THE RELATIONSHIP BETWEEN POOR MATHEMATICAL SKILLS AND GRADE 10 LEARNERS' PERFORMANCE IN CERTAIN CONCEPTS IN LIFE SCIENCES – A CASE STUDY OF MICROSCOPE USAGE AND GRAPHING SKILLS IN LEJWELEPUTSWA DISTRICT IN THE FREE STATE PROVINCE

By

MANDY DE VRIES

Submitted in accordance with the requirements for

the degree of

MASTER OF SCIENCE

in

LIFE SCIENCE EDUCATION

at the

University of South Africa

Supervisor: Prof. Harrison I. Atagana

28 October 2020

Contents

Abstract

Current literature on the integration of mathematical skills in Life Sciences states that integration levels are poor and sub-standard. Mathematics is often taught discretely and without global applications, leaving learners with the inability to answer questions in Life Sciences that depend on basic mathematical competencies. The aim of this research study was to investigate whether or not the performance of Grade 10 pupils in Life Sciences is negatively affected by poor basic mathematical skills. Topics within the field of Life Sciences, such as microscopy and cellular biology, were selected as key focus areas for this study, because in these topics learners are expected to aptly apply skills of measurement, calculation and graphing.

Grade 10 Life Sciences requires the application of basic mathematical skills in most topics. A quantitative approach was used to collect numerical data in order to establish if there was a connection between weak mathematical skills at the end of Grade 9 and poor performance in Grade 10 Life Sciences in data analysis problems that require application of these mathematical skills. The data was statistically analysed using SAS (Statistical Analysis System) with the Shapiro-Wilk test. The aim of the data analysis was to obtain p values, as well as the Pearson Correlation Coefficient with the use of quantitative models. The scores that were retrieved for theoretical knowledge compared to questions requiring mathematical skills, showed a significant mean difference in the scores ($p < 0.0001$). When correlating the Grade 9 Mathematics final score with the scores of the questions in two tests requiring mathematical skills, the Pearson Correlation Coefficient was 0.61200, and 0.56406 respectively. The findings in this study suggest that there is a possibility that the marks obtained in Life Sciences by Grade 10 learners could increase substantially if they possess basic arithmetic abilities to successfully complete questions that also include the capacity to portray core math skills. Such issues reflect as much as 40% of the overall Life Sciences mark. It is expected that the findings of this research study will aid in an increased incorporation of mathematical skills into Life Sciences. A systematic approach to the teaching of mathematical skills in order that these skills may be integrated and applied to Life Sciences questions and topics is recommended.

Operational description of key terms and abbreviations

Below are the terminologies and concepts used in this research study.

ACER

This is a recognised international developer of educational assessment and reporting tools for schools and systems (ACER, 2019).

ANA

This acronym stands for the Annual National Assessment and it is carried out by the Department of Basic Education as a benchmarking tool for assessing basic academic levels.

CAPS

Curriculum and Assessment Policy Statement document as issued by the Department of Basic Education in South Africa.

This document represents a policy statement for learning and teaching in South Africa and comprises the Curriculum and Assessment Policy Statements for each approved school subject, policy relating to promotion requirements and protocol for assessment. The document ensures that education is standardised across grades and subjects.

Benchmarking

Benchmarking refers to evaluation by comparison with a standard. This standard is determined by various assessment bodies according to the CAPS.

FET

This acronym stands for the Further Education and Training Phase (Grades 10 – 12) as described by the Department of Basic Education in South Africa (Education, National Curriculum Statement (NCS) Further Education and Training (FET) phase Grade 10 - 12 Life Sciences, 2011).

Graphing skills

This skill-set involves the use of written information or a given set of data to create graphs such as bar graphs, line graphs, pie charts, and scatter plots. This skill also enables a learner to choose between different scales, adjust graphs to fit the data and to use graphs to determine relationships between variables.

IEB

Independent Examinations Board of South Africa

Mathematical skills

These are the skills that are required in order to use the science of mathematics to successfully manage scales, averages, percentages, conversions and translate tabulated data to a graphic form or vice versa.

Microscope usage

Microscopic usage involves the concepts of magnification, scale, conversion and relative size when using microscopes, and in the application of cellular biology.

Performance

The ability to competently manage, apply and understand microscope usage, and graphing skills in a Grade 10 Life Sciences context. In addition, performance also includes successfully answering questions that are related to these skills.

Senior Phase

The senior phase of a learner's education refers to the phase that includes Grades 7 to 9.

SAS

This stands for the Statistical Analysis System and it is a computer package that is used in order to analyse data statistically.

SPSS

The Statistical Package for the Social Sciences is a computer package programme that allows researchers to analyse data statistically.

Umalusi

This is the Council for Quality Assurance in General and Further Education and Training, and advanced education; in addition to the training curriculum of the National Qualifications Framework (NQF) (South African Government, 2013).

ACKNOWLEDGEMENTS

I will like to acknowledge the assistance and goodwill of the following people in this endeavour, which includes my family for their patience and support over the last few years, and St Dominic’s College Welkom staff and pupils for their support, as well as their permission to conduct this research study. Furthermore, I would also like to thank Dr Rodney Jacobs for his guidance and advice, and lastly, to Professor H.I. Atagana from UNISA for his professionalism, guidance and encouragement during the course of this research study.

CHAPTER 1 – INTRODUCTION

This research study is based on the researcher determining if there is a relationship between poor mathematical skills at the end of Grade 9 and poor academic performance in Grade 10 Life Sciences in topics where mathematical skills are required. The focus of this study is specifically in the Life Sciences topics of microscopy and areas where graphing skills are required.

1.1. Background of the study

Life Sciences pupils in Grade 10 are expected to apply mathematical skills in the interpretation of experimental data or findings that are obtained during practical investigations. The researcher noted that Grade 10 learners struggle to apply basic mathematical skills and concepts into the four basic knowledge strands as set out in the National Curriculum Statement (NCS) for Advanced Education and Training (FET) process of the Department of Basic Education (Education D. o., 2011). The researcher noted that weak mathematical skills prevented learners from achieving the clear objectives of the Life Sciences curriculum as defined in the NCS document (Education, National Curriculum Statement (NCS) Further Education and Training (FET) phase Grade 10 - 12 Life Sciences, 2011) which therefore effectively results in poor performances in Life Sciences assessments. Mathematical skills are needed in several aspects of Grade 10 Life Sciences and particularly in the areas of microscope use and graphing of information, which formed the basis for this case study. Hence, in light of the information discussed, this research study seeks to show that poor mathematical skills among Grade 10 Life Sciences pupils may have a negative impact on academic performance in the fields of microscopic and graphics skills; as these skills involve the direct use of some basic mathematical skills.

In addition, this study hopes to identify and propose strategies to develop the mathematical skills needed by Grade 10 Life Sciences learners in order to improve their academic performance in Life Sciences. In a study conducted by Tariq (2004) on the decline of mathematical competencies in Life Sciences students, it was found that undergraduate students are less competent in basic mathematical skills than they had been in previous years. Hester (2014: 54) conducted a similar study and found that the application of mathematical skills is necessary for students, in order for them to skilfully apply quantitative knowledge to biological problems. Continuing in the same vein, Dornette (2018) stated that Mathematics is an important part of Science, and many students do not possess the necessary basic mathematical skills that are required in the field of science.

1.2. Statement of the Problem

Within the academic and teaching sphere, there is much concern for learners who do not have the prerequisite Mathematics abilities or knowledge required at the end of a Grade 9 academic year. The CAPS document states that pupils should be able to record information, measure and interpret as follows : "*Record information or data: This should include recording observations or information as drawings, descriptions, in simple table format, as simple graphs, etc. The skill of 'recording' is transferable across a range of different scientific activities. Measure : Learners should know what to measure, how to measure it and have a sense of the degree of accuracy that is required. A variety of things could be measured including (but not limited to) length, volume, temperature, weight or mass and numbers (counting). Measuring is a way of quantifying observations and in this process learners should learn to make estimations. Interpret: Learners should be able to convert information from one form, in which it was recorded, into another, for instance converting a table into an appropriate graph. Learners should be able to perform appropriate simple calculations, to analyse and extract information from tables and graphs, apply knowledge of theory to practical situations, recognise patterns and/or trends, appreciate the limitations of experimental procedures as well as make deductions based on evidence."* (Education D. o., 2011).

This concern exists, because the Grade 10 Life Sciences curriculum requires that this prerequisite be necessary in order for learners to critically deal with data and problems which require basic mathematical skills as quoted from the CAPS document. The researcher suggests that an instructional approach to integrate learning in Mathematics and Life Sciences could possibly improve the academic performance of learners in Life Sciences, since the Grade 10 Life Sciences learners involved in this study struggle with the application of quantitative graphing skills, estimating the relative size of objects, and scaling with specific reference to biology. The data available from the final Grade 9 end of year school mathematics learner achievement tests were used to indicate mathematical skills of the Grade 10 Life Sciences learners by subjecting the data to correlational analysis. The scores that were retrieved for theoretical knowledge were compared to questions requiring mathematical skills.

1.3. Purpose of the study

The purpose of this research study is to determine the mathematical skills, specifically in the areas of microscope use and graphing, of Grade 10 Life Sciences learners using their Grade 9 end-of-year mathematical results as a reference. In addition, this study aims to determine whether or not this has an impact on poor learner performance in Grade 10 Life Sciences in the areas of microscope use and graphing skills. By adopting a constructivist research approach that considers the connection between the acquisition of knowledge related to situated learning and instruction, the skills and knowledge of Grade 10 pupils in the field of microscopy and graphing skills, with reference to Life Sciences, will also be examined. The study further aims to identify that performance in Life Sciences amongst Grade 10 learners can be improved by improved learners' competencies in basic Mathematics and also by integrating Mathematics into the Life Sciences curriculum. Indeed, it is important for the purposes of this study, to recognise that the performance in Life Sciences among Grade 10 learners may be improved by implementing integration methods between Mathematics and Life Sciences.

Therefore, with regards to the case study in this research, it will be used as a point of reference and is intended to demonstrate that Grade 10 Life Sciences learners at the Welkom co-educational school in the Free State Province of South Africa, have weak mathematical skills that hinder their performance in certain aspects of Life Sciences; more particularly in problems relating to the use of microscopes and relative size as well as graphing techniques.

Measuring tools for testing learning outcomes in the use of microscopes and relative size as well as graphing skills were used to collect quantitative data. Microscopy skills were tested using basic scale and magnification measurements. The skills in graphing were assessed by means of questions which required learners to plot graphs from provided data tables and the use the correct scales on the axes as well as questions which related to the interpretation of graphs that had relation to aspects of the grade 10 Life Sciences curriculum.

1.4. Research Questions

In order to adequately address the problem stated in this study, the following research questions and their respective sub-questions will aid in this regard.

