tambo Coastal District (ORTCD) which is the area where the study has its focus.

Looking forward to working with you.

My phone number is 0732707180 and my email is fiemoyo12@gmail.com

Yours faithfully

Sifiso Moyo

APPENDIX E: PERMISSION LETTER TO THE SCHOOL

RESEARCH TITLE: THE USE OF OPEN DISTANCE E-LEARNING (ODeL) TO SUPPORT LIFE SCIENCES TEACHERS IN THE USE OF VISUAL MODELS TO TEACH GENETICS

The Principal

School Address

Insert contact person's telephone number and email address

Dear Principal

RE: REQUEST FOR PERMISSION TO CONDUCT AN ACADEMIC RESEACH IN YOUR SCHOOL.

RESEARCH TITLE: THE USE OF OPEN DISTANCE E-LEARNING (ODeL) TO SUPPORT LIFE SCIENCES TEACHERS IN THE USE OF VISUAL MODELS TO TEACH GENETICS

I, Sifiso Moyo a Master's of Education student at the University of South Africa (UNISA), student number 48282863 hereby request to conduct an academic research in your school. My supervisor is Professor Lindelani E. Mnguni in the Department of Science and Technology. The study is not funded. We are inviting you to participate in the study titled "The use of Open Distance e-Learning (ODeL) to support Life Sciences teachers in the use of visual models to teach genetics."

The aim of this study is to investigate use of Open Distance E-Learning to support Life Sciences teachers in the use of visual models to teach genetics. In this study, there are no foreseeable risks. The study will entail requesting teachers to respond to questionnaires and telephone interview questions. This study will contribute in equipping teachers with innovative strategies that will positively benefit learners and improve in the concept of genetics.

Thank you in advance.

Yours faithfully

S. Moyo (0732707180, email address fiemoyo12@gmail.com)

APPENDIX F: QUESTIONNAIRES

Data collection instruments for the proposed study

QUESTIONNAIRE

Answer the following question by writing or crossing (X) in the correct box.

A: What is your age, as at your last birthday?

B. What is your gender?

a) Male

b) Female

1 C1

2 C2

3 C3

4 C4

5 C5

6 C6

7 C7

C. In the following list, mark all the qualifications that you currently hold.

a) Advanced certificate in Education

b) Postgraduate Diploma in Education

c) Bachelor of Education

d) Honours degree

e) Master's degree

f) Doctoral degree

g) Other

D. In the following list, mark all the channels through which you learn about Open Distance e-Learning

1 D1

2 D2

3 D3

4 D4

5 D5

6 D6

7 D7

8 D8

c) Billboards and notice boards

d) Workshops

e) Colleagues

f) Professional development studies

g) Newspapers/magazines

h) Internet

i) Textbooks

j) Other

E. How has Covid 19 affected teaching and learning in Life Sciences? In the following list indicate the appropriate response.

Positively Negatively No effect Unsure

Support your answer

_____

_____

_____

_____

_____

_____

Do you think visual models can help improve teaching and learning during the Covid 19 pandemic era? Yes/No/Maybe or Unsure

Support your answer

APPENDIX G: INTERVIEW QUESTIONS

INDICATE YOUR RESPONSES TO THE QUESTIONS AND STATEMENTS BELOW. FOR EACH RESPONSE INDICATE IF STRONGLY DISAGREE, DISAGREE, UNSURE, STRONGLY AGREE, AGREE.

1. It is okay to use Open Distance e-Learning for improving pedagogical content understanding.
   Support your view
2. It is okay to use Open Distance e-Learning for improving genetics teaching methods using visual models.
3. It is okay to use Open Distance e-Learning for teaching Life Sciences.
4. Some teachers will probably think it is okay to use Open Distance e-Learngg for improving teachers' content understanding.
5. Other teachers will probably think it is okay to use Open Distance e-Learning for improving teaching methods.
6. My peers will probably think it is okay to use Open Distances e-Learning for teaching Life Sciences.
7. I would use Open Educational e-Learning Resources for improving my content understanding.
8. I would use Open Educational e-Learning Resources for improving my teaching methods.
9. I would use Open Educational e-Learning Resources for teaching Life Sciences.

10. I have the necessary skills to use Open Educational e-Learning Resources in Life Sciences.
11. I have technology necessary to use Open Educational e-Learning Resources in Life Sciences.
12. I have sufficient time to use Open Educational e-Learning Resources in Life Sciences.

INDICATE YOUR RESPONSES TO THE FOLLOWING QUESTIONS:

13. As a Life Science teacher, do you always go to class to teach grade 12 learners genetics well prepared?
    Support any of the responses you selected above
14. Do your learners get a better understanding of genetics in grade 12?
    Support your answer
15. Do you think use of visual models to teach genetics in grade 12 may be of help?
    Support your answer
16. Have you ever used usual models in teaching genetics in grade 12?
    Support your answer
17. Does your school have any visual models to teach genetics?
    If yes, which ones?
18. If no, would you like them to be bought?
    And which ones?
19. Does involvement of all senses contribute in teaching of Life Sciences online?
20. Are all schools equipped with enough facilities for teaching Life Sciences?

QUESTIONS ON COVID 19

1. Does social distancing affect the carrying out of experiments in Life Sciences during the COVID19 period?
2. Are Life Sciences teachers equipped to teach Life Sciences online during the COVID period?
3. What challenges do teachers face in teaching Life Sciences online during COVID 19?
4. Does learning Life Sciences online affect content coverage?