# EXPLORING THE AFFORDANCES AND CONSTRAINTS OF BLENDED LEARNING ON ENHANCING LIFE SCIENCES GRADE 12 LEARNERS' UNDERSTANDING OF GENETICS

**By**

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## ABSTRACT

*The study explored the affordances and constrains of blended learning on enhancing Life Sciences Grade 12 learners understanding of Genetics. The study took place in Limpopo province, Capricorn region under Capricorn South circuit. This study used Situated Learning theory as a theoretical framework and qualitative research approach where single case study served as a design. Furthermore, the study conveniently sampled 22 Grade 12 Life Sciences learners and data was collected through participative observation, semi-structured interviews and document review (written tasks).* Among other things the findings of the study revealed that the integration of blended learning afforded learners' understanding of Genetics and also caused language constrains among the learners. It was recommended that future studies look into teachers and learners' attitudes towards blended learning.

***Key words: Blended learning (BL), genetics, and traditional teaching method.***

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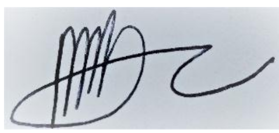
**DECLARATION**

I hereby declare that the entire dissertation, titled “Exploring the affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners' understanding of Genetics" took place in Moletlane Circuit in Limpopo province. It was never submitted before at any higher institutions of learning. I own the work as I wrote and cited relevant literature; all sources under the study have been properly cited and used. I hereby submit the paper to University of Limpopo in fulfilment of the requirements for master in education.

Signature  Date: 01/12/2022

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# CHAPTER 1: The study's foundation

## 1.1. Motivation and Background

In many nations, including South Africa, Life Sciences is one of the subjects taught in secondary schools. Life Sciences draws more learners than physics and chemistry (Thornhill Morgan, 2010). At the secondary school level, it is taught to learners as a basis for plants and animal human growth. In the field of Life Sciences, it explains how events in the living world interact, including how the world is structured, how it works, how life develops, how it exists, and how it interacts with its environment and other living things (Okori & Jerry, 2017; Umar, 2011). Learners identify their strengths and career interests in Life Sciences (Fredriksson, Gajek & Jedeskog, 2009). Further highlighting the importance of Life Sciences for numerous faculties of learning that make substantial contributions to the country's technological development, Ahmed (2008) notes that it is a required subject in many academic fields. The quality and quantity of science education provided in secondary schools develops future scientists, engineers, technologists, and related professionals. However, although Life Sciences has popularity and appeal among South African learners, performance at the senior secondary school level has been average (Ahmed, 2008).

It is believed that, in order to cover the annual teaching plan on time and faster, the majority of Life Sciences teachers employ the traditional teaching method (Liu & Ding, 1980). The majority of classroom settings generally use traditional approaches (Noreen, Majid & Rana, 2019). The teacher is regarded as the focal point of the classroom, in charge of all activities, and responsible for ensuring that all communications are delivered to learners directly through the deductive method of instruction (Diepreye & Odukoya, 2019). Diepreye and Odukoya (2019) added that during teaching and learning periods in the classroom, the main physical work done by learners is either taking notes or remaining sitting to answer any questions from the teacher.

Learners become passive learners because there is no way for them to speak up or present during class. It renders the entirety of teaching using one teaching style or standard teaching methods dull and uninspiring (Noreen et al., 2019). They are also expected to complete assignments, quizzes, and exams, which makes them passive learners (Idogho, 2015). Passive learning is described as a procedure where the teacher teaches learners in class, who then memorise the knowledge without receiving any feedback from the teacher (Shreyasi, 2017). The teacher reads the definitions to the class and learners are expected to write down/record and absorb knowledge. Although passive this learning is cost effective, teacher centred, and presents a great deal of information (Xingcui, 2011).

In contrast to the passive learner, who only takes in, processes, and internalises knowledge, the active learner actively engages in learning (Salman, 2009). When a learner is actively involved in producing designs, ideas, and important contributions, they are working with clear instructions on how to do tasks, which help the learners focus more on how the material being studied relates to them. Making learners actively participate in the learning process is known as active learning (Chidubem & Feyisetan, 2020). The teacher must provide engaging activities to encourage active participation from the students in order to implement an active learning approach (Wabwoba, Okoth & Mugambi, 2021) The adoption of the active teaching methodology stimulates meaningful individual participation and introduces new concepts (Kpolovie, Joe, & Okoto, 2014).

Therefore, technology should support traditional teaching method as a blend to create a learner-centred classroom setting, where learners are actively learning to enhance their conceptual understanding of life science. All South African schools' curriculum should include technology, and a more contemporary approach, according to some (Tanui, Kibbos, Walaba & Nassiuma, 2008). The South African Department of Basic Education (DBE), while encouraging teachers to embrace the new opportunities that made teaching more meaningful and gratifying, noted the fact that information communication and technology (ICT) presented new opportunities and difficulties for teachers and teaching (DBE, 2003). According to Salavati's (2016) research, using technology effectively as pedagogical tool can transform teaching into successful learning by offering learners new options for discovery. The curriculum was enhanced by the use of technologies in the classroom, such as smart board technology, which made the lessons more engaging and participatory. The usage of this technology in the classroom allowed learners to examine images, diagrams, films, and charts on a large screen, which improved their learning experiences (Salavati, 2016). The use of smart boards in the classroom, for instance, "benefits teaching and learning by raising test results, improving learners' learning, enhancing literacy, and boosting learners' attentiveness" (Cox, 2012).

Learners have difficulties related to Life Sciences concepts (Dikmenli, 2010). These difficulties are caused by misinterpreted experiences of genes and inheritance, undifferentiated concepts as well as textbooks. If this issue is ignored, effective learning of Genetics will not take place (Grayson, 1995). The researcher, based on his classroom experience, noticed that learners have difficulties with Genetics. It is a fundamental area in biology; however, it is perceived as difficult by learners and teachers (Knippels, Waarlo & Boersma, 2005). Understanding processes in the human body and biological concepts can be a challenge since all these processes occurring in the human body cannot be visible to the naked eye. (Rotbain, Marbach-ad & Stavy, 2010).

Genetics is the branch of biology concerned with heredity and biochemical instructions that pass information from one generation to the next (Watson, 1968). It is primarily concerned with genes, heredity, and variation in living things (Lanie, Jayaratne, Sheldon, Kardia, Anderson, Feldbaum, & Petty, 2004). According to Oztas (2016), genetics is the study of the nature and behaviour of genes, as well as the basic hereditary units. It is the research into how DNA is passed down from generation to generation. Secondary school life science programmes incorporate tough subjects like genetics and heredity (Kindfield, 1994). Difficult topics like Monohybrid Crosses, which is a genetic diagram that shows how traits are passed down from generation to generation, are explained. We can't make informed decisions on genetics unless we have a better understanding of it (Deniz, 2015).

Genetics is an important part of education and is considered the foundation of the life science curriculum, requiring learners to comprehend and understand it (Choden & Kijkuakul, 2020). It is the focal point of recent discoveries in the field of Life Sciences, and it is a particularly challenging issue for instructors and learners because it entails relationships between concepts at various levels of Life Science (Karagöz, 2011). Learners' grasp of genetics and attitudes should improve as a result of using the blended learning approach in Life Sciences (Yapici, 2012).

Blended learning (BL) is a teaching method that combines two or more instructional methods (Length, 2010). BL, according to Caravias (2014), is training that is delivered through a combination of approaches. Graham (2006) describes the BL technique as combining virtual instruction with computer-mediated instruction. It is an approach to creating a learning environment that is aided by the effective use of a variety of delivery techniques, teaching models, and learning styles, and is based on clear communication between the teacher and the learner (Heinze & Procter, 2006).

Although it is believed that BL has a great deal of promise to improve learning, learners frequently have to use a lot of mental energy processing the information. Different designs engaged in the extension of active visual learning of materials have an impact on how well learners are educated. When designing a BL lesson, the teacher has to take into account the learning objectives, learner characteristics, content, settings, and plan for curriculum integration to decide whether the information should be displayed as a static visualised (image), dynamic animated (animations), or interactive dynamic visualisation (simulations). However, Höffler and Leutner's 2007 study found that dynamic visualisations are more useful than static ones.

The classroom learning environment will continue to shift from teacher-centred inactive lessons to interactive learning experiences as new advancements and accessibility of Information Communication and Technology (ICT) emerge (Choden & Kijkuakul, 2020). Teacher-centred classrooms are widely seen as ineffective and outdated (Gilboy, Heinerichs, Pazzaglia & Chester, 2015). The traditional classroom is a learning environment defined by pedagogical practices that focus primarily on content distribution and do not require learners to actively study. As a result, models are frequently used in Life Sciences education to assist learners to visualize micro processes (Lee, Tsai, Journal, April & Tsai, 2013).

There are attributes which influence the success of teaching and learning through BL within the study. Based on the context of the study they are regarded as affordances (Gibson, 1979) and constraints (Greeno, 1998). Gibson (1979) defined affordances as what the environment provides to an individual, or a group of possibilities offered for a potential action by the researcher. An affordance is influenced by the surroundings as well as potential researcher actions. He created the term affordance to explain how a goal-oriented actor (learners) interacts with an object (technology) in their environment in terms of the action choices that the BL affords the actor (Lombardo, 2019). Instead, affordances come into play as a result of the interaction that exists between BL and the learners with whom it interacts within the study.

Constraints are the circumstances and connections between attributes that give the course of action organisation and direction (Greeno, 1994). Let's take a look at a doorway which allows access to a room; a closed door restricts access, complementing affordances; constraints are not the exact opposite of them but are likewise essential for activity to occur (Kennewell, 2001). Constraints and affordances cannot be separated since they are complementing rather than the polar opposites of one another (Brown, Stillman, & Herbert, 2004).

In the context of the study, instead of being understood as characteristics of either learners or technology, affordances and constraints are employed as relational concepts, or potential interactions between learners and technology. Affordances and constraints are best phrased in terms of action verbs, such as shared knowledge or information sharing (Majchrzak & Markus, 2013).

According to DBE (2011), integrated and combined teaching approaches provide opportunities for both the teachers and learners to learn. This approach provides an opportunity for learning from local and international experts and access to computers to develop computer literacy skills and interaction among learners and teachers. As a researcher, I aim to use a variety of resources and activities to create a personalised, learner-centred environment.

## 1.2. Problem Statement

The revision booklet of Life Science FET highlights Genetics as a study of variation and inheritance, a fundamental part of Life Sciences, which is relevant to our everyday life (DBE, 2017). It helps learners to learn about the relationship between generations, sex-linked diseases, and genetic engineering amongst other things (DBE, 2011). Thus, learners are expected to have a clear understanding of genetics and be able to know how to solve genetic problems (DBE, 2011). Understanding of genetics is applied in and relevant to various aspects of society. A better understanding of genetics allows us to make knowledgeable decisions about Genetics associated controversial issues imposed by daily life (Deniz, 2015). There are career opportunities in the field of Genetic Engineering and Pathology.

However, it is reported that secondary school learners experience several difficulties relating to and understanding of Genetics and genetics-related concepts (Dikmenli et al., 2011; Marbach-Ad & Stavy, 2000). There is a number of previous studies that reported secondary school learners to have numerous conceptional difficulties concerning genetics (Etobro & Banjoko, 2017). Content delivery of genetics remains a problem for teachers which results in learners finding the concept difficult (Dikmenli et al., 2011). DBE diagnostic reports highlight learners' difficulties in solving the Monohybrid Cross on incomplete dominance and their inabilities to highlight the correct format for monohybrid genetic cross (DBE, 2016-2019). If these difficulties are not addressed, learners may not be able to correctly describe and understand the relations between generations i.e., inheritance and how DNA and chromosomes enable continuity and change (DBE, 2011). Therefore, in light of the aforementioned, the researcher intends to explore the affordances and constraints on enhancing Life Sciences Grade 12 learners' understanding of Genetics using BL.

### 1.3. Purpose of the study

The purpose of this study was to explore the affordances and constraints of enhancing Grade 12 learners' Life Sciences understanding of Genetics using BL.

### 1.4. Objectives of the study

- To explore the affordances of blended learning for enhancing grade 12 life science learners' understanding of Genetics.
- To explore constraints for BL for enhancing grade 12 life science learners' understanding of Genetics.
- To explore the extent to which BL can enhance the understanding of genetics among Grade 12 Life Science learners.

### 1.5. Research Questions

- **Main research question one**
    - What are the affordances and constraints for enhancing grade 12 Life Sciences learners' understanding of Genetics using BL?

**The following sub-questions were also answered:**

- What are the affordances for enhancing grade 12 Life Sciences learners' understanding of Genetics using BL?
- What are the constraints for enhancing grade 12 Life Sciences learners' understanding of Genetics using BL?

- **Research question number two**
    - How does BL enhance Life Sciences grade 12 learners' understanding of Genetics?

### 1.6. Defining core terms

**Definition of core terms that are repeatedly used in this study are itemised below.**

- **Genetics** is mainly the study of heredity, or carrying of certain genes from specific generations to the next (Mendel, 1901).
- **Blended Learning (BL)** the term "blended learning" is said to be a learning method whereby many teaching approaches can be used in educational settings and employing technology to support current traditional teaching methods (Garrison, 2004).

- **Traditional teaching method** is a teaching approach that is teacher-directed, with lessons designed to encourage learners to sit still and listen (Tularam & Machisella, 2018).
- **Monohybrid Cross** is a diagrammatic presentation of a how a single characteristic of interest can be transmitted from one generation to another (Piegorsch, 1990).
- **Information Communication and Technology (ICT)** states the application of technology in communication, data dispensation and storage to impact learners' knowledge (Srivastava, 2016).

## 1.7. Research paradigm

The nature of the research questions was influenced by the study's use of the interpretivist research paradigm. The term paradigm refers to a philosophical way of thinking and was first used by Thomas Kuhn in his book *The Structure of Scientific Revolutions* in 1962. According to Kivunja, Ahmed and Kuyini (2017), "paradigms provide a worldview, which is the perspective, or thinking, or school of thought, or collection of common beliefs that guides the meaning or interpretation of research data." The interpretivist paradigm provides conceptual tools that enable researchers to fully comprehend a phenomenon and its complexity within the context in which it occurs (Creswell, 2007).

## 1.8. Research Approach

The adoption of a qualitative research approach in this study was the outcome of the interaction between the interpretivist paradigm and the qualitative research approach, as shown in (Thahn, 2015). According to Creswell (2007), this method provides opportunity for an in-depth description of learners' opinions about the usage of BL when implemented in a Life Science classroom curriculum. In support, Niewenhuis (2007) emphasised that the goal of qualitative research is to describe and comprehend a phenomenon in its natural setting. This qualitative research approach can be used in this study since it gives the researcher a setting from which to conduct in-person interviews and communicate with research participants in their everyday environments (McMillan and Schumacher, 2010). Simons (2009) asserts that numerous case studies have the ability to involve participants (learners) in the study process. The researcher utilised a descriptive research design to gather data that characterised occurrences and organise the data, and then draw conclusions about trends and patterns linked to the accessibility of school resources and how these resources affect teaching and learning.

### 1.9. Research design

In order to explore, comprehend, and assess the extent and utilisation of BL in particular secondary schools in the Capricorn District, this study used a descriptive case study research approach. The study also looked into the affordances and constraints of BL on enhancing learners' understanding of genetics. This research design gave the researcher the chance to record various viewpoints, identify contested viewpoints, and show the influence of important participants and their interactions (Baxter & Jack, 2010). Many case studies have the potential to involve participants in the study process, according to Simons (2009). In order to establish trends and patterns pertaining to the availability of school resources and other factors, the researcher utilised a descriptive research approach to gather data that characterised events.

Twenty-two (22) Life Sciences learners from the Moletlane circuit around Zebediela in Limpopo province were involved in this study. The learners were requested to complete a document review task, be observed and interviewed. The study used unstructured interviews throughout the lesson to help reflect on learners' opinion. The demonstration is elaborated on in chapter 3 of the study.

### 1.10. Significance of the Study

This study proposes a platform where both teachers and learners deliver and acquire knowledge from the discipline of Life Sciences content. As a result, this could benefit the Life Sciences curriculum advisors and teachers to enhance their pedagogical content knowledge to deliver content to learners. The use of BL in a life science classroom will help improve the quality of education in Life Sciences as a learner will be actively constructing their content knowledge, thus creating a learner-centred learning environment. The study aims to produce practical significant data which will have a positive impact in real-life situations.

### 1.11. Research report plan

The study's introduction and its background context are provided in Chapter one (1). The information the study intends to establish is included in the chapter along with a brief literature review. The research questions are made up of the study's research problem and the drive of the study. This chapter contains a summary of the chapters in the thesis. The next chapter's is also provided in the summary.

In detail, the applicable literature review of this study was discussed in chapter 2. It starts with the introduction of the section, followed by detailed discussions on what genetics is. The literature in this chapter includes the studies that were done across the globe. This includes South Africa and

Limpopo as the target. Furthermore, the conceptual framework was explained in the chapter. The conclusion and summary are linked to the next chapter.

The methods used for the study and how it will address the research issues are covered in chapter three (3). This covers the discussions about the sampling technique, design, data collection and analysis in depth. The data analysis includes quality criteria, ethical issues and a summary of the chapter is at the end.

Regarding chapter 4, the data was collected using three phases. Data gathered from observing the twenty-two (22) learners served as the basis for the study. The next phase of data presentation is the data gathered through semi-structured interviews throughout the lessons and the document review in the third phase of the data presentation. This is lastly followed by the outline of the chapter and the chapter that followed in the form of summary.

The study's conclusions are discussed in the final chapter. The discussion and findings aid in outlining the conclusions and recommendations.

## 1.12. Conclusion

This chapter provided an overview of the background and motivation that led the researcher to decide to conduct this kind of study. The research problem, which described the issue that motivated the study in depth, was presented after this. The purpose of the study, together with the research questions that served as a guide, the research design summary, the importance of the investigation, and finally, is followed by the plan for the research report.

# CHAPTER 2: Literature Review and Theory of the study

## 2.1 LITERATURE REVIEW

## Introduction

This chapter focuses on genetics, blended learning (BL) and Information communication and technology (ICT) in a science classroom. It also covers the several pedagogies that can be employed with BL as an effective teaching strategy to enhance learners' understanding of genetics.

### 2.1.1. Genetics

Genetics is the study of invisible processes at various organisational levels, including proteins, genes, chromosomes, cells, tissues, and organs (Etobro & Banjoko, 2017). The study of genetics is a subject that is extremely important in contemporary education and can be seen as the foundation of scientific literacy, necessitating learners' comprehension and understanding (Altunoglu & Seker, 2015; Tshering, & Dorji, 2017). It is common knowledge that many learners find the subject abstract and challenging (Nandiyanto et al., 2018). Hence, Kilic and Sağlam (2014) found that the study of genetics requires high levels of reasoning to enable learners' understanding of the concept. The concept should be taught using an approach that makes it modest for learners to grasp the content and relate it to their daily experience (Choden & Kijkuakul, 2020). We are in a technological age where learners are fascinated by how technology functions and find it amusing that it can be used to develop instructional strategies that assist learners to understand the genetics concept

According to Choden and Kijkuakul (2020), there are several learning difficulties about genetics among secondary school learners such as genetic engineering, cloning, inheritance, variation, evolution and Monohybrid Cross in genetic concept. Dikmenli (2010) added that since the mid-20$^{th}$ century, genetics has progressed rapidly and has become a challenge in all countries. Hence, Kilic and Sağlam (2014) found that the study of genetics requires high levels of reasoning to enable learners' understanding of the concept. According to the results of multiple studies in grades 7 to 12, difficulties may be caused by misunderstandings that teachers and learners have regarding different genetics subtopics (Altunoglu & Seker, 2015; Osman, BouJaoude & Hamdan, 2017; Shaw, Van Horne, Zhang & Boughman, 2008); Yates & Marek, 2013). Learners defined ideas about genetics from a previous class or because mistakes in the curriculum statement and textbooks made things more difficult (Nusantari, 2014; Sanders & Makotsa, 2016).

Abovementioned issues indicated that learners have challenges with basic concepts of genetics in Life Sciences which should have been clarified in grade seven where the basics of Genetics are introduced. According to previous studies, a traditional classroom setting may be a challenge to educate and learn about genetics (Choden & Kijkuakul, 2020). The primary barrier to developing a coherent conceptual framework is learners' lack of awareness of genetic linkages. Recent studies have revealed that learners at all levels, as well as the public, have a poor comprehension of genetics and its different elements (Lewis & Wood-Robinson, 2014). To address these difficulties teachers should create a learning environment that makes it easier for learners to have a clear in-depth understanding of the concept of genetics.

This study focuses on Monohybrid Cross as a challenge experienced by grade 12 Life Science learners. In the middle of the nineteenth century, Gregor Mendel solved the genetic puzzle (Mendel, 1901). He raised pea plants and studied the inheritance pattern at various stages of generation to experiment on them (Piegorsch, 1990). Considered the father of genetics, Gregor Mendel (1822–1884) developed the basic principles of heredity theory. Mendel is the founder of genetics. He proposed three laws: the Law of Independent Assortment, the Law of Dominance, and the Law of Segregation (Wolf et al., 2022).These laws were developed by tests on pea plants with various characteristics (Mendel, 1901).

The process of passing traits from one generation to the next is known as Mendelian inheritance. Genes that are carried from one set of parents to the next determine the inherited qualities (Etobro & Banjoko, 2017). Each parent contributes one pair of genes to the offspring. Though a characteristic may not be visible, its gene can nevertheless be passed on to the following generation. Although this knowledge is not in line with biological theory, learners do understand how genes contribute to the transmission of traits (Etobro & Banjoko, 2017). The entirety of the genes inherited from each parent determines attributes in the same way. The mechanisms of genes and variants are more complex when seen under a microscope, despite the fact that this may be the case based on observations, they can be explained through Monohybrid Cross.

A Monohybrid Cross involves two organisms that have distinct variants at a single genetic locus of interest (Piegorsch, 1990). In a Monohybrid Cross, the character(s) under study are controlled by two or more mutations at a single gene locus. Each parent in such a hybrid is chosen to be true breeding homozygous for the specified trait (Medina, 2011). When a cross meets the requirements to be a Monohybrid Cross, it is typically identified by a distinctive distribution of second-generation (F2) offspring that is frequently referred to as the monohybrid ratio (Westerlund & Fairbanks, 2010). The inheritance of one gene occurs through Monohybrid Crosses. Through Punnett Square, it is simple to demonstrate.

**2.1. 2. Using appropriate teaching methods vs covering the learning information time**

There are various teaching strategies for effectively teaching complex topics in a learner-centred manner (Rodriguez, Diaz, Gonzalez & Gonzalez-Miquel, 2018), which might certainly satisfy the needs indicated above. However, most Life Sciences teachers utilise the traditional technique since it is seen to be easier and faster to cover the learning information on time (Liu & Ding, 1980). In general, traditional methods are used for the majority of classroom instruction (Noreen et al., 2019). The teacher is seen as the centre of the classroom, in charge of all activities, and responsible for ensuring that all messages are delivered to learners either directly via him or through the deductive method of instruction. The traditional approach focuses on the content. This maintains the instructor's more dynamic, subjective, and less emotive characteristics (Singh, 2004). Traditional methods primarily ignore higher levels of reasonable outcomes in favour of reviewing true information (Rao, 2001). The majority of learners in a traditional classroom are just able to copy what is put on the board; they are unable to handle the information efficiently through analysis, evaluation, and investigation (Noreen et al., 2019). Learners become disinterested in learning as a result of their limited intellectual capacity. Furthermore, as a result, teachers can complete the annual teaching plan on time but produce learners that are not able to answer high-order questions based on Bloom’s taxonomy.

Three hierarchical models, collectively known as Bloom's taxonomy, are used to group educational learning objectives into varying degrees of complexity and specificity (Rooyen & De Beer, 2019). According to Bloom's taxonomy, an assessment should be constructed so that it has four questions of varying difficulty levels from levels 1-4 when evaluating learning through written work tasks (Armstrong, 2010). A teacher must analyse the level of difficulty of their learner's work and create a comfortable range of task questions spanning from simple to complex to establish a well-balanced question paper for an assessment task. This model is broken down into levels at the school level and classified as;

- Level 1 – Knowledge (remembering)
- Level 2 – Comprehension
- Level 3 – Application & Analyses

- Level 4 – Evaluate & Synthesise

#### 2.1.2.1 The result of using one teaching method to teach science

The use of one method of teaching inhibits learners' knowledge of genetics (Diepreye & Odukoya, 2019). The primary physical work performed by learners during teaching and learning sessions in the classroom is either taking notes or staying seated to respond to any questions from the teacher. Because there is no mechanism for learners to speak or present in class, they become passive learners. It makes the entire process of teaching through one teaching method or traditional teaching method uninteresting and dry (Noreen et al., 2019). Typically, a science teacher may provide a few examples, solve a few problems on the board, and occasionally conduct experimental demonstrations (Miller, 2006). It gives neither the educator nor the learners any room for movement. Learners consider the dialect, but they are not in a position to speak it with ease.

According to this interpretation of scientific education, learners view science as a body of information to be memorised without understanding or challenging it. A review of the literature suggests that the traditional ways of teaching science often fail to sufficiently develop learners‟ understanding of scientific concepts (Dowdy, 2020). For instance, Taasoobshirazi and Carr (2008) believe that traditional ways of teaching science, which usually involve memorisation of concepts and computations, often result in learners' failure to comprehend the deeper conceptual connections within the problems. This way of teaching, according to these authors, encourages poor problem-solving approaches and limited comprehension of learned concepts and ideas.

Traditional classrooms are widely seen as outdated and ineffectual (DiPiro, 2009; Gilboy, Heinerichs, Pazzaglia & Chester, 2015). Such educational environments can be identified by pedagogical approaches that concentrate solely on content distribution (also known as "dumping"), in which learners infrequently engage in peer-to-peer interaction, debate, and hands-on learning (Gilboy et al., 2015). The inability of learners to effectively connect what they learn in science classrooms to their real-life experiences is frequently linked to their opinion of science education as irrelevant and challenging (Miller, 2006). Other studies and researchers (EIRMA, 2009; Kyle, 2006; Onwu, 2000) have highlighted the failure of traditional teaching approaches to connect the study of science to learners' everyday experiences. Learners are more likely to develop negative attitudes about science if they cannot perceive the relevance of the material they learn in scientific classes.

As a result, the use of active learning methods, which incorporate more than one teaching style, has been considered, as it allows learners to be participative since they are interested in the subject, hence improving their performance (Rodriguez et al., 2018).

#### 2.1.2.2 Blended learning as an appropriate teaching method for monohybrid

The use of more than one teaching method in the study is regarded as BL which encourages learners to be active and independent learners who are responsible for their learning and can evaluate their progress as well as that of other learners (Bux Jumani et al., 2018). As a result, blending traditional teaching methods and technology creates a learning environment where learners are actively participating in their learning which creates interest and a better understanding of the concept taught (Thi et al., 2014).

It would be impossible to ignore the enormous potential of technology as a tool for the classroom given its current integrated role in our society. A lot of research promotes the usage of technology in the classroom (Krebs, 2015). According to some studies (Alijani, Kwun, & Yu, 2014; Chacko, Appelbaum, Kim, Zhao & Montclare, 2015), technology-enhanced instruction results in learners' highest levels of engagement in their studies. In addition, some scholars have argued that learners view using technology and other methods of teaching and learning as valuable (Schultz et al., 2014).

Additional research suggests direct correlations between academic achievement and learner active engagement (Yasar & Demirkol, 2014). As a result, learners tend to be highly engaged when interacting with technology and in experiential learning activities; it can be inferred that the blended teaching/learning model can serve to improve learner academic performance (Demirer & Sahin, 2013; Light & Pierson, 2014). Two different studies by Yasar and Demirkol (2014) and Schultz et al. (2014) have shown that a combination of both technology-based instruction and traditional instruction can improve learner academic success

This method creates a learner-centred environment that allows learners to interact, participate, and be involved in the learning process (Garrison & Kanuka, 2004). As a result, this method produces learners who can apply and analyse the concept that they have learned in a real-life situation. BL increases learners' engagement in the classroom to curb passive learning by the traditional method and promote an engaged and more active learning environment

### 2.1.3 Blended Learning

#### 2.1.3.1 Conceptualising blended learning

The word 'blended' is defined as combining two or more things together (Ngoasong, 2021). BL can be defined as the combination of face-to-face, traditional classroom methods and computer-mediated activities, whether it is online or not (Williams, 2018). Graham (2019) added that it is an innovative educational approach, offering a versatile and tailored learning experience for learners. BL as a pedagogy combines the classroom and online education in various ways since it is further defined as a combination of face-to-face traditional interaction with a teacher in a school location, with additional instruction which is performed in an online learning environment that accompany digital content and teamwork with fellow learners (Gulc, 2014). It can also be to simply integrate videos, power point presentations, blogs and other media into class work (Williams, 2018). It enables one to support learning that focuses on the best learning mode in order to achieve the specific outcome. Teachers can blend different modes of learning when teaching in order to achieve different learning outcomes (Elmore, 2014).