Question 1: What are the consequences of poor mathematical skills on the performance of Grade 10 Life Sciences learners at a co-educational school in Welkom, Free State Province, with specific emphasis on problems related to the use of microscopes and determining relative size, and graphing skills?

Question 2: Are learners able to utilise mathematical skills taught in Grade 9, such as size, relation, proportions and mapping, and the reading of graphs and apply the skills in Grade 10 Life Sciences in the fields of microscope use to determine relative sizes and graphing?

Question 3: What is the relationship between the mathematical knowledge of Grade 10 students in matters of scale, ratio, percentage and graphing, and their success in answering Life Sciences questions based on the application of their skills, in microscope use and graphing problems?

In addition to the main research questions, the following sub-questions are presented below to further aid in the investigation.

Sub-question 1.1 : How does the application of Mathematics skills influence the performance of Grade 10 Life Sciences learners in the field of problems related to microscope use regarding relative size and in graphing skills?

Sub-question 2.1.: To what degree did Grade 10 Life Sciences learners acquire the cognitive abilities of understanding magnitude, proportion, ratio and projecting, interpreting of graphs, and the necessary magnification use, and graphing skills that were taught in Grade 9?

Sub-question 2.2.: With regards to microscope and graphing, how well can learners incorporate their Mathematics abilities into problems that involve size, measuring, ratio, and the mapping, and analysis of graphs into Grade 10 Life Sciences problems?

1.5. Statement of Hypothesis

Poor academic performance in mathematical skills among Grade 10 Life Sciences learners throughout the selected study group, has a negative effect on the academic achievement in Life Sciences with particular reference to areas concerning microscope use in order to determine relative size as well as in graphing skills.

1.6. Research Objective

It must be noted that the focus of this research study is not to identify the possible reasons behind the poor mathematical skills that Grade 10 pupils possess, but rather its intention is to highlight that the Grade 10 Life Sciences performance in assessments which contain mathematical based questions, may be negatively affected by poor mathematical skills, specifically in the fields of microscope usage and determining relative size as well as graphing. Therefore, one of the goals of this study is to establish if the theory is correct and to recommend strategies to improve the mathematical skills of grade 9 learners at the particular school where the case study is undertaken. Furthermore, with further research being possibly conducted in many other high schools in the country, another goal would be to discuss the application of Mathematics skills in Life Sciences in order to maximise the performance results of Life Sciences learners.

Figure 1 shows the links between the research objectives and the research questions

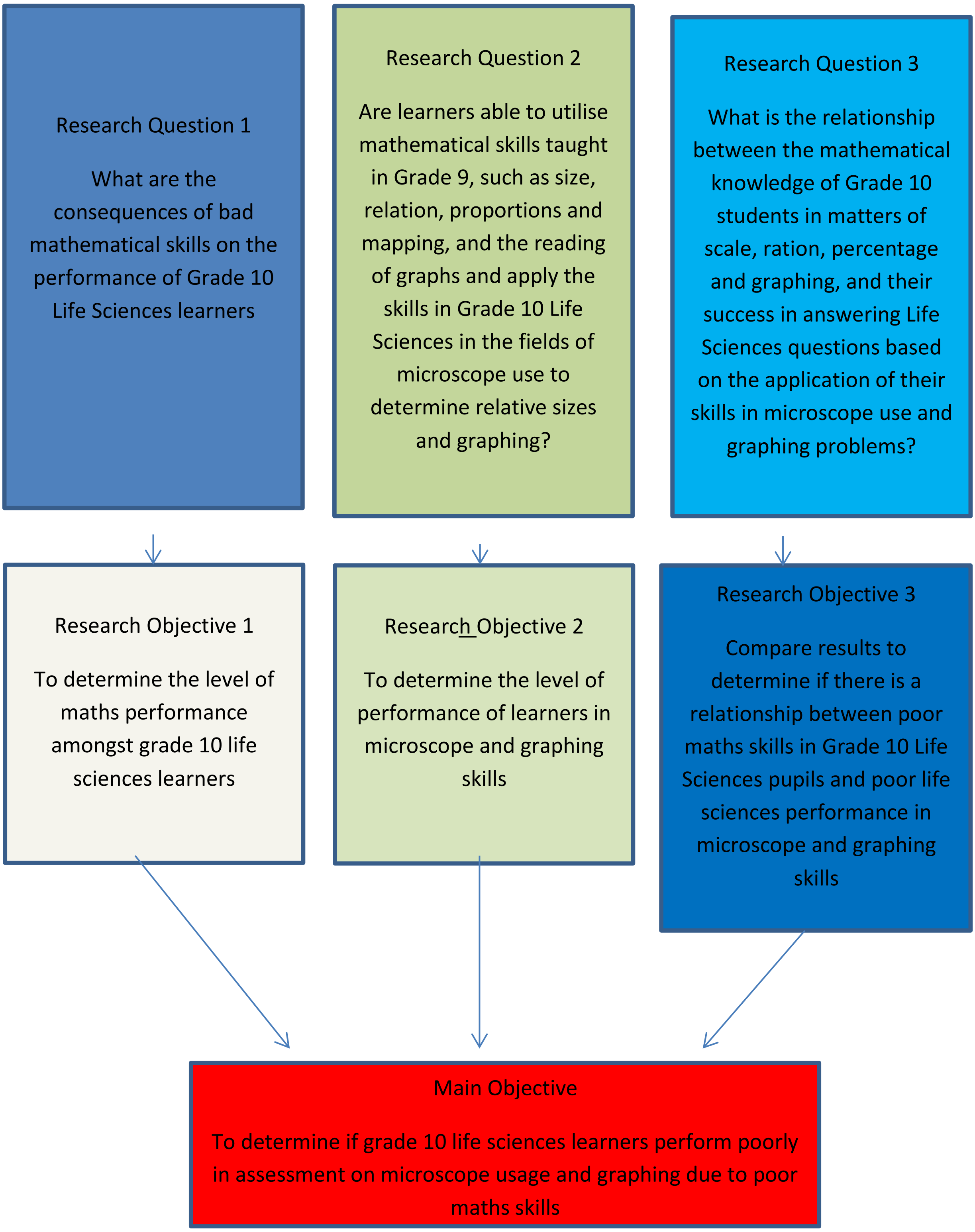


Figure 1: The correllation between research objectives and the research questions

1.6.1 Assumptions

The following assumptions that are made in this study include:

- All Grade 10 Life Sciences learners were given equal opportunities to exercise the skills needed in the field of Life Sciences concerning the use of microscopes or graphics skills.
- All Grade 10 Life Sciences learners have been subjected to the same teaching methods, lessons and exercises.
- The Life Sciences segment of the Grade 7 to Grade 9 General Education and Training (GET) phase, which serves as a fundamental basis for the FET phase of Life Sciences, was completed and passed by all Grade 10 Life Sciences learners.

The mathematical section of the Grade 7 to 9 General Education and Training (GET) stage, which is the actual basis for the FET stage in other subjects, was completed by all Grade 10 Life Sciences learners. Regarding English instruction, the Grade 10 Life Sciences learners were articulate and fluent, and there were no apparent linguistic obstacles to learning the material in Life Sciences or Mathematics.

1.7. Significance of the study

The significant details that will be produced by this study may be able to determine if mathematical skills are integral in the FET phase of the Life Sciences curriculum (Education D. o., 2011). This research study also desires to foster a convergence between the learning fields of Mathematics and Life Sciences in order to enable learners to obtain better results in the FET process of Life Sciences evaluations. It is expected that if Life Sciences learners have the required mathematical skills needed to meet the clear objectives of the FET phase curriculum (Education, National Curriculum Statement (NCS) Further Education and Training (FET) phase Grade 10 - 12 Life Sciences, 2011), then their test scores in Life Sciences may improve. If the research model is proved to be correct, this research hopes to create an independent aspect of Mathematics that can be incorporated into the curriculum of Grade 10 Life Sciences, that could ensure that learners are fully equipped with the necessary mathematical skills required to achieve the goals of the Life Sciences curriculum's FET phase.

1.8. Scope of the Study

1.8.1. Boundaries

The delimitations for this study will be highlighted and discussed in this sub-section. One of the delimitations for this study includes the skills in microscope use relating to relative size, and graphing as the fields of Life Sciences to be studied. The criteria of the FET document defines certain goals in Life Sciences to be met in Grade 10. As discussed in the review of the literature in Chapter Two, the document highlights the following areas: record details or information, measurement of, and the interpretation of data. (Education, National Curriculum Statement (NCS) Further Education and Training (FET) phase Grade 10 - 12 Life Sciences, 2011).

With regards to the second delimitation, it is noted that regardless of understanding the critical components of Life Sciences that are associated with microscope work and graphing, Grade 10 learners mathematical skills are low in important aspects of measurement, conversion and graphing. Moreover, they are often unable to satisfy the above goals, therefore microscope work and graphing were chosen to be two key areas on which to concentrate. According to van Staden (2017) and MacMillan (2018), a deficiency in one field of mathematics typically creates additional problems of learning, and that a proper knowledge of numbers is essential to any part of education as it is important to incorporate all components.

The third delimitation involves the relevant case study that was chosen due to the amiable interaction between the researcher and the community. In relation to the achievement of learners in Life Sciences regarding areas in microscope use and graphing, numerical skills and knowledge was considered. These variables will be used to investigate the relationship between mathematical skills and successful application in these fields. The group of learners in this case study was chosen with the expectation that if poor mathematical skills of Grade 10 Life Sciences learners was remediated and gradually integrated into Life Sciences teaching and assessments, then their results in Life Sciences would improve. The case analysis was conducted using a constructivist epistemology and also positivism, in order to utilise the quantitative data and grades to illustrate whether or not there is a correlation between weak mathematical abilities and the ability to fulfill the goals of the Life Sciences course in the fields of microscope use, and graphing abilities. In order to decide whether there is a relationship between both mathematical output and Life Science skills, and knowledge in microscope skills, and graphing which involve maths abilities, numerical values have been used to evaluate the Pearson Correlation coefficient.

1.9. Conclusion

This research study involves a small group case study to determine if a relationship exists between poor mathematical skills at the end of Grade 9 and poor academic performance in Life Sciences in Grade 10. The focus of this study are the areas of microscopy and graphing skills, both of which require basic mathematical skills in order to compute relative sizes and in order to construct a range of graphs using data provided in tables or case study information. The researcher has identified that the Grade 10 learners struggle to integrate mathematical knowledge into the field of Life Sciences.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The research problem of determining the relationship between poor mathematical skills amongst learners of Grade 10 Life Sciences and the impact that this has on the successful application of skills in Life Sciences, especially in the fields of microscope usage and graphs, was highlighted at the beginning of this research study. This literature review will analyse and discuss which mathematical skills and knowledge are needed in Life Sciences at Grade 10 level, as well as which capabilities should be obtained in Mathematics at Grade 9 level for application in Life Sciences. Literature, as well as the findings on further research that links Mathematics and Life Sciences, and other sciences, will also be explored to inform the relationship between mathematical skills and Life Sciences performance. Any discussions that may shed light on possible solutions to the lack of integration of Mathematics skills into Life Sciences will be reviewed, including which possible strategies may be required to improve integration. In addition, certain problems associated with implementing an integrated curriculum approach will be discussed in this chapter.

2.2. Literature review

2.2.1. The identification of mathematical skills acquired by the end of Grade 9

Research has been done on mathematical achievements amongst Grade 9 learners in South Africa (Makhubele, 2019). This research highlighted factors associated with the problems of learners' poor performance in Grade 9 mathematics particularly in the Annual National Assessments (ANA). The findings of this research are important for this study, as they are based on mathematical skills that should be acquired in Grade 9 in accordance with the Curriculum and Assessment Policy Statement (CAPS) for the senior phase (Grades 7 – 9) (Education, Curriculum Assessment Policy statement (CAPS) Grade 7 - 9

Mathematics, 2011). The mathematical skills mentioned thus far that should be acquired by the end of Grade 9, are listed in the CAPS document as follows:

2.2.1.1 Record information or data

This should include recording observations or information as drawings, descriptions, in simple table format, as simple graphs, etc. The skill of 'recording' is transferable across a range of different scientific activities.

2.2.1.2 Measure

Learners should know what to measure, how to measure it and have a sense of the degree of accuracy that is required. A variety of things could be measured including (but not limited to) length, volume, temperature, weight or mass and numbers (counting). Measuring is a way of quantifying observations and in this process learners should learn to make estimations.

2.2.1.3 Interpret

Learners should be able to convert information from one form, in which it was recorded, into another, for instance converting a table into an appropriate graph. Learners should be able to perform appropriate simple calculations, to analyse and extract information from tables and graphs, apply knowledge of theory to practical situations, recognise patterns and/or trends, appreciate the limitations of experimental procedures as well as make deductions based on evidence." (Education, National Curriculum Statement (NCS) Further Education and Training (FET) phase Grade 10 - 12 Life Sciences, 2011).

The skills listed above as being required in Grade 10 Life Sciences indicate that mathematical knowledge and competence are required in order to be able to achieve the outcomes required in Grade 10 Life Sciences. These skills are also seen as important in the research done by Cohen (Cohen, 2004) and Bowman (Bowman & Husbands, 2011) where the essential links between basic Mathematics and Life Sciences were highlighted.

2.2.2. Grade 9 learners' actual mathematical performance as an indication of mathematical skills

Recent studies have shown that South African learners perform poorly in Mathematics when compared to their global counterparts (van Staden, 2017). In 2012, national assessments such as the Annual National Assessment (ANA) results for Grade 9 Mathematics showed that the national average mark was 13%, and in 2013 they were 14%. Furthermore, in 2014 they were 11% and no further results were released since then (MacMillan, 2018). The Minister for Basic Education, Angie Motshekga, announced in May 2017 that the ANA would be replaced by the National Integrated Assessment Framework (NIAF) and the implementation of the NIAF would commence in 2018 (Gerber, 2017). However, with no results yet available for Grade 9 performances from the framework's latest diagnostic tests, this study will refer to the results of the previous ANA tests.

Bansilal (2017) studied the results of Grade 9 Mathematics in the ANA tests and compared them to the results that were achieved in the learners' final exam. She found that the results of the school Mathematics assessments were significantly higher than those of the ANA results in Mathematics, but that there was a strong correlation between the learners' scores in both tests that were assessed (Bansilal, 2017). This suggests that both the ANAs and the school tests had assessed similar skills, but school assessments had indicated higher competencies in Mathematics skill areas (Bansilal, 2017). This fact can be problematic when Mathematics skills are required in other learning areas such as Life Sciences, and therefore learners may not be sufficiently equipped to cope with the skills required by the Life Science curriculum; despite having obtained satisfactory results in school based Mathematics assessments.

2.2.3. Mathematical skills required by Grade 10 learners in Life Sciences

Mathematical skills that are required in Grade 10 Life Sciences are coherently explained in the CAPS document for the FET phase of Life Sciences (Education D.o., 2011). The essential skills that are referred to in this study are listed in the CAPS document as follows:

2.2.3.1. Record information or data

Observations or details should be documented as sketches, explanations, in simple table format, as simple graphs, etc. The 'recording' capacity can be transferred through a variety of different research activities.

2.2.3.2. Measure

Learners should understand what to calculate, how to quantify it, and also have a grasp of the requisite level of accuracy. It is possible to calculate a variety of objects, including (and not restricted to) size, volume , temperature, mass or weight, and figures (counting). Measuring is a method to quantify findings and learners can figure out how to make projections in this process.

2.2.3.3. Interpret

Learners should be able to translate material, such as converting a table into a suitable graph, from one form in which it was documented to another. Students should be able to perform suitable simple calculations, interpret and extract information from tables and graphs, apply theoretical expertise to realistic conditions, identify patterns and/or trends, understand the weaknesses of experimental methods, and make evidence-based deductions. The ability to carry out these abilities is dependent on mathematical competence in the fields of graph estimation, quantification, measurement and interpretation." (Education D.o., 2011).

2.2.4. The effect of mathematical skills in other science learning areas, especially Life Sciences

van Staden (2017) argues that weaknesses in the smallest area of Mathematics usually causes difficulties in other learning areas. MacMillan (2018) corroborates and explains that a sound understanding of numbers is crucial to every part of the curriculum, as all parts should be integrated. In the Life Sciences FET phase, 30% of the marks in summative assessments are allocated to skills relating to the aims specified in the CAPS as *"2.5.2.4 Record Information or Data. This should include* *recording observations or information as drawings, descriptions, in simple table format, as simple graphs, etc. The skill of 'recording' is transferable across a range of different scientific activities.*

2.5.2.5 Measure.Learners should know what to measure, how to measure it and have a sense of the degree of accuracy that is required. A variety of things could be measured including (but not limited to) length, volume, temperature, weight or mass and numbers (counting). Measuring is a way of quantifying observations and in this process learners should learn to make estimations.

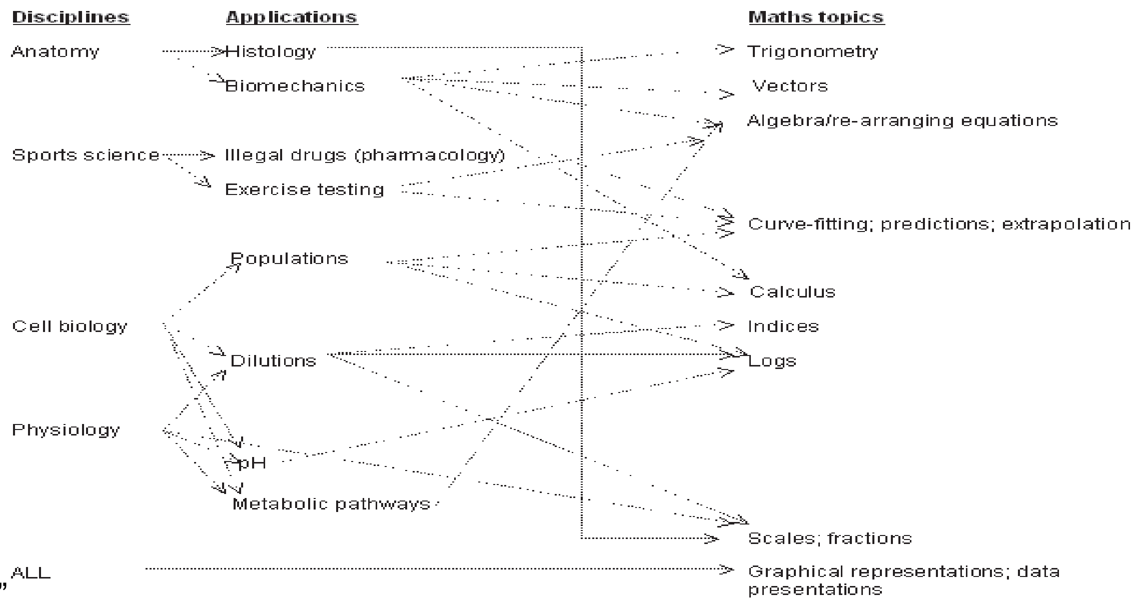
2.5.2.6 Interpret. Learners should be able to convert information from one form, in which it was recorded, into another, for instance converting a table into an appropriate graph. Learners should be able to perform appropriate simple calculations, to analyse and extract information from tables and graphs, apply knowledge of theory to practical situations, recognise patterns and/or trends, appreciate the limitations of experimental procedures as well as make deductions based on evidence." (Education, National Curriculum Statement (NCS) Further Education and Training (FET) phase Grade 10 - 12 Life Sciences, 2011).

The above aims are directly related to mathematical skills. Karsai (2010), and Karsai and Kampis (2010) state that Mathematics enters at every stage of Science, and that the interdisciplinary approach is at the heart of many research areas including Life Sciences. This collaboration is more common in research, but it is a challenge at school levels where teachers must be trained to do collaborative work (Karsai & Kampis, 2010). The idea of integrating the teaching of mathematical skills into Life Sciences has relevance to this research since Life Sciences in the senior phase has many topics that depend on mathematical knowledge and skills.

Karsai (2010), and Karsai and Kampis (2010) point out that the field of Biology/Life Sciences is changing and becoming more quantitative; and that there are challenges which need to be addressed in education. Karsai and Kampis (2010) suggest that new educational initiatives should focus on combining laboratory procedures with mathematical skills that could underpin the integration of Mathematics and Biology at various levels. Quinnel (2012) and Quinnel, Thompson and Le Bard (2012) identified that educators could not make sense of the fact that learners battled to perform simple operations, such as multiplication and division in a science environment. It was found that a lack of confidence in Mathematics was an obstacle to learning that prevented learners from engaging in the science disciplines. It was found that students transfer their maths anxiety rather than their maths skills to other disciplines, and that this has important implications for how sciences are taught (Quinnel, Thompson, & LeBard, 2012). This in turn makes it challenging for teachers as they expect learners to be able to transfer their mathematical skills to their science studies (Quinnel et. al., 2012). Quinnel (2010) highlights the fact that Mathematics can be a learning obstacle in life sciences, and that this issue can be addressed by re-focussing teaching practices (Quinnel et. al., 2012).