This approach involves learner- teacher or learner-learner interactions encompassing lessons, discussions, and practical activities, supplemented by online resources such as multimedia content, interactive simulations, quizzes, and virtual discussion forums (Garrison & Vaughan, 2019). By incorporating technology and personalized instruction, BL accommodates diverse learning styles and paces, enabling students to navigate through content at their own speed and thereby promoting heightened engagement and motivation (Means, Toyama, Murphy, Bakia & Jones, 2020). The utilisation of data analytics to monitor learners' interactions with online materials empowers teachers to gain valuable insights into individual progress, facilitating targeted interventions and instructional refinements (Picciano, 2017). While offering advantages such as flexibility, engagement, and data-driven insights, BL encounters challenges including equitable technology access and effective pedagogical design, necessitating thoughtful consideration (Singh, 2018). Successful implementation demands a harmonious fusion of pedagogical expertise and technological resources to ensure a comprehensive and effective learning journey for students in diverse educational settings.

BL is a new type of education prepared for a certain group by combining the positive aspects of different learning approaches. BL will provide a big convenience for the course to achieve its target by combining the face to face interaction in traditional learning and time, place and material richness provided by Web-based learning. Yılmaz and Orhan (2010) state that the best way to solve the lack of interaction problem faced in technology-based learning is to blend traditional learning and online learning. Throne (2019) emphasizes that the blending of these two learning approaches occurs by combining CD ROM, e-mail, conference, online animation, audio message, multimedia technology and real classroom environment and he states that it should be presented to the student with traditional classroom management and face to face learning. From this point of view, BL can be a good solution by offering different learning environments to the learners who have individual differences as well as approaches to learning (Halverson & Graham, 2019).

The term "blended learning" refers to a procedure used in educational settings to describe how technology might support current teaching methods (Garrison & Kanuka, 2004). Although BL has been a notion for a while, its nomenclature did not become widely accepted until the beginning of the twenty-first century. In a formal education programme, BL takes place frequently (Staker & Horn, 2012).

BL pedagogy can be used effectively to enhance learners' conceptual understanding in high schools and is reported to have a higher effectiveness than traditional learning (Zhang & Zhu, 2020). Since learners must acquire certain abilities to fully benefit from a multi-modal blended curriculum, the integration of BL across the curriculum is neither automatic nor obvious. Any BL approach must be supported by a facilitator/teacher who can assist learners to improve their abilities and accelerate their learning if it is to be successful (Brown & Davis, 2004).

BL is when traditional face-to-face learning is combined with computer-mediated instruction (Ellis, Steed & Applebee, 2006; Francis & Shannon, 2013; Graham, 2006; Halverson, Graham, Spring, Drysdale & Henrie, 2014; Mtebe & Raphael, 2013; Nsofor, Umeh, Ahmed & Sani, 2014) However, BL incorporates many models of techniques, styles, and cutting-edge technologies for teaching and learning. In other words, the combination motivates learners to participate in collaborative and active learning. Combining audio-plus or audio-visual resources with traditional teaching methods is referred to as blending (Machumu et al., 2018).

#### 2.1.3.2 Blended learning models in high school

An aged educational system benefits from the excitement and improved learner engagement that the BL model in schools provides (Krebs, 2015). According to Krebs (2015), BL in high school creates a setting where teachers can deepen learners' conceptual understanding in the following ways: first, moving away from passive teacher-centred environments towards active learner-centred environments; second, embracing technology as an educational tool; and third, implementing efficient hands-on learning protocols. Technology-based learning and experiential learning will be combined in the mixed classroom-teaching approach, according to Krebs (2015). It is implemented through the combination of physical and virtual learning activities.

BL inspires learners to pursue independent learning. Additionally, it aided in the growth of learners' peer learning, reflective thinking, and sense of teamwork (Bux Jumani et al., 2018). Due to its support for different learning styles, BL has increased interest and engagement in learning. They went on to say that BL has improved their educational knowledge and improved the effectiveness of their instruction. In more detail, teachers believe that BL has promoted a learner-centred environment, which in turn has encouraged individualisation (Bux Jumani et al., 2018). Pedagogy could change as a result of the BL approach (Garrison & Kanuka, 2004). Planning and professional development are required, according to Bhati, Mercer, Rankin, and Thomas (2009), for the effective integration of technology and topic knowledge into a hybrid pedagogical approach.

#### 2.1.3.3 Integrating blended learning across the curriculum.

Teachers are integrating BL across the curriculum, and the curriculum has adopted a new approach to ICT by allowing learners to use ICT both inside and outside of the classroom (Selwyn, Potter & Cranmer, 2010). BL is also incorporated into CAPS in South Africa through the use of the "Spark" instructional concept. One BL model that is in line with the South African National Curriculum is "Spark," which could give the curriculum more depth for the benefit of both the teachers and the learners (Brewer & Harrison, 2013). Any integration process, like implementing BL across the curriculum, calls for efficient change management.

According to Brewer and Harrison (2013), the integration of ICT into the classroom allows learners who excel academically to advance without being constrained, while learners who struggle academically receive additional support. As a result, everyone participates in class and no one falls behind. Automation, adaptive repetition, and computer-assisted activities also improve learning. Brewer and Harrison (2013) acknowledge that teachers can gain from ICT in the learning environment and classroom.

#### 2.1.3.4 Implementing Blended Learning in a classroom.

There are various teaching strategies for effectively teaching complex topics in a learner-centred manner (Rodriguez et al., 2018), which might certainly satisfy the needs of the genetics concept. This environment emphasizes the knowledge, abilities, attitudes, and beliefs that learners contribute to the learning process, with its motivation deriving from the constructivist learning paradigm.

Most Life Sciences teachers utilise the traditional technique since it is seen to be easier and faster to cover the learning information on time, even though this method of teaching inhibits learners' knowledge of genetics (Liu & Ding, 1980). As a result, the use of active learning methods, which incorporate more than one teaching style, has been considered, as it allows learners to be more alert, and participative, hence improving their performance (Rodriguez et al., 2018).

Teachers require assistance in using BL to personalise instruction (Soifer, 2015). Given the current state of BL, recognizing pedagogical shifts and instructional techniques will give a framework for instructors working in these settings (Rodriguez et al., 2018).

According to the available research on BL, the technique is always a successful teaching approach in terms of improving learners' performance. Teachers can play a significant role in teaching scientific concepts and, from a constructivist perspective, learners will gain meaningful knowledge about biological concepts. Scientifically literate learners should be able to use and apply basic biological concepts when considering biological problems or issues.

Research by Yasar and Demirkol (2014) and Schultz et al. (2014) have revealed that a blend of both technology-based instruction and hands-on instruction can enhance learner academic performance. In Life Sciences classrooms, web-based instruction, videos, and social media explorations can be mixed with hands-on experiments, laboratory investigations, simulations, research projects, and project-based learning to expand knowledge (Danker, 2015; Yasar & Dermirkol, 2014).

Content analysis and method triangulation were used to confirm that the blending approach was effective in helping learners to acquire basic knowledge about genetics and to eliminate most difficulties about the five central subtopics in the study of genetics (Choden & Kijkuakul, 2020). The BL technique has been demonstrated in numerous studies to have favourable effects on students' achievement (Glenna, Gollnick & Jones, 2007). Although blended courses presented in research studies have a very diverse structure, the potential benefits have been extensively studied and are applicable to many sectors of education. The use of ICT in education has an impact on how learners learn. The rise of ICT as a learning technology forces us to consider different learning theories. Teachers plan and lead learners through several structured sequences to accomplish the desired outcome in the traditional teaching process.

Teachers must understand how learners connect complicated ideas and utilise this information to inform the development of instructional aids that facilitate an integrated grasp of genetics (Lewis & Wood-Robinson, 2014).

Caulfield (2011) proclaims that because it makes use of learners' digital habits, BL is more desirable than only employing face-to-face/traditional teaching. High levels of learner achievement can also be attained using BL. Learners can work independently with new concepts by mixing multimedia and traditional approach, while the teacher can move around and support learners who may require assistance. ICT integration in BL has been shown to improve learners' attitudes toward learning. In a classroom setting that uses BL, learners must show independence to accomplish objectives. Blending works best when technology and instruction complement one another (Caulfield, 2011).

The adaptability and individualisation of learning experiences offered in a mixed-learning classroom may be a factor. As a result, teachers can make the most of the time they spend facilitating learning.

#### 2.1.3.5 Advantages of the Blended Learning Approach

BL can bring teachers and learners closer together, allowing teachers to share subject materials, syllabi, opinions, and online assessments along with traditional face-to-face activities such as traditional teaching methods (Caravias, 2014). The use of a BL strategy in the classroom has three key advantages: increased time flexibility; lack of reliance on the teacher's time limits and time for thought. This method allows learners to express themselves and ask questions without restriction. Meeting varied needs and learning styles (Caravias, 2014) is usually a beneficial teaching strategy in helping learners understand concepts better. The usage of this technology in the classroom allowed learners to examine images, diagrams, films, and charts on a large screen, which improved their learning experiences (Salavati, 2016). The use of smart boards in the classroom, for instance, improves teaching and learning by increasing test results, improving students' learning, promoting literacy, and increasing students' attentiveness (Cox, 2012). BL is more than just the union of in-person and online learning; it also entails the creation of engaging teaching and learning environments, accessibility to course materials from any location, and shared collaborative learning environments that empower learners to address societal and educational issues (Saleh & Khader, 2016). Currently, developing countries' higher education systems place a significant priority on developing, planning, and implementing BL strategies for teaching and learning (Alvarez Jr, 2020).

Learners in BL situations get to know one another's cultures, which allows for more interaction in the learning environment. With BL, learners have equal possibilities, and their success is based on their mental prowess and emotional drive (Usoff & Khodabandelou, 2009). BL is preferred to the conventional lecture style and encouraging statistics have arisen to question the conventional teaching methods used by professors (Alaneme, Olayiwola, & Reju, 2009). Blending not only allows us to deliver information more effectively and efficiently, but studies also demonstrate gains in pass rates (Ngoasong, 2021).

#### 2.1.3.6 Affordances and constrains of Blended Learning

Gibson (1979) developed the term affordance, which is applied to both the human computer interaction (Gaver 1991, Norman 1988, 2015), and education literature (Downes 2002; Kennewell 2001) to explain opportunities offered to users in ICT-based learning settings. He analysed the characteristics of a variety of various environmental elements combined to form a compound that offers an affordance. Additionally, circumstances contribute to an affordance by providing it. A description of affordances by Gibson was based on his affordance-based ecological theory of perception, depending on the possibility of environmental and biological interaction. This is like in an ecological system when there are affordances for a specific individual to rely on the potential for a relationship to exist between the learners and the environment. In a learning environment aided by technology interactions between the hardware, software, and other entities it provides affordances for the teacher and learners. Constraints are the circumstances and connections between attributes that give the course of action organisation and direction (Greeno, 1994). A doorway, for instance, provides access to a room; a closed door restricts access, while complementing affordances, constraints are not the exact reverse of them (Kennewell, 2001).

The affordances and constrains of BL frequently differ from aspects of the environment that are directly connected to the curriculum (Kennewell, 2001). Furthermore, when applying knowledge of the subject, ICT skills may impact the preferred approaches and processes chosen. As a result, the introduction of ICT modifies the interactions in the pedagogical setting to the point where it justifies a special place in a framework for analysing teaching and learning in classrooms right now.

The relational ideas of technology affordances and constraints, which are separate from both technological aspects and human objectives, are valuable because they aid in the explanation of two prevalent empirical findings (Majchrzak & Markus, 2013). First off, while using a technology, people and organisations may fail to appreciate its apparent promise. Second, sometimes or frequently, people and organisations use technology in ways that weren't intended by the creators (Datnow & Park, 2013). As relational concepts, affordances and constraints help scholars understand that what one person or organisation with a specific set of capabilities and purposes can or cannot do with a technology may be very different from what another person or organisation with a different set of capabilities can do with the same technology (Gedik, Kiraz & Özden, 2012). In the context of the study learners as actors are interacting with technology as an object to enhance their understanding of genetics. The researcher as a facilitator created an environment that allowed learners to interact with technology and traditional teaching method as an affordance but attributes as constraints also concurrently occur.

### 2.1.4. Information Communication and Technology (ICT)

ICT and its applications have undergone significant transformation over the past 20 years, which has compelled changes in educational practices and procedures (Adu & Olatundun, 2013). Education was once considered a social activity, and it was believed that close-knit relationships with learners were the only way to provide high-quality instruction. The educational system has changed considerably over the last few years, as of right now. Both developments in teaching approaches and changes in government policy towards ICT in schools are to blame for these shifts. As a result, educational institutions and teachers must modify, improve, and update their technological competencies.

ICT use has revolutionised how people are taught and how people learn. It is difficult to conceive a learning environment that will not encourage the use of ICT given the continuous increase in technology in daily life. The digital generation, which is continuously surrounded by technology, is referred to as today's learners. ICT education, and the mastery of basic ICT-related skills can now be regarded as important as reading, writing, and numeracy. ICT encompasses more than computers and computing-related activities. Computers play a significant role in modern information management; however, other technologies and systems also comprise the phenomena of ICT (Adu & Olatundun, 2013). ICTs, according to Adu and Olatundun (2013), can raise educational standards in several ways. ICTs have the potential to change society. ICT use can change the emphasis of the classroom from one that is teacher-centred to one that is learner-centred. In a classroom with ICT, teachers and learners have access to new teaching and learning tools, which alters how things are done in the classroom, enhancing the effectiveness of the teachers.

ICTs are affecting society in a big way. They have an impact on every element of life. The effects are becoming more noticeable in classrooms. Society is pressing schools to respond appropriately to this technological progress since ICTs provide both learners and teachers with additional options to adjust learning and teaching to individual requirements (Mikre, 2011). According to Tinio (2002), ICTs can increase access to education while also enhancing the significance and quality of education in poor countries.

Rapid improvements in information and communication technologies (ICTs) have functioned as a catalyst for educational change around the world in recent years (Totter, Stütz, & Grote, 2006). Africa is likewise seeking to benefit from the technological revolution to make progress in the field of education (Kaul, 2022) These technologies hold enormous promise for addressing today's educational difficulties, such as a lack of access to high-quality higher education. Open and distance learning modalities, notably print and radio/audio, have traditionally been utilised to increase access (Boitshwarelo, 2009). ICT visualises lesson content and provides learners with activities that are aided by visual representations, such as animation and graphs, to make the abstract exist and to clarify concepts (Barak & Hussein-Farraj, 2013).

#### 2.1.4.1 ICT in South Africa

Blignaut and Howie present a summary of South Africa's national objectives (2016). Phase 1 of the roll-out plan was carried out by the South African government between 2004 and 2007. The programme aimed to create an education and training system that would support ICT integration in teaching and learning and train teachers to feel comfortable using ICT, establish a framework that would allow educators to integrate ICT in the curriculum, determine the availability of ICT, use high-quality educational content, and to connect schools to the Internet.

According to Draper (2010), South African science teachers were able to use ICT to enhance teaching and learning. ICT was reportedly used in the classrooms of South African instructors in a variety of methods, including 1) simulations and 2) data loggers during the practical task, for conceptual understanding of science, and learner motivation in science, respectively. For the presentation of lessons, teachers have been seen using ICT equipment like interactive whiteboards and presentation software. Science subjects like chemical reactions and friction are explained using simulation software during an actual investigation. Draper (2010) recommended that ICT be gradually incorporated into schools and teaching and learning activities in her results. A network of schools in Johannesburg using BL was introduced by eAdvance in January 2013 under the name Spark Schools (Brewer & Harrison, 2013). To provide high-quality education that can be scaled out throughout the nation, South Africa needed an effective, affordable, and sustainable educational paradigm. According to Brewer & Harrison (2013), Spark schools are schools where a BL paradigm is a combination of classroom instruction and instructional technologies, designed to fit the specific needs of each learner. This combination enables rapid and individualszed learning. Spark Schools acknowledge that teachers are overworked and that some jobs, such as the repetitive acquisition of fundamental skills, can be made easier by computers.

#### 2.1.4.2 ICT in a classroom

ICT can be integrated into the educational setting in several ways. The educational case for using multimedia in the classroom is strengthened since it aligns with how humans naturally digest information. Our eyes, ears, and brain work together to create a processing system that converts meaningless data into useful information. Thus, it is crucial to make sure the multimedia you choose will help you achieve your learning objectives while using multimedia to improve your teaching and learning practices (Majumdar, 2006).

For both learners and teachers, information and communication technology promotes high-quality education and an effective teaching-learning environment. Information and communication technology (ICT) has been shown in several studies to give educational opportunities and environmental preparedness for classroom learning. More specifically, ICT plays a larger role in knowledge generation and information processing for issue-solving and future exploration. Using ICT in classroom learning provides a more practical, engaging, and inventive approach. It is a powerful tool that creates a practical environment and supports new teaching and learning methods, as well as assisting learners in developing knowledge and skills in teamwork, communication, and problem-solving.

However, integrating ICT into classroom learning remains solely the responsibility of the facilitator/teacher. It is important to recognize the crucial role that science teachers play in setting up the framework for effective ICT-supported learning by choosing and assessing the most appropriate technological resources for achieving chosen curriculum goals (Savec, 2017).

#### 2.1.4.3 Blending ICT with the traditional classroom

The advantages of both traditional classroom instruction and ICT-supported learning are combined in the unique idea of BL. The entire potential of traditional classroom instruction is provided by BL, where learners have abundant opportunities to connect with their teachers and get influenced by their values and behaviour (Lalima & Lata Dangwal, 2017). Face-to-face communication facilitates communication. Both teachers and learners are capable of receiving instant feedback that is favourable to your process of teaching-learning.

This method of teaching is based on the planned transfer of knowledge with some interaction with the subject as a means of consolidating knowledge acquisition. It is dependent on the individual's understanding process. Learning is considered in this domain as the creation of meaning rather than the memorisation of information. Through their provision and support for resource-based, learner-centred learning, ICTs present various opportunities. The more people who use ICTs in their learning process, the greater the influence will be.

#### 2.1.4.4 The importance of ICT in Blended Learning

ICT enables teachers to use more creative teaching approaches. Learners can benefit from ICT by increasing the quality and amount of information available to them and expanding the variety of learning materials. Furthermore, multimedia-enhanced learning resources provide the potential to accommodate diverse learning styles. Text, animated pictures, sound, hypertext, video, and online interaction can all be used for individual, group, and mass instruction.

According to research findings, the use of ICT has a favourable impact on learners' learning outcomes, resulting in a radical change away from the traditional teacher-centred method and toward a more learner-centred approach (Lopez, 2015; Kirschner & Woperies, 2003).

Syfers (2010) added that the proper use of ICT can catalyse the paradigmatic shift in both content and pedagogy that is at the heart of 21st-century education reform. ICT is capable of promoting the acquisition of knowledge and skills that will enable learners to learn for the rest of their lives. When properly implemented, ICT, particularly computers and Internet technologies, enable new approaches to teaching and learning rather than merely allowing teachers and learners to accomplish what they did before in a more efficient manner. These innovative approaches to teaching and learning are based on constructivist learning theories. An act is a tool that can be used across the curriculum or in specific courses to promote the development of ICT-related skills, knowledge, processes, and attitudes. It's a tool for improving learners' learning results by combining existing curricula and learning processes (Khvilon & Patru, 2018).

As part of a larger curriculum, ICT has the potential to change not only how but also what learners learn. All of this points to the importance of ICT in the transformation of schooling's organisation and structure (Khvilon & Patru, 2002). The application of ICT in science education emphasizes the integration of relevant skills in pedagogical use that are linked to a variety of teaching methods used across the curriculum.

Computer simulation is one of the technical achievements. Computer simulations are dynamic models created by computers that show theoretical or simplified representations of real-world components, phenomena, or processes (Bell, 2016). Computer simulations are programs that allow learners to engage with a computer model of the natural or physical world, as well as a theoretical system (Weller, 1996). Learners can study systems, alter variables, and test ideas in a learner-centred environment called simulation (Windschitl & André, 1998). Technology has been noted as playing an increasingly important role in curriculum delivery; it has been found that its proper use can enhance teaching and learning (Aladejana, 2016).

#### 2.1.4.5 The effect of ICT in Life Sciences Education

The role (of ICT) in Life Sciences education simplifies the visual presentation aspect of instruction. Visual learning accounts for 80% of our learning. As a result, the graphic presentations of the particular issue were simple enough for teachers and learners to understand. (Çırak Kurt & Yıldırım, 2018). If learners' instructors learn how to integrate ICT into their classroom education, it will be more effective. With the use of ICT, information can be provided quickly and conveniently, allowing learners to better understand a topic through correct visualisation and enjoy new learning experiences ( Senthilkumar , Sivapragasam & Senthamaraikannan, 2014).

It's also a universal truth that it can't replace teachers because they're such an important element of good education, and technology can't succeed without people. Technology, teaching methods, and modes are the only things that can be changed, adjusted, and upgraded. These revolutionary developments brought about by ICT compelled all educational participants to consider the future, and educational institutions, approaches, and visions accordingly.

The nature of knowledge is changing as a result of current social changes, which will necessitate significant educational reforms as well as a new understanding of the roles of teachers and learners (Gilbert, 2005; Hargreaves, 2003; Anderson, 2008). The majority of developing nations, including South Africa, are still in the early stages of adopting contemporary technology tools like computers and the Internet. Although the majority of developing nations are actively creating ICT policies (Hare, 2007; Moonen, 2008; Tilya, 2008), it has been discovered that the impact of these rules on educational practice is minimal (Gedik et al., 2012).

#### 2.1.4.6 Disadvantages of ICT

According to Aladejana (2016), virtually little effort has been made to integrate ICT into secondary school classrooms. In order to improve learning and performance, it is imperative to refocus efforts on integrating technology into the classroom. ICT use in African schools has been cited as being hindered by a lack of suitable funding, inadequate infrastructure, unstable power supplies, a lack of electricity, unqualified staff, poverty, and limited or no internet connectivity (Ndlovu, 2015) BL, on the other hand, may be a better option.

There may be a variety of difficulties while incorporating ICT into teaching and learning because it is thought to be a complex process. These difficulties are known as "barriers" (Schoepp, 2005). Any obstacle that makes it harder to move forward in achieving a goal is referred to as a barrier (WordNet, 1997, as cited in Schoepp, 2005).

To improve the quality of teaching and learning and to increase learners' understanding of what is being taught, ICT in education and the curriculum as a whole are being integrated (Mathevula & Uwizeyimana, 2014). Due to a lack of competence to influence the use of ICT for curriculum delivery, the promise of ICT to stimulate pedagogy has not yet been completely realized (Srivastava, 2016).

## 2.2. Role of theory in the study

The theory underpinning my study is situated learning theory (SLT). According to this learning theory, learning occurs naturally as a result of interactions and relationships centred on a particular domain that occur within a social, cultural, and historical context (Lave & Wenger, 1991). Lave and Wenger developed this theory's implementation processes in 1991, which is why they conducted their study on sociocultural development, community practice, and legitimate peripheral participation (Jonassen, 2004). According to Lave and Wenger (1991), the real-world environment is what determines how people interpret concepts and this social context in which learning occurs through interpersonal relationships and the linking of existing knowledge to real-world contexts. It incorporates group work and peer reflections to promote collaborative learning through social interactions (Owen-Pugh, 2002; Riveros, Newton & Burgess, 2012). Situated learning highlights the idea that a lot of what is learned is specific to the setting in which it is taught (Lave, 1988; Lave & Wenger, 1991; Greeno, 1994).

The situated nature of learning provides further support for science teacher preparation that integrates learning about educational technology within the context of learning to teach science, and in the context of the study BL is utilised (Bell & Park, 2008; Luft, Roehrig, & Patterson, 2003; Mishra & Koehler, 2007; Smetana & Bell, 2011).

In this study, learners are socially interacting with each other and their environment through collaborative learning (BL) where they are actively constructing their knowledge in a classroom setting. In these classroom settings, learners learn based on relationships between each other and their environment, where the teacher tries to get the learners involved in the communities of practice and where there is a close link between learning and doing (Wolfson & Willinsky, 1998; Mills, 2013; O'Kelly, 2016).

The theory underpinning the study was chosen as the theoretical foundation since it is based on an anthropological understanding of natural learning in natural contexts. Theoretically, situated learning has the potential to be advantageous because it places learners in real-world settings where socially acquired knowledge is frequently valued, increases the likelihood that what is learned will be applied in similar circumstances, and strategically makes use of the learner's prior knowledge on a particular topic (Lave & Wenger, 1991).

Therefore, situated cognition emphasizes interactions between the learner, other learners, and BL in a sociocultural environment (Allal, 2001; Schell & Black, 1997). Learning is shaped by the way that learners connect, with the resources they utilise in these interactions, by the activity itself, and by the social setting in which it occurs. Lave (1996) contends that "adding contextual settings to learning experiences, treating relationships between people, tools, and activity, as they are provided in social practice, offers a more hopeful alternative. Therefore, the information acquired through learning in a situated context is practical knowledge that reflects the values of the learners themselves.

The following are the basic characteristics of contextual learning theory as proposed by Lave and Wenger (1991)

- The sociocultural theory of development serves as the foundation for situated learning. According to the theory, a person's environment has a big impact on how they develop cognitively.
- Communities of practice should be places for learning. Learners interact with one another to achieve common learning objectives.
- As they progress, learners join the community of practice as legitimate peripheral participants (LPPs).

### 2.2.1 Sociocultural theory development

The core idea behind this theory is that social contact serves as the foundation for cognitive growth in individuals (Vygotsky, 1978). Every function in a child's cultural development, according to Vygotsky (1978), "appears twice: first, on the social level, and then on the individual level; first, between people (interpsychological), and then inside the child" (intrapsychological). This holds for concept development, logical memory, and voluntary attention.

In the context of this study, I explored how learners' understanding of genetics can be afforded by BL from the culture of their Life Science classroom and their peers. The classroom social interaction and classroom culture are responsible for shaping conceptual understanding of a learner as an empty vessel to a master of the content taught in the classroom. Classroom culture can be regarded as the classroom setting and the language of communication in a Life Science classroom

Cooperative learning is therefore a characteristic of sociocultural interaction (PHSN Binti Pengiran, 2018). The learners shouldn't be cut off from their surroundings; instead, they should be encouraged to interact with other learners, teachers, or other knowledge sources like books, journals, and computers (Kouicem & Nachoua, 2018).

### 2.2.2. Community of practice

Community of practice are people in groups who share a common interest or passion for a certain topic and who are improving their performance through interactions. However, individuals are brought together by shared, similar activities and by the lessons they have learned through taking part in the activities (Wenger, 1998). Everybody participates in communities of practice that are present everywhere, according to Lave and Wenger's (1991) argument. According to the situated learning theory, learning involves people participating in a community of practice at work, at home, or school. In this study, a group of learners in grade 12 who were exposed to BL while learning about the concept of genetics created their community of practice.

According to Lave and Wenger (1991), three existent factors—the domain, the community, and the practice—define communities of practice. The domain includes both a network of colleagues and a practice denoted by a shared field of expertise. Membership demonstrates a commitment to the field and demonstrates shared skills that set the community's members apart from the general populace. While the community pursues its interest in the field, members of the group engage in related activities and discussions to help one another and exchange information.

The participants can relate to and learn from each other through this type of exercise. This is why, in my study, I gave the grade 12 Life Sciences learners the freedom to collaborate in groups for the sole aim of comprehending genetics as a community. With the use of BL, they participated in conversations where they were able to impart their genetic knowledge. Learning took place amongst learners in this manner. The community of practice members is executant in terms of the practice. They create what is known as a shared practice, which is a collection of resources including exposures, impressions, materials, and approaches to problem-solving. The interactions involved here could continue for a while.

### 2.2.2 Learners as Legitimate Peripheral Participants (LPP)

LPP is the learning process that occurs when a beginner is brought to the community of practice (Lave & Wenger, 1991). In a collaborative activity, LPP illustrates how beginners become experts. From the viewpoint of Lave and Wenger, learning is viewed as a social context that is achieved through a community of practice. Through side activities, beginners get accustomed to the duties being performed. According to LPP, a novice's physical and social participation in a community of practice is what qualifies them as a member. If there is a trainer-trainee relationship between a master and a novice, the master has the power to legitimise the novice and to keep track of how much access the novice has to the various activities and interactions of the community. The conditions in which the novices' endeavour fit are understood if they can maintain a watch on the masters' practices.

Participants are originally positioned outside of the community of practice. As individuals gain confidence and knowledge, they increasingly participate in the primary activity and move from LPP to full participation (Wenger, 1991:37). Learning is seen more as a social activity than as an individual's pursuit of knowledge. As a result, the situation's nature has a big impact on the procedure (Tennant, 1995)

Greeno (1994) supported Lave and Wenger's (1991) idea of situated learning and its effects in a classroom setting. It is founded on the belief that social contact, realistic (real-life) context, and constructivism are the best ways to learn (Greeno, 1994). Individuals' views and behaviours are interpreted as resulting from their participation in social, cultural, and historical contexts in a situated viewpoint on a research issue (Turner & Nolen, 2015). As a result, the theory will be implemented in the context of this study based on the following principles;

### 2.2.4. Social interaction

Social Interaction is a way in which individuals act and react concerning one another (Cerulo, 2009). This assumes that understanding, significance, and meaning are developed through relating with other human beings (Amineh & Asl, 2015). According to Vygotsky (1978), community and cultural mediation have a significant impact on other people's knowledge, and learning occurs as a result of contact going towards a person. It alters the responsibility of knowledge acquisition from the teacher/facilitator to learners and also alters the learner from an inactive empty vessel to an active participator and a co-constructor of knowledge (Akpan, Igwe, Mpamah & Okoro, 2020)

In this study, social environment is a vital element in the growth of learner understanding. What a learner learns about the world and comes to know as knowledge depends on the society in which he lives and the social contexts in which he participates. The infant, therefore, learns through social interactions as well as through aspects of his own culture like language. As the learners will be socialising in the study as learners they learn from each other and the environment.