The research by Tariq can be seen as seminal work that has provided the framework for further research in the field of mathematical skills and Life Sciences. Tariq's first research on electronmicroscopy appeared in 1984 and she has written or co-written 81 articles which outline her research into mathematical skills and performance in Life Sciences and other areas (Tariq V. , 2021). Tariq (2005) states that for many who teach in the field of Life Sciences, it remains a challenging task to ensure that learners are able to harness and maintain the necessary skills required in mathematical knowledge It was found that in Life Sciences, a wide range of disciplines require mathematical skills and that many learners lack confidence in their ability to deal with basic mathematical concepts; thereby being unable to calculate accurately, and efficiently even with a calculator (Tariq 2005). Learners were unable to manipulate or appreciate numbers and equations, to use scientific notation, or to explain and make predictions from data presented in graphs, charts and tables (Tariq 2005). Tariq's (2005) studies aimed at producing a learning resource which can support learners in their acquisition of Mathematics skills. The following key areas of Life Sciences and their link to Mathematics was identified, and are presented directly from the text (Tariq et. al., 2005).

“Fig 1: Examples of some relationships between Life Science disciplines and math topics (Tariq., 2005).”



„

Tariq’s, (2005) study indicates that all disciplines in Life Sciences require the ability to handle graphical representation, and data presentations. These skills form the basis of this current research study.

2.3. Empirical literature

Bergevin (2010) discussed integrating Mathematics into Life Sciences education. A biology-orientated mathematics course content was recommended for students who planned to major in the biological sciences (Bergevin, 2010). The basis for this new maths course content stemmed from an educational dilemma that was identified by Bowie(2008). Adamee (2016) stated that in tandem with the exponential evolution of biological comprehension, dramatic developments in computational analyses and experimental techniques are changing the field of Biology. Although the majority of students in Biology are expected to take prerequisite subjects in maths, a lack of experience and proper education in computation, and concerning that of critical quantitative thinking, has left many students ill-prepared to engage in new fields such as quantitative biology. In addition to this observation, Bergevin (2010) identified the challenges for educators and postulated that maths content should be integrated into Life

Sciences courses. Furthermore, the challenge for students, was to use mathematics courses to develop critical thinking skills (Bergevin, 2010).

Strategies that educators could adopt included incorporating biological content into maths courses, developing effective mathematics refresher sessions in the maths faculties, and considering how mathematical content could be integrated into Life Sciences (Bergevin, 2010). Bergevin (2010) further mentions that there are significant differences in views across departments. The perception of the Facutly of Mathematics regarding maths, was that it was a field of science that drew important conclusions; whereas the Faculty of Life Sciences saw maths as being a part of "quantitative literacy". That is, a tool or language (Bergevin, 2010). The perception of the Faculty of Mathematics regarding Biology was that it was *"science fiction", while the Faculty of Life Sciences viewed Biology as being an "evolutionary science that first asks how, then why"* (Bergevin, 2010). Student expectations indicated that students in a mathematics course prefer to learn or do maths and be 'taught to the test', as opposed to developing analytical and quantitative reasoning skills that will enable critical thinking (Bergevin, 2010).

While integration is desirable, it can have negative repercussions, as found by Mwakapenda (2010). In a pilot study by Mwakapenda (2010), an investigation regarding the extent to which teachers make connections between mathematical concepts and concepts from other disciplines, was conducted. The findings reveal that although it may be desirable for teachers to make connections with disciplines that are not within their areas of specialisation, it may not be feasible due to the extent of demands placed on teachers. Integration requires that teachers have, and are aware of a broad range of knowledges within, and outside the curriculum (Mwakapenda, W; Dhlamini, J, 2010). Mwakapenda and Dhlamini (2010) identified that the mathematical aspects that need to be taught in another discipline be available to teachers other than those teaching maths. He further argued that integration may not succeed in cases where the teacher is socialised to believe that their teaching roles are restricted to those subjects in which they have been trained (Mwakapenda, W; Dhlamini, J, 2010). Additionally, learners may face tension in classes where opportunities for making connections between mathematics and other learning areas are available, but are neglected or inappropriately used by teachers (Mwakapenda & Dhlamini, 2010).

Gross, Brent and Hay (2004) discussed findings that based on the realisation that modern biology research requires a breadth of skills that go beyond the limited set of expectations to which students are exposed. The capacity of students to be critical thinkers and problem solvers has necessitated that quantitative principles useful to Biology students be included in various curriculums (Gross et al., 2004). Botha (2008) pointed out the fact that due to new insights that are continually being made in Biology, some of which include 20th century computer programming and rapid developments in the field, it is important for biologists to educate themselves about concepts from other disciplines (Gross et al., 2004). Acer (2019) states that maths and computer sciences should be incorporated into Life Sciences education in order to better facilitate insights, and developments in the discipline. Adamee (2016) stipulated that maths is still largely taught as a 'discrete' course and students do not seem to be capable of transferring their maths skills to their biology courses. He specified that a system of computational maths workshops that target biology faculty students should be conducted in order to improve mathematical skills in Biology; and that ultimately, there should be full-fledged curriculum reform to encourage interdisciplinary expertise (Gross, L; Brent, R; Hoy, R, 2004).

Cohen (2004) maintains that a synergy between Biology and mathematics can extend, and enrich both fields. Cohen (2004) placed the interactions between Biology and Mathematics according to their historical perspectives, and discussed how the two disciplines influenced each other. His most significant findings that are relative to this study, pay attention to addressing the synergy between Biology and Mathematics in the future. Cohen (2004) stressed that early emphasis should be placed on quantitative skills in primary and secondary schools, and that there should be more opportunities for training in both Biology and Mathematics. Furthermore, Cohen (2004) maintains that the future of sciences lies in the exciting opportunities for the collaboration of athematics and Biology. Mathematics can help biologists grasp extensive problems, and Biology can help mathematicians by providing challenges that could stimulate major innovations in Mathematics (Cohen, 2004).

Madlung, Bermer, Limelbau, Tullis (2011) explored the potential negative effects of interdisciplinary math-biology instruction. The study highlighted the fact that quantitative work is increasingly being integrated into Biology, but that little is known about the adverse effects of this integration. Such effects may include the development of broader, but shallower skills or the possibility of math anxiety that can cause some students to disengage in the classroom (Madlung et al., 2011). Madlung et al (2011) showed that integrating more Mathematics into Biology courses did not have a negative effect on the performance of students. This observation assisted more advanced students to better understand underlying biological principles and concepts by offering additional insights into problems (Madlung et al., 2011).

Scholars such as Adamec (2016) state that many students interested in Biology find the use of mathematics skills a barrier to their studies. She suggests that mathematics be fused with Biology and that the subjects should not be kept separate. She quotes Dr Karen Nelson saying that, *“There is a lot of power even in very simple math. However, that doesn’t make the very simple math easy to integrate”* (Adamec, 2016). Therefore, it is clear that students should develop mathematical literacy in order to be able to approach their biological studies successfully. Jungck (2012) concurs and highlights the importance of mathematical skills in microbiology in various areas including designing experiments, and the visualisation of relationships. Some of the mathematical skills used in biological microscope work range from engaging students in counting, measuring and calculating, to graphing (Jungck, 2012). These maths skills are needed in all areas of microscope work, and are crucial for Grade 10 Life Sciences pupils when studying the sections of the curriculum regarding the microscope.

Marder (2017) considered the integration of Science Technology Engineering and Maths (STEM), along with the risks that are attached to integrating these areas in secondary schools. Marder (2017) points out that many Science students do not like to be pressed to make use of mathematics, and many Mathematics students dislike being pressed to use tools outside their discipline (Marder, 2017). Marder (2017) further explains that scientists and mathematicians will be asked to implement new standards, however, they themselves may not possess the skills that STEM education will ask of students. He further suggests that although teachers will struggle to prepare their students, current and future secondary school teachers need to understand a broader curriculum than is known, it is a struggle that is worth undertaking (Marder, 2017).

Osborne (2007) argues that education in the sciences should aim to develop scientific literacy that is necessary in contemporary society. He states that current practices in education create tension between training and educating future scientists. Hence, it is vital that pupils not only have knowledge, but become critical consumers of scientific knowledge. Osborne (2007) states that any particular body of knowledge within the spheres of science that prioritises the cognitive excellence of one's labour, that is the evidence of science, has lacked in offering certain requirements. In essence, the importance of being able to use knowledge in practical applications is stressed (Osborne, 2007).

Ozgun-Koca (2001) mentions that the effective use of representations in maths and science has gained importance in the 21st century, with graphical representations playing a special role (Ozgun-Koca, 2001). He maintains that graphs can summarise complex information or relationships effectively, and that they are increasingly being used in science to represent, and interpret relationships; moreover, that it is crucial for every student to be able to interpret and construct graphs (Ozgun-Koca, 2001). He reports that studies done by Brasell and Rowe (1993) on high school physics students revealed that the students did not understand the fundamental properties, and functions of graphs in representing relationships among variables. Ozgun-Koca (2001) also refers to research done by Janvier (1981) in which it was shown that mathematics classes emphasise the need to read data, and construct certain points on graphs, while the global meanings, and interpretation of graphs is omitted.

In the article *"Understanding the world through math"*, AsiaSociety (2018) states that mathematics is often studied as a pure science, however, it needs to be applied to other disciplines. The importance of pupils being able to make global connections using mathematics is stressed on account of the world being interconnected. There are a range of opinions that state that everyday mathematics shows these connections and possibilities, and it is a powerful tool for making sense of the world, as well as solving real problems (AsiaSociety, 2018). In addition, teachers should teach rigorous and appropriate mathematical content with the use of global examples, and that if students are given the right content and context in a globally infused mathematics curriculum, they will be able to make connections using mathematicss; and therefore be able to apply mathematic strategies to solve problems (AsiaSociety, 2018). In essence, mathematics should assist students to make sense of the world (AsiaSociety, 2018).

Academics such as Fellabaum (2011), initiated the Mathematics in Life Sciences (MLS) programme at the University of Missouri as a means to integrate Mathematics into Life Sciences. Research at the university reported that it was critical for the success of students and for the success of STEM as a whole; and furthermore, to stimulate the integration between Mathematics and Life Sciences in order to prevent academic failure amongst students (Fellabaum, 2011). Best practices for the integration of Mathematics and Life Sciences was put forward by Fellabaum (2011) and this strategy includes the development of a curriculum that involves interdisciplinarity through interactions with the Mathematics and Life Sciences faculties. The MSL programme was well received by students who experienced success in their studies and research as a result of the programme, and it is serving as model for other similar programmes at the university (Fellabaum, 2011).

Staying in line with the discussion on math curriculums, Suurtaam (2011) studied how an inquiry-orientated mathematics curriculum could assist learners in solving problems, as well as being able to develop a deeper understanding of mathematical concepts. The evidence suggested that such a curriculum posed many challenges for teachers as it required major pedagogical changes, and a reorientation of teachers' basic beliefs (Suurtaam, 2011). Teacher changes to bring about a shift in practice required vital administrative support, teacher collaboration and programme coherence in order for new pedagogical practices to be developed (Suurtaam, 2011). From the current discussion, it seems as though this idea of integrating Mathematics and Life Sciences may be problematic within the current South African school system.

Sorgo (2010) proposes a model of pedagogical mathematical-biological content knowledge, stating that developing the connection between Biology and Mathematics is one of the most important ways to shift the paradigms of both science disciplines. He emphasises that the two disciplines need to be developed and connected in order for students to be able to combine their knowledge, thus enabling them to make connections by themselves (Sorgo, 2010). Many biological processes can be described and explained with the use of mathematical models, and on the most basic level, Biology requires fundamental skills of graphing, percentages and simple calculations (Sorgo, 2010). Sorgo (2010) further mentions that teachers should be trained in pedagogical mathematical-biological content knowledge, in order to develop a successful connection between these disciplines. Therefore, this training could help prepare minds that will be able to combine both disciplines at elementary and higher levels of study (Sorgo, 2010).

This literature review highlights the fundamental link between mathematics and Life Sciences. Mathematical knowledge and skills are important for pupils to be able to perform calculations and interpret the information that is presented in Life Sciences. The notion of adjusting the teaching curriculum to allow for mathematics and Life Sciences to be more closely integrated provides a possible solution to the problem of the seeming “disconnect” between mathematical skills and the performance in Life Sciences where these skills are required. Knowledge and skills in both these subjects should be integrated during teaching and learning in order for pupils to be able to interpret information and attribute meaning to the data that is presented in Life Sciences. The literature review indicates that Life Sciences performance is closely reliant on basic mathematical skills and that there is a need to integrate the two subjects in order to improve the academic performance in Life Sciences.

2.4. Theoretical framework

The research hypothesis that was discussed in chapter one, was approached using the following theoretical framework. Vygotsky’s theory of constructivism

(1978) emphasises the role of integrating various skills and competencies for learning to be accomplished effectively (Hwang, 1996) (Peschl, 2001), and this study hopes to be able to suggest a more integrated approach to the teaching of mathematics and Life Sciences at school level.

The Zone of Proximal Development (ZPD) is described by Vygotsky as the gap between what the pupil knows and what the pupil can achieve when given appropriate guidance and support (Hudson, 2012). Mathematics is an area where learning can occur within Vygotsky's constructivism framework, since unlearned material is connected to that which is familiar through scaffolding. The scaffolds assist a student to make sense of new situations, build on prior knowledge, and transfer learning (Hudson, 2012). The integration of Mathematics and Life Sciences can be linked to Vygotsky's view that the child does not spontaneously develop concepts independent of their meaning in the social world (Berger, 2005). Vygotsky's theory of concept formation explains how the divide between mathematical knowledge and Life Sciences concepts can be bridged and integrated (Berger, 2005) if both knowledge fields are advanced systematically and in an integrated manner.

The mathematical skills that learners will be expected to apply will be those that are laid down in the CAPS document for the senior phase, Mathematics Grade 7 – 9 (Education D.o., 2011). The skills required by Grade 10 learners in microscope usage and graphing will be those laid down in the CAPS document for the FET phase, Life Sciences Grade 10 – 12 (Education D.o., 2011). Therefore, Vygotsky's constructivism theory (1978) forms the basis for explaining how meaningful learning takes place and is therefore a fundamental framework for this study.

A case study approach will be used for the duration of this study, as it will provide an in depth understanding of the situation. In addition, the case study will narrow the scope of a very broad field of research in order to gather quality quantitative data. This data will be analysed to indicate and determine if there is an effect on Grade 10 learners' skills in microscope usage and graphing, and whether or not their mathematical performance is poor.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction to Research Design and Methodology methodology

In order for the objectives of this research study to be realised, a quantitative methodological approach was used. This approach was used in conjunction with a case study that was based in a Welkom co-educational school in the Free State province. Multi data gathering methodology techniques were used in this study; that is, prepared test questioning and artifact analysis from past Mathematics testing at the end of the Grade 9 year. The textual Life Sciences test is attached (Appendix A) and descriptions of the material of each question is provided in section 3.6. (Synopsis of Test Tasks). Correlational analysis was undertaken with the statistical data to assess if low mathematical performance would have an effect on the performance of learners in areas of microscopy, and graphing abilities. The study group chosen for the case study were 26 Grade 10 Life Sciences students from an independent high school in Welkom, Free State Province. The students are both females and males but are between 15 and 17 years of age.

3.2. Research design and procedure

3.2.1. Research design

Employing a quantitative approach in this study may indicate that Life Sciences marks of learners are negatively affected by poor mathematical skills rather than poor Life Sciences knowledge or competencies. The pre-existing marks from the end of Grade 9 were used since all learners did basic Mathematics, and the expectation is that the skills as required in the CAPS document for Mathematics for the senior phase should have been mastered (Education D.o., 2011). The testing instrument was set using questions from a range of Grade 10 Life Sciences text books to ensure that the questions are of the appropriate standard. Fifty percent of the test was based on Grade 10 Life Sciences content from the curriculum that could be studied, and another 50% of the test involved questions in microscopy and graphing using the basic mathematical skills that should have been mastered by learners by the end of Grade 9.

The research purpose was to assess whether Grade 10 Life Sciences students under perform in the assessment of microscopy and graphing skills as a result of poor mathematical skills in these areas. This was done using a quantitative methodology and a written assessment / testing approach.

The research determined the level of mathematical performance among Grade 10 Life Sciences learners in the case study group in the areas of microscope skills and graphing skills using quantitative test data and then compared the quantitative results in each learning area to determine whether there was a correlation between poor mathematical skills and performance in Grade 10 Life Sciences questions .

3.2.2. Procedure

In order to determine whether or not pupils grasped and studied the basic Life Sciences content (Section A of Appendix A), theoretical knowledge in the fields of microscope work and graphing was examined, and afterwards the relevance of mathematical ability and application to this material was assessed (Section B of Appendix A). The marks that were earned by students in their final exams at the end of Grade 9 were used and derived from the actual report cards of Grade 9. The obtained results for the IEB performance analysis tests conducted in Mathematics at the end of Grade 9 were derived utilising an academic central database.

Microscopy skills were tested using basic scale and magnification measurements, and the skills in graphing were assessed by means of questions which required learners to plot graphs from provided data tables. In addition, the use of the correct scales on the axes as well as questions which related to the interpretation of graphs that had relation to aspects of the Grade 10 Life Sciences curriculum, was also tested. To improve the credibility and structural validity of this study, as well as to guarantee that the results achieved during the first sitting were representative and stable over time, a re-retest of the instrument (Appendix A) was performed

3.3.Research Process

As stated, a quantitative research approach was employed and a case study was used in order to investigate the research issue. Using a non-exploratory approach that was predictive-correlational, data for this study was collected from previous documentation, and written testing or questioning. An overview of the research process is summarised below, including the steps that were taken in the research process as shown in Figure 2.

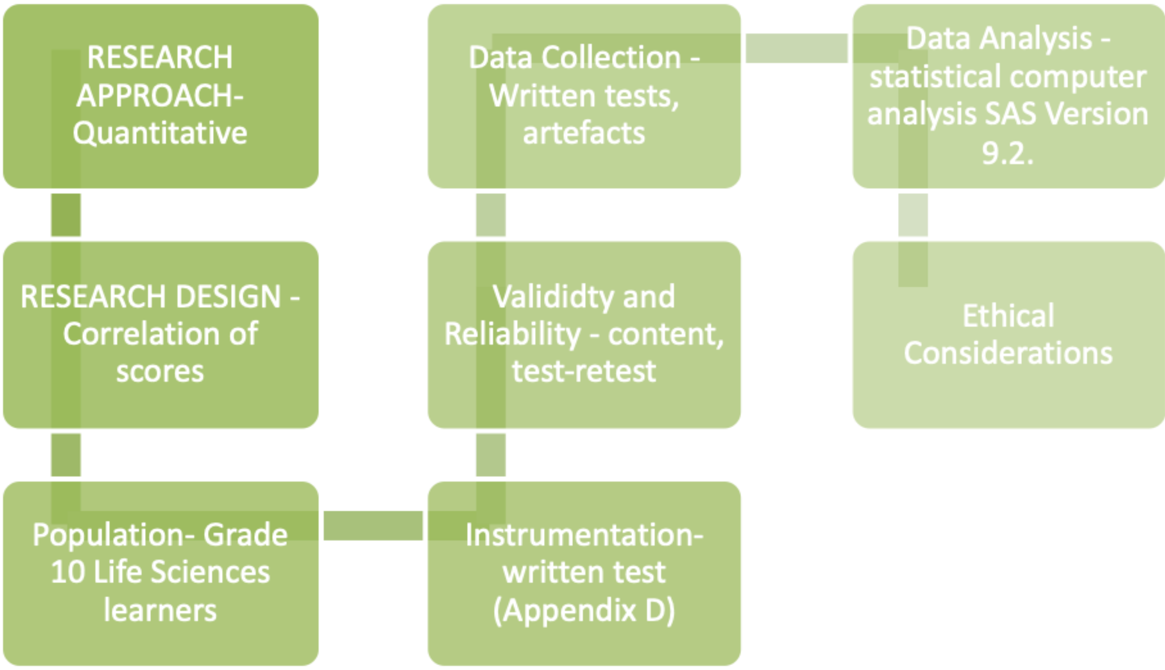


Figure 2: Diagrammatic representation of the steps in the research model

3.3.1. Time dimension

- First testing: the learners in the case study group were tested as a group; time allowance of 120 minutes; scheduled for assessment lesson on 13 March 2019, Wednesday in the school Media Centre.

- Retest: all the learners were tested as a group; time allowance of 120 minutes, scheduled for assessment lesson on 27 March 2019, Wednesday in the school Media Centre.
- Artefact 1: final Grade 9 Mathematics marks for the year ending 2018, and exams written in November 2018.
- Artefact 2: IEB benchmarking test results in Grade 9 Mathematics done during October 2018.

3.3.2. Population

All Grade 10 Life Sciences pupils which included both girls and boys, from Welkom, Free State, were research participants and formed part of the population of this study. Overall, 26 participants were present. The participants are aged between 14 and 17 years of age, and can communicate in English. The language medium of communication at the school is English, and all learning, teaching and testing is done in this language. The participants were selected according to the criteria that were set out for the scope of this study, whereby the researcher hypothesised that Grade 10 learners may have difficulty in answering questions on microscopy, and graphing that are based on fundamental mathematical skills. All participants had received reports at the end of Grade 9 indicating that they were competent in Mathematics at Grade 9 exit level.