From a situated perspective, individuals learn as they engage in and become deeply ingrained in a learning community or culture, engaging with the community, and learning to comprehend and participate in its history, cultural norms, and laws (Fenwick, 2000; Lave & Wenger, 1991). The idea of peer-to-peer interaction is one of the most significant of Vygotsky's theory implementations. Teachers today tend to understand the value of peer-to-peer connection for a variety of reasons, such as learners may learn the value of some activities that seem significant to their classmates.

The finest learning settings, according to Lave, are those that have social interactions, real-world circumstances, and technologies. Learning occurs in a hands-on, project-based environment as a result of engagement in a community of learners. The teacher's responsibility in the discourse community in the classroom is to actively support learners in overcoming challenges by pushing the limits of their comprehension with challenging situations and assisting learners in managing ambiguity (Gredler, 2016). Based on the theory, teachers may integrate educational technology as a tool into the activities of their learners (Kouicem & Nachoua, 2018). For instance, in this study, the researcher designed lessons that mandate that learner use tools such as a computer to help enhance learners' conceptual understanding in groups and collaboration.

### 2.2.5. Constructivism

Constructivism is a significant process where learners learn through active participation to construct or create basic knowledge by themselves (Akpan, Igwe, Mpamah & Okor, 2020). Jerome Bruner proposed the constructivism hypothesis in 1966 (Olorode & Jimoh, 2016). People developed their understanding and knowledge of the world, by experiencing things and reflecting on those experiences (Akpan et al., 2020). There are some philosophical meanings and individual meanings that some theorists support within the context of education. This idea has commonly been described as a learning philosophy predicated on the idea that via reflection on one's prior experiences and learning environment, one can create new knowledge of the world in which one lives. In this study, learners will be actively constructing their knowledge making a connection with what they already know with new information learning through BL.

For instance, constructivism is described by Naylor and Keogh (1999) as an approach whose fundamental tenet is that "learners can only make meaning of new situations in terms of their previous understanding." According to Searle (1999), Constructivism is built upon premises of a social construction of reality. Lev Vygotsky presented social constructivism as a learning theory in 1968. Language and culture, according to the theory, are the frameworks through which humans experience, communicate, and comprehend reality. Knowledge, according to the social constructivist, is created by learners working together with other learners, teachers, and peers (Akpan et al., 2020).

Learners actively participate in the learning process, connecting new concepts to what they already know to create meaning. Constructivism, in the opinion of Flynn, is a philosophy that "is about assisting the learner to progress beyond mere recall (memorisation) toward understanding, application, and competence" (2004). In this study, learners will be actively constructing their knowledge through interaction with their peers and ICT. Therefore, constructivism acknowledges that learning occurs when learners interact with their environment and prior information to actively produce new knowledge. This suggests that the teacher does not impart information, but rather gives learners the tools and incentives to do it. Furthermore, because it forges a solid bond between the individual and his society, it aims to adapt the individual to the environment he lives in, and fosters a sense of belonging to that society. Constructivism theory is a fundamental theory that can be used as a tool to understand and recognize the society with its knowledge and technologies in the study.

### 2.2.6. Authentic context

Authentic learning is defined by Sindelar and Brownell (2001) as educational activities that give learners the chance to investigate real-world problems through authentic learning experiences in collaborative learning contexts. Even though the contextual learning model has been used in both teaching and learning (Standal & Jespersen, 2008; Wolfson & Willinsky, 1998). Authentic context typically focuses on the real-world and participation in virtual communities of practice (Lombardi & Oblinger, 2007). In this study, tackling real-world problems motivates learners, and they frequently exhibit a preference for doing rather than listening.

BL is used as a technological tool to promote learning, in line with the situated learning theory, which contends that learning to integrate technology into education is most effective when it occurs in a realistic situation (Friedrichsen, Dana, Zembal, Munford & Tsur, 2001; Luft et al., 2003; Mishra & Koehler, 2007; Smetana & Bell, 2011; Willis & Mehlinger, 1996). According to Brown, Collins, and Duguid (1989), Brown and Duguid (1993), and Collins, Brown, and Newman (1989), a situated learning environment offers an authentic context that replicates how knowledge will be applied in real-life situations, preserves the full context of the situation without fragmentation or decomposition, and encourages exploration while taking into account the inherent complexity of the real world. In the study, learners were expected to construct their knowledge independently, socially, and authentically during the lesson presented using the BL method. It is expected that, through this lens, learners will be taking responsibility for their conceptual understanding of genetics while learning from each other through the use of more than one teaching approach.

**Conclusion**

The literature on the use of BL in classrooms for teaching and learning has been reviewed in this chapter. The review demonstrates that despite obstacles, using BL in the classroom is very advantageous for the learning process. The difficulties that teachers face in using BL in the classroom must therefore be addressed. Additionally, situated learning in the study was discussed in the chapter as the study's primary theoretical foundation. Since technological development is accelerating, teachers can now include technology in constructivist learning theories. By using ICT as a tool for learning, constructivist learning theories like activity theory and social constructivism have transformed pedagogy. More study on efficient learning theories is needed given the growing use of technology.

# CHAPTER 3: Research Methodology

## 3.1. INTRODUCTION

This chapter describes the research technique, including the research design, sample, data collection, data analysis, quality standards, ethical issues, and permission to conduct the study. According to Polit and Hungler (2004), methodology refers to ways of obtaining, organising and analysing data. Methodology decisions depend on the nature of the research question. Methodology in research can be considered to be the theory of correct scientific decisions (Mouton & Marais 1996). In this study, methodology refers to how the research was done and its logical sequence.

## 3.2. Research approach

The study used a qualitative research approach. The approach involves the interpretive, naturalistic approach to subject matter by the researcher (Creswell, 2012). Qualitative research is defined by Creswell as an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem (Creswell, 2009). Furthermore, the approach involves gaining understanding of a particular phenomenon. It enables the researcher to explore the phenomenon in depth, putting emphasis on the process rather than on results, and allowing insights into change processes (Mkhonto, 2010; Babbie & Mouton, 2001).

The rationale for using this approach was because this study sought to explore the affordances and constraints of blended learning (BL), which required the researcher to gain understanding of phenomena in depth by emphasising the process instead of results. As such the qualitative research approach afforded the abovementioned to be carried out. Furthermore, the rationale for using this approach was because, in qualitative research, the researcher collects and interprets data and reports the research findings in a detailed descriptive manner (Given, 2008). That way, the researcher is able to make sense of and interpret the phenomenon in terms of the meanings that people bring (Mbengwa, 2010). Learners' ability to understand and explain concepts relating to their learning experiences was fundamental in this regard.

## 3.3. Research design

A research design is defined as a strategic framework for action that serves as a bridge between research questions and the execution or implementation of the research (Durkheim, 2006). It also entails establishing and planning ways in which the research is to be conducted, so that sound conclusions in relation to the research questions as well as the problem statement are reached (Mbengwa, 2010).

The research design that underpinned this study was a single interpretative case study based on Stake. According to Stake (1995), case study is defined as a plan to analyse a case or multiple cases in a bounded system to explore in-depth the involvement of the participants in the study. The rationale for using this design was because I as a researcher sought to conduct a study on a group of learners in the same grade, studying the same subject and confined to the same environmental conditions, which qualified them as a case. Hence, the participants in this study, in this case study, were the Grade 12 Life Sciences learners. Furthermore, Johnson and Christensen (2017) suggested that case study offers the researcher the chance to examine a phenomenon in its actual setting. In the context of this study the phenomenon is represented by Grade 12 B Life Science learners.

### 3.1.3 Sampling

Sampling is a process of selecting subjects or participants to take part in a research investigation on the ground that they provide information considered relevant to the research problem (Oppong, 2013). Scott and Usher (2011) also stated that sampling refers to the selection of a subset of persons or things from a larger population, also known as a sampling frame, with the intention of representing the particular population. According to Streubert and Carpenter (1999), participants are chosen based on their first-hand knowledge of phenomenon of interest.

This study was conducted in a secondary school in Moletlane circuit in Limpopo Province. The school had a population of seventy-two (72) Grade 12 Life Science leaners from two different classes A and B, and their age ranged from 16 to 18. Population is a group of humans or items that are the subject of a scientific inquiry (Casteel & Bridier, 2021). The first class (A) had fifty (50) learners whilst the second class (B) had twenty-two (22) learners.

The study used two sampling methods namely: **Purposive and convenient sampling**

Purposive sampling was used in the study to sample participants who took part in the study, based on the fact that they were in a Grade 12B Life Sciences classroom (Stake, 1995). Hence, purposive sampling is defined by Arikunto (2010) as the process of choosing a sample by taking a subject that is not based on the level or area, but is taken based on the specific objective.

Convenient sampling referred to selection of participants based on their easy availability and accessibility to the researcher (McLeod, 2021). This technique allowed me to select individuals who were readily available at the time of the study. Furthermore, this technique is often used when the researcher wants to collect data quickly or lacks resources or time to employ more rigorous sampling techniques (Neuman, 2013).

The second (B) class was conveniently and purposefully sampled as it meets the sample requirements for the study. The sample was gender sensitive as it has a gender balance between male and female learners. Twelve (12) females and ten (10) male learners participated in the study. The rationale for using purposive and convenient sampling are: (1) ‘Purposively’: In the study learners who participated in the study were in one school situated within the aforementioned circuit, in the second class, the B class, and studying Life Sciences. (2) ‘Conveniently’ the learners (participants) in the study were chosen because they are in the same grade that I teach. Thus, I can easily have access to these learners without incurring any cost during data collection and the learners will be in a comfortable environment as learners are familiar with me.

### 3.2 Data collection

Data collection is a systematic process that I used to gather and measure information on selected individuals to answer research questions and evaluate outcomes (Creswell, 2017). Due to the qualitative nature of this study, the study constitutes the liberty of using multiple data collection instruments (Msimanga & Lelliott, 2013). Furthermore, Stake (1995) advocated the use of particular protocols and processes that represent efforts that go beyond mere data collection repetition to a deliberative attempt to determine the validity of data collected in the study. Thus, data was collected through written work (document review), participative classroom observations and semi-structured interviews, concurrently. The data was collected for the duration of three classroom sessions of sixty minutes each. Data was collected in terms of audio and written documents.

All above instruments were used in a classroom discourse. Classroom discourse refers to the language and communication that takes place between teachers and learners within a classroom setting (Mercer, 2014). It encompasses the ways in which teachers and learners use language to discuss, analyse, and interpret academic content, as well as the norms and rules that govern communication within the classroom (Walsh, 2011).

**Classroom environment**

- Grade 12 B classroom had twenty-two learners.
- These learners were grouped into four groups 1-4.
- Group 1 and 2 had five learners each and group 3 and 4 had 6 learners each.
- In each group learners were given a number from 1-22
- Group 1 had (1-5), Group 2 (1-5), Group 3 (1-6), Group 4 (1-6)
- Each learner in a group were given a code e.g. Learner 1 in group 1 was given **G1-L1** Learner 1 in group 2 – **G2-L1**

The audio recorder was set before collecting data. The lessons were structured in such a way that it would be possible to employ BL in action to enhance the learning of genetics and I as the researcher was observing, and simultaneously interviewing learners throughout the session. Afterwards learners were given a short test based on genetics which was then marked. These classroom sessions were conducted using BL as a teaching method.

As the researcher I was a participative observer: I was observing learners as they were engaged in a classroom sessions. I was observing classroom arrangement, learners' behaviour, body gestures and the interaction among learners with the use of the BL method. This classrooms session employed BL throughout the three sessions.

### 3.2.1 Written work (Class activities)

Learners were given written work to complete i.e., an activity after each lesson, then these activities were graded and used to find out if learners reflect an enhanced understanding of the concept taught. An effective style of designing activity questions were used, which involved lower-order and higher-order cognitive levels (Swart, 2010). The activities were prepared with the aid of past papers from the examination bank focusing on the topic taught. Written work of high order questions provided significant data to be analysed qualitatively. The data collected determined how BL enhances Life Sciences grade 12 learners' understanding of Genetics. This instrument addresses research question two: How does BL enhance Life Sciences grade 12 learners' understanding of Genetics.

**It is important to highlight to that classroom observation and semi-structured interviews occurred concurrently during each classroom session, the rationale is explained bellow**

### 3.2.2 Classroom Observation

Life Sciences grade 12 learners were observed in their classrooms, where teaching and learning took place, as part of this study. Observation is regarded as a way of listening and watching a phenomenon occurring (Kumar, 2011). Observation, according to Macmillan and Schumacher (2010), is the process by which a researcher gets a sense of the everyday activities taking place at the study location. To gain a deep grasp of the research phenomenon, both the lessons and the interactions between the learners were observed for this study. Observation is divided into two type's i.e. participative observer and non-participative observer. The participative observer is taking part in the activity taking place, while the non-participative observer is passively not involved in the activity (Kumar, 2011).

I as the researcher was taking part as a participative observer, as I was observing learners engaging in the learning of Genetics through BL. As the researcher, I also participated in classroom activities, and I was able to monitor the lessons with permission and in this capacity.

Lesson observation took place throughout the three sessions which lasted for sixty minutes per session.

**Observation checklist**

- Role as a participative observer.
- Have a means for recording observation – an observational protocol audio recorder.
- Observe learners' interaction, behaviour and how they express themselves throughout the sessions.
- Take notes throughout the observation.
- Use complete sentences for detailed field notes

**Table 3.1: Observation schedule**

| **Observation** | **Description of aspect observed** |
|---|---|
| • Classroom arrangement | |
| • Learners' interaction: Learner to learner | |
| • Learners' classroom behaviour and reaction | |
| • Learner interaction: Learner to teacher | |

### 3.2.3 Semi-structured Interviews

Semi-structured interviews are interviews with participants based on a pre-determined set of questions or topics, while also allowing for open-ended responses and follow-up questions to explore participants' experiences and perspectives in more detail (Kvale & Brinkmann, 2009). In a semi-structured interview, the interviewer has a general framework of questions to ask, but they have the flexibility to probe deeper into the participant's answers or to ask additional questions to clarify any ambiguities (Rubin & Rubin, 2012).

The rationale for using semi-structured interviews in research is that they allow researchers to gather rich and detailed data about participants' experiences, attitudes, and perspectives (Creswell, 2014) on learners understanding of Genetics. Semi-structured interviews offer a balance between the standardisation of closed-ended questions and the flexibility of open-ended questions. The pre-determined set of questions or topics provides a degree of standardisation, which helps to ensure that all participants are asked similar questions, enabling the researcher to make comparisons across participants (Creswell, 2014). These interviews took place in the form of questions that I asked the learners during classroom discourse throughout the three 1 hour sessions I had with the learners. As learners were in small groups, a maximum of eight learners were interviewed in each of the three sessions. Questions asked were based on learners' observed behaviours, reactions, answers and questions which were asked by learners during each session.

The questions which arose from the sessions are as follows:

**Semi-structured interview questions for 3 days.**

- What is genotype?
- What is phenotype
- What is the relationship between genotype and phenotype in a Monohybrid Cross? (drawn from learners' response to the questions presented on chapter 4)
- Can you explain what a Monohybrid Cross is?
- What is the difference between a dominant allele and a recessive allele?
- How can you determine the genotype of an individual based on its phenotype?
- What is the Punnett square and how is it used to predict the outcomes of a Monohybrid Cross?
- Can you provide an example of a Monohybrid Cross and show how to use a Punnett square to predict the offspring genotype and phenotype ratios?
- What is meant by the term heterozygous and how does it differ from homozygous?
- How can incomplete dominance and codominance affect the outcomes of a Monohybrid Cross?
- How do environmental factors influence the expression of traits in an individual?

**The rationale for using participative observation and semi-structured interviews concurrently**

Observation and interviews capture different aspects of the research topic. Observation focuses on the actual behaviours, interactions, and context, providing a direct view of participants' actions. On the other hand, interviews explore participants' thoughts, perceptions, and subjective experiences (Marshal & Rossman, 1998). By using both methods, researchers can capture both the observed behaviours and the participants' interpretations and reflections on those behaviours.

In the context of the study, participative observation allowed me to study the phenomenon within its natural context. By observing participants in each classroom session, researchers can gain insights into how the environment and social dynamics influence behaviours (Creswell, 2014). Interviews, on the other hand, provide an opportunity for participants to reflect on their experiences, provide context, and offer explanations for their actions observed during the study (Boyce & Neale, 2006). The combination of both methods helps contextualise the observed behaviours and provides a deeper understanding of the underlying factors. Using participative observation and semi-structured interviews concurrently can enhance the validity of the research findings. The data collected from different sources were compared and validated.

The findings from observation and interviews align or converge, strengthen the credibility of the results and provide greater confidence in the interpretations made. By using observation and semi-structured interviews concurrently, researchers can benefit from the strengths of each method and overcome their limitations. This combined approach provided a more comprehensive, contextualized, and validated understanding of the research topic.

## 3.3 Data analysis

The data gathered through interviews as recordings were replayed to assist in transcribing the data properly. Data gathered through classroom observation was thematically analysed. Thematic analysis is a systematic approach where rich data is organised and unpacked into codes and themes based on the study (Braun & Clarke, 2006). They point out that this system makes it possible for the researcher to interpret the group experiences, to keep track of their data analysis processes, and the method is user-friendly and adaptable. The data gathered from the observation, interviews and document review were analysed using thematic analysis where themes were generated from data emanating from what was observed and the responses provided by learners during interviews and from the activities they were given (Stake, 1995). Furthermore, codes were used to identify the learners who participated and the responses they provided and the emerging trends thereof (Saldana, 2009).

## 3.4 Document analysis (class activities)

Document analysis is a method of gathering data that enables researchers to systematically utilise written evidence to address research inquiries (Bowen, 2009). This technique allowed me to examine and interpret data in order to gain a deeper comprehension and insight into the subject matter (Corbin & Strauss, 2008). In order to assess how the Blended Learning (BL) integration can afford or constrict the understanding of genetics by grade 12 learners, learners were assigned three writing tasks, and I collected their scripts for analysis. These scripts were treated as documents to be analysed for the identification of any affordances and constraints in understanding Genetics when BL is integrated into the Life Sciences classroom. As per Stake (1995), data collection and analysis can occur simultaneously. Hence, the same activities (class activities) were used both for data collection and analysis purposes.

### 3.3.1 Quality Criteria

This study was guided by a qualitative approach that determines its trustworthiness focusing mainly on the validity, transferability and reliability (Lincoln & Guba, 1985; Pieterse, 2014).

- **Credibility**

According Frambach, Van der Vleuten and Durning (2013, p. 552) credibility is defined as the "extent to which the study's findings are trustworthy and believable to others". In an attempt to address this aspect, I relied on the use of multiple data sources to achieve triangulation, where data collected from observations and semi-structured interviews were supplemented with document reviews. This study adopted a purposive sampling strategy to obtain credible study information. This is in line with given's (2008) view that triangulation helps the researcher to look at the data from different perspectives and viewpoints to get a holistic picture of the environment. The document reviews were used to determine if what learners reflected from the classroom discourse (observations and semi-structured interviews) could be reflected from a written activity. Hence ( Cummings,Mason,Shelton & KayeBaur, 2015) cautioned that a study's credibility or internal validity guarantees that its goals are met.

- **Dependability**

According to Frambach et al. (2013, p. 552), dependability is defined as "the extent to which the findings are consistent in relation to the contexts in which they were generated". In an attempt to address this aspect, I collected multiple times until I achieved saturation where no new themes emerged. Hence, dependability correlates with the notion of reliability and it is stability of research data over time and conditions (Pieterse, 2014). It ensures consistency in the research and shows how well the data captures the evolving circumstances of the phenomenon being examined (Lincoln & Guba, 1985). In the context of the study to ensure dependability, the researcher took measures to ensure that if the research was to be repeated under the same circumstances, using the same methods and involving the same participants, similar outcomes would be achieved. In this study, the incorporation of complementary techniques such as focus groups, individual interviews, and document analysis helped address issues related to dependability. As Guba (1981) highlights, the weaknesses of one method were compensated by the strengths of the others, thereby strengthening the dependability and credibility of the findings. Additionally, the researcher addressed dependability issues by providing in detail all research procedures and result analyses, enabling another researcher to repeat the same protocol and produce trustworthy and dependable results. The purpose of reliability tests was to demonstrate the stability and consistency of the inquiry process.

- **Transferability**

Transferability refers to the extent to which the researcher’s working hypothesis can be applied to another context (Carlson, 1998).The extent to which the results of one study can be transferred to different settings is what Merriam (1998:39) defines as transferability; this study provided descriptive data, interpretation and a conclusion which support each other and the content of the study. This allowed a third party to make a general judgment and whether the results can be applied in other contexts. In the context of the study, I employed thorough and inclusive explanations of the outcomes derived from semi-structured interviews, participatory observations, and reviews of documents. This approach was taken to emphasize the practical applicability of the findings in different environment

- **Confirmability**

The presence of confirmability ensured that the findings of the study are independent of the researcher's biases, motivations, interests, or points of view. According to Miles and Huberman (2006), a key element in establishing confirmability is how often the researcher admits their own proclivities, viewpoints, and preconceptions. In terms of confirmability, this researcher has provided a thorough methodological description, outlining the approaches that have been preferred and why, attempting to lay out and explain the processes carried out in the research process, as well as admitting any inadequacies in the research process. The role of triangulation is important in promoting conformability to reduce the effects of investigator bias. In the context of the study, the researcher was keeping detailed records of the research process, including data collection, analysis, and interpretation, allowing supervisor to follow the researcher's decision-making and verify the credibility of the findings. Therefore engaging with other researchers to discuss and review the research process and findings to provide different perspectives and help identify potential biases.

The extent to which the researcher's assumptions about the properties of the data was validated by those who read or study the research findings is referred to as confirmability (Carlson, 1998). The researcher examined the study products' internal coherence, including the data, findings, interpretations, and recommendations

### 3.3.4 Ethical Considerations

When humans are involved in a study, ethical considerations are required, and they should always be considered during the research process (Creswell, 2013). As a result, learners were guaranteed of anonymity, confidentiality, and privacy declaration forms will be signed (Newman, 2000). The study was conducted in a way to maintain a good relationship and trust between the researcher and participants. The researcher made it a point that no one be harmed or discouraged, and he respects participants' opinions and rights.

### 3.3.5 Permission to conduct the study

From the Turfloop Research Ethics Committee, the researcher received approval to carry out the study (TREC). The study cannot be conducted without approval from the aforementioned departments. Thus, the study had informed consent from both the school and each participant, taking into consideration each individual's permission, confidentiality, privacy, gender, religion and reciprocity. Participants were informed about the purpose of the study. Then the researcher sought permission from the Limpopo Department of Basic Education, before seeking permission from the circuit of the school earmarked for data collection. The school principal and Grade 12 class teacher were asked for permission to conduct the study in the classroom.

### 3.3.6 Informed Consent and Assent forms

Informed consent and assent forms both play a role to inform study participants of critical data regarding the study, such as risks and benefits, before deciding whether or not to participate (Nnebue, 2010). The participants were gently taught both forms. Participants were also notified that they have the option to leave the study at any time. In other words, the researcher ensured that participants understood the research's logic as well as its goals and objectives.

### 3.3.7 Anonymity and Confidentiality

The researcher advised the participants that their identities will not appear in the research papers, ensuring confidentiality. This research's data was only be utilised for the study. The purpose of the pseudonyms and codes was for easy recording, analysis and grouping. The completed responses were kept safe and secured by the researcher

### 3.3.8 Bias

Participants were not selected based on their performance, and there were no specific criteria for their presence. Their participation in the study was voluntary, meaning they were not compelled, forced, or obliged to take part. However, all learners in the grade $12^{B}$ class were provided with an equal opportunity to learn about Genetics through the integration of BL. Even if some learners chose not to participate in the project, the researcher still conducted separate lessons on Genetics to ensure that all learners in the class were taught the topic.

As the researcher was collecting data from the school where he is employed, it was crucial to ensure that there was no bias or influence exerted on the participants. The participants were not forced into participating in the study (McMillan & Schumacher, 2010). To prevent any feelings of pressure, the researcher enlisted the help of a neutral colleague, such as the Head of Department (HOD), who was not involved in teaching the class. The HOD explained the research procedures to the participants, ensuring transparency and clarity in the study's conduct.

### 3.3.9 Conclusion

In order to study the use of BL in teaching and learning, this chapter gave a clear and justified methodological approach. Unstructured interviews, classroom observations, and document analysis were all used in this study's qualitative methodology. The gathered information was analysed in accordance with Moustakas' (1994) suggested analytical processes, which included transcription, individual textual description, the analysis's reporting, fundamental structure, and individual structural description. In addition, the chapter covered issues with the reliability, dependability, conformability, and ethics of the data gathered to assure the validity of the study.

The subsequent chapter contains the research findings. Additionally, information is offered in regard to the research questions and the equipment utilised to gather information for each participant group.

# CHAPTER 4: Results presentation and discussions

## INTRODUCTION

An in-depth evaluation of the research data is provided in this chapter. A technique of making sense of the data, according to Stake (1995), is known as data analysis. A method that is qualitative was chosen, as described in Chapter 3. To determine the procedures put in place by the researcher to ensure the efficient use of Blended learning (BL), data was gathered from classroom observation, learners' interviews and document review. This data was then thoroughly evaluated. As a result, the research questions may be answered.

The analysis and interpretation of the research findings are provided in this chapter. A qualitative methodology was used, as explained in Chapter 3. Data which was gathered using the above-mentioned instruments, was carefully analysed to determine the procedures put in place by the researcher to explore BL in a classroom. In doing so, the research questions were answered.

Analysing qualitative data was done with research data. According to Burton, Brundrett, and Jones (2008), in order to organise, compile, and interpret qualitative data, emerging main themes must be found. Qualitative data is more prone to ambiguity. To learn more specifically about how using BL might improve teaching and learning, data was gathered from participants. To accomplish this, themes found in the data were found, analysed, and reported on. According to Burton et al. (2008), this technique thoroughly organises and explains data sets. As a result, the researcher explained the results in terms of the participants' actual experiences. Themes were discovered through data analysis. By grouping the detected topics according to content similarity, patterns were developed. The themes that came up during the participant conversation are shown below.

Three instruments were used to collect the data with the aim to gather quality data as each element answers a specific research question.

## 4.1 Presentation of Results

I will start by providing the reader with the background of classroom environment. The class that participated in the study was a Grade 12[B] that had 22 learners with both traditional genders (female and male) well represented. The learners were grouped into four groups with the following arrangements: Groups 1 and 2 comprised of five learners each, while groups 3 and 4 comprised six learners each. The participating learners and the groups they belong to were provided codes/keys to help identify them during classroom discourse. The following keys/codes were used: G1= Group 1; L1= Learner 1; G1-L1= Learner 1 from Group 1; G2-L1 = Learner 1 from Group 2.

**N.B:** During data collection, my role as a researcher was to serve as a teacher, observer and an interviewer. As such, during the process of teaching, I referred to myself as the teacher.

The table (4.1) below represents the brief overview of the three lessons presented during data collection. The table reflects the topic, subtopics taught over the duration of three days and this includes other aspects of the lesson plan such as objectives, teaching methods and resources, to mention a few.

Table 4.1: The overview of the three lessons presented

| | |
|---|---|
| **Subject & Grade** | Life Sciences Grade 12 |
| **Topic** | Genetics |
| **Subtopic** | Monohybrid Cross |
| **Objectives of the lesson** | At the end of the lesson, learners should be able to define and clearly explain the following:<br>**Day 1 topic**<br>➢ Genotype and Phenotype |
| | At the end of the lesson, learners should be able to define and clearly explain the following:<br>**Day 2 topic**<br>➢ Types of dominance and Monohybrid Cross structure |
| | **Day 3 topic**<br>➢ At the end of the lesson learners should be able to demonstrate and solve Monohybrid Cross problems. |

| | |
|---|---|
| **Teaching method** | **Day 1:** Blended traditional teaching method with ICT. Lesson presentation through slides. |
| | **Day 2:** Blended traditional teaching method with ICT. Lesson presentation through animation**.** |
| | **Day 3:** Blended traditional teaching method with ICT. Lesson presentation through videos |
| **Resources** | Laptop; Projector; Whiteboard; Answer and series study guide; CAPS examination question papers (2017-2022) |
| **Duration** | 60 minutes for each day |
| **Introduction** | Check learners' prior knowledge about genetics by using Q & A method; Give learners a chance to express their idea about genetics and provided background information on genetics; Genetics is the study of heredity – how genetic characteristics are passed on from parents to child; Who discovered genetics? Gregor Mendel is regarded as the father of genetics for his work on garden pea plants that helped explain how genes are passed from parents to offspring. |
| **Lesson Presentation using slides** | **Day 1: POWER POINT**<br>Allele; Genotype; Phenotype |
| | **Day 2: VIDEO**<br>Types of dominance; Monohybrid Cross structure |
| | **Day 3: ANIMATION**<br>How to answer Monohybrid Cross questions |
| **Activity/Assessment** | Class activity from previous question papers (2017-2022) |

**Day 1: Presentation and analysis of data**

The focus of lesson was on Allele, Genotypes and Phenotypes. I used a variety of data collection tools, as such I will briefly deliberate on the sequence in which they were presented. I will firstly present the data concurrently drawn from the classroom observations and semi-structured interviews (see annexure A). Lastly, I present the data drawn from the class activity given to the learners towards the end the lesson.