3.3.2.1. Profile of the participants

All the participants live in Welkom, either permanently or in boarding. Some participants in boarding originated either from other provinces in South Africa, or from Lesotho. The participants represented a range of socio-economic backgrounds and came from both rural, and urban backgrounds; and they also represented a range of home languages. To note, all the participants were physically and emotionally healthy.

3.3.3. Sampling and sampling technique

The sample included all Grade 10 Life Sciences learners who attend contact classes. The researcher decided on this approach due to the fact that the school only has 280 learners, and the classes in Life Sciences normally range between 20 and 35 learners per grade. Therefore, all learners needed to be included to ensure that the population was not too small. Life Sciences learners from other grades, and other high schools were excluded from this study to minimise the broadness of the scope. In essence, a case study approach was decided upon in order to reduce the number of variables that may affect the results of the data.

3.3.3.1. Design

To reiterate, the population of this study consisted of the entire Grade 10 Life Sciences class that is registered at the study group school in Welkom, Free State. Therefore, in terms of design, this can be called a fixed, generalised category.

3.3.3.2. Units of analysis for the case study group

- Test 1: an intact, complete class of pupils (26 in total) that exhibited a range of abilities.
- Retest: an intact, complete class of pupils (26 in total) that exhibited a range of abilities.
- Artefact 1: all pupils (26 in total) that exhibited a range of abilities.
- Artefact 2: pupils who attended the school in 2018 and who had written the IEB benchmarking test in Mathematics (23 in total) that exhibited a range of abilities.

3.3.3.3. Demographics

The demographics of the test sample are summarised below in Table 1. This data was not analysed further due to the fact that the research questions were aimed at Grade 10 Life Sciences learners as a whole. However, the data is included for completeness.

Table 1 :

Demographics of test sample for test, re-test and artefact 1.

	Gender		
Ethnicity	*Male*	*Female*	*Total*
White	*1*	*7*	*8*
Black	*6*	*12*	*18*
Total	*7*	*19*	*26*

3.4. Measuring instrument

3.4.1. Test development

As discussed, the measuring instrument was designed by the researcher using a range of textbooks for Grade 10 Life Science learners as guides, and the standard according to the requirements of the FET phase was maintained (Education D.o., 2011). The test was moderated by three Life Sciences teachers who gave oral feedback. This was done to determine if there were issues of confusion with regards to the question formulation and the tasks, as well as the time allowed to complete the test. The test was formulated in plain English so that the instructions were clear and unambiguous. Minor changes were made to question 1.1. in section A, and the time allowance was increased from 80 minutes to 120 minutes to ensure that all pupils completed the test.

A written test (see Appendix A) was used as a measuring instrument, which assessed areas of the Life Sciences Grade 10 curriculum for the FET phase, dealing specifically with the sections on microscopy and cell biology. The test was designed to link directly to the research goal (*To determine if grade 10 life sciences learners perform poorly in assessment on microscope usage and graphing due to poor maths skills*). To ensure that the research goal was met, the test comprised of two sections, A and B. Section A contained knowledge and insight based questions that were related to microscopy, and cellular biology, and the total mark for this section was 50. This mark reflected the knowledge and ability to understand Life Sciences content and knowledge without the incorporation of mathematical skills. Section B contained questions that were directly related to mathematical skills, and the ability to perform basic mathematical skills in graphing, and calculation with regards to microscope work, and cellular biology. The total mark for section B was also 50. This mark reflected the ability to apply basic mathematical skills in a Life Sciences context. The marks for Section A and Section B of the test were added to give a percentage for the total test.

3.4.2. Artefacts

The learners' final marks (as a percentage) in Mathematics for Grade 9, for the year 2018, as well as the marks from an independent benchmarking test, implemented by the IEB in October 2018, towards the end of the Grade 9 year, was used as a reference point for Mathematics performance and competency.

The process followed during the design and application of the test with the artefacts is summarised in Figure 4.

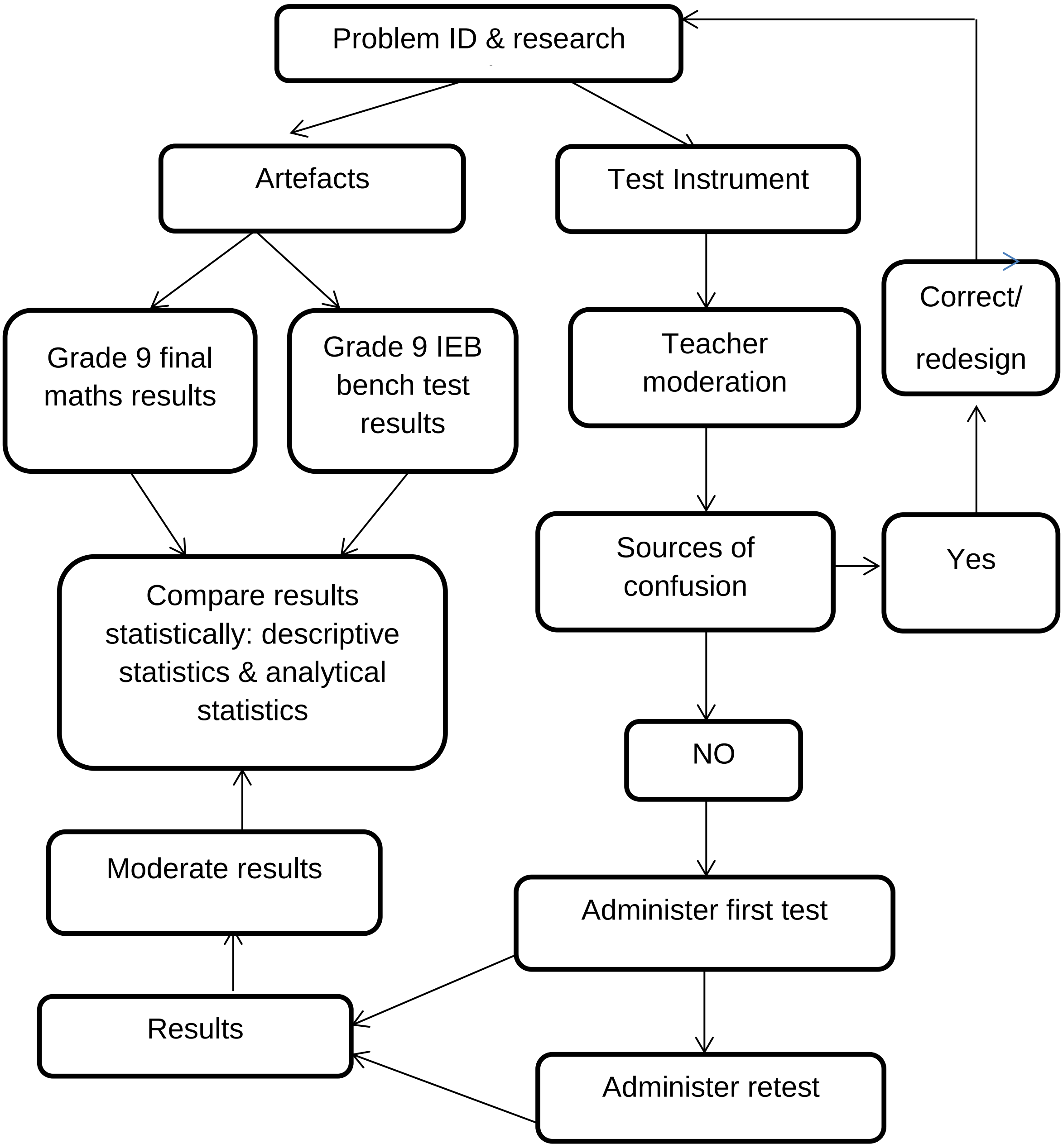


Figure 4: Flowchart of test development and application

3.5. Validity and reliability

3.5.1. Validity

The validity of the test (Appendix A) was based on set out criteria. The first of such involved content validity, whereby the item validity was ensured as a result of the selected items for the test, that were directly related to the areas of the curriculum being considered in the research hypothesis. These areas were based in a cellular biology context. The sampling validity of the test was ensured by the questions on microscope usage, and cellular biology that were selected to represent a sample over a range of possible content areas within these sections. The items selected were of the appropriate standard for Grade 10 learners, as they were adapted from Grade 10 learner textbooks.

The second criteria involved the marks that were allocated for items in the test, and they were aligned with the amount of time that the learners were given to complete the test. The test was structured into two sections, and the questions in these sections mirrored one another with regards to content, and mark allocation. This ensured that a valid comparison could be drawn between the knowledge and understanding of Life Sciences (section A), and the ability to apply mathematical skills in a Life Sciences context (section B). The test was compiled and marked with clear instructions and vocabulary that was appropriate for the learners. This compilation also included a consistent mark allocation and equal mark allocations in each section. The test was completed independently, by the learners without assistance in a controlled environment. Furthermore, the test was user friendly as it was a 'write on' test with answers to be written below each question.

Other criteria that support the validity of this study, include the fact that learners were permitted to use scientific calculators to assist with calculations in order to get accurate results. Furthermore, the instrument was moderated internally by three experienced teachers in Mathematics and Life Sciences, and the marked tests were moderated by experienced Life Sciences and Maths teachers to ensure that the marking was in accordance with the memorandum. The marking of the tests was evaluated as being fair, and consistent.

3.5.2. Reliability

The reliability of the test (Appendix A) was based on criteria, which included a test-retest reliability or stability that was conducted. The test was administered to the learners and after a two week period had lapsed, the same test was administered to the learners. The two sets of scores were correlated and the results were evaluated to determine the reliability of the test. The test-retest reliability was used to ensure that the scores obtained were representative, and stable.

Referring to the validity and reliability of the first artefact (Mathematics results at the end of Grade 9, for the 2018 academic year), reliability was based on the following information which highlights that the results were based on summative tests, that assessed the mathematics skill areas as described in the CAPS document for the senior phase (Education D.o., 2011). There was emphasis on areas that are important for mathematical competence in higher Mathematics grades. The summative tests were moderated internally and externally by experienced mathematics teachers to ensure that they conformed to Bloom's taxonomy, and that they addressed all the skill areas in the CAPS document. In addition, the tests were written in controlled examination conditions and reflect each learner's individual work.

The tests were marked and the marking was moderated, both internally and externally, to ensure that marking was accurate according to the memorandum, and that marking was fair and consistent.

The reliability of the second artefact (IEB benchmarking test in Grade 9 Mathematics, for the 2018 academic year) is based on the fact that the IEB is an autonomous institution of assessment for schooling, as well as adult evaluations; and it is approved by Umalusi. Between Grade 3 and Grade 10, the IEB provides the ACER global benchmarking assessments. ACER develops scientifically developed evaluation methods which can provide analytical information that is useful for understanding the academic progress of students. The subjects discussed in this research study were a part of the Grade 9 ACER International Benchmarking Exam.

The reliability of the results was ensured by applying the research method consistently, and the test-retest method was also applied. Only one researcher was involved in this research study and the steps that were used for each measurement of the test were the same. The conditions of the research were standardised as far as possible, and data was collected in the same consistent circumstances to reduce the influence of external factors. The same testing conditions were also applied to the test and retest. The analysis of the results was done consistently and accurately, and the results were computed electronically using the verified SAS Version 9.2 for statistical analysis. The analysis of the mean scores and deviations for the test-retest showed a p value of 0.4554 for the difference in the mean scores between Test 1, and Test 2. The p values indicated that there was not a significant mean difference of the scores in the different sections in Test 1 and Test 2. This therefore supports the reliability of the test instrument, as learners achieved similar scores in Test 1 and Test 2 in each section.

The validity of the results was further ensured by choosing an appropriate method of measurement. All scores were expressed as percentages. Use was also made of the IEB benchmarking test marks in mathematics, as the benchmarking test is based on the ACER testing system which is internationally recognised, and applied. This study considered the correlations and relationships between the results to show the impact that Mathematics performance has on the scores of questions based on mathematical skills, with regards to graphing and microscope work. It is suggested that a larger sample could increase the external validity of the research findings.

3.6. Synopsis of Test Tasks (Appendix A)

3.6.1. Question 1

3.6.1.1. Question 1: Section A

The question included theoretical knowledge of the microscope, its care and use, as well as the interpretation of drawings that depicted microscopic views of cells. The marks allocated for this question were 20.

3.6.1.2. Question 1: Section B

The question involved calculating the magnification of objects when viewed under the microscope, determining the actual size of organelles when microscopic views were provided, and determining the size, and magnification if scale lines are provided. The marks allocated for this question were 20.

3.6.2. Question 2

3.6.2.1. Question 2: Section A

In this question, learners were required to identify cells and organelles, as well as their functions from drawings. The marks allocated for this question were 10.

3.6.2.2. Question 2: Section B

A table with information was provided and learners were expected to draw a pie graph by using the data from a table, to illustrate the relative amounts of the various elements that are present in a cell. Calculations were required for this question, and the marks allocated were 10.

3.6.3. Question 3

3.6.3.1. Question 3: Section A

This question was source based and the information provided was about cancer and cell division. The questions also tested the knowledge of cell division and cancer. The mark allocation for this question was 10.

3.6.3.2. Question 3: Section B

In this question, a table showing the percentage number of cancer cells that were found in various parts of the body of a patient who underwent cancer testing, was presented. Learners were expected to draw a suitable graph using the data that was provided. The marks allocated were 10.

3.6.4. Question 4

3.6.4.1. Question 4: Section A

Question 4 presented a diagram of a microscopic view of a blood smear that showed the composition of blood. Questions in this section were based on the identification of cells and their functions. The number of marks allocated for this question were 10.

3.6.4.2. Question 4: Section B

For this question, a graph to show the number of red blood cells per $1mm^3$ at various heights above sea level was presented. Questions included reading information from the graph, describing the relationship shown by the graph, and calculating the amount of blood cells at a given altitude. The mark allocation for this question was 10.

3.7. Data collection procedures

Data collection was done using written test documentation and artefacts of previous mathematical test results from Grade 9 final examinations, for the 2018 academic year. These results were obtained from the computer data base with the permission of the school.

After a period of two weeks, the Grade 10 Life Sciences learners were given a retest of the test (Appendix A). The same test was administered under the same conditions. The completed tests were marked by the researcher and moderated as for the initial testing.

3.7.1. Test and retest

To note once again, a written test served as the instrument to collect data that was linked to the learners' Life Sciences knowledge in the areas of the microscope and cellular biology (Section A), and for testing their mathematical competencies in answering questions related to the microscope, or graphing related to cellular biology (Section B). The test was administered to all the learners after they were taught the work on the microscope, and cells. Learners were informed of the test date three weeks in advance and had adequate time to study the relevant sections of work, and to prepare for the written test. The test was conducted during school hours in a designated assessment period, and learners were given two hours to complete it. The learners were seated as is required for all school tests, and normal test conditions were applied to ensure that the learners worked independently. Each learner had their own calculator and maths set. The tests were administered by an independent invigilator with many years of experience as a Grade 12 external examination invigilator.

The invigilator is not associated with the Science, Life Sciences or Maths departments, and this detail was important so as to ensure that the pupils did not receive any assistance during the test. Learner anxiety regarding the test was minimised, as learners completed the test under normal school circumstances that were familiar to them. The completed tests were returned and marked by the researcher. A randomly selected sample consisting of six tests was moderated by three experienced Maths and Life Sciences teachers to ensure that the marking was impartial, and accurate. Furthermore, no discussions regarding the test took place with the learners. After two weeks had lasped, the learners were given a retest of the test and it was administered under the same conditions. The completed tests were then marked and moderated as per the regulations of the initial test.

3.7.2. Artefacts: Grade 9 marks and benchmarking marks

As stated in the beginning of this section, the marks that were achieved by Grade 9 pupils in Mathematics at the end of Grade 9, for the 2018 academic year, were obtained from the school's database. Also, the marks that were achieved by Grade 9 pupils who attended the school in 2018 and who had written the IEB benchmarking test in Mathematics, were also retrieved from the school's database. Therefore, in light of the information thus far, it is hoped that should the data support the research hypothesis, then future research studies may be conducted on a larger scale.

3.8. Methods of data analysis

3.8.1. Descriptive statistics

Test scores in this study were captured and recorded electronically by the researcher using the Microsoft Excel programme. The scores for section A of the test constituted a total of 50 marks, and they were converted into percentages. The scores for section B of the test were made up of a total of 50 marks and were also converted into percentages. Therefore, all scores used were presented as percentages. Further analysis was performed by a statistician using SAS (Statistical Analysis System) Version 9.2., and in order to examine the distribution of the data, the Shapiro-Wilk test was used. For numerical results, statistical techniques such as standard deviations, were measured. The statistical difference with in-score and 95% confidence ranges for the standard deviations in the grades, were computed for the variable information in order to correlate the grades for the two parts of each test, as well as between the tests.

3.8.2. Analytical statistics

Concerning analytical statistics, including the paired t-test, they were utilised to investigate whether or not the mean variations were important within the learners' scores. Correlation analysis was performed by a statistician and were interpreted by the researcher, to examine whether the Mathematics grades of the participants at the end of Grade 9, were associated with the grades of the research study test in sections A and B. The Pearson correlation coefficient (r) and the coefficient of determination (r^2) were both calculated, and regression analysis was used to investigate if the math scores of the learners at the end of Grade 9 (Y) had a significant effect on the scores in sections A, and B of the test. For the purposes of the analysis, a significance level (α) of 0.05 was used.

3.9. Limitations or flaws of the study

The limitations or areas of weakness/flaws in this study that could be addressed and improved upon in future research included limitations in the case study group and the areas of skills assessed. Some of the limitations of the study design and sample entail caution when interpreting the data. These limitations are briefly summarised below.

The first limitation to the results of this study is with regards to the sample population that was selected. The case study group was one class of Grade 10 Life Sciences learners at one independent school following the same curriculum in life sciences. The case study group was not a random sample, and therefore the results cannot be generally applied to a larger population without further, extensive research (Simon, 2011). Some learners in the case study group were studying mathematical literacy as a subject and others were studying pure mathematics; and it is possible that the exposure to different curriculums may have an effect on mathematical skills. The choice of mathematics and mathematical literacy was not initially identified as a limitation, since the mathematical skills required for Grade 10 Life Sciences are those that are expected to have been acquired during the Grade 9 year of mathematics teaching. Moreover, the research did not take into consideration the demographics of the group. The gender profile of the sample was skewed towards females who comprised 73% of the sample. The mathematical ability of female learners compared to male learners could be a factor that should be taken into account as there is a possibility that males and females have different mathematical abilities, and this could have influenced the results. However this was not the focus of this research. Three learners in Grade 10 were new to the school and had not completed the IEB benchmarking test in mathematics in the 2018 academic year; and therefore the data was not available for those learners. With reference to the issue of language, not all learners spoke English as a home language. There is a possibility that language barriers may hinder learning and understanding in both Life Sciences, and Mathematics. Future research could possibly consider a similar research study involving participants whose mother tongue and language of instruction were the same in order to minimise the effect of language barriers.

There is a limitation to the overall results of this research concerning the scope of this research study's hypothesis -(Poor academic performance in mathematical skills among Grade 10 Life Sciences learners throughout the selected study group, has a negative effect on the academic achievement in Life Sciences with particular reference to areas concerning microscope use in order to determine relative size as well as in graphing skill). The main focus of this research was microscope and graphing skills in Grade 10 that required basic mathematical skills to complete. Other areas of Life Sciences were not considered in this study. Future research could extend to other topics in Life Sciences that involve mathematical skills in order to get a broader range of data.

The results of the achievement tests were dependent on the quality of the test itself in order to get valid results (Simon, 2011). When compiling the test instrument, it was challenging to match the questions in Section A with those in Section B according to Bloom's taxonomy, and the levels of each question in each section may not always match. The test instrument was moderated by three other senior Life Sciences educators in order to minimise the possible discrepancy in the Bloom's levels of questions in each section. Lastly, learners were aware that the study involved a test-retest approach, and because of this, it is possible that some learners may have memorised certain questions from the first test in order to study some aspects, and thereby improve their scores in the retest. In order to minimise this limitation, there was a two week time period between the test and the retest.

With regards to time, this study was conducted over a limited period of time, and it considered the results of only one group of Grade 10 learners, and not several groups over a number of years. Future research could track the progress of several Grade 10 groups for a number of years to determine if there is any improvement in their ability to apply mathematical skills to Life Sciences as they become more familiar with the types of questions that require mathematical skills and have scaffolding and integration with the mathematical skills and their application to relevant areas in Life Sciences. This would align with Vygotsky's constuctivism theory as pupils move increasing through the Zone of Proximal Development.

The limitations that were highlighted and discussed in this section were taken into consideration when analysing the results of the study. Future studies may consider using a larger group of learners from different schools, or different regions in order to determine if there is a general link between mathematical performance and Life Sciences skills in microscope usage, and graphing. Such research endeavours may also investigate other areas or topics in Life Sciences where mathematical skills are involved in order to determine if there is a correlation with the results.

3.10. Research Ethics

This research was conducted according to the UNISA Policy for Research Ethics (2016), and ethical clearance was granted through UNISA as prescribed by UNISA's guidelines for post-graduate students (ERC reference: 2018_CGS/ISTE+008).

In accordance with the policies on ethics in research studies, the participants were notified that their identities would be protected and that individual test marks will not be revealed. Therefore, in order to assure them anonymity, participants were assigned numbers. Participants were informed of the purpose of the testing and signed participation forms in agreement to be part of the research population. All the participants in this study participated voluntarily and were informed of the research study’s purpose. No remuneration or compensation was given to any pupil or parent in exchange for participation.