- **Classroom observations**

The following is the presentation and analysis of data generated from the classroom observation that took place on day 1. Hence, the following observations depicted in Table 4.2 below were made, with the overall comments discussed thereafter.

Table 4.2: Observations made during lesson one.

| **Descriptive** | **Description of aspect observed** |
|---|---|
| Classroom arrangement | **Classroom Layout:**<br>Learners’ desks in groups of four, facing each other, leaving enough space between each group of desks to allow for easy movement.<br>Learners' desks were arranged in a way that all learners were able to view both the board and projection screen.<br>**Resources used for BL:**<br>A projector, projection screen, whiteboard & a laptop were used. |
| Learners’ interaction: Learner to learner | Learners were actively interacting with one another, talking about the difference between Genotypes and Phenotypes.<br>**Teacher:** what is the difference between Genotype and Phenotype?<br>**G1-L5:** "*Genotypes and phenotypes! They're the two important terms in Genetics. The genotype means a person’s genetic makeup, and the phenotype means the traits that can be seen,* |

| | |
|---|---|
| | *because of that Genetic makeup, right?"*<br>**G2-L4:** "Genotype *is like the internal structure or code that determines our traits, and phenotype is what we see or observe."*<br>**G3-L2:** "*So, let's say we have the genotype "BB" for a specific gene. That means we have two copies of the dominant allele and if the dominant allele results in brown eye colour, then our phenotype would be having brown eyes".* |
| Learners' classroom behaviour and reaction | Classroom created a space were learners felt confident, free to share their ideas and ask questions about Genotype and Phenotype.<br>**G1-L3**: "*We've been studying chromosomes recently and how they contribute to traits like physical qualities and other things."*<br>**G2-L3:** "*I think genetics is what tells us about genes".*<br>**G3-L4:** ***(confidently)*** *"Based on the G2-L3's response I disagree: genetics is about what happens within or under microscopic level, it is not about our physical features."* |
| Learner interaction: Learner to teacher | Learners felt free to ask the teacher questions about the concept.<br>**G3-L5** *So, if I understand correctly, even if two individuals have the same genotype, their phenotypes can be different if they are exposed to different environments?"*<br>**G2-L3:** *"They are found in pairs and we call them Alleles."*<br>**G4-L1:** *"I can give an example. Let's consider eye colour in humans. The genotype for eye colour may include alleles for brown, blue, or* |

| | |
|---|---|
| | *green eyes. The phenotype, on the other hand, would be the actual eye colour a person has, such as brown eyes".*<br>**G1-L5:** "*The genotype influences the phenotype through the expression of genes. Genes provide the instructions for building proteins, which play a crucial role in determining an organism's traits".*<br>Learners were actively learning through visualisation and the use of animation; they were responsible for their learning. |

***Overall comment***

The classroom layout was designed to promote collaboration and easy movement. The arrangement of learners' desks in groups of four facing each other allowed easy interactive discussions and engagement between learners and the teacher.

Based on the classroom observation, learners were actively interacting with one another. The table above reflects that **G1-L5** gave a brief difference between Genotype and Phenotype, also **G2-L4** gave the idea of what he thought would simply give the difference between the terms. On the other hand, **G3-L2** provided examples to clearly elaborate the difference between the two concepts. Based on the abovementioned this shows that learners from different groups were able to interact with one another and have a common understanding of the concepts.

Learners were free and able to confidently share their ideas. This is evident from **G3-L4** who confidently disagreed with **G2-L3** regarding the definition of Genetics by expressing her opinion freely with other groups. The classroom atmosphere was supportive, conducive to interaction and allowed learners to be free to express their opinions. In addition to the learners' active participation in discussions, **G4-L1** provided an example of eye colour, illustrating how the Genotype (alleles for brown, blue, or green eyes) influences the Phenotype (actual eye colour) and G3-L2 contributed an example to support the concept, explaining how a Genotype of "BB" for a specific gene could result in a Phenotype of brown eyes if the dominant allele for brown eye colour is present.

Learners were able to ask question where they had challenges. **G2-L3 and G3-L5** were able to ask the teacher to clarify how simply they can define Genetics. The teacher was able to interact with learners to clarify the misconception they had. Overall, the classroom promoted active learning where they were able to interact with one another and the teacher.

**Semi-structured-Interviews**

In this section I present the questions I asked the learners and the responses learners provided during lesson 1. As I present the dialogue I had with learners and the learners, I will also share the learners' silent moments, confused moments and learning moments that emerged during the lesson.

The interaction below shows my attempt to decipher the learners' prior knowledge of Phenotype and Genotype and the learners' answers reflected some misunderstanding and confusion on their part and minor understanding of the concept by a few learners:

**Teacher:** Good day. Today's lessons will be based on the basics of Monohybrid Cross i.e. Genotype, Phenotype, allele and dominance which we need to know and clearly understand to have a better understanding of Monohybrid Cross.

**Teacher:** Firstly, what do you know about Genetics?

**G2-L3:** *"I think genetics is what tells us about genes"*.

**G3-L4: (confidently)** *"Based on **G2-L3** response I disagree: genetics is about what happens within or under microscopic level to us, not about what we can see."*

**G3-L2:** "*Genetics is the study of genes, heredity, and the variation of traits in living organisms"*.

**G4-L5:** "Genetics is the study of genes. Our genes carry information that gets passed from one generation to the next."

**G1-L3**: "*We've been studying chromosomes recently and how they contribute to traits like physical qualities and other things; they can be regarded as part of Genetics"*

**Teacher**: Genetics explores how traits are passed down from parents to offspring through genes. Now, one basic concept in genetics is DNA. Can anyone explain what DNA is?

Based on learners' **(G1-L3, G3-L4, G3-L2** and **G2-L3)** arguments/responses about Genetics, this reflects that learners had difficulties with Genetics. This is evidently drawn from **G2-L3** *"I think genetics is what tells us about genes"*. As well as **G3-L4 (confidently)** *"Based on **G2-L3** response I disagree; genetics is about what happens within or under microscopic level to us, not* *about what we can see" and* **G1-L3**: "*We've been studying chromosomes recently and how they contribute to traits like physical qualities and other things; they can be regarded as part of Genetics"*

Based on **G1-L3 and G2-L3** responses, they reflected that they cannot distinguish between a gene, chromosome and Genetics, as gene and chromosome are basic structures of Genetics (Hartl & Jone, 2017). The abovementioned reflects that learners have limited understanding of what Genetics is. This reflects what was revealed by Choden and Kijkuakul (2020), that there are several learning difficulties about of Genetics aspects such as gene and chromosomes among secondary school learners. However, according to the Life Science Curriculum and Assessment Policy Statement (CAPS), learners are expected to have a basic understanding of Genetics from as early as Grade 7 (see DBE, 2011).

The learners mentioned below were able to give a clear definition of Genetics, which reflects that not all learners have difficulties with the concept of genetics. The learners needed only an elaboration of the concept with the aid of virtual presentation. This is evidently drawn from **G3-L2** "*Genetics is the study of genes, heredity, and the variation of traits in living organisms"* and **G4-L5** *"Genetics is the study of genes. Our genes carry information that gets passed from one generation to the next."*

This interaction below reflects the learners' responses to some of my questions relating to characteristics of the genes in order to explain the term Genotype and the role of chromosomes and DNA. It was during this interaction where a learning moment occurred:

**Teacher:** Mm. Thank you. But Genetics is the study of heredity – how genetic characteristics are passed on from parents to child. So, what do you think a gene does?
**G1-L3: (Learner appeared to be disinterested)** *"A gene? Um, I think it's like, the plans for your characteristics and it tells what each cell should do."*
**Teacher:** How do your genes control those characteristics? Any ideas? **G3-L17** what do you think?
**G3-L17: (Learner facial expression showed confusion)** *"I'm not sure, hm. I recently learned that it is in the nucleus and that it is then transferred*
**Teacher:** What do genes do in the body? Anyone? (As I move around learners observing their reactions to the question.)
**G1-L2: (learner appeared confident)** *"Oh. Um. The genetic code in DNA, which instructs the*

*body to produce proteins, makes up genes, and they merely carry the information that instructs the body how to function and develop".*

**Teacher:** Genes are passed down from parents to offspring, carrying genetic traits and characteristics across generations. They determine inherited traits such as eye colour, hair type, and blood type. (Shown on the power point presentation)

**Teacher:** Okay, a gene is a segment of DNA found on chromosomes, it is responsible for our physical features as it is transferred from parents to offspring. What is a Genotype? What do you think it does in our body?

**G1-L1:** *"Um. Well Genotype, um, consists of genetic code which is used for our physical appearance"*.

**G3-L6**: *"Um not sure, but I think Genotype is the genetic makeup of an individual which determines the physical appearance"*.

**Learning moment**

Learners were trying to link a Genotype and a gene as they had different ideas about how the two are related. Learner **G3-L6** just needed clarity on what she knows so that she can link the terms. This reflects that learners can only memorise what they have learned in the previous grades but are not able to elaborate on what they have learned, which raises the question regarding their conceptual understanding of Genetics. **G1-L1** and **G1-L2** had an idea of what a Genotype is, they only needed virtual presentation and clarity from the teacher in order to have a better understanding of the concept. Virtual presentation was presented in the segment that follows.

In this interaction, I was trying to have the learners provide a definition of Phenotype and Allele. It was during this time that a silent moment occurred and I took some measures as explained below.

**Teacher:** Perfect, both your answers are correct in line with the definition of Genotype, it is the genetic makeup of an individual which is responsible for our appearance.

**Teacher:** let's look at the slides for the definition and examples of Genotype.

**G1-L5:** *"How can we easily tell if some letters represent a particular Genotype?"*

**G2-L3:** *"They are found in pairs and we call them Alleles"*

**Teacher:** Good, both answers are correct. What is an Allele?

**Teacher:** Any ideas?

**Learners were Silent for a moment**

The silent moment revealed that learners lack understanding of the term allele. They were doubtful to ask questions or speak up because they were unsure of the answers. In order to guide learners, a Power Point presentation displayed the definition of an Allele and possible examples and allowed the learners to discuss and share ideas about Alleles as a class.

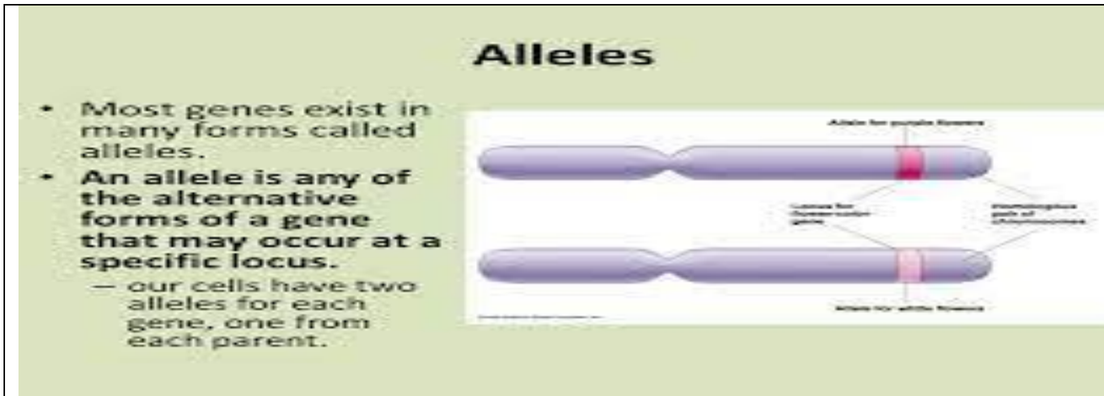


*Figure 4.1: Presentation of alleles (Reece, 2011, p. 275)*

I observed and facilitated as learners were discussing the display of allele with each other assisting where necessary. The presentation concluded the concept of Allele as the teacher was going through each group to check if they had a common understanding of the concept taught.

**Teacher:** Can anyone tell me what they understand by the term "allele"?

**G3-L5:** "*Um, I think an allele is a different form of a gene that exists at a specific place on a chromosome".*

**G4-L5:** "*If I understand correctly, genes are like the instructions that determine our characteristics, and alleles are the different versions of those instructions. They can be slightly different from one another."*

**Teacher:** Just like you said **G4-L5**, alleles are alternate versions of a gene that can code for different variations of a particular trait. These variations can result in observable differences among individuals. Typically, an individual will have two alleles for each gene, one inherited from each parent. These two alleles may be the same or different, determining whether the trait is homozygous or heterozygous.

**Teacher:** So, what's the difference between recessive and dominant alleles?

**G3-L3:** "*Alleles are different forms of a gene that can be found at the same location on a* *chromosome. Each individual inherits two alleles for each gene, one from each parent"*.

**G4-L4:** "*Dominant alleles are expressed or "seen" in the phenotype, which is the observable trait of an organism. If an individual has even just one copy of the dominant allele, it will be expressed in their phenotype, masking the presence of any recessive allele"*.

**Teacher:** So, does that mean the recessive allele is not expressed at all?

**G1-L4:** Recessive alleles are only expressed in the phenotype if an individual has two copies of the recessive allele. In other words, if an individual has one dominant allele and one recessive allele, the dominant allele will be expressed, and the recessive allele will remain hidden in the phenotype.

**G2-L2:** Can you give us an example to help clarify this?

**Teacher:** Yes, let's consider the inheritance of eye colour in humans. Suppose we have two alleles, "B" for brown eyes (dominant) and "b" for blue eyes (recessive). If an individual has two copies of the dominant allele (BB), they will have brown eyes because the dominant allele masks the presence of the recessive allele. However, if they have one dominant allele and one recessive allele (Bb), they will still have brown eyes because the dominant allele is expressed. Only when an individual has two copies of the recessive allele (bb) will the blue eye colour be expressed in the phenotype.

**Learning moment**

**In the dialogue shown above, Learners are actively learning from another and interacting with the teacher.**

The lesson continued, now focusing on topic two of the day which is the Phenotype and Genotype. A question and answer (Q&A) method was used to check with learners if they had any idea about the topic.

**Teacher:** what is a Phenotype?

**G3-L4:** *"It's a physical appearance of an individual**. (Learner was chosen because she looked certain)".***

**Teacher:** what do others think?

**G2-L2:** ***"(looked like he was not familiar with this term) P**henotype is what we can see with a naked eye".*

**G4-L1:** *"Um I don't know Sir"***.**

**G1-L5 (face hidden)**: *"Genotype is the physical appearance of an individual determined by Genotype."*

**G4-L3**: *"Genotype refers to the genetic makeup of an organism, specifically the combination of alleles it possesses for a particular trait".*

**Teacher:** That's correct, G4-L3. And what about Phenotype?

**G2-L5: "***Phenotype refers to the observable traits or characteristics of an organism that result from the interaction between its Genotype and the environment".*

**Learning moment**

The dialogue above reflects the interaction between the teacher and learners as learners were responding to questions asked by the teacher**. G4-L3 was able to give a correct definition, G3-L4 and G2-L2** had a bit of an idea of what Genotype is, while **G1-L5** was clueless but free to share what he thought with the class.

**Teacher:** So, we can say that Genotype is the genetic information, while Phenotype is the physical expression of that genetic information. Now, let's delve a little deeper. Can anyone provide an example of a Genotype and its corresponding Phenotype?

**G4-L1:** "*I can give an example. Let's consider eye colour in humans. The Genotype for eye colour may include alleles for brown, blue, or green eyes. The Phenotype, on the other hand, would be the actual eye colour a person has, such as brown eyes".*

**Teacher:** Very well **G4-L1**. It's important to note that while the Genotype provides the possibilities for different traits, the Phenotype is what we can observe and measure. Now, let's explore how Genotype and Phenotype are connected. How do you think the Genotype influences the Phenotype?

**G1-L5:** *"The Genotype influences the Phenotype through the expression of genes. Genes provide the instructions for building proteins, which play a crucial role in determining an organism's traits".*

**Teacher:** Right, the Genotype provides the blueprint for protein synthesis, which ultimately affects the physical characteristics of an organism. However, it's essential to remember that the Phenotype can also be influenced by environmental factors**.**

**G1-L5**: *"So, if I understand correctly, even if two individuals have the same Genotype, their Phenotypes can be different if they are exposed to different environments?"*

**Teacher: G1-L5** lets consider a plant with the Genotype for tall growth. However, if this plant grows in an environment with limited sunlight, it may exhibit a shorter Phenotype due to its reduced access to light.

**G3-L5 (excited) "***mmmm. I now understand how Genotype and Phenotype are related and how environmental factors can impact the expression of traits".*

**Teacher:** what is the relationship between Genotype and Phenotype?

**Collaborative learning moment**

The dialogue below shows learners (G1-L5, G2-L4, G3-L2) from different groups helping each other differentiate the terms along with an example as the whole classroom listened to their discussion.

**G1-L5:** *"The Genotype refers to an individual's genetic makeup, while the Phenotype refers to the characteristic we can see resulting from that genetic makeup, right?"*

**G2-L4:** *"Genotype is like the internal code that determines our traits, and Phenotype is what we see or observe. It's interesting how our genetic information can influence our physical characteristics".*

**G3-L2:** *"So, let's say we have the Genotype "BB" for a specific gene. That means we have two copies of the dominant allele. And if the dominant allele results in brown eye colour, then our Phenotype would be having brown eyes".*

**Teacher:** I'm glad to hear that, understanding the concepts of Genotype and Phenotype is important in the field of genetics, and it opens the door to exploring more advanced topics. Keep up the great work, everyone!

**G1-L5, G2-L4 & G3-L2** from different groups were helping each to have a common understanding of the concept. These learners were able to share their ideas about how each understood how Genotype, Phenotype and allele are linked.

I used the PowerPoint presentation to display the definition of Phenotype and possible examples and allowed the learners to discuss and share ideas about Alleles as a group and then as a class.

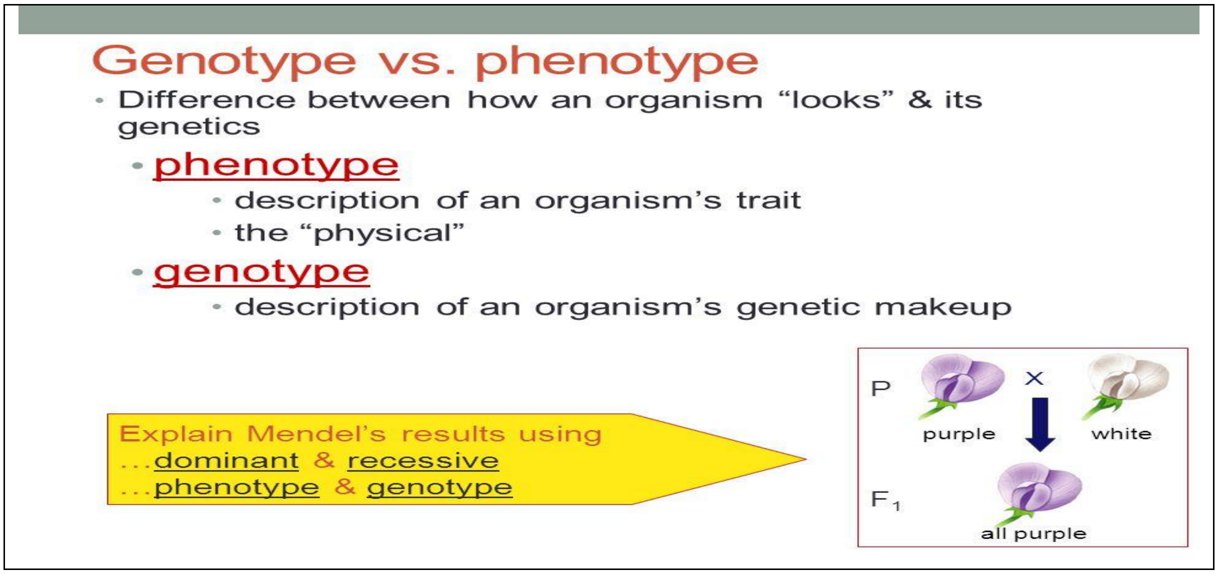


*Figure4.2: Presentation of Genotype and Phenotype ( Reece,* 2011, p. *340)*

**Teacher:** what is the relationship between Genotype and Phenotype?

**G2-L5**: *"Genotype is the genetic makeup of an individual which determines the physical appearance of an individual which is regarded as Phenotype"*

**G2-L3:** *"Both Genotype and Phenotype determine one's appearance which is transferred from parents to offspring".*

**Teacher:** can we have a summary of the lesson**?**

**G3-L5:** ***"****The way the lesson was presented enabled me to grasp all the basic information required for a better understanding of Monohybrid Cross. The demonstrations done in class improved my understanding".*

**Overall comments**

Learners learned that genetics is the study of how traits are passed down from parents to offspring through genes. Although they were able discussed concepts like Genotype, Phenotype and allele, some learners had challenges explaining what was a gene and a chromosome. Genotype refers to an individual's genetic makeup, while Phenotype is the observable traits resulting from that genetic makeup. Alleles are the different forms of a gene. They also learned that genes control characteristics by providing instructions for building proteins, which ultimately affect physical features. Additionally, they understood that Genotype and Phenotype are connected, but the Phenotype can also be influenced by environmental factors. Overall, the lesson helped learners gain a better understanding of the basics of Monohybrid Cross. This was evident from learners' response: **G2-L5** "*Genotype is the genetic makeup of an individual which determines the physical appearance of an individual which is regarded as Phenotype"*

G2-L3 "Both Genotype and Phenotype determine one's appearance which is transferred from parents to offspring".

**Class activity for lesson 1**

Learners were giving an activity to complete at the end of the lesson. This activity was extracted from one of the previous exam papers and was used as an assessment task to assess learners' level of understanding of the concept.

**Task 1**

**Question paper from the 2019 (Capricorn South) June examination**

2.1.

In humans, being a tongue roller (R) is dominant over a non-roller (r). A man who is a non-roller marries a woman who is heterozygous for tongue rolling.

a) Father's Phenotype ________
b) Father's Genotype ________
c) Mother's Phenotype ________
d) Mother's Genotype ________
e) What is the probability of this couple having a child who is a tongue roller? _____________

**G2 - (L1-L5)**, **G3-(L1,L2,L5) and G4-(L1,L2,L3)** were able to provide parents Genotype and Phenotype; only few from the abovementioned were not able to answer (e) .**G3-L1- G3-L6,** were not able to give the probability of the Phenotype of the parents. **G1-L1- G4-L4,** were able to calculate the probability but did not provide the final answer. **G4-L5 – G4-L6** were able to calculate the probability and provide the answer to the question. Learners in **G1** (**L1-L5), G2-(L3&L4) and G4-(L4&L6)** did not provide correct answers to the asked questions which reveals that they had a challenge in distinguishing between Phenotype and Genotypes of each parent and providing the correct Genotype along with their Phenotype. This led to the abovementioned learners not being able to answer the follow-up questions which is question (e). The above-mentioned reflects that those learners did not understand the concept which was taught in lesson

1, which were the basics required for a Monohybrid Cross.

**Task 2**

**Question paper from the 2019 June examination**

2.2 In rabbits the dominant allele (**B**) produces black fur and the recessive allele (**b**) produces white fur. Study the genotypes of four rabbits.

| **Rabbit** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Genotype** | BB | Bb | Bb | bb |

2.2.1 Give the phenotypes of:

(a) Rabbit **2** (1)

(b) Rabbit **4** (1)

2.2.2 State the genotypic ratio that is shown in the table above. (2)

2.2.3 If rabbits **1** and **4** were mated together and had 12 offspring, how many of these would you expect to be black? (1)

2.2.4 Rabbit **3** was allowed to breed with rabbit **4**. Use a genetic cross to show the possible phenotypes and genotypes of the F1 generation for fur colour. (6)

**G2 - (L1-L5)**, **G3-(L1, L2, and L5) and G4-(L1, L2, and L3)** were able to provide Rabbit 2 and 4 Genotype along with their genotypic ratio. **G3-L1- G3-L6,** were not able to give the probability of the Phenotype of the child. **G1-L1- G4-L4,** were able to calculate the probability but did not provide the final answer. **G4-L5 – G4-L6** were able to calculate the probability and provide the answer to the question. Learners in **G1** (**L1-L5), G2-(L3&L4) and G4-(L4&L6)** did not provide correct answers while **G1 (L3-L4)** left blank spaces to the asked questions which reveals that they did not have a clear understanding of the concept (Phenotype and Genotype). This led to the abovementioned learners not being able to answer the follow-up questions (question 2.2.4). The abovementioned reflects that those learners did not understand the concept which was taught in lesson 1, which were the basics required for a Monohybrid Cross.

**Overall comments**

Only a few learners were able to grasp the concept (Genotype and Phenotype) of day 1 lesson. This is reflected by learners' response to the activities. Learner's responses were variations in the understanding and performance of different learner groups **(G1, G2, G3, and G4)** and individual learners within those groups (L1-L6). Some learners were able to accurately provide genotypes and phenotypes, calculate probabilities, and answer questions correctly, while others struggled with these concepts and had challenges distinguishing between genotypes and phenotypes. This indicates a lack of understanding of the fundamental concepts taught in Lesson 1, which are essential for understanding Monohybrid Crosses. Further guidance and clarification may be necessary to ensure all learners grasp these concepts effectively

The teacher collected learner's scripts after they have completed the activity for marking. Learners' performance was used to answer research question number two.

**End of the lesson**

### 4.2.1. Day two

The focus of lesson 2 was on Types of Dominance and Monohybrid Cross structures. As in day I used a variety of data collection tools. As such I will briefly deliberate on the sequence in which they were presented. I will firstly present the data concurrently drawn from the classroom observations and semi-structured interviews (see annexure A). Lastly, I will present data drawn from the class activity given to the learners towards the end the lesson.

- **Classroom observations**

The following is the presentation and analysis of data generated from the classroom observation that took place on day 2. Hence, the following observations depicted in Table 4.3 below were made, with the overall comments discussed thereafter.

Table 4.3: Observations made during lesson 2.

| **Descriptive** | **Description of aspect observed** |
|---|---|
| Classroom arrangement | **Classroom Layout:**<br>Learners’ desks in groups of four or more, facing each other, leaving enough space between each group of desks to allow for easy movement.<br>Learners' decks were arranged in a way that all learners were able to view both the board and projection screen.<br>**Resources used for BL:**<br>A projector, projection screen, whiteboard & a laptop were used. |
| Learners’ interaction: Learner to learner | Learners displayed a sense of independence and initiative by taking ownership of their learning.<br>**G2-L2:** *Yes, I think so. It's when we cross two parents that differ in only one trait, right?*<br>**G3-L4:** “I agree *So, let's say we cross a homozygous dominant pea plant (TT) with a homozygous recessive pea plant* |

| | |
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| | *(tt) and what do you think the result will be?"*<br>**G1-L4**: "*Well, since T is dominant and t is recessive, all the offspring should be heterozygous (Tt)".*<br>**G4-L5:** "*That's correct! And what if we cross two heterozygous pea plants (Tt x Tt)?".*<br>With the aid of virtual presentation.<br>Learners sharing ideas within their groups.<br>**G4-L4:** "*In incomplete dominance, neither allele is completely dominant over the other. Instead, a blend or intermediate Phenotype is observed when both alleles are present. It's like mixing two colours to get a new shade".*<br>**G4-L6:** "*Let's take the example of flower colour in snapdragons. If we have a gene for flower colour, where the red allele (R) is incompletely dominant over the white allele (W), then a plant with the Genotype RW will have pink flowers. The red allele doesn't completely overpower the white allele, resulting in a blend of red and white".*<br>Some learners were actively engaged in class discussions, asking questions, and contributed their ideas. They showed a positive attitude towards the concept |
| Learners' classroom behaviour and reaction | Learners had the opportunity to contribute their thoughts, ask questions, and participate actively in the learning |

| | |
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| | process.<br>**G2-L8:** *"Complete dominance is when one allele completely masks or overrides the expression of another allele. So, only the dominant allele is visible in the Phenotype".*<br>**G3-L4:** "*Let's take the example of flower colour in pea plants. If we have a gene for flower colour, where the dominant allele is purple (P) and the recessive allele is white (p), then a plant with the Genotype PP or Pp will have purple flowers because the dominant allele P completely masks the expression of the recessive allele p".*<br>Learners were actively learning through visualisation and the use of animation; they were responsible for their learning. |
| Learner interaction: Learner to teacher | Learners were able to give definition of Genotype based on the previous lesson. Learners' response;<br>**G2-L6**: *Genotype is a genetic makeup of an individual which is responsible for our appearance.*<br>**G1-L5**: *"Genotype is the physical appearance of an individual determined by Genotype"*<br>**G4-L3**: "*Genotype refers to the genetic makeup of an organism, specifically the combination of alleles it possesses for a particular trait".*<br>Learners have gained new insights and reinforce their understanding of |

| | |
|---|---|
| | concepts. |

***Overall comments***

The classroom arrangement was designed to promote collaboration and easy movement. The arrangement of learners' desks in groups of four or more facing each other allowed easy interactive discussions and engagement between learners and the teacher.

Learners from different groups (**G2-L2, G3-L4**, **G1-L4**, **and G4-L5**) displayed a sense of independence and initiative by taking ownership of their learning taking ownership of their learning. **G2-L2 "***Yes, I think so. It's when we cross two parents that differ in only one trait, right?"* **G3-L4 "**I agree*, let's say we cross a homozygous dominant pea plant (TT) with a homozygous recessive pea plant (tt), what do you think the result will be?"* **G1-L4"**"*Well, since T is dominant and t is recessive, all the offspring should be heterozygous (Tt)".* These learners were actively learning from one another in different groups. **G2-L2** asked a question seeking clarity from his fellow classmates which led to a productive class discussion creating an active learning environment and made all learners free to ask questions.

In addition, learners displayed a positive attitude towards the concept by asking questions, and contributing their ideas based on **G1-L3's** behaviour which indicates a willingness to learn by asking questions. **"G1-L3** *Um, what is dominance?"* and a genuine interest in the concept. **G3-L4** supported **G2-L6** by providing an example in order to agree and support what he mentioned, thus reflecting a conducive learning environment. These learners (**G4-L5, G4-L4, G4-L6, G2-L8, and G3-L4**) discussed the concept of Monohybrid Cross with examples, reflecting an improvement in understanding the concept. They were able to explain the concept of incomplete dominance, using the analogy of mixing colours to create a new shade. Learners also discussed the outcomes of genetic crosses, showcasing their knowledge of dominant and recessive alleles.

Lastly learners were able to reflect on the previous lesson as the teacher was checking their level of understanding from the concepts taught in lesson 1 using question and answer method. Learners from different groups were able to correctly respond to the questions asked: **G2-L6, G1-L5***,* **and G4-L3** (see dialogue below). Learners reinforced their understanding of concepts by sharing their understanding within their groups. The use of these visual aids helped them grasp the concepts more effectively and facilitated their responsibility for their own learning. By engaging with visual content, they were able to comprehend complex ideas and connect them to real-world examples.

- **Semi-structured-Interviews**

In this section I present the questions I asked the learners and the responses learners provided during lesson 2. As I present the dialogue I had with learners, as in day 1, I will also share the learners' silent moments, confused moments and learning moments that emerged during the lesson.

The lesson started with the teacher reflecting on the previous lesson about genetics using the questions and answer method.

**Teacher:** Good day. Today's lesson is a continuation of the previous lesson we had on the basics of Monohybrid Cross.
**Teacher:** what do you know about Genotype?

**Learning moment**

Based on the learners' responses, this reflects their level of understanding of the concept taught in lesson one, as a PowerPoint presentation was used to display Genotype and Phenotype. Some of the learners were able to distinguish between a Genotype (see dialogue below) and a Phenotype while some had challenges as revealed by class activity (see class activity 1).

**G2-L8**: Genotype is a genetic makeup of an individual which is responsible for our appearance.
**G1-L5**: "Genotype is the physical appearance of an individual determined by Genotype"
**G4-L3**: "Genotype refers to the genetic makeup of an organism, specifically the combination of alleles it possesses for a particular trait".

**Teacher:** Today, we're going to dive into genetics. Specifically, we'll be discussing two important subtopics: types of dominance and the structure of Monohybrid Crosses.

**Teacher:** Let's start with types of dominance. Dominance refers to the relationship between alleles, or different forms of a gene, in determining a particular trait. There are three types of dominance: complete dominance, incomplete dominance, and codominance. Can anyone explain what complete dominance means?

**Learning moment**

The dialogue below shows learners from each group actively interacting with the teacher and their peers' discussion of what they have learned from the video presentation. As the teacher posted questions, learner **G3-L4** and **G4-L4** demonstrated that they can explain with examples the difference between recessive and dominant allele. Learners **G4-L6** and **G3-L5** added their perspective with the aid of examples reflecting better understanding of the concept

**G2-L8:** "*Complete dominance is when one allele completely masks or overrides the expression of another allele. So, only the dominant allele is visible in the Phenotype".*

**Teacher:** Good, **G3-L4**! Can you give us an example of complete dominance?

**G3-L4:** "*Let's take the example of flower colour in pea plants. If we have a gene for flower colour, where the dominant allele is purple (P) and the recessive allele is white* (p), then a plant with the Genotype PP or Pp will have purple flowers because the dominant allele P completely masks the expression of the recessive allele p".

**Teacher**: Good Now, let's move on to incomplete dominance. Who can explain what this term means?

**G4-L4:** "*In incomplete dominance, neither allele is completely dominant over the other. Instead, a blend or intermediate Phenotype is observed when both alleles are present. It's like mixing two colours to get a new shade".*

**Teacher:** Exactly! Could you give us an example of incomplete dominance?

**G4-L6:** *"Let's take the example of flower colour in snapdragons. If we have a gene for flower colour, where the red allele (R) is incompletely dominant over the white allele (W), then a plant with the Genotype RW will have pink flowers".*

**Teacher:** Well done! Finally, let's talk about codominance. Who can explain what this term means?

**G4-L6:** *Codominance occurs when both alleles are fully expressed in the Phenotype. It's like having two dominant alleles working together instead of one being dominant over the other.*

**Teacher:** Excellent! Can you provide an example of codominance?

**G3-L5:** *Of course! Let's consider the example of human blood types. The A and B alleles for blood type are codominant, while the O allele is recessive. If a person has the Genotype AB, both the A and B alleles are fully expressed, resulting in the AB blood type.*

**Teacher:** Fantastic explanation! Now that we have covered the types of dominance, let's move on to the structure of Monohybrid Crosses. A Monohybrid Cross involves the study of single-trait inheritance. It's a way to predict the outcomes of offspring by crossing parents with known Genotypes. Does anyone remember how we represent the alleles in a Monohybrid Cross?

**G3-L4:** **"***We use uppercase and lowercase letters to represent alleles, with uppercase representing dominant alleles and lowercase representing recessive alleles".*

**Teacher:** That's right! And when we cross two individuals with known Genotypes, we can use Punnett squares to predict the possible Genotypes and Phenotypes of their offspring. Can anyone explain how a Punnett square is set up?

**G1-L6:** A Punnett square is a grid-like structure with the possible gametes from each parent listed along the top and side. We then combine the corresponding gametes to determine the Genotypes and Phenotypes of the offspring.

**Teacher:** Mm. Thank you. So today will be talking about types of dominance

**G1-L3**: *"Um, what is dominance?"*

Using the animation presentation displayed the **definition of dominance, types of dominance and possible examples and allowed the learner to discuss and share ideas about types of dominance as a group after some time as a class.** Using the animation presentation to display the Monohybrid Crosses processes, the Teacher explained through the display of animation, teaching learners step by step and explaining to the learner how they can construct a Monohybrid Cross.

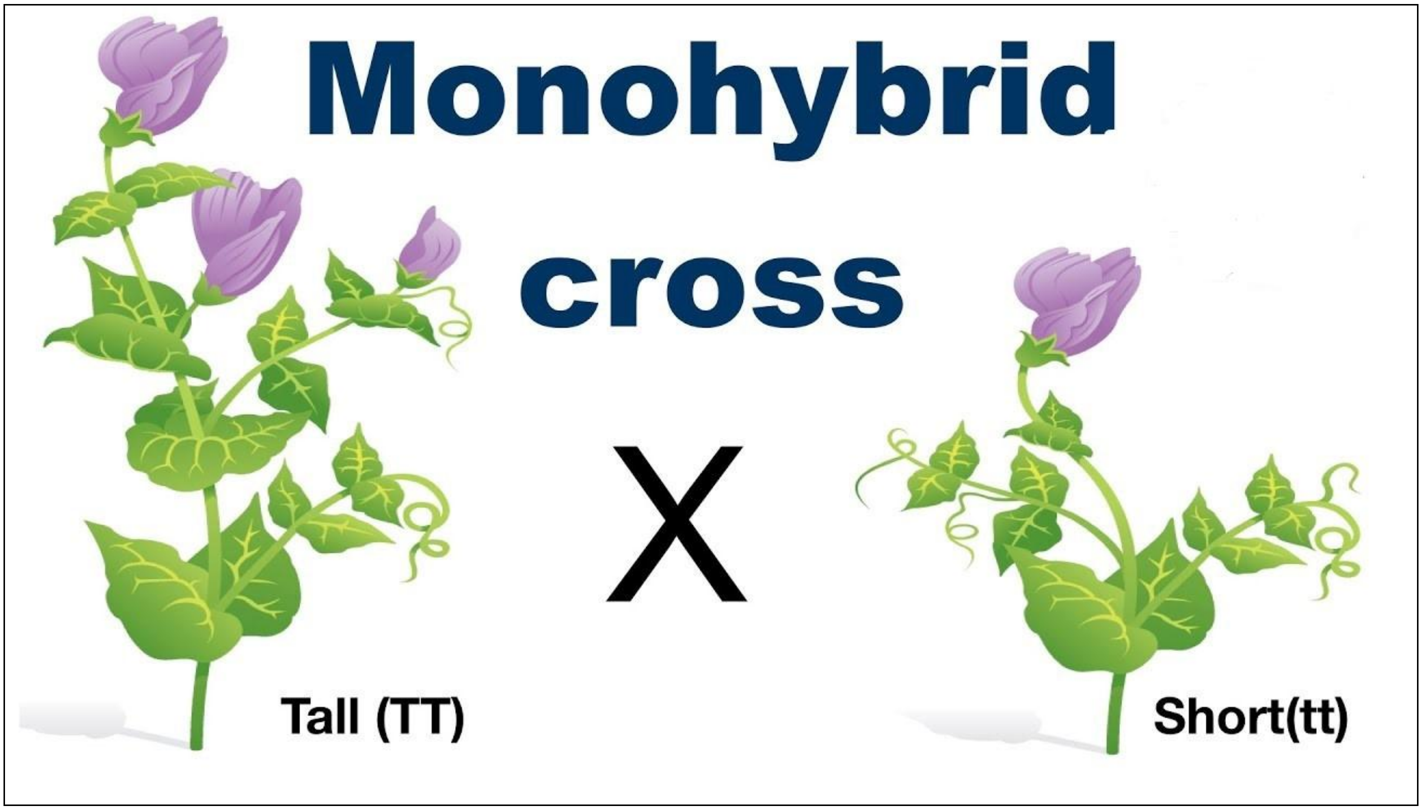


*Figure 4.3: Animation of Monohybrid Cross (Reece, 2011, p. 374*)

**Based on the display**

- All Learners can share what they are constructing from the animation.
- All Learners are actively participating.

**Learning moment between learners**

**G1-L1:** *Hey, have you understood the concept of a Monohybrid Cross?*

**G2-L2:** *Yes, I think so. It's when we cross two parents that differ in only one trait, right?*

**G3-L4:** *Exactly! So, let's say we cross a homozygous dominant pea plant (TT) with a homozygous recessive pea plant (tt). What do you think the outcome will be?*

**G1-L4**: *Well, since T is dominant and t is recessive, all the offspring should be heterozygous (Tt).*

**G4-L5:** *That's correct! And what if we cross two heterozygous pea plants (Tt x Tt)?*

**G1-L1**: *Then we can use a Punnett square to predict the outcome. The possible Genotypes of the offspring should be TT, Tt, and tt, in a 1:2:1 ratio.*

**G3-L3:** *And what about the phenotypic ratio?*

**G3-L6:** *The phenotypic ratio should be 3:1, with three offspring showing the dominant trait (Tall) and one showing the recessive trait (Dwarf).*

**Teacher:** It seems like you have a good understanding of the concept of a Monohybrid Cross and how to predict the genotypic and phenotypic ratios. Keep up the great work! If you have any more questions or if there's anything else you'd like to discuss, feel free to ask

**Teacher:** Anyone to represent complete, incomplete and co-dominance on the board using an example?

**G3-L6**: How can we easily distinguish between dominance?

**G3-L5:** Looking at the animation, the physical appearance or how one looks based on their parents can reveal the dominance of the characteristics.

**G1-L1, G2-L4, and G3- L4& G3-L6 (Chosen as they were trying to hide their faces):** *After the presentation on the board, the class discussed what they had presented followed by an animation presentation to address difficulties which arose on their presentation.*

**Learning moment**

Learners hide their faces mostly when they have difficulties or are confused; choosing them provides an opportunity for the teacher to check their level of understanding of the concept in order to help address the difficulty as the whole classroom.

**Teacher**: Now let's talk about Monohybrid Cross

Using the animation presentation displayed the definition of a Monohybrid Cross, types of dominance and possible examples and allowed the learner to discuss and share ideas about types of Monohybrid Crosses as a group after some time as a class.

The animation presented the structure of monohybrid step by step with simple to complex examples. This included the structure from the parent's Genotype, first filial generation and the ratios.

**Teacher:** In a Monohybrid Cross, we're looking at the inheritance of a single trait controlled by two alleles. Alleles are alternative forms of a gene that occupy the same position, or locus, on a pair of homologous chromosomes. Each parent contributes one allele for that trait to their offspring. For example, let's say we're looking at flower colour, and we have one allele for purple flowers (P) and another allele for white flowers (p), the combination of these alleles determines the Phenotype, or physical appearance, of the offspring.

**G4-L6:** *Since the offspring will inherit one allele from each parent, that combination determines their Phenotype. But what if one parent has two alleles for purple flowers (PP), and the other has two alleles for white flowers (pp)? How does that work?"*

**Teacher:** if one parent has two alleles for purple flowers (PP) and the other has two alleles for white flowers (pp), it means they are both homozygous for that trait. When they cross, all their offspring will inherit one allele from each parent, resulting in a heterozygous Genotype (Pp). In this scenario, the dominant allele (P) for purple flowers will determine the Phenotype, and all the offspring will have purple flowers.

**G2-L2 (looking for clarity):** "*I see. So, if both parents are heterozygous (Pp), what will the offspring's Genotype and Phenotype be?"*

**Teacher:** When both parents are heterozygous (Pp), they can produce two different types of gametes, carrying either the dominant allele (P) or the recessive allele (p). Through random fertilisation, their offspring can inherit different combinations of these alleles. In this case, there's a 25% chance of obtaining homozygous dominant (PP), 50% chance of heterozygous (Pp), and 25% chance of homozygous recessive (pp) offspring. The Phenotype will follow Mendel's principle of dominance, where the dominant allele (P) will determine purple flower colour, and the recessive allele (p) will result in white flower colour.

**G3-L6 (confused)**: ""*One more question: How can we predict the phenotypic ratio of offspring in a Monohybrid Cross?"*

**G1-L3 (confidently***):* *"Predicting the phenotypic ratio involves applying Mendel's laws of segregation and independent assortment. In a Monohybrid Cross, where we're focusing on a single trait, we can use a Punnett square to visualise the possible combinations of alleles in the offspring. By filling in the squares with the alleles from both parents, we can determine the different Genotypes and predict the corresponding Phenotypes. The phenotypic ratio is then based on the number of squares showing each Phenotype. For example, if we cross two heterozygous plants (Pp x Pp), the phenotypic ratio would be 3:1, with three purple-flowered plants and one white-flowered plant on average."*

**G3-L6 (excited):** ***"****I think I understand now. The Punnett square helps us see the possible combinations, and the phenotypic ratio gives us an idea of the offspring's. Thank you"*

**Learning moment**

**G3-L6** had a bit of a challenge on how to present a Punnet diagram but with the help of few classmates **G1-L3** they were able to provide a clear explanation which helped learner **G3-L6.**

**Teacher:** Understanding Monohybrid Crosses is an important foundation for genetics. If you have any more questions or need further clarification, don't hesitate to ask.

***Overall comment***

The learners demonstrated a good understanding of the concept of a Monohybrid Cross, which involves crossing two parents that differ in only one trait. **G1-L1** was able to correctly identified the genotypic and phenotypic outcomes of a Monohybrid Cross between a homozygous dominant parent (TT) and a homozygous recessive parent (tt), predicting that all the offspring would be heterozygous (Tt) Genotype and exhibit the dominant trait. Learners also correctly recognized that when two heterozygous pea plants (Tt x Tt) are crossed, a Monohybrid Cross can be used to predict the genotypic and phenotypic ratios. Learner (**G2-L2**) stated that the genotypic ratio would be 1:2:1 (TT: Tt:tt), and the phenotypic ratio would be 3:1 (dominant trait: recessive trait). During the presentation on dominance and Monohybrid Crosses, some students initially hid their faces, indicating potential confusion or difficulty with the topic. I used this opportunity to measure their understanding and address any difficulties they might have had. The use of an animation presentation helped clarify their understanding. I encouraging group discussions and allowing learners to share their ideas and ask questions. Learners grasped the concept of a Monohybrid Cross and its role in predicting genotypic and phenotypic ratios. They understood that the Monohybrid Cross helps visualise possible allele combinations, while the phenotypic ratio provides information about the expected physical traits of the offspring.

**Class activity for lesson 2**

Learners were given an activity to complete at the end of the lesson. This activity was extracted from one of the previous exam papers and was used as an assessment task to assess learners' level of understanding of the concept taught in the lesson.

**Question paper from September 2020**

**Question 1**: Use a genetic cross to show the possible Phenotypes and Genotypes of the F1 generation for fur colour when mouse 1 is dominant over mouse 2. **(6)**

**G2 (L1-L5)**, **G3 (All learners), G4 (L1,L2,L3) and G3 (L3,L4 &L5)** were able to draw a Monohybrid Cross with required elements showing if mouse 1 is homozygous dominant (MM) and mouse 2 is homozygous recessive (mm), all the F1 offspring will have the dominant phenotype, which means they will exhibit the fur colour of mouse 1. Therefore, the phenotypes of the F1 generation would be all mice with the dominant fur colour. Learners in **G1** (**L1-L5), G2 (L3&L4) and G4 (L4&L6)** did not provide all required elements of a Monohybrid Cross. Their response revealed they need clarity in terms of Genotype of the parents. "*The Phenotypes and Genotypes of the F1 generation for fur colour when mouse 1 is dominant over mouse 2 would depend on the dominance relationship between the two alleles. Without knowing the specific dominance relationship, it is not possible to determine the exact Phenotypes and Genotypes of the F1 generation".* Abovementioned response reveals that they had a challenge in writing the Genotypes of each parent.

**Question 2**: Use a genetic cross to show the possible Phenotypes and Genotypes of the F1 generation for fur colour when mouse 2 is dominant over mouse 1. **(6)**

**G2 (L1-L5)**, **G3 (All learners), G4 (L1, L2, L3) and G3 (L3,L4 &L5)** were able to draw a Monohybrid Cross with required elements showing mouse 2 is dominant over mouse 1 in terms of fur colour, the possible phenotypes of the F1 generation were determined by the genotypes of the parent mice. Assuming mouse 1 is homozygous recessive (mm) and mouse 2 is homozygous dominant (MM), all the F1 offspring will have the dominant phenotype, which means they will show the fur colour of mouse 2. Therefore, the phenotypes of the F1 generation would be all mice with the dominant fur colour.

Learners in **G1** (**L1-L5), G2 (L3&L4) and G4 (L4&L6)** did not provide all required elements of a Monohybrid Cross. Their response revealed they need clarity in terms of Genotype of the parents. "*The Phenotypes and Genotypes of the F1 generation for fur colour when mouse 2 is dominant over mouse 1 would depend on the dominance relationship between the two alleles. Without knowing the specific dominance relationship, it is not possible to determine the exact Phenotypes and Genotypes of the F1 generation".* Abovementioned response reveals that they had a similar challenge in writing the Genotypes of each parent that they experienced in the first question.

**Question 3**: Use a genetic cross to show the possible Phenotypes and Genotypes of the F1 generation for fur colour when neither mouse 1 nor mouse 2 is dominant over the other. **(6)**

**G2 (L1-L5)**, **G3 (All learners), G4 (L1, L2, L3) and G3 (L3,L4 &L5)** were able to draw a Monohybrid Cross with required elements showing when neither mouse 1 nor mouse 2 is dominant over the other for fur colour, the possible phenotypes and genotypes of the F1 generation would depend on the specific genotypes of the parent mice. Let's assume mouse 1 is heterozygous (Mm) and mouse 2 is also heterozygous (Mm). In this case, the F1 generation would exhibit a phenotypic ratio of 1:2:1, with one-quarter of the offspring displaying the dominant fur colour of mouse 1 (MM), half of the offspring displaying an intermediate fur colour (Mm), and one-quarter of the offspring displaying the dominant fur colour of mouse 2 (mm). Learners in **G1** (**L1-L5), G2 (L3&L4) and G4 (L4&L6)** did not provide all required elements of a Monohybrid Cross. *"In this scenario where neither mouse 1 nor mouse 2 is dominant over the other for fur colour, the phenotypes and genotypes of the F1 generation would be influenced by genetic interactions. These interactions could lead to unique patterns of inheritance that are not easily predictable without further knowledge of the specific genetic factors involved".* Abovementioned response reveals that they had a similar challenge in writing the Genotypes of each parent that they experienced in the first question.

**Overall comment**

The responses from learners in **G1, G2, and G4** indicate a lack of clarity in terms of understanding and writing the genotypes of the parent mice in the given genetic crosses. Without knowing the specific dominance relationship between the alleles and the genotypes of the parent mice, it is not possible to determine the exact phenotypes and genotypes of the F1 generation for fur colour. Learners in G3, on the other hand, were able to draw a Monohybrid Cross with the required elements and provide accurate conclusions based on the given information. It is important for learners to understand the concept of dominance and Genotype-Phenotype relationships in order to accurately predict the outcomes of genetic crosses. Thus learners should further explore and understand these concepts to effectively analyse and predict the outcomes of genetic crosses.

The teacher collected learners' scripts after they had completed the activity for marking. Learners' performance was used to answer research question number two.

**End of the lesson**

**4.3.1. Day three, topic: Genetics; subtopic: Construction of Monohybrid Cross and solving monohybrid problems.**

Based on the lesson plan for the activity the researcher incorporated BL in the form of a laptop and a projector to display video presentations with the help of traditional methods progressively.

During classroom discourse, the following observations depicted in table 4.2 were made, with overall comments discussed thereafter.

Table 4.4: Observations made during lesson 3.

| **Descriptive** | **Description of aspect observed** |
|---|---|
| Classroom arrangement | ➢ **Classroom Layout:**<br>Leaners' desks in groups of four of more, facing each other leaving enough space between each group of desks to allow for easy movement.<br>**Resources used for BL:**<br>A projector, projection screen, whiteboard & a laptop were used. |
| Learners' interaction: Learner to learner | Learners are showing interest in understanding how traits are inherited and how to predict offspring characteristics. Learners demonstrate curiosity about Monohybrid Crosses.<br>**G1-L4:** *"I'm struggling a bit with drawing a Monohybrid Cross. Anyone to help me out?"*<br>**G2-L4:** *"I'd be happy to help. Let's start by understanding the basics. A Monohybrid Cross involves studying the inheritance of a single trait between two individuals. Do you have a specific trait in mind?"*<br>**G1-L4:** *"Yes, let's take the example of flower* |

| | |
|---|---|
| | *colour in pea plants. The dominant allele for flower colour is "P" for purple, and the recessive allele is "p" for white. How do we begin?"*<br>**G4-L3:** *"Great choice! To start, we need to identify the Genotypes of the parent plants. Let's say we have a purple-flowered plant with Genotype Pp as the parent. What Genotype would you like to assign to the other parent?"*<br>**G1-L4:** "*Let's use a white-flowered plant as the other parent. So, its Genotype would be pp. Now, we need to determine the possible Genotypes and Phenotypes of the offspring".*<br>**G2-L4:** "*To determine the Genotypes, we need to combine the alleles from each parent. We can represent the Genotypes of the offspring in a Punnett square. Have you worked with Punnett squares before?"* |
| Learners' classroom behaviour and reaction | Learners are effectively working together in groups to solve and discuss problems with concepts related to Monohybrid Cross. They are effectively communicating and sharing ideas, actively engaging in activities, to understand and apply the principles of Monohybrid Cross. |
| Learner interaction: Learner to teacher | Learners were engaged in the meaningful and intellectually authentic curriculum as they were using critical thinking and problem-solving.<br>Learners were actively learning through visualisation and the use of video; they were responsible for their learning. |

***Overall comment***

Learners displayed interest in understanding the inheritance of traits and actively participated in discussions. They asked questions, shared ideas, and demonstrated curiosity about Monohybrid Crosses. One of the learners from group one **(G1-L4)** was struggling to draw Monohybrid Cross, but was able to freely ask for help from her peers**.** Group 2 learners were able to draw the crosses and one of the learners (**G2-L4)** was more than happy to clarify for **(G1-L4)** challenges he had.

Learners were actively involved in constructing Monohybrid Crosses and solving related problems. They worked collaboratively in groups, communicated effectively, and shared ideas to understand and apply the principles of Monohybrid Crosses. This type of environment encourages participation and supports a positive learning experience.

The use of video presentations allowed learners to visualise the processes involved in Monohybrid Crosses. Visual aids can enhance comprehension and make abstract concepts more accessible.

Overall, the lesson seems to have effectively facilitated student engagement, collaboration, and understanding of Monohybrid Crosses.

The lesson started with the researcher reflecting on the previous lesson about Monohybrid Cross using the questions and answer method.

Using the videos presentation which displayed the Monohybrid Crosses processes, the researcher explained through the display of video, explaining to the learner step by step how they can construct Monohybrid Cross and possible examples which allowed learners to discuss and share ideas about types of dominance as a group after some time as a class.

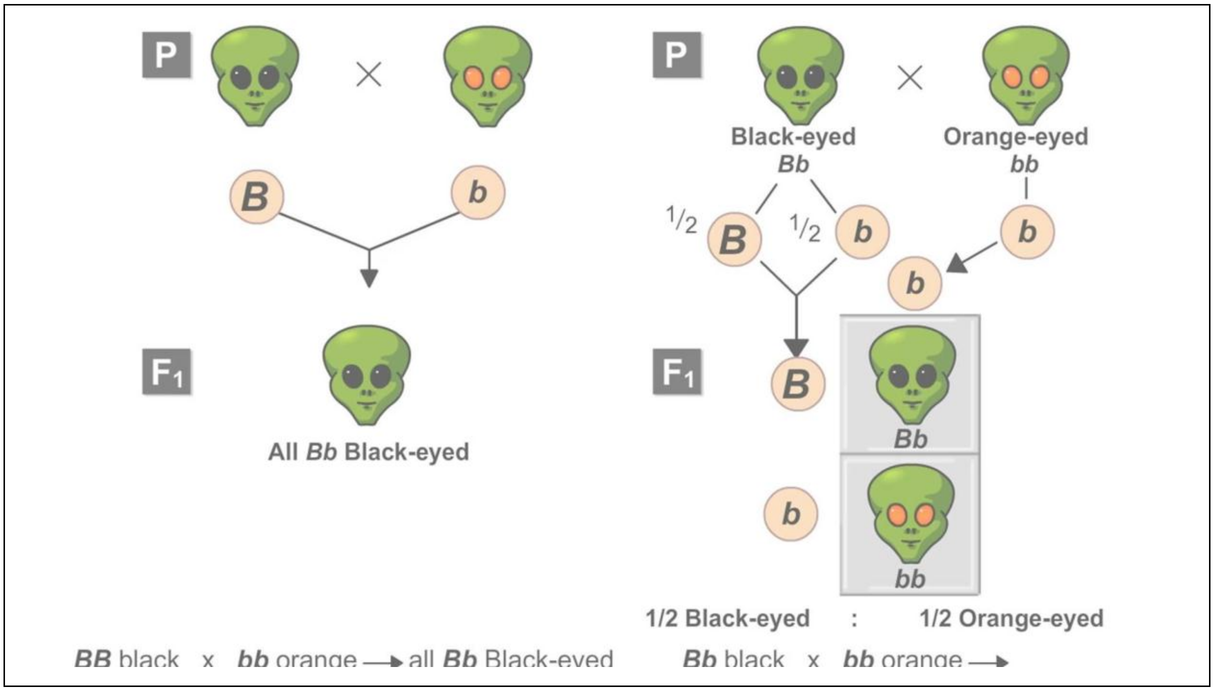


*Figure 4.4: Monohybrid Cross - video display (Reece, 2011, p. 380)*

**Teacher:** Good day. Today's lesson is a continuation of the previous lesson we had on Monohybrid Crosses.

Learners were allowed to work on their own throughout the session, socializing and sharing their thoughts in groups.

**Learning moment**

The dialogue below represents learners (all group) interaction with the teacher where they had a prolonged and meaningful conversation, where **G1-L4** was able to reveal she had some difficulty but **G2-L4 & G3-L3** were able to share how they understood the concept with her, resulting in **G1-L4** being able to construct Monohybrid Crosses. All learners were able to draw and demonstrate all elements of the Monohybrid Cross while those who were struggling were helped within each group.

**G1-L4:** "*I'm struggling a bit with drawing a Monohybrid Cross. Anyone to help me out?*"

**G2-L4:** *"I'd be happy to help. Let's start by understanding the basics. A Monohybrid Cross involves studying the inheritance of a single trait between two individuals. Do you have a specific trait in mind?"*

**G1-L4:** "*Yes, let's take the example of flower colour in pea plants. The dominant allele for flower colour is "P" for purple, and the recessive allele is "p" for white. How do we begin?"*

**G4-L3:** *To start, we need to identify the Genotypes of the parent plants. Let's say we have a purple-flowered plant with Genotype Pp as the parent. What Genotype would you like to assign to the other parent?"*

**G1-L4:** *"Let's use a white-flowered plant as the other parent. So, its Genotype would be pp. Now, we need to determine the possible Genotypes and Phenotypes of the offspring".*

**G2-L4:** *"To determine the Genotypes, we need to combine the alleles from each parent. We can represent the Genotypes of the offspring in a Punnett square. Have you worked with Punnett squares before?"*

**G1-L4:** "*Yes, I have. So, we'll write the Genotype of one parent along the top of the square and the Genotype of the other parent along the side, right?"*

**G2-L4:** "*That's correct! Since the first parent's Genotype is Pp, we'll write P above and p below. For the second parent with the Genotype pp, we'll write p above and p below. Now, we can fill in the squares with the possible allele combinations."*

**G1-L4:** *"So, when we combine P from the first parent with p from the second parent, we get Pp. And when we combine p from the first parent with p from the second parent, we get pp. Is that right?"*

**G3-L3:** *"Yes, we have two possible Genotypes for the offspring: Pp and pp. Now, we need to determine the Phenotypes associated with these Genotypes"*

**Teacher:** Good! **G2-L4** clearly explained how we can answer Monohybrid Cross questions and I'm impressed; now let me take you through Monohybrid Cross.

**Teacher:** Great! Let's start by revisiting some basic genetics. Who can remind me what a Monohybrid Cross is?

**G2-L4:** *"It's a genetic cross involving only one trait or characteristic, right?"*

**G3-L6:** *"A Monohybrid Cross refers to a specific type of genetic cross involving two individuals that differ in only one trait."*

**G4-L5:** *"It's when you cross two individuals that are both heterozygous for a single trait, isn't it?"*

**G2-L5:** ***"****To better understand it, let's consider an example. Imagine we have two plants, both with purple flowers. However, one plant carries the dominant allele for purple flowers (PP), while the other carries the recessive allele for white flowers (pp)."*

**G1-L4:** "*Okay, so when we cross these two plants, we'll be studying the inheritance of flower colour, right?"*

**G1-L3:** *"Yes! We're interested in finding out what traits will be passed on to the offspring. Since* *both plants are heterozygous for flower colour, they can produce two types of gametes: P (containing the dominant allele) or p (containing the recessive allele)".*

**G3-L2:** "So, when we perform the Monohybrid Cross, we would represent the parental generation as PP (dominant) and pp (recessive), correct?"

**Learning moment**

The learner was actively constructing their understanding of the concept of a Monohybrid Cross. Learners were helping each other with the concept.

**At the end of the session, learners were given an activity to complete, to check learners' level of understanding of the concept based on videos.**

Learners were giving an activity to complete at the end of the lesson. This activity was extracted from one of the previous exam papers and was used as an assessment task to assess learners' level of understanding of the concept taught in the lesson.

**Question paper from 2021 December**

3.1 In mice, the allele for red fur colour (R) is dominant over the allele for grey fur colour (r). It also happens that all embryos, which are homozygous for the dominant factor, will always die before birth. If a colony of heterozygous mice were inbred to produce 300 young living mice, how many of these offspring would be likely to have red fur and how many will have grey fur? Use a genetic diagram to show how you arrived at your answer. (7)

- All learners were able to draw a complete Monohybrid Cross diagram consisting of all elements of the cross.

3.2

Hornless (H) in cattle is dominant over horned (h). A homozygous hornless bull is mated with a homozygous horned cow. What will be the Genotype and Phenotype of the first generation? Show your work. **(6)**

- All learners were able to draw a complete Monohybrid Cross consisting of all elements of the cross. Showing a homozygous hornless bull (HH) is mated with a homozygous horned cow (hh), all the offspring in the first generation will be heterozygous (Hh) for the hornless trait. Since hornless (H) is dominant, the phenotype of all the offspring will be hornless.
- Learners were able to add a punnet square to emphasise this level of understanding of the concept.

**Overall comments**

Most learners have improved their conceptual understanding of Monohybrid Crosses and their level of reasoning improved to a point where they can answer complex questions. Low prior knowledge learners also made substantial improvement in Monohybrid Crosses and appeared to be interested, motivated and engaged throughout the three sessions.

Based on learners' response through the session their conceptual understanding improved with each session but learners showed conceptual improvement when animation and video were used in the lesson. In the lesson, most learners showed that they were still a challenge for class activity as they were not able to differentiate between the terms. In lesson two, after the animation presentation, they showed that they are able to draw the difference between Genotype and Phenotype. In lesson three learners as they were learning through videos were able to ask questions and help each other understand the concept better by using examples to explain Monohybrid Cross to each other in groups and as the whole classroom.

Additionally, it aided in the growth of learners' peer learning, reflective thinking, and sense of teamwork. Due to its support for more than one teaching approach, additionally they were grateful for the high-quality assistance they received when they encountered difficulties.

**Conclusion**

Rich and descriptive data was gathered, and the qualitative research methodology format was crucial. Semi-structured interviews, document review and in-classroom observations were used to gather data for this study. The planning and execution of classroom collaboration and class activities, behavioural issues, and difficulties encountered are topics that emerged from the data, in order to respond to the study's research questions.

The teacher collected learner's scripts after they had completed the activity for marking. Learners' performance was used to answer research question number two.

**End of the lesson**

### 4.5 Discussion of findings through tenets of situated learning theory as a lens

The findings of this study are discussed using the situated learning theory (SLT) tenets as the lens. Situated learning theory is a learning approach through constructivism within an authentic context involving social interactions (Lave & Wenger, 1991). SLT is based on the philosophy that one learns through the following tenets: social interaction, authentic (real-life) context, and constructivism (Greeno, 1994). This study adopted SLT proposed by Greeno (1994). Supporting Lave and Wenger, Greeno's (1994) SLT is grounded on the perception that the best way to learn is through social interactions, constructivism, and authentic context. Greeno's (1994) idea of SLT is that the interpretation of learners' views and behaviours is a result of participation in a culturally and socially situated point of view. To this point, the discussion of findings will be presented based on the abovementioned tenets.

Constructivism is an approach to learning where learners actively build their knowledge and that actuality is determined by the knowledge of the learners (Elliot et al, 2000). In this study constructivism held that it was expected that learners bring some prior knowledge (including traditional culture) or conceptions into the real-life learning environment (Driver, 1986; Naidoo, 2005). Social interaction is the process through which learners act and react towards others around them (Turner & Nolen, 2015). Social interaction with others allowed learners to relate themselves to situations they were in. Collaborative learning activities were used during lesson presentations to let the learners use their views in a natural setting (Crotty, 1998). Authentic context focuses on participation in natural settings in communities of practice (Lombardi & Oblinger, 2007). In this study the theory of situated learning allowed learners to construct knowledge among them using BL. For the constructed knowledge to make sense, it has to be integrated into the already existing knowledge (Ausubel, 1968). Emphasising the same idea, with constructivism and social interactions in mind, I considered what learners already knew and allowed them to put their knowledge into practice (Creswell, 1999).

The discussion of findings is guided by the tenets of SLT as a lens, which are social interactions, authentic context and constructivism. This discussion of the findings drew data from the observations, semi-structured interviews and document analysis conducted through the three lessons presented.

### 4.6. The integration of BL in enhancing Life sciences learners understanding of Genetics: The affordances

- Addressing the research question: What are the affordances for enhancing grade 12 Life Sciences learners' understanding of Genetics using BL?

It is a mandate by the CAPS for Life Sciences that more than one method should be used to enhance learner's conceptual understanding with integrated teaching and learning. However, the learners' responded to display different possibilities that afforded the understanding of Genetics. The analysis done from observations and semi-structured interviews revealed that learners were able to learn Genetics through the integration of BL. The following are the affordances which emerged throughout the three lessons.

- Learner engagement
- Active learning and collaboration
- Ability to voice opinions
- Helpful in clarifying
- Assessment and feedback
- Time management

**Learner Engagement**

The use of (BL) in classroom enhanced learner engagement by offering diverse and interactive learning materials. Multimedia such as videos, animation and simulations provided engaging content that captures learners' attention which can made complex Genetics concepts more likable and understandable by learners. The ability to access resources throughout the lesson allowed learners to explore at their own pace, fostering greater engagement. Genetics is a subject that often benefits from supplemental resources such as diagrams, case studies, and practice problems. BL allows teachers to provide a wide array of resources beyond the traditional classroom setting, enhancing learners' learning experience.

### Active Learning and Collaboration

Throughout the three lessons, learners were interacting with the content, each other, and the teacher through various activities. This included discussions, group work, problem-solving tasks, and debates enable learners to actively participate and collaborate, even outside the physical classroom. Active learning promoted critical thinking, deeper understanding and have improved

BL provides affordances for active learning through a combination of in-person and multimedia. These Interactive elements helped learners visualize abstract concepts, enhancing the understanding Monohybrid Cross. Active Learning provided an opportunities for interactive and collaborative activities. Classroom discussion and learner's collaborative participation facilitated peer-to-peer learning, enhancing learners' teamwork and communication skills.

**G1-L4:** "*I'm struggling a bit with drawing a Monohybrid Cross. Anyone to help me out?"*
**G2-L4:** *"I'd be happy to help. Let's start by understanding the basics. A Monohybrid Cross involves studying the inheritance of a single trait between two individuals. Do you have a specific trait in mind?"*
**G1-L4:** "*Yes, let's take the example of flower colour in pea plants. The dominant allele for flower colour is "P" for purple, and the recessive allele is "p" for white. How do we begin?"*

Above shown dialogue reveals that learners are active learning as a class and collaboration as they are responsible for their own learning.

### Ability to Voice Opinions

The classroom environment was conducive and offered learners the affordance to express their opinions more comfortably. This can lead to increased participation in class discussions and debates, as some learners might find it easier to voice their thoughts in written formats. Learners were able to ask questions and share their opinion with the whole class. The Integration of BL in grade 12 Life Science class helped clear the difficulties that learners had regarding the topic

**G4-L3:** *To start, we need to identify the Genotypes of the parent plants. Let's say we have a* *purple-flowered plant with Genotype Pp as the parent. What Genotype would you like to assign to the other parent?"*

**G1-L4:** *"Let's use a white-flowered plant as the other parent. So, its Genotype would be pp. Now, we need to determine the possible Genotypes and Phenotypes of the offspring".*

**G2-L4:** *"To determine the Genotypes, we need to combine the alleles from each parent. We can represent the Genotypes of the offspring in a Punnett square. Have you worked with Punnett squares before?"*

Above shown discussion among learners reveals that they were free to voice out their opinions and share their ideas with the whole class.

**Helpful in Clarifying**

BL environments afford learners the opportunity to review and clarify concepts through various resources. Recorded lectures, digital notes, and supplementary materials are easily accessible for review, aiding learners in understanding and reinforcing difficult concepts.

**Assessment and Feedback:**

Affordances in a BL classroom extend to assessment and feedback mechanisms. Class activities and assignments can provide immediate feedback, allowing students to gauge their understanding.

**Time Management**

BL affords learners the flexibility to manage their time effectively. Allowed learners to access materials at their own time. This can be particularly beneficial for learners with varying commitments outside of the classroom. Another affordance was time efficiency. This was also found to be significant by Garnham and Kaleta (2002). Learners were able to ask and respond to questions without time limitations, and flexibly subject the content. This opportunity was mainly attributed to the active learning. A final factor indicated by the learners involved their preference to use the environment more efficiently by staying focused on the content. BL accommodate a range of learning abilities and preferences. Learners who require additional time or resources to grasp genetics concepts can ask for videos, power point and animation materials as needed, while those who quickly grasp the concepts can progress more rapidly.

Immediate feedback was provided, allowing learners to identify their strengths and areas needing improvement. BL encourages learners to develop strong time management skills. They need to allocate time for both multimedia activities and in-person interactions, which can be beneficial for their overall educational experience. It's important to note that the successful implementation of BL in teaching genetics requires careful planning, technology integration, and ongoing assessment of learner's engagement and learning outcomes.

**Conclusion**

Affordances in a BL classroom contribute to a dynamic and interactive learning experience. They enable increased engagement, active learning, collaborative opportunities, comfortable expression of opinions, efficient clarification of concepts, improved assessment and feedback processes, and enhanced time management for both learners and teachers.

### 4.6.1 Social interactions

Social interaction refers to the process by which learners engage with and respond to their fellow learners (Turner & Nolen, 2015). The findings related to social interaction were derived from the observations made during the three presented lessons. Based on my observations, social interactions fostered effective communication among the four groups. This indicated a positive attitude and interest among the learners towards the lesson. When learners are genuinely interested in the subject matter, it suggests that they will find it easier to grasp and learn the content. According to the underlying theory of this study, situated learning theory (Lave & Wenger, 1991), learners become active participants in a community of practice, and collaborative engagement with others enhanced their learning and understanding of scientific concepts.

During the first lesson, learners from different groups were discussing the definition of Genotype. This discussion highlighted the nature of social interactions and how they can influence the learning process.

**G1-L5:** *"The Genotype refers to an individual's genetic makeup, while the Phenotype refers to the characteristic we can see resulting from that genetic makeup, right?"*
**G2-L4:** *"Genotype is like the internal structure or code that determines our traits, and Phenotype is what we see or observe. It's interesting how our genetic information can influence our physical characteristics".*

**G3-L2:** *"So, let's say we have the Genotype "BB" for a specific gene. That means we have two copies of the dominant allele. And if the dominant allele results in brown eye colour, then our Phenotype would be having brown eyes".*

This reaction demonstrates that social interactions enable learners to freely express their thoughts and engage in discussions to reach conclusions. Through social interactions, learners have the opportunity to develop skills such as compromise, sharing, and collaboration, all of which contribute to working together towards common objectives. Social interactions can also facilitate incidental or non-coerced learning, where learners acquire knowledge and skills without explicit instruction or pressure (Janse, 2020). Learning is perceived as a social participation process rather than the acquiring of knowledge as individuals.

### 4.6.2 Authentic context

Authentic context in learning emphasises engaging learners in real-life settings within communities of practice (Lombardi & Oblinger, 2007). This educational approach enables learners to explore and discuss concepts in a meaningful manner within contexts that are relevant to them. In this particular study, learners were provided with the opportunity to discuss the inheritance of traits or characteristics from parents to offspring. For example, they examined how flowers often share the same colour as one of their parents. They were also encouraged to create monohybrid crosses to predict the first generation of offspring based on specific parental traits. By engaging in these activities, learners were able to connect theoretical concepts to real-life situations, enhancing their understanding of genetics and inheritance.

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**G4-L6:** *since the offspring will inherit one allele from each parent, that combination determines their Phenotype. But what if one parent has two alleles for purple flowers (PP), and the other has two alleles for white flowers (pp)? How does that work?"*

**Teacher:** if one parent has two alleles for purple flowers (PP) and the other has two alleles for white flowers (pp), it means they are both homozygous for that trait. When they cross, all their offspring will inherit one allele from each parent, resulting in a heterozygous Genotype (Pp). In this scenario, the dominant allele (P) for purple flowers will determine the Phenotype, and all the offspring will have purple flowers.

**G1-L4**: "*For example, in a cross between two heterozygous individuals (Aa x Aa), the possible offspring genotypes are AA, Aa, and aa, with a predicted ratio of 1:2:1. The phenotype ratio can be determined by observing the physical characteristics or traits of the offspring. For example, if the dominant trait is red flowers and the recessive trait is white flowers, a 3:1 phenotypic ratio would indicate that three-fourths of the offspring have red flowers.*

### 4.6.3 Constructivism

Constructivism is an approach to learning where learners actively build their knowledge and learning is actuality determined by the knowledge of the learners (Elliot et al, 2000). Constructivism emphasises the construction of knowledge by learners based on their encounters. To show that constructivism promotes the understanding of Genetics, is made clear by the conduct and responses of learners displayed in the third lesson conducted in this study. Learners were constructing their own knowledge, both individually and collectively. Each learner had a set of ideas and abilities from which to build knowledge in order to address issues brought on by the environment. In order to promote an active science classroom, the community, other learners and the teacher must establish the environment, and provide the necessary encouragement.

**G3-L1:** "*Now, when we cross these two plants, we would use a Punnett square to determine the possible Genotypes and Phenotypes of the offspring. The Punnett square is a simple grid that helps us visualise the genetic combinations."*

**G4-L1:** "*I remember the Punnett square from the video! We write the possible gametes of one parent along the top and the other parent along the side, and then we fill in the squares, right?"*

**G4-L3***: "Yes, you've got it! In this case, we would write P and p along the top and side of the square. Then we combine the letters in each box to determine the Genotypes of the offspring."*

### 4.6.4 Time efficiency during the lesson

Learners had unlimited time to ask questions, get feedback, discuss, and absorb the material at their own pace. This opportunity was mostly due to the virtual presentation setting, and it was more effective for the learners when they had access to lesson presentation as videos and slides following traditional teaching lessons. The accessibility of subject materials (notes) was a significant time-saving feature. The learners mentioned that they preferred to use the BL more effectively by concentrating on the genetics and less on the peripheral concerns (i.e., teacher-centred approach.). This also permitted for more effective utilisation of BL.

Learners through semi-structured interviews mentioned that they were able to learn new skills, and the genetic relevance to real-world situations as additional motivating elements. The above-mentioned reflect on the theory underpinning the study. These were the driving forces behind the learners' extrinsic motivation. According to Klein, Noe, and Wang (2006), learning environments' instructional qualities and learner characteristics are both important. Additionally, learners' efforts were facilitated rather than hindered, thus they became more motivated.

### 4.7 The integration of BL in enhancing Life Sciences learners' understanding of Genetics: The constraints

- Addressing the research question: What are the constraints for enhancing grade 12 Life Sciences learners' understanding of Genetics using BL?

The integration of BL into the learning of Life Sciences may be constrained by language, to understanding of concepts and processes. The language being used, the learners' interactions and communication styles, were linked to the cultural characteristics of the study area. The language of instruction was English rather than their mother tongue. Language barriers arise for learners who are uncomfortable with sharing their perspectives during group discussion, as well as for non-fluent English speakers. The study habits of the learners and their patterns of engagement and communication were additional in this category.

The study revealed that planning and development of lesson or instructional materials for BL take longer than the traditional teaching setting. Using a mixed approach is more demanding in its preparations for teaching and learning. This clarifies the notion put forth By Ma'arop and Embi (2016) who defined BL as a financial and physical strain.  In other words, more time was used on preparing tasks' instructional materials like animation, video and power point, responding to questions, and assessing work produced by learners. To respond to this research question, data was collected from the same lesson. The following are constrains which emerged throughout the three lessons.

- Access to Technology
- Technical Challenges

- ➢ Pedagogical Design

**Access to Technology**

This constraint refers to the availability and accessibility of technological devices, such as computers, tablets, and internet-connected devices that learners and teachers need to participate effectively in the BL environment. Addressing this constraint involves finding ways to provide equitable access to technology for all learners, potentially through device lending programs, providing internet access in underserved areas.

**Technical Challenges**

Both learners and the teacher encountered technical difficulties, such as software glitches, slow internet connections, or compatibility issues with various devices and platforms. These challenges disrupted the learning process and led to frustration for both the teacher and learners. Creating effective video and power point content that complements in-person instruction requires careful pedagogical planning**.** Technical challenges encompass various issues related to using technology for BL, such as software compatibility. Learners and teachers may encounter difficulties with logging in, navigating online platforms, accessing learning materials, or participating in virtual discussions.

**Pedagogical Design**

In Genetics, understanding complex concepts often involves visualizations, interactive models, and hands-on activities. Translating these activities into an animation format while maintaining their educational value can be challenging and time consuming. BL relies heavily on technology, including computers, internet access, and various software tools. Some students might struggle with online components if they lack the necessary technology or reliable internet connectivity.

BL may require learners to be more self-directed and motivated, as they navigate both in-person and multimedia components. Maintaining learner engagement and motivation in a technology included setting can be more difficult compared to face-to-face interactions only, potentially impacting learning outcomes. Designing effective assessments that accurately measure learners understanding of genetics concepts can be complex in a BL context.

It was also found that some learners could not share their ideas which did not promote learning in this case. Looking at the response when asked a question:

**Teachers:** What is a Genotype?
**G4-L3:** "*Um I don't know Sir*"**.**

The comments given by the abovementioned learner indicated that the social and cultural background of learners may affect how they relate with other learners, thus inhibiting social interactions in this case

## 4.8 Discussions of findings.

To establish how the integration of BL enhanced life Science Grade 12 learners' understanding of Genetics, learners were observed, interviewed and given 3 activities to write and I collected the scripts for analysis. The main purpose was to check whether the learners understood the topic of Genetics on which they were taught three lessons. In this study, learners' scripts were regarded as documents to be analysed to detect if there were any hindrances and affordances in the understanding of fermentation when BL is integrated into Life Sciences learning in class. According to Stake (1995), data collection and analysis can be done simultaneously. Therefore, the same activities were used for data collection and analysis.

### 4.8.1 Discussion of day one findings.

**Observation**

As a participative observer I assisted where possible as learners were learning and socially interacting. Semi-structured interviews were conducted during the lesson. Questions arose based on learners' behaviour and response to the employed teaching approach. This was done to address research question one. Based on the interviews, learners developed better understanding of the concepts, and they view BL as a better teaching approach which allows them to independently learn on their own.

**The following was observed during the lesson:**

The classroom was arranged in a way that promoted collaboration and easy movement. The desks were organised in groups of four or more, facing each other, allowing for interactive discussions and engagement between learners and the teacher. Learners had a clear view of both the board and the projection screen. BL was employed during the lesson, utilising resources such as a projector, projection screen, whiteboard, and laptop. Learners actively interacted with one another, creating a learner-centred environment. They cooperatively learned in groups, helping each other make sense of the basic concepts of genotypes and phenotypes.

Learners demonstrated some challenges in understanding genetic concepts and their application. They discussed chromosomes, genes, and their relationship to physical features. However, they engaged in critical thinking and problem-solving by providing examples and explanations related to eye colour and the influence of genotypes on phenotypes.

The learners exhibited calm behaviour and showed interest in helping each other comprehend the topic. They fostered an inclusive and respectful learning environment, where ideas were shared, genetic concepts were discussed, and learning took place through collaboration. Learners actively participated in the meaningful curriculum, demonstrating critical thinking and problem-solving skills.

Learners took responsibility for their own learning. They actively learned through visualisation and the use of animation, indicating their engagement and involvement in the lesson. This suggests that the classroom environment encouraged learners to be proactive in their learning process.

In conclusion, the classroom arrangement, utilisation of BL, collaborative interactions, and the learners' engagement and responsibility for their learning contributed to a rich and meaningful learning environment. Although some learners encountered challenges in understanding genetic concepts, their active participation, critical thinking, and problem-solving skills demonstrated progress in comprehending the topic. The inclusive and respectful atmosphere fostered a positive classroom dynamic, promoting cooperative learning and knowledge sharing among the learners.

**Analysing participants’ response to interview questions:**

Interview questions were drawn from learner’s behaviour and body gestures throughout the lesson. Learners were attentive and involved in class interaction.

The interview records were transcribed after the interviews. When the interview transcripts were ready, I listened to the audio more than once and compared the transcripts to what was spoken in the interview. The interview questions are for day 1 to day 3, participant’s responses were grouped based on their similarity and a summary was drawn up and presented in the following way:

- **What is an Allele?**

**G3-L5,** states that "*an Allele is a different form of a gene that exists at a specific location on a chromosome"*, which is a correct description. Alleles are alternative versions of a gene that occupy the same position (locus) on a chromosome. Different alleles can result in variations in traits or characteristics. **G4-L5** correctly explains that genes are like instructions that determine our characteristics, and alleles are different versions of those instructions. It mentions that alleles can be slightly different from one another, which is also accurate. Alleles can have variations in their DNA sequence, resulting in different expressions of a trait.

***Overall comment***

Learners provided accurate descriptions of alleles. They highlight that alleles are alternative forms of a gene found at a specific location on a chromosome, and they can have slight variations that contribute to different expressions of traits or characteristics. The use of virtual presentation helped them have a better understanding of the concept.

- **What is the difference between a dominant allele and a recessive allele?**

**G3-L3** explained that alleles are different forms of a gene found at the same location on a chromosome. It also mentions that individuals inherit two alleles for each gene, one from each parent. This provides background information about alleles. Additionally, **G4-L,** describes dominant alleles as "*those that are expressed or 'seen' in the Phenotype"*, which refers to the observable trait of an organism. It states that even if an individual has just one copy of the dominant allele, it will be expressed in their phenotype and mask the presence of any recessive allele.

Furthermore **G3-L6** expands on the explanation by stating "*that dominant alleles are expressed in the Phenotype when present in a heterozygous Genotype (represented by a capital letter")*. It also mentions that recessive alleles are only expressed when present in a homozygous genotype (represented by a lowercase letter). **G1-L4** correctly states that dominant alleles are usually represented by capital letters (e.g. A), while recessive alleles are represented by lowercase letters (e.g. a). This is a common convention used in genetics to differentiate between the two types of alleles. Lastly **G4-L2** mentions the context of a monohybrid cross and explains that the dominant allele masks the expression of the recessive allele. This results in a phenotype that shows the dominant trait. This highlights the impact of dominant alleles on the observable traits in a monohybrid cross.

***Overall comment***

Learners provided accurate explanations of the difference between dominant and recessive alleles. Dominant alleles are expressed in the phenotype, even with just one copy, while recessive alleles are only expressed in a homozygous genotype. Dominant alleles mask the expression of recessive alleles, resulting in a phenotype that shows the dominant trait in a monohybrid cross.

- **What is a Genotype?**

**G3-L4** responds that *"genotype is the physical appearance of an individual".* This statement is actually incorrect. Genotype refers to the genetic makeup or genetic code of an organism, which includes the specific alleles or versions of genes that an individual possesses. The response of **G1-L1** includes that genotype consists of a "*genetic code used for physical appearance"*. While it is true that genotype is based on the genetic code, it is not solely related to physical appearance. Genotype encompasses all the genetic information of an individual, including traits that may not be visually observable. The response of **G3-L5** reveals a better understanding of the term, by providing an accurate description. It states that "*genotype is the genetic makeup of an individual"*, which determines physical appearance. However, it is important to note that genotype influences more than just physical appearance.

***Overall comment***

Learners' response to the question reveals that there are some challenges and incomplete explanations. Genotype refers to an individual's genetic makeup, including the specific alleles they possess, and it influences not only physical appearance but also other traits and characteristics.

- **What is a Phenotype?**

**G3-L4** suggests that phenotype is the physical appearance of an individual. While physical appearance is a part of phenotype, it is not the complete definition. Phenotype refers to all the observable traits and characteristics of an individual, including physical appearance and behaviour.

**G2-L1** mentions that “*Phenotype is what can be seen with the naked eye*”. This statement is partially correct, as many aspects of Phenotype are observable. However, it does not capture the full scope of phenotype, as it includes both visible and non-visible traits.

***Overall Comment***

Learners provided limited understanding of phenotype. Phenotype encompasses all the observable traits and characteristics of an individual, including physical appearance, behaviour, and various other features, not just what can be seen with the naked eye.

- **What is the relationship between genotype and phenotype in a Monohybrid Cross**

**G2-L3** states that *both “Genotype and Phenotype determine one's appearance and are transferred from parents to offspring”*. This statement is partially correct. In a Monohybrid Cross, the Genotype refers to the genetic makeup of an individual with respect to one specific gene, while the Phenotype refers to the observable traits resulting from that genetic makeup. The response of **G2-L6** is correct, stating that the “*Genotype is the genetic makeup of an individual that determines the physical appearance, which is regarded as the Phenotype”*. This learner was able to accurately describe the relationship between Genotype and Phenotype in a Monohybrid Cross.

**G1-L1** mentions that the “*Genotype consists of a genetic code used for physical appearance”*. While this statement is partially correct, it does not fully describe the relationship between Genotype and Phenotype in a Monohybrid Cross. **G4-L3** reveals a lack of knowledge about the relationship between genotype and phenotype in a Monohybrid Cross.

***Overall comment***

Learners’ responses provided a mix of accurate and partially accurate descriptions of the relationship between genotype and phenotype in a Monohybrid Cross. The correct information is that the genotype refers to the genetic makeup, while the phenotype refers to the observable traits resulting from that genetic makeup. Learners demonstrated that the active learning as a group through virtual means makes learning fun and simple for them to grasp the content taught.

Based on learners' response the method improved their understanding of Monohybrid Cross and made it easier for them to understand the concept.

**Class activity**

**Learners were given an activity to complete at the end of each lesson.**

**Analysing participants' response to class activity:**

18. In humans, being a tongue roller (R) is dominant over non-roller (r). A man who is a non-roller marries a woman who is heterozygous for tongue rolling.

Father's phenotype **non-roller** Mother's phenotype **tongue roller**

Father's genotype **rr** Mother's genotype **R r**

| | R | r |
|---|---|---|
| r | Rr | rr |
| r | Rr | rr |

**Genotypic ratio** **Rr : rr**

**Phenotypic ratio** **Tongue roller : non-roller** **(50% chance tongue roller, 50% chance non-roller)**

What is the probability of this couple having a child who is a tongue roller? 50%

Looking at learners' document review on task one, most learners (**G1-L1, G1-L5, G2-L6, G2-L1, G2-L2, G3-L5, G3-L6, and G4-L1-L6)** were unable to draw the structure of Monohybrid Cross nor differentiate between genotype and phenotype. These learners left blank spaces: this clearly shows that the learners didn't know the answer/had no idea on how to approach the question that had been asked. Some learners had an idea about how to draw Monohybrid Cross, but they only needed clarity on how to draw the structure. These scores reveal that indeed these learners had challenges on the topic These learners (**G1-L2, G1-L3, G2-L2, G3-L1, and G4-L6)** revealed that they had an idea on how to draw a structure on a Monohybrid Cross since they were able to represent the elements of the structure, but they also had a challenge of distinguishing between a genotype and a phenotype. The last group of learners were learners **G1-L7, G2-L3, G3-L4, G3-**

**L1, G3-L14** and **G3-L5;** these learners were able to draw a complete structure of the Monohybrid Cross with all the elements but they were not able to give the genotypic ratio of the F1 offspring**.**

***Overall Comment***

The majority of learners **(G1-L1, G1-L5, G2-L6, G2-L1, G2-L2, G3-L5, G3-L6, and G4-L1-L6)** performed poorly in the Task 1 activity. This indicates that these learners were unable to draw the structure of a Monohybrid Cross and couldn't differentiate between genotype and phenotype. The presence of blank spaces suggests that they either didn't know the answers or were unsure how to approach the question.

Some learners **(G1-L2, G1-L3, G2-L2, G3-L1, and G4-L6)**, indicated that they had some understanding of how to draw a structure for a Monohybrid Cross. However, they still faced challenges in distinguishing between genotype and phenotype.

A smaller group of learners **(G1-L7, G2-L3, G3-L4, G3-L1, G3-L14, and G3-L5**) were able to draw a complete structure of a Monohybrid Cross, including all the elements. However, they struggled to provide the genotypic ratio of the F1 offspring.

In conclusion, based on the scores and observations, it is clear that many learners faced difficulties with the topic of Monohybrid Crosses. While some learners had a basic understanding of the structure and elements, they struggled with differentiating between genotype and phenotype. Only a small group of learners were able to successfully draw the complete structure, but they still encountered challenges when determining the genotypic ratio of the F1 offspring.

According to previous studies, a traditional classroom setting may be a challenge to teach and learn about genetics (Choden & Kijkuakul, 2020)**.** The traditional teaching approach used to teach this topic resulted in producing learners who do not have the basics of genetics. This topic is introduced in grade 9 as a basic to prepare these learners for grade 12 and future or authentic context of the topic. The challenges that these learners have regarding the topic can be based on the fact that, according to Taasoobshirazi and Carr (2008) traditional ways of teaching science, which usually involve memorisation of concepts, often result in learners' failure to comprehend the deeper conceptual connections within the problems. These learners are only able to memorise but unable to analyse and break down questions in order to respond to asked questions.

### 4.8.2 Discussion of day two findings

**Observation**

**The following was observed during the lesson:**

The arrangement also ensured that all learners had a clear view of both the board and the projection screen, promoting better visual learning. The learners actively participated in discussions, showing a good understanding of genetic concepts. They were able to provide definitions and explanations related to the topic. For instance, they correctly defined genotype as the genetic makeup of an individual and understood how it determines physical appearance. Learners also demonstrated an understanding of incomplete dominance, explaining it through the analogy of mixing colours to create a new shade.

The learners displayed a sense of independence and initiative by taking ownership of their learning. They engaged in meaningful discussions, asked questions, and contributed their ideas. This active engagement fostered a positive attitude towards the concept and allowed learners to be interested and invested in their own learning. It was noted that in session 1, learners in their groups were struggling to define and describe Monohybrid Cross, I frequently had to intervene and help them. Nevertheless, combining BL with the traditional method also promoted better understanding. Yasar and Demirkol (2014) also agreed that the results of combining two strategies improve learner's conceptual understanding of a given concept.

Learners showcased their ability to apply their understanding of genetic concepts. They discussed the outcomes of genetic crosses, correctly identifying the dominant and recessive alleles and predicted the genotypes and phenotypes of the offspring. This demonstrated their critical thinking and problem-solving skills in the context of genetics.

Effective Use of Resources: The use of visual aids such as a projector, projection screen, whiteboard, and laptop, along with animations and presentations, appeared to enhance the learning experience. Learners actively learned through visualisation and animation, which helped them grasp the concepts more effectively.

In conclusion, the observations and data collected during the lesson on Dominance and Monohybrid Cross indicate that the learners were actively engaged, displayed a good understanding of genetic concepts, and demonstrated critical thinking skills. The classroom arrangement, learners' interaction, and effective use of resources contributed to their positive attitude towards the subject. The use of visualisation and animation appeared to be beneficial in facilitating their learning experience.

The BL teaching approach results reveal that learners have improved their level of thinking in terms of analysing and applying what they know in order to respond to the asked questions. From the above results I conclude that the BL method or approach has improved most learners' conceptual understanding of the process of genetics.

In the study, teacher-centred teaching was eliminated. From session 2 learners were seen to be more independent and engaged in their learning, and the researcher's involvement in classroom instruction was gradually reduced in comparison to the first session.

**Analysing learners' response to interview questions**

- **How can you determine the genotype of an individual based on its phenotype?**

Firstly **G2-L3** suggests that to determine the genotype of an individual based on its phenotype, you can use a Punnett square or another method to combine the possible alleles from the parent genotypes. It also mentions that the Phenotype ratio can be determined by observing the physical expression of the dominant and recessive traits in the offspring. **G3-L1** states that the "*Genotype ratio can be determined by analysing the possible combinations of alleles resulting from the parental Genotypes*." It provides a brief explanation without going into further detail.

The response of **G1-L4** provides a more comprehensive explanation. It mentions that "The *Genotype ratio can be determined by considering the possible offspring genotypes resulting from the parental Genotypes"*. It also provides an example of a cross between two heterozygous individuals (Aa x Aa) and the resulting genotypes (AA, Aa, and aa) with a predicted ratio of 1:2:1. Additionally, it explains that the phenotype ratio can be determined by observing the physical characteristics or traits of the offspring. **G4-L3** states he does not know the answer.

***Overall comment***

Learners provided different levels of understanding regarding determining the Genotype based on the Phenotype. The more detailed explanations mention using methods like Punnett squares and analysing possible allele combinations from parental genotypes. They also highlight the importance of observing physical traits to determine the phenotype ratio.

- **What is a Monohybrid Cross?**

**G1-L3** described a monohybrid cross as a "*genetic cross between individuals that differ in only one trait"*. It specifies that this cross typically involves a single gene locus with two different alleles. This explanation highlights the focus on a single trait and gene locus in a monohybrid cross. Addtionally, **G2-L4** stated that a Monohybrid Cross *"is a type of genetic cross where two individuals that differ in only one trait are bred together*." This explanation emphasizes the breeding aspect of the cross and the fact that only one trait is under consideration. **G3-L3** gave a correct answer by explaining that a monohybrid cross involves examining the inheritance pattern of a single gene and its alleles in the offspring. This description highlights the focus on studying the inheritance of a specific gene and its different forms (alleles) in the cross. Lastly **G4-L2** states that a monohybrid cross is useful for studying the basic principles of genetics, such as the laws of segregation and independent assortment. This explanation highlights the educational value of a monohybrid cross in understanding fundamental genetic principles.

***Overall Comment***

Learners were able to give correct explanations of a Monohybrid Cross. It involves breeding individuals that differ in only one trait and focuses on studying the inheritance pattern of a single gene and its alleles. Monohybrid Crosses are useful for understanding basic genetic principles.

- **Can you explain the concept of dominant and recessive alleles in a Monohybrid Cross?**

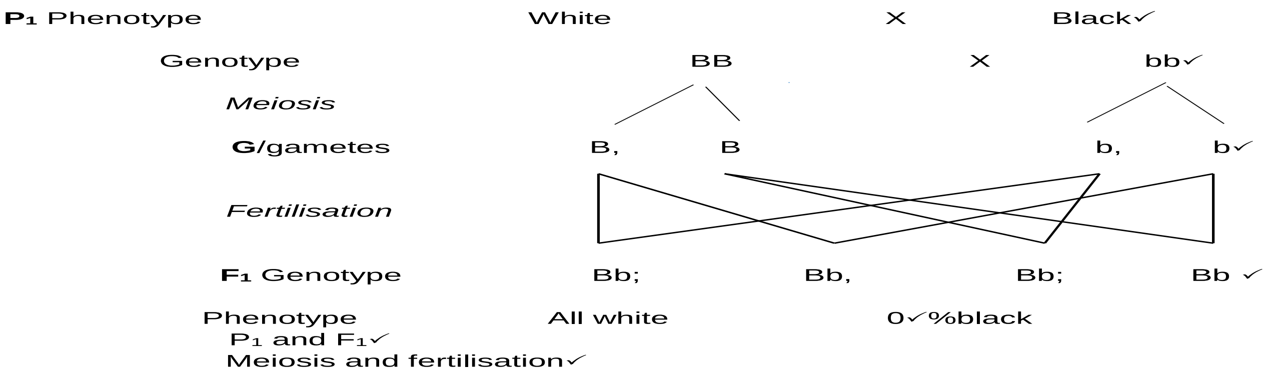
**G3-L6** explains that dominant alleles are expressed in the phenotype when present in a heterozygous genotype, which is represented by a capital letter. It also mentions that recessive alleles are only expressed when present in a homozygous genotype, represented by a lowercase letter. This explanation highlights the different expression patterns of dominant and recessive alleles. Furthermore **G1-L4** stated that "*dominant alleles are usually represented by capital letters (e.g. A), while recessive alleles are represented by lowercase letters (e.g. a)"*. This is a common convention used in genetics to differentiate between the two types of Alleles. Lastly **G4-L2** mentions the context of a "*Monohybrid Cross and explains that the dominant allele masks the expression of the recessive allele"*. This results in a phenotype that shows the dominant trait. It highlights the impact of the dominant allele on the observable traits in a monohybrid cross.

***Overall comment***

Learners were able to provide accurate explanations of dominant and recessive alleles in a monohybrid cross. Dominant alleles are expressed in the phenotype, while recessive alleles are only expressed in a homozygous genotype. Dominant alleles mask the expression of recessive alleles, resulting in a phenotype that shows the dominant trait in a monohybrid cross. The use of capital and lowercase letters to represent dominant and recessive alleles is a common convention in genetics.

**Class activity**

**Learners completed a class activity at the end the lesson**




All learners were able to analyse and determine the genotype of each parent and provide the correct genotype along with their phenotype. The learners **G-L1, G1-L3, G1- L4, G1-L15, G2-L1, G2- L3, G3-L1, G3-L2, and G4-L1-L4** revealed that they had an idea of how to draw a structure on a Monohybrid Cross since they were able to represent the elements of the structure but they also had a challenge of distinguishing between a genotype and a phenotype. These learners **G1-L2, G2-L3, G3-L4, G4-L4, and G4-L6** showed improvement. All learners were able to write all elements of a monohybrid structure but demonstrated a partial understanding of the concepts.

The learners **G1-L1, G1-L3, G2-L1, G2-L4, G3-L2** and **G4-L3** were able to draw a complete Monohybrid Cross consisting of all elements of the cross.

***Overall Comment***

The learners **G-L1, G1-L3, G1-L4, G1-L15, G2-L1, G2-L3, G3-L1, G3-L2, and G4-L1-L4** improved with classroom lessons. This suggests that these learners demonstrated proficiency in analysing and determining genotypes, as well as correctly identifying phenotypes. They were able to represent the elements of the Monohybrid structure but had difficulty distinguishing between genotype and phenotype. These learners demonstrated an ability to obtain a higher level of proficiency, indicating a deeper understanding of the concepts related to Monohybrid Crosses.

Learners **G1-L1, G1-L3, G2-L1, G2-L4, G3-L2, and G4-L3** were able to draw a complete Monohybrid Cross with all the necessary elements. This suggests a comprehensive understanding and proficiency in constructing a Monohybrid Cross.

Learners constructed their own understanding of the Genetics through BL and were able to share the information among each other as guided by the theory of the study. Based on learners' response to semi-structured interview questions throughout the session their conceptual understanding has improved with each session, which reveals that it is important for learners to first understand the basics and history of the topic or concept. At first, learners were not able to distinguish the two terms genotype and phenotype and define the two but with the aid of BL in the traditional teaching method and more sessions we had in class they were able to also give alleles of genotypes.

### 4.8.3 Discussion of day three findings

**Observation**

**The following was observed during the lesson:**

I observed that learners could easily understand the improvised BL, along with the terminologies, and they were aware of what needed to be done in terms of classroom arrangement. Learners were familiar with the teaching method and fascinated by BL at this point. With each level of independence learners reached in the sessions, the researcher's role got less outlined as a facilitator. In comparison to the session 1 and session 2, learners' level of confidence increased during the sessions. Learner's active participation was noted by the researcher. At this point learners were able to distinguish genotype and phenotype, name and use different types of dominance in a Monohybrid Cross.

BL created a setting where learners felt welcomed, prepared to engage in dialogue, had a sense of belonging and accomplishment, as well as the inspiration to develop the ability to ask and answer questions. The duty of a teacher includes helping learners to develop their thinking skills by presenting multiple points of view and drawing connections between them, directly responding to their questions, and summarising the discussion. These kinds of initiatives are crucial to maintaining alignment between the dynamic world of technology and the academic community. BL will facilitate the addition of modern active learning, making instructions more clear**.**

**Analysing learners' response to interview questions**

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- **How would you determine the genotype and phenotype ratios in the offspring of a Monohybrid Cross?**

**G2-L3** suggests using a Punnett square or another method to combine the possible alleles from the parent genotypes to determine the genotype ratio. It also mentions that the phenotype ratio can be determined by observing the physical expression of the dominant and recessive traits in the offspring. **G3-L1** states that the genotype ratio can be determined by analysing the possible combinations of alleles resulting from the parental genotypes. **G3-L1** provides a brief explanation without going into further detail. **G1-L4** provides a more comprehensive explanation. **G1-L4** gives an example of a cross between two heterozygous individuals (Aa x Aa) and the possible offspring genotypes (AA, Aa, and aa) with a predicted ratio of 1:2:1. It also explains that the phenotype ratio can be determined by observing the physical characteristics or traits of the offspring. further provides an example using red and white flower traits and explains the resulting phenotypic ratio.

**G4-L6** correctly explains that homozygous genotypes have two identical alleles for a particular gene, either both dominant (e.g. AA) and both recessive (e.g. aa). It also mentions that heterozygous genotypes have two different alleles, one dominant and one recessive (e.g. Aa). This explanation highlights the distinction between the two types of genotypes based on allele identity.

***Overall comment***

Learners were able to provide accurate explanations. To determine genotype and phenotype ratios in a monohybrid cross, one can use methods like Punnett squares to analyse allele combinations and observe physical traits. Homozygous genotypes have two identical alleles, while heterozygous genotypes have two different alleles**.**

- **What is meant by the term heterozygous and how does it differ from homozygous?**

**G2-L4** "defined *homozygous as having either two dominant alleles (BB) or two recessive alleles (bb). It provides an example using eye colour, where someone with two brown alleles (BB) would be homozygous for brown eye colour, and someone with two blue alleles (bb) would be homozygous for blue eye colour"*. This explanation emphasizes that homozygous individuals have identical alleles for a specific gene. Additionally, **G3-L4** added the explanation of heterozygous using the example of eye colour and two alleles: brown (B) and blue (b). It states that someone with one brown allele and one blue allele (Bb) would be heterozygous for eye colour. Highlighting that heterozygous individuals have different alleles for a specific gene.

***Overall comment***

Learners were able to provide accurate explanations of heterozygous and homozygous genotypes. Heterozygous individuals have two different alleles for a specific gene, while homozygous individuals have either two dominant alleles or two recessive alleles for that gene. The example of eye colour helps illustrate the concepts clearly.

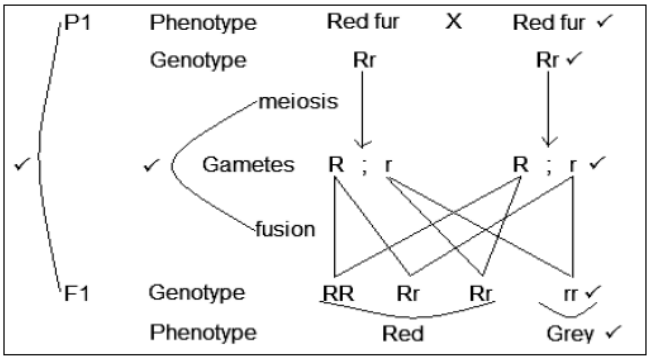
- **What is the Punnett square and how is it used to predict the outcomes of a Monohybrid Cross?**

  Overall, all learners were able to provide accurate explanations of the Punnett square and its use in predicting the outcomes of a monohybrid cross. The Punnett square is a visual tool used to determine the possible combinations of alleles from two parents for a specific trait. It helps in understanding the inheritance patterns and predicting the genotypes and phenotypes of the offspring.

**Written work**

**Learners were given an activity to complete at the end of the lesson.**

3.1




**Individuals with RR will die before birth:**
Phenotypic ratio is therefore 2 red fur : 1 grey fur
(rather than 3 red fur : 1 grey fur)
Therefore: 200 / two thirds of the population has red fur
100 *✓/ one third of the population has grey fur
**Any 6 points from diagram plus 1 compulsory point for the answer above (*)** (7)

All learners were able to analyse and determine the genotype of each parent and provide the correct genotype along with their phenotype. This reflects that they have improved their conceptual understanding as compared to the first lesson. Learners have developed a skill to draw and master the structure of Monohybrid Cross. Furthermore **G1-L1, G1-L5, G2-L1, G2-L3, G2-L14, G3-L1, G3-L3, G3-L4, G4-L1, G4-L2 and G4-L3** revealed that they had an idea on how to draw a structure on a Monohybrid Cross since they were able to represent the elements of the structure but they also had a challenge of distinguishing between a genotypic and phenotypic ratio. These learners, **G1- L2, G1-L3, G1-L4, G2-L2, and G3-L5,** were able to write all elements of a monohybrid structure but demonstrated a partial understanding of the concepts. The learners **G1-L4, G1-L4, G2-L2, G3-L2, G3-L2** and **G4-L5** were able to draw a complete Monohybrid Cross consisting of all elements of the cross.

**Overall result of the three lessons**

The BL activities related to genetics encouraged the learners to be active and engaged throughout the lesson. At the beginning of the study, this independence was slower because much time was spent introducing and learning the blended approach but the issue with time management improved with practice and the learners were comfortable with the BL steps and could concentrate on the lesson. The blended approach was more of an influence from lesson 2 onwards having adjusted to a non-traditional approach which was then made simpler according to the learners' context and understanding throughout the lessons.

After all the discussions made, learners were requested to write down their responses to the questions they were discussing. The responses were submitted to the educator to be analysed. The first document consisted of 4 questions to respond to:

**Findings of the study: in relation to the research questions.**

- **How does blended learning enhance Life Sciences grade 12 learners' understanding of Genetics?**

The finding regarding this research question revealed BL was effectively employed using various resources such as projectors, projection screens, whiteboards, and laptops. Learners actively interacted with these resources and engaged in cooperative learning within their groups, helping each other understand the basic concepts of genotypes and phenotypes. While learners initially had some difficulty in grasping genetic concepts and their application, they demonstrated critical thinking and problem-solving skills. They provided examples and explanations related to genotypes and phenotypes, particularly in the context of eye colour, showing progress in understanding these concepts.

Learners exhibited calm behaviour and displayed interest in helping each other comprehend the topic. They promoted respectful learning environment, where ideas were freely shared, and discussions on genetic concepts took place collaboratively. Learners actively participated in the curriculum, showcasing critical thinking and problem-solving skills.

Learners took ownership of their learning process, actively engaging with visualisation and animations. Their active involvement indicated a proactive attitude towards learning, suggesting that the classroom environment supported and encouraged learners to take responsibility for their own learning.

Overall, the findings indicate that the classroom arrangement, utilization of BL, collaborative interactions, and learners' engagement and responsibility for learning contributed to a rich and meaningful learning environment. Despite initial challenges in understanding genetic concepts, learners demonstrated progress through their active participation, critical thinking, and problem-solving skills. The respectful atmosphere fostered a positive classroom dynamic, promoting cooperative learning and knowledge sharing among the learners.

The learners showed a clear understanding of genotype and phenotype in a Monohybrid Cross, providing explanations for each term. The employment of BL played a significant role in improving their conceptual understanding. Furthermore, the learners acknowledged that active group learning through virtual means made the learning process enjoyable and simplified the process of grasping the content taught.

In conclusion, the findings highlight the effectiveness of BL in creating an engaging and collaborative learning environment. Learners demonstrated progress in understanding genetic concepts, showcasing critical thinking and problem-solving skills.

### 4.9. Chapter conclusion.

In this chapter, data collected through observations, semi-structured interviews, and document analysis were presented, analysed, interpreted, and discussed. The aim was to explore and identify the key issues that emerged from the findings. By utilising these various data sources, a comprehensive understanding of the research topic was obtained. The data were carefully examined, and relevant themes and patterns were identified and discussed in order to address the research questions.

# CHAPTER 5: Summary, conclusions and recommendations

## 5.1 INTRODUCTION

In the previous chapter, the findings were presented, interpreted, and discussed, providing an in-depth understanding of the affordances and constraints related to Grade 12 Life Sciences learners' understanding of Genetics when using blended learning (BL). The study's limitations and recommendations for further research are discussed in this chapter.

## 5.2. Overview of the study

The primary aim of this study was to explore the affordances and constraints of learners' understanding of Genetics when integrating BL. The research was conducted in a secondary school located in a rural area within the Limpopo province in Moletlane circuit. The study required the researcher to incorporate BL methods into the teaching and learning of Genetics. Data collection was carried out through the use of observations, semi-structured interviews, and document analysis.

According to the Curriculum and Assessment Policy Statement (CAPS) document, the integration of more than one teaching method into Life Sciences teaching is mandated to aid learners in understanding scientific concepts (DBE, 2011). In this study, I assumed the role of an observer, teacher and facilitator in integrating BL into the learning process, drawing on the principles of Vygotsky's sociocultural theory (Vygotsky, 1978). To achieve the aim of the study as mentioned in the first paragraph, the following research questions were presented:

- What are the affordances and constraints for enhancing grade 12 Life Sciences learners' understanding of Genetics using BL?
- How does BL enhance Life Sciences grade 12 learners' understanding of Genetics?

In order to obtain credible and trustworthy answers to the research questions, a qualitative case study design was employed.

**What are the affordances and constraints for enhancing grade 12 Life Sciences learners' understanding of Genetics using blended learning?**

The finding regarding this research question revealed that the integration of BL afforded learners' understanding of Genetics. This was evident when learners were able to draw Monohybrid Crosses and use real life examples to emphasize their understanding of the concept. The findings related to constraints revealed that the integration of BL might cause a language constraint to the learners' understanding of Genetics. Reactions such as withdrawal and passiveness during the activities displayed some constraints towards learning. The fact that some learners could not answer some questions, with a virtual presentation, was a challenge.

**How does blended learning enhance Life Sciences grade 12 learners' understanding of Genetics**?

The researcher created an active learning environment that allowed learners to be active and learn from each other. To enhance learners' conceptual understanding, the researcher used the appropriate method or strategy which is BL. BL was successfully integrated into the classroom, and the teacher created non-traditional learning environments, combining new technology with new pedagogy, create socially engaged learning environments, and promoting cooperative interaction, collaborative learning, and group work. This necessitates learning a new set of classroom management techniques. In addition, Armstrong (2014) discovered that "ICT promotes successful teaching and learning, enabling learners to take charge of their learning. This study backs up a study by Sabin, Snow, and Viola (2016) that claimed classroom technology improves teaching and learning, and enhances workplace soft skills, such as critical thinking and independent research. Learners' document analyses (script marks) revealed that learners' conceptual understanding of the concept has improved from lesson one to three. Learners' response to the question and logical reasoning has improved. Therefore, integrating BL in a classroom setting improved grade 12 learners' conceptual understanding of genetics.

## 5.3 Limitation of the study

According to McMillan and Schumacher (2010), caution should be exercised while using qualitative research methods. Twenty-two participants from one secondary school were carefully chosen as the sample for this study to explore BL in both teaching and learning. The study's conclusions cannot be applied to all schools in the province or other regions of the nation because it used a relatively small sample of twenty-two participants who were grade 12 learners from a chosen school in Limpopo Province in a short period of time using a qualitative research design. The learners were having trouble managing their time while learning the blended method, but with repetition, they became familiarised to the BL and were able to focus on the topic at hand.

## 5.4 Recommendations

Throughout the study, the effectiveness of the teaching after the adoption of the two methods traditional teaching method and interrogation of ICT was continuously evaluated. The use of more than one teaching method in the classroom encourage learners to be active and independent learners who are responsible for their own learning and they are able to evaluate their own progress as well as that of other learners (Bux Jumani et al., 2018).The researcher was able to observe and reflect on the teaching approach and identify workable alternatives to address any difficulties or issues learners may have had in the classroom regarding genetics. Additionally, BL served as a useful reminder of the crucial function of a researcher as a facilitator in promoting and putting into practice the learner-centred active learning approach that produced fruitful outcomes, according to Yasar and Demirkol (2014).

Information Communication Technology and traditional teaching method can be combined by teachers as a teaching strategy to help their learners become more engaged, self-sufficient, and self-assured learners (Draper, 2010). The study promotes the use of technology because it was found to positively support the intervention. It is also advised that researchers look into how this strategy affects learners and teachers, or possibly look into how attitudes toward genetics have changed both before and after the intervention.

The results presented were collected from one class ($12^{B}$) in one school. The recommendation for future research is that more learners from different schools and the whole Further Education and Training (FET) band may be included. It is further suggested that participants be from different geographical areas so that different cultural practices may be involved.

- **Teachers**

It is important to support teachers in learning how to connect with their learners on a deeper level. They should make an effort to use a variety of teaching strategies, such as BL, group work, solo work, and cooperative learning, to help learners experience a diversity of teaching and learning philosophies. Since they often get bored, learners require a variety of teaching techniques. When teaching, teachers should focus on the needs of their learners and help them build on their prior knowledge as they work with others in their groups. In order to succeed as teachers, they must use the appropriate teaching method or tactics.

- **Head of Department**

HODs in schools should motivate teachers to collaborate and work as a team to achieve a common objective.

- **School Management team**

The use of BL as a teaching and learning tool should be discussed and put into practice by the school management team. Teachers should feel empowered and have the SMT's support.

## 5.5 Conclusion of the study

Stake (1993) suggests that case study findings cannot be generalised due to the unique context and limited sample size. However, the findings of this research demonstrate the relationship between prior knowledge and learners' understanding of Genetics when utilizing BL integration. The aim of this study was to explore the affordances and constraints of integrating BL in the understanding of Genetics among Grade 12 Life Sciences students. McKnight et al. (2015) argue that science learning becomes more interesting and meaningful when learners actively participate and connect to real-life experiences. Aligning with the perspective of McKnight et al., this study found that learners experienced meaningful learning when actively involved. Their active engagement in the study increased their interest and excitement about the topic.

Qualitative data collected through observations, semi-structured interviews, and document analysis revealed both affordances and constraints on learners' understanding of Genetics when BL was integrated. Observations demonstrated that cooperative learning motivated and interested learners. Furthermore, the learners' attitude during discussions and the process of creating Monohybrid Crosses indicated that they were able to learn through familiar practices.

The findings from document analysis indicated that the majority of groups were prepared and receptive to BL integration. Most groups were able to answer questions and successfully complete Monohybrid Crosses. The integration of BL facilitated the understanding of the complex principles of Genetics. The qualitative data from observations, semi-interviews, and document analysis highlighted that the integration of BL enhanced learners' understanding of Genetics in Life Sciences.

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**ANNEXURE A: interview transcription**

**Learners responds of interview questions from each group:**

Learner were concurrently interviewed throughout the three sessions, questions asked were based on learners observed behaviours, reactions and question asked by learners during each session. The questions which arose from the sessions are as follows:

**Semi-structured interview questions for day 1 followed by learners' response.**

**What is an Allele?**

**G3-L5:** Um, I think an allele is a different form of a gene that exists at a specific place on a chromosome.

**G4-L5:** if I understand correctly, genes are like the instructions that determine our characteristics, and alleles are the different versions of those instructions. They can be slightly different from one another, right?

- **What is the difference between a dominant allele and a recessive allele?**

**G3-L3:** "*Alleles are different forms of a gene that can be found at the same location on a chromosome. Each individual inherits two alleles for each gene, one from each parent"*.

**G4-L4:** "*Dominant alleles are expressed or "seen" in the phenotype, which is the observable trait of an organism. If an individual has even just one copy of the dominant allele, it will be expressed in their phenotype, masking the presence of any recessive allele"*.

**G3-L6**: "*Dominant alleles are those that are expressed in the phenotype when present in a heterozygous genotype (represented by a capital letter), while recessive alleles are only expressed when present in a homozygous genotype (represented by a lowercase letter)".*

**G1-L4*:*** *"Dominant alleles are usually represented by capital letters (e.g., A), while recessive alleles are represented by lowercase letters (e.g., a)".*

**G4-L2**: "*In a Monohybrid Cross, the dominant allele masks the expression of the recessive allele, resulting in a phenotype that shows the dominant trait."*

- **What is genotype?**

**G3-L4 (shocked):** *"Genotype is it's a physical appearance of an individual"**.***

**G1-L1:** Um. Well genotype um, consists of genetic code which is used for our physical appearance".

**G3-L5**: "*um in not sure but I think genotype is the genetic makeup of an individual which determines the physical appearance*

- **What is phenotype**

**G3-L4 (Hid her face):** "*it's a physical appearance of an individual*

**G2-L1 (confused):** ***"****Phenotype is what we can see with a naked eye*".

- **What is the relationship between genotype and phenotype in a Monohybrid Cross?**

**G2-L3:** *"Both genotype and phenotype determines ones appearance which is transferred from parents to offspring".*

**G2-L6**: "*Genotype is the genetic makeup of an individual which determines the physical appearance of and individual which is regarded as phenotype"*

**G1-L1:** "*Um. Well genotype um, consists of genetic code which is used for our physical appearance".*

**G3-L5**: "*um in not sure but I think genotype is the genetic makeup of an individual which determines the physical appearance."*

**G2-L6**: "*Genotype is the genetic makeup of an individual which determines the physical appearance of and individual which is regarded as phenotype"*

**G2-L3:** "*Both genotype and phenotype determines ones appearance which is transferred from parents to offspring".*

**G1-L1:** "*Um. Well genotype um, consists of genetic code which is used for our physical appearance*.

**G3-L5**: "*um in not sure but I think genotype is the genetic makeup of an individual which determines the physical appearance"*

**G4-L3:** "*um I don't know Sir"***.**

**Semi-structured interview questions for day 2 followed by learners' response.**

- **How can you determine the genotype of an individual based on its phenotype?**

**G2-L3:** *"To determine the genotype ratio, you would use a Punnett square or another method to combine the possible alleles from the parent genotypes. The phenotype ratio can be determined by observing the physical expression of the dominant and recessive traits in the offspring*".

**G3-L1:** "*The genotype ratio can be determined by analysing the possible combinations of alleles that result from the parental genotypes".*

**G1-L4**: "*For example, in a cross between two heterozygous individuals (Aa x Aa), the possible offspring genotypes are AA, Aa, and aa, with a predicted ratio of 1:2:1.The phenotype ratio can be determined by observing the physical characteristics or traits of the offspring. For example, if the dominant trait is red flowers and the recessive trait is white flowers, a 3:1 phenotypic ratio would indicate that three-fourths of the offspring have red flowers.*

**G4-L3:** "*um I don't know Sir"***.**

- **What is a Monohybrid Cross?**

**G1-L3**: "*A Monohybrid Cross is a genetic cross between individuals that differ in only one trait, typically involving a single gene locus with two different alleles".*

**G2-L4:** "A *Monohybrid Cross is a type of genetic cross in which two individuals that differ in only one trait are bred together".*

**G3-L3:** "*It involves the examination of the inheritance pattern of a single gene and its alleles in the offspring".*

**G4-L2:** "*This type of cross is useful for studying the basic principles of genetics, such as the laws of segregation and independent assortment"*.

- **Can you explain the concept of dominant and recessive alleles in a Monohybrid Cross?**

**G3-L6**: "*Dominant alleles are those that are expressed in the phenotype when present in a heterozygous genotype (represented by a capital letter), while recessive alleles are only expressed when present in a homozygous genotype (represented by a lowercase letter)".*

**G1-L4*:*** *"Dominant alleles are usually represented by capital letters (e.g., A), while recessive alleles are represented by lowercase letters (e.g., a)".*

**G4-L2**: "*In a Monohybrid Cross, the dominant allele masks the expression of the recessive allele, resulting in a phenotype that shows the dominant trait."*

**Semi-structured interview questions for day 3 followed by learners' response.**

- **How would you determine the genotype and phenotype ratios in the offspring of a Monohybrid Cross?**

**G2-L3:** *"To determine the genotype ratio, you would use a Punnett square or another method to combine the possible alleles from the parent genotypes. The phenotype ratio can be determined by observing the physical expression of the dominant and recessive traits in the offspring*".

**G3-L1:** "*The genotype ratio can be determined by analysing the possible combinations of alleles that result from the parental genotypes".*

**G1-L4**: "*For example, in a cross between two heterozygous individuals (Aa x Aa), the possible offspring genotypes are AA, Aa, and aa, with a predicted ratio of 1:2:1.The phenotype ratio can be determined by observing the physical characteristics or traits of the offspring. For example, if the dominant trait is red flowers and the recessive trait is white flowers, a 3:1 phenotypic ratio would indicate that three-fourths of the offspring have red flowers and one-fourth have white flowers"*.

- What is the difference between homozygous and heterozygous genotypes?

**G4-L6:** **"***Homozygous genotypes have two identical alleles for a particular gene, either both dominant (e.g., AA) and both recessive (e.g., aa). Heterozygous genotypes have two different alleles, one dominant and one recessive (e.g., Aa)".*

- **Can you explain what a Monohybrid Cross is?**

**G1-L3**: "*A Monohybrid Cross is a genetic cross between individuals that differ in only one trait, typically involving a single gene locus with two different alleles".*

**G2-L4:** "A *Monohybrid Cross is a type of genetic cross in which two individuals that differ in only one trait are bred together".*

**G3-L3:** "*It involves the examination of the inheritance pattern of a single gene and its alleles in the offspring".*

**G4-L2:** "*This type of cross is useful for studying the basic principles of genetics, such as the laws of segregation and independent assortment"*.

- **What is meant by the term heterozygous and how does it differ from homozygous?**

***G2-L4:*** *"Homozygous means having either two dominant alleles (BB) or two recessive alleles (bb). In the eye colour example, if someone has two brown alleles (BB), they would be homozygous for brown eye colour. On the other hand, if someone has two blue alleles (bb), they would be homozygous for blue eye colour."*

***G3-L4:***"*Let's take an example to make it clearer. Suppose we're talking about eye colour, and the gene for eye colour has two alleles: brown (B) and blue (b). If someone has one brown allele and one blue allele (Bb), they would be heterozygous for eye colour."*

***G3-L6:*** *"heterozygous means having one dominant allele and one recessive allele".*

- **What is the Punnett square and how is it used to predict the outcomes of a Monohybrid Cross?**

**G3-L3**: *"A Punnett square is a visual tool used in genetics to predict the possible outcomes of a cross between two individuals for a specific characteristic. It's especially useful for Monohybrid Crosses, which involve the inheritance of a single trait".*

**G4-L6:** "*Well, in a Monohybrid Cross, you have two parents, each carrying two copies of a particular gene, one from each parent. Let's say we're looking at the inheritance of eye colour, with "B" representing brown and "b" representing blue. When you make a Punnett square, you write the possible combinations of these genes from each parent along the sides of a square grid"*.

**ANNEXURE B: Letter Limpopo Department of Basic Education**

Email: 201403109@keyaka.ul.ac.za

Cell: 071 892 4583.

P.O BOX 346
GROOTHOEK
0628
23 MARCH 2022

Head of Department
Limpopo Provincial Department of Education
113 Biccard and 24 Excelsior Streets
Polokwane
0700

Dear sir/Madam

**Request for permission to conduct research**

1. The matter above bears reference.

2. I am a Science Education, Master's student at the University of Limpopo. As part of the requirements for the fulfilment of the degree I need to conduct a research and produce a thesis.
3. This letter serves to request for permission to conduct research at **secondary one of the schools in Moletlane** Circuit of the **Capricorn South Education District**.
4. The topic of the proposed research is **"Exploring the affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners' understanding of Genetics"**. Participant will be grade 12 Life Sciences learners. My research process will not affect the day-to-day academic activities of the school. All the relevant research ethics will be adhered to.
5. I will be glad if the department can grant me the permission to conduct this research.

Yours in Education

**M.N MATLALA**

**ANNEXURE C: Letter to circuit**


Email: 201403109@keyaka.ul.ac.za

Cell: 071 892 4583.

P.O BOX 346

GROOOTHOEK

0628


The Circuit Manager

Moletlane Circuit

Limpopo Department of Basic Education

Groothoek

0628

**Request for permission to conduct research study at Moletlane Circuit**

Dear Sir/Madam

Herewith I would like to request from the circuit manager of the aforementioned circuit permission to conduct academic research at one of the schools operating within the prescripts of the circuit. Currently I am a registered Masters student in Science Education at the University of Limpopo, Turfloop Campus. As part of the requirements for the fulfilment of the degree I am required to conduct a research and produce a thesis.

The title of my research project is: **Exploring the affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners' understanding of Genetics.**

The purpose of the study: to explore the affordances and constraints of enhancing Life Sciences Grade 12 learners' understanding of Genetics using blended learning.
Addressing the following question:

5. What are the affordances and constraints of enhancing Life Sciences grade 12 learners' understanding of Genetics?
6. How does blended learning enhance Life Sciences grade 12 learners' understanding of Genetics?

The study will involve grade 12 Life Sciences learners. The learners will be sent invitation letters requesting their participation in the study. The learners will be requested to complete three activities on genetics. After the learners have completed the three activities, they will be interviewed throughout the lesson using unstructured interview schedule. Face-to-face interviews with learners will take place the lesson during. Learners will be required to respond freely in their own terms, explain and defend their answers. In other words, open-ended face-to-face interviews will allow learners to respond in whatever way they found appropriate based on their personal experiences and knowledge using audio recorder for safe keeping and recording of the correct responses made by the learners. Lastly the learners will be observed once in their classrooms throughout the lessons using blended learning. The observations will not be video recorded. Participation is voluntarily and if one wishes to withdraw anytime he or she will be allowed do so. I am going to adhere to all ethical procedures. Lastly, participant's identity and research site will be protected, and pseudonyms will therefore be used in the research study.

Any queries regarding the research project may be directed to Mr M.N Matlala @ 071 892 4583
Supervisor: karabo.chuene@ul.ac.za

Tel no:  015 268 3888

Co-supervisor: Dr T.G Maluleke, tinyiko.maluleke@ul.ac.za

Tel no: 015 268 3888

Kind Regards

**M.N Matlala**

**ANNEXURE D: Letter to school principal**

Email: 201403109@keyaka.ul.ac.za

Cell: 071 892 4583.

P.O BOX 346

GROOTHOEK

0628

23 MARCH 2022

PRINCIPAL OF THE SCHOOL
MATLADI PROJECT SCHOOL
PRIVATE BAG X488
GROOTHOEK
0628

Dear sir/Madam

**Request for permission to conduct research**

1. The matter above bear's reference.

2. I am a Science Education, Master’s student at the University of Limpopo. As part of the requirements for the fulfilment of the degree I need to conduct a research and produce a thesis.
3. This letter serves to request for permission to conduct research at **one of the secondary schools in Moletlane** Circuit of the **Capricorn South Education District**.
4. The topic of the proposed research is **“Exploring the affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners' understanding of Genetics”**. Participant will be grade 12 Life Sciences learners. My research process will not affect the day-to-day academic activities of the school. All the relevant research ethics will be adhered to.
5. I will be glad if the department can grant me the permission to conduct this research.

**Yours in Education**

**M.N Matlala**

**ANNEXURE E: Participants Consent Form**

Dear participant

My name is **Mpho Nobert Matlala**, student number **201403109** and am currently studying towards a Master’s in science education. As a part of my study, I am required to carry out research titled: **Exploring the affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners' understanding of Genetics.** The purpose of this study is to explore the affordances and constraints of enhancing Life Sciences Grade 12 learners' understanding of Genetics using Blended learning.

I would appreciate it if you would allow me to spend little of your time with you for observations, interviews and written activities. Please bear in mind that this is an academic endeavour, anonymity will be compulsory, and the data collected will be used only for research purposes, and all responses are confidential and will be treated as such.

As a participant selected and agreed to partake in the study you will then be observed, interviewed, and be given activities to write in your class for three lessons.

ARE THERE ANY CONDITIONS THAT MAY EXCLUDE YOU FROM PARTICIPATING IN THE STUDY?

- ❖ You must be a learner in grade 12 registered for Life Sciences in Secondary School in Moletlane circuit.
- ❖ You may be below or over 18 years old to participate in this research.

WHAT WILL BE REQUIRED OF YOU IN THE STUDY?

Should you decide to partake in the study, you should expect the following:

- ❖ To sign the consent form
- ❖ To be observed for three lessons by the researcher during the lesson.
- ❖ To be interviewed by the researcher during the lesson presentations.
- ❖ To write the activities during the 3 lessons presented

WHAT ARE THE POSSIBLE BENEFITS THAT MAY ARISE FROM THE STUDY?

The benefits of participating in the study are as follows:

- ❖ The research will help improve your conceptual understanding of Genetics.

WILL YOU RECEIVE ANY FINANCIAL COMPENSATION OR PAYMENTS FOR PARTICIPATING IN THE STUDY?

Please be informed and note that you will not receive any form of payment for taking part in the study.

WHAT ARE YOUR RIGHTS AS A PARTICIPANT IN THE STUDY?

You have the right to withdraw from participating in this study at any given time as your participation is voluntary. Should you wish to withdraw you will not be penalised or have any future disadvantages. You do not have to provide a reason for your decision to withdraw from participating in the study. You may also be excused from participation if you do not comply with the researcher's requirements as this may temper with the authenticity of the outcomes of the study.

HOW WILL CONFIDENTIALITY AND ANONYMITY BE ENSURED IN THE STUDY?

Confidentiality of the data will be kept, and your identity will only be known to the researcher. Your identity will not be revealed during or after the study even when the study is published.

**Consent Form**

I ______________________________ agree to participate in the research study named: **The affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners' understanding of Genetics.**

The temperament and rationale of the study has been explained to me in writing and I am therefore participating voluntarily.

I give permission for my participation, observation, and interview with **(Mr. M.N Matlala)** ___________________

I understand that no financial compensation will be made for participating in the study.

I understand that I can withdraw from the above stated research study, without any penalties, at any time, either before it commences or while I am participating.

I understand and accept all my rights as a participant.

I understand that anonymity will be ensured in the write-up by disguising my identity.

Signed: __________________________ Date: ___________________

## ANNEXURE F: Informed Consent Document

Email: 201403109@keyaka.ul.ac.za

Cell: 071 892 4583.

P.O BOX 346

GROOTHOEK

0628

23 MARCH 2022

**INFORMED CONSENT DOCUMENT TO CONDUCT CLASSROOM OBSERVATIONS OF LIFE SCIENCES LEARNER'S, WHILST BEING TAUGHT**

## THROUGH THE USE OF BLENDED LEARNING APPROACH, CHILD IS ATTENDING THE LESSON

**TITLE OF THE RESEARCH STUDY: Exploring the affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners' understanding of Genetics**


**SUPERVISOR:** Mr K.J Chuene
**CO-SUPERVISOR:** Dr. T.G Maluleke
**ADDRESS:** Turfloop Campus
**CONTACT NUMBER:** 015 268 3888

**POST GRADUATE STUDENT:** Mpho Nobert Matlala
**ADDRESS:** P.O. Box 346
Groothoek
0628
**CONTACT NUMBER:** 201403109@keyaka.ul.ac.za or Tel: 071 8924 583


Please take some time to read the information presented here, which will explain the details of this study. Please ask the researcher or person explaining the research to you any questions about any part of this study that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research is about.

This study has been approved by the **University of Limpopo, Turfloop Research Ethics committee** and will be conducted according to the ethical guidelines and principles of Ethics and other international ethical guidelines applicable to this study. It might be necessary for the research ethics committee members or other relevant people to inspect the research records.

**What is this research study all about?**

This research study is designed to help Life Sciences Grade 12 learners. This study explores the influence of blended learning intervention on teaching Genetics in Grade 12 classroom. This study will be conducted by Mr Mpho Nobert Matlala who is a Masters student at the University of Limpopo, Turfloop Campus and is supervised by experienced researchers trained in the field of

Life Sciences education. This study will be conducted in school situated in Zebediela and Moletlane circuits.

**How does this study effect your child?**

Your child's school as a learner have been selected to take part in the study. The focus of the research is on your child as Life Sciences learner. Because your child takes Life Sciences as a school subject and will be present in the class when the researcher conducts lessons using blended learning approach and will be observed by the researcher, we need your permission that your child may be present during lesson observation. Thus, your child will be a participant in the study. I will not have any personal contact with your child whatsoever, and your child will be expected to participate during the lesson observation, as my focus as a researcher will be solely on the Life Sciences learners.

What will be expected of your child?

The lesson observation will only focus on your child as a learner. As such, your child will be expected to participate and being a learner and behaving in the same way he/she would normally behave during a Life Sciences lesson. The only difference is that the researcher will interact and observe with your child in the classroom during the lesson.

**Will your child gain anything from taking part in this research?**

There are direct gains for your child, however the findings of the study may promote and improve his/her conceptual understanding of genetics.

**Are there any risks involved for your child by being present in the classroom when his/her teacher's lessons are observed?**

Your child's presence in the classroom during the lesson observations does not pose a foreseeable risk to your child or his/her classmates.

**How will we protect your child's identity?**

As previously stated, the focus of this research falls on your child as a Life Sciences learner. There will be communication taking place between the researcher and your child and **no video recordings will be made** during the lesson observations. The researcher will have access to your child's written schoolwork and assessments will be conducted by the researcher with your child. Your child's identity will not be revealed in any way by the research, and the name of the school that your child attends, nor will the name of his /her Life Sciences teacher be revealed in the research report.

**What will happen with the findings?**

The findings of the research will primarily be used for obtaining a Master degree in Sciences Education.

**Will you or your child be paid to take part in this study and are there any costs for you or your child?**

The observations of learners' Life Sciences lessons will take place during school hours as scheduled on the school's timetable.  Consequently, you and your child will not be paid as there are no costs involved for you or your child.

**Is there anything else that you should know or do?**

Kindly feel free to contact any one of the researchers involved in the research should you have any questions, or if you encounter any difficulties understanding this letter or need more information concerning the research. We will be happy to answer your questions. You are also welcome to contact the principal of the school, who is fully aware of this research.

- You can contact Mr K.J Chuene at 015 268 3888 or Karabo.chuene@ul.ac.za if you have any further questions or have any problems.
- You can contact Mpho Nobert Matlala at 071 892 4583 or via email at 201403109@keyaka.ul.ac.za if you have any further questions or have any problems.
- You can also contact the University of Limpopo, School of Education, on 015 268 3138 if you have any concerns that were not answered about the research or if you have complaints about the research.

Kindly specify/indicate on the next page whether you give your permission to be present in the classroom when the researcher conducts observations of your learners' Life Sciences lessons.

Yours sincerely

Mr M.N Matlala

Principal Investigator

**Declaration by the parent/guardian**

Hereby I (*name and surname)* ……………………………...………… give my permission that my child may be present when the researcher, Mpho Nobert Matlala, conducts observations of his/her Life Sciences lessons, in the research study titled: The affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners understanding of Genetics.

Signed at (*place*) .....................…........…………… on (*date*) …………...……… 20....

| | |
|---|---|
| ............................................................. | .......................................................... |
| **Signature of parent/guardian** | **Signature of witness** |

**Declaration by person obtaining consent**

I *(name)* …………………………………………….……… declare that:

- I clearly and in detail explained the information in this document to

  ………………………………………………….

- I did/did not use an interpreter.
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above

- I gave him/her time to discuss it with others if he/she wished to do so.

Signed at (*place*) .....................….......……………. on (*date*) …………....………20....

...............................................................

Signature of person obtaining consent

**Declaration by researcher**

**I Mpho Nobert Matlala** ……………………………………………….……… declare that:

- I explained the information in this document to ………………………………. **or** I had it explained by …………………………………… who I trained for this purpose.
- I did/did not use an interpreter
- I encouraged him/her to ask questions and took adequate time to answer them

  or I was available should he/she want to ask any further questions.
- The informed consent was obtained by an independent person.
- I am satisfied that he/she adequately understands all aspects of the research, as described above.
- I am satisfied that he/she had time to discuss it with others if he/she wished to do so.

Signed at (*place*) .....................….......…………… on (*date*) …………....………. 20....

...............................................................

**Signature of researcher**

**ANNEXURE G: Assent Form**

Dear participant

My name is Mpho Nobert Matlala, student number 201403109 and am currently studying towards a Master’s in science education. As a part of my study, I am required to carry out research titled: **The affordances and constraints of blended learning on enhancing Life Sciences Grade 12 learners' understanding of Genetics.** The purpose of this study is to explore the affordances and constraints of enhancing Life Sciences Grade 12 learners' understanding of Genetics using Blended learning.

I am requesting you to be in a research study. Research is a way to test new ideas. Research helps us learn new things. Whether or not to be in this research is your choice. You can say Yes or No. Whatever you decide is OK.

**Why are you requested to be in this research study?**

You are being requested to be in the study because you are in a grade 12 Life Sciences class.

**What is the study about?**

The researcher seeks to explore the affordances and constraints of enhancing Life Sciences Grade 12 learners' understanding of Genetics using Blended learning.

**What will happen during this study?**

If you agree to be in this study, you will have to be observed, interviewed, and write some activities during lessons presented.

**Are there any conditions that may exclude you from participating in the study?**

- ❖ You must be a learner in grade 12 registered for Life Sciences in Secondary School in Moletlane circuit.
- ❖ You must be below 18 years old to participate in this research.

**What will be required of you in the study?**

Should you decide to partake in the study, you should expect the following:

- ❖ To sign the assent form
- ❖ Your parent/ guardian should give consent
- ❖ To be observed for three lessons by the researcher during the lesson participation.
- ❖ To be interviewed by the researcher during the lesson participation.
- ❖ To write the activities during the 3 lessons participation.

**What are the possible benefits that may arise from the study?**

The benefits of participating in the study are as follows:

- ❖ The research will help improve your conceptual understanding of Genetics.

**Will you receive any financial compensation or payments for participating in the study?**

Please be informed and note that you will not receive any form of payment for taking part in the study.

**What are your rights as a participant in the study?**

You have the right to withdraw from participating in this study at any given time as your participation is voluntary. Should you wish to withdraw you will not be penalised or have any future disadvantages. You do not have to provide a reason for your decision to withdraw from participating in the study. You may also be excused from participation if you do not comply with the researcher's requirements as this may temper with the authenticity of the outcomes of the study.

**How will confidentiality and anonymity be ensured in the study?**

Confidentiality of the data will be kept, and your identity will only be known to the researcher. Your identity will not be revealed during or after the study even when the study is published.

**Signatures**

Before deciding if you want to be in the study, ask any questions you have. You can also ask questions during the time you are in the study.

If you sign your name below, it means that you agree to take part in this research study.

Your Name (Printed) ___________________________________

Age_______________________________________________

Your signature_________________________________________

Date_________________________________________________

Signature of Person Obtaining Consent____________________

Date_________________________________________________

Signature of Witness_____________________________________

Date_________________________________________________

## ANNEXURE I: Ethical Clearance

**University of Limpopo**
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 3935, Fax: (015) 268 2306, Email: anastasia.ngobe@ul.ac.za

**TURFLOOP RESEARCH ETHICS COMMITTEE**

**ETHICS CLEARANCE CERTIFICATE**

**MEETING:** 27 June 2022

**PROJECT NUMBER:** TREC/151/2022: PG

**PROJECT:**

| | |
|---|---|
| **Title:** | The Affordances and Constrains of Blended Learning on Enhancing Life Sciences Grade 12 Learners Understanding of Genetics. |
| **Researcher:** | MN Matlala |
| **Supervisor:** | Mr KJ Chuene |
| **Co-Supervisor/s:** | Dr TG Maluleke |
| **School:** | Education |
| **Degree:** | Master of Education in Science Education |

**PROF D MAPOSA**
**CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE**

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

**Note:**

i) **This Ethics Clearance Certificate will be valid for one (1) year, as from the abovementioned date. Application for annual renewal (or annual review) need to be received by TREC one month before lapse of this period.**

ii) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee, together with the Application for Amendment form.**

iii) **PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.**

Finding solutions for Africa

# ANNEXURE J: Permission to Conduct Research in Limpopo (DoE)

**LIMPOPO**
**PROVINCIAL GOVERNMENT**
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
**EDUCATION**

CONFIDENTIAL

Ref: 2/2/2 Enq: Makola MC Tel No: 015 290 9448 E-mail:MakolaMC@edu.limpopo.gov.za

**Matlala nm**
P O Box 346
GROOTHOEK
0628

**RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH**

1. The above bears reference.
2. The Department wishes to inform you that your request to conduct research has been approved. Topic of the research proposal: **"EXPLORING AFFORDANCES AND CONSTRAINTS OF BLENDED LEARNING ON ENHENCING LIFE SCIENCE GRADE 12 LEARNER UNDERSTANDING OF GENETICS "**
3. The following conditions should be considered:

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

3.2 Arrangements should be made with the Circuit Office and the School concerned.

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

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

3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected).

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

REQUEST FOR PERMISSION TO CONDUCT RESEARCH : MATLALA NM Page 1

**Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700**
**Tel:015 290 7600/ 7702 Fax 086 218 0560**

4 Furthermore, you are expected to produce this letter at Schools/ Offices where you intend conducting your research as an evidence that you are permitted to conduct the research.

5 The department appreciates the contribution that you wish to make and wishes you success in your investigation.

Best wishes.

Mashaba KM
**DDG: CORPORATE SERVICES**

19/07/2022
**Date**



Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel:015 290 7600/ 7702 Fax 086 218 0560

**ANNEXURE K: Activities**

**DAY 1**

| | |
|---|---|
| **RESEARCHER**: Matlala M. N | **RESOURCES**: Projector, Laptop, Study Guides, White Board Markers, CAPS Document, Past papers & Journal |
| DATE: | TOPIC: Genetics (**Monohybrid Cross**) |

ACTIVITY OBJECTIVES: learners should be able to: **Diagrammatically present Monohybrid Crosses**

LESSON PRESENTATION: **lesson will be presented with the blend of traditional teaching approach and ICT which is the use of laptop and projector for animation**.

ASSESSMENT:

2.1.

In humans, being a tongue roller (R) is dominant over non-roller (r).  A man who is a non-roller marries a woman who is heterozygous for tongue rolling.

Father's phenotype ________ Mother's phenotype ________

Father's genotype ________

Mother’s genotype ________

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What is the probability of this couple having a child who is a tongue roller? _____________

2.2 In rabbits the dominant allele (**B**) produces black fur and the recessive allele (**b**) produces white fur. Study the genotypes of four rabbits.

| **Rabbit** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Genotype** | BB | Bb | Bb | bb |

2.2.1 Give the phenotypes of:

(a) Rabbit **2** (1)

(b) Rabbit **4** (1)

2.2.2 State the genotypic ratio that is shown in the table above. (2)

2.2.3 If rabbits **1** and **4** were mated together and had 12 offspring, how many of these would you expect to be black? (1)

2.2.4 Rabbit **3** was allowed to breed with rabbit **4**. Use a genetic cross to show the possible phenotypes and genotypes of the F1 generation for fur colour. (6)

**Day 2**

The diagram below shows a crossing between a homozygous black mouse and a homozygous white mouse.  Use relevant symbols for the alleles of fur colour and show diagrammatically a genetic cross between mouse 1 and mouse 2 to show the possible genotypes and phenotypes of the first filial generation (F1). Name and describe the type of dominance shown (if any).

X

**MOUSE 1** **MOUSE 2**

**Question 1**: Use a genetic cross to show the possible phenotypes and genotypes of the F1 generation for fur colour when mouse 1 is dominant over mouse 2   (6)

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**Question 2**: Use a genetic cross to show the possible phenotypes and genotypes of the F1 generation for fur colour when mouse 2 is dominant over mouse 1
(6)

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**Question 3**: Use a genetic cross to show the possible phenotypes and genotypes of the F1 generation for fur colour when neither mouse 1 nor mouse 2 is dominant over the other. (6)

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**Question 4** : Use a genetic cross to show the possible phenotypes and genotypes of the F1 generation for fur colour when both mouse 1 and mouse 2 are dominant
(6)

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**DAY 3**

3.1 In mice, the allele for red fur colour (R) is dominant over the allele for grey fur colour (r). It also happens that all embryos, which are homozygous for the dominant factor, will always die before birth. If a colony of heterozygous mice were inbred to produce 300 young living mice, how many of these offspring would be likely to have red fur and how many will have grey fur? Use a genetic diagram to show how you arrived at your answer. (7)

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3.2 Hornless (H) in cattle is dominant over horned (h). A homozygous hornless bull is mated with a homozygous horned cow. What will be the genotype and phenotype of the first generation? Show your work (6)

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