In addition, written permission was obtained from the school (also referred to as the gatekeeper) to conduct the research. The parents/guardians of the learners were informed of the research study and written permission was received to allow their children to participate in the study. This research study is a low-risk ethical research project since the learners were in a normal school environment, and were not exposed to external threatening or harmful factors; such as individuals, testing methods, questioning, or physical environment. The school is an independent institution and thus permission from the Department of Education’s district manager was not required. However, regardless of that, written permission from the Executive Head of the school was granted in order to move forward with the research study. (Gatekeeper). The application was based on the template provided by UNISA. (See Appendix D)

CHAPTER 4: DATA ANALYSIS, RESULTS AND DISCUSSION

4.1. Introduction

In order to realise the objectives of this study, the analysis of the data was done using SAS Version 9.2. Further analysis was done statistically using SAS Version 9.2., and the Shapiro-Wilk test was also used to investigate the distribution of the variables. Descriptive statistics of means and standard deviations was calculated for numerical data; and in addition to this, analytical statistics namely the paired t-test, was used to investigate if the mean differences in the scores of the learners was significant. Furthermore, correlation analysis was used to investigate if the mathematics scores of the learners correlated with the scores of the learners in the written tests. The Pearson correlation coefficient (r) and the coefficient of determination (r^2) was calculated, and regression analysis was employed to determine whether students' mathematics scores had a major impact on the scores provided in the testing phase in the handwritten Life Sciences tests. The statistics were interpreted by the researcher.

4.2 Profile of the Participants

The participants in the research were the whole class of grade 10 Life Sciences learners (26) at an independent, English medium, school in Welkom, in the Free State Province. The participants were both male and female and of different ethnicity (Table 1) Participants were aged between 14 and 17 years. All the participants lived in Welkom, either permanently or in boarding. Some participants in boarding originated from other provinces in South Africa or from Lesotho.

The participants represented a range of socioeconomic backgrounds and came from both rural and urban backgrounds. All participants were physically and emotionally healthy. The participants represent a range of home languages, although the language of secondary education and of testing of all the learners was English.

All participants had received reports at the end of Grade 9 (2018) indicating that they were competent in Mathematics at Grade 9 exit level.

All the participants in the research participated voluntarily and were informed of the research purpose. Participants and their parents received letters of information prior to the research, and provided informed consent for participation in the research. No remuneration or compensation was given to any pupil or parent in exchange for participation.

4.3. Results

4.3.1. Distribution of variables

The actual marks for each test and the final Grade 9 Mathematics marks are shown below in percentages as Table 2.

Table 2 : Marks and Percentages for Test 1 and Test 2 and Final Grade 9 Mathematics Percentages

ID	Test1 SectonA	Test1 SectionB	% Test 1	Test2 SectionA	Test2 SectionB	% Test 2	Grade9 % Maths
1	29	22	50	32	30	62	81
2	37	21	58	34	22	56	49
3	29	16	45	29	18	47	74
4	23	13	36	18	15	33	42
5	44	20	64	42	27	69	70
6	37	10	47	24	21	45	47
7	32	10	42	22	22	44	42
8	36	14	50	34	19	53	71
9	25	29	54	2	10	12	64
10	23	16	39	28	20	48	40
11	42	12	54	41	13	54	65
12	33	31	64	39	28	67	51
13	35	15	50	34	12	46	47
14	28	9	37	20	8	28	30
15	32	22	54	30	23	53	69
16	21	14	35	23	20	43	64
17	22	6	28	15	5	20	32
18	31	15	46	33	13	46	43
19	34	17	51	36	15	51	64
20	27	11	38	34	14	48	47
21	35	27	62	33	25	58	78
22	43	32	75	43	28	71	78
23	36	24	60	41	24	66	60
24	34	19	53	32	21	53	74
25	22	8	30	16	7	23	40
26	29	22	51	29	18	47	88

Using the Shapiro-Wilk test, the distribution of variables for the test sections (Test 1 and Retest – Test 2), the Grade 9 final Maathematics marks, and the Grade 9 IEB benchmarking marks is shown below in Table 3.

Table 3: Distribution of variables using the Shapiro-Wilk test

Variable	**Statistic**		**p Value**	
Test1_SectionA_Perc	W	0.960295	Pr< W	0.3974
Test1_SectionB_Perc	W	0.960172	Pr<W	0.3949
Test2_SectionA_Perc	W	0.934082	Pr<W	0.0970
Test2_SectionB_Perc	W	0.974318	Pr<W	0.7365
Grade9_Maths_Perc	W	0.951126	Pr<W	0.2464
IEB_Benchmarking_Test	W	0.935318	Pr<W	0.1425

Interpretation of the p value:

If $p \geq 0.05$, then the variable has a normal distribution; the mean and standard deviation can be reported, and parametric techniques can be used in the analysis.

If $p < 0.05$, then the variable does not follow a normal distribution; the median and inter-quartile range can be reported, and non-parametric techniques can be used in the analysis.

All the variables in the study followed a normal distribution and thus means, and standard deviations were calculated, and parametric techniques were used.

4.3.2. Means and standard deviation of data

The means and standard deviations for all the data are summarised below in Table 4.

Table 4: Mean values and standard deviations of data used in research

Variable	N	Mean	Std Dev	Minimum	Maximum
Test1_SectionA_Perc	26	63.00	13.08	42.00	88.00
Test1_SectionB_Perc	26	35.00	14.31	12.00	64.00
Test2_SectionA_Perc	26	58.77	19.42	4.00	86.00
Test2_SectionB_Perc	26	36.77	13.65	10.00	60.00
Grade9_Maths_Perc	26	58.08	16.34	30.00	88.00
IEB Benchmarking	23	33.83	13.76	9.00	56.00

.

4.3.3. Comparison of section A and section B scores for Test 1, and Test 2

To assess whether there was a relationship to support this study's hypothesis, the obtained results for section A were compared with the results obtained for section B. The parallelisation within the results and 95% confidence ranges for the standard deviation in the grades were calculated for the dependent data. This was to determine if there was a possible correlation of the two parts of each test and between each test. The paired t-test was used to investigate if the mean differences in the scores of the learners between the sections of the test was significant. The results are summarised in Table 5 and Table 6.

Table 5: T-test procedure results of the differences in the mean scores in Test 1: section A and Test 1: section B

N	Mean	Std Dev	Std Err	Minimum	Maximum
26	28.0000	15.4195	3.0240	-8.0000	60.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
28.0000	21.7719	34.2281	15.4195	12.0928	21.2852

DF	t Value	Pr > |t|
25	9.26	<.0001

N	Mean	Std Dev	Std Err	Minimum	Maximum
26	28.0000	15.4195	3.0240	-8.0000	60.0000

Table 6: T-test procedure results of the difference in the mean score in Test 2: section A and Test 2: section B

N	Mean	Std Dev	Std Err	Minimum	Maximum
26	22.0000	15.7582	3.0904	-16.0000	56.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
22.0000	15.6351	28.3649	15.7582	12.3585	21.7527

DF	t Value	Pr > |t|
25	7.12	<.0001

Interpretation of the p-value:

If p ≥ 0.05, then there is no significant mean difference in scores between the sections (that is, the two scores are the same).
If p < 0.05, then there is a significant mean difference in scores between the sections (that is, the two section scores are different).

The p values show a significant mean difference between section A and section B. Therefore, the p values were significant to the research questions and hypothesis.

4.3.4. Comparison of the scores in sections A and sections B between Test 1 (test) and Test 2 (retest)

The scores that were obtained for section A of Test 1 were compared to those obtained for section A of Test 2, and the scores obtained in section B of Test 1 were compared to those of section B of Test 2, in order to determine if there was a correlation to support the research hypothesis; and to establish the internal validity, and reliability of the instrument. The mean differences in the scores and 95% confidence intervals for the mean differences in the scores, was calculated for the dependent data. The paired t-test was used to investigate if the mean differences in the scores of the learners between the tests was significant. The results are summarised below in Table 7 and Table 8.

Table 7: T-test procedure results of the differences in the mean scores in Test 1: section A and Test 2: section A

N	Mean	Std Dev	Std Err	Minimum	Maximum
26	4.2308	12.9161	2.5330	-14.0000	46.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
4.2308	-0.9861	9.4477	12.9161	10.1295	17.8294

DF	t Value	Pr > |t|
25	1.67	0.1073

Table 8: T-test procedure results of the differences in the mean scores in Test 1: section B and Test 2: section B

N	Mean	Std Dev	Std Err	Minimum	Maximum
26	-1.7692	11.8973	2.3332	-24.0000	38.0000

Mean	95% CL Mean		Std Dev	95% CL Std Dev	
-1.7692	-6.5746	3.0362	11.8973	9.3305	16.4231

DF	t Value	Pr > |t|
25	-0.76	0.4554

Interpretation of the p-value:

If $p \geq 0.05$, then there is no significant mean difference in scores between the tests (that is, the two section scores are the same for the two tests).

If $p < 0.05$, then there is a significant mean difference in scores between the tests (that is, the two section scores are different for the two tests).

The above p values showed no significant mean difference in the scores between the test and the retest. This, thus supports the reliability of the test.

4.3.5. Comparison of scores of Grade 9 learners in mathematics at the end of Grade 9 and scores in Section A and B of the Test 1 and Test 2

The Pearson Correlation Coefficient (r) of scores was calculated to investigate if the mathematics scores of learners at the end of Grade 9 correlated with the scores in section A and B of the test. Furthermore, how much of the change that was observed in the scores in section A and B of the test (X) was due to the change in the mathematics scores of learners at the end of Grade 9 (Y). The results are shown in Table 9.

Table 9: Pearson Correlation Coefficient (r) and p values for Test 1 and 2 scores in sections A, and B related to Grade 9 mathematics scores

Pearson Correlation Coefficients, N = 26 Prob > |r| under H0: Rho=0	
	Grade9_Maths_Perc
Test1_SectionA_Perc	0.40144 = r 0.0421 = p
Test1_SectionB_Perc	0.61300 0.0009
Test2_SectionA_Perc	0.40002 0.0429

Pearson Correlation Coefficients, N = 26 Prob > |r| under H0: Rho=0	
	Grade9_Maths_Perc
Test2_SectionB_Perc	0.56406 0.0027

Interpretation of the p-value:

If p ≥ 0.05, then there is no significant correlation between the two scores.

If p < 0.05, then there is a significant correlation between the two scores.

Interpretation of (r) value strength:

r = 0.0 – 0.4 weak correlation

r = 0.5 – 0.6 moderate correlation

r = 0.7 – 0.99 strong correlation

Therefore, the p values show a significant correlation between the scores.

Therefore, the r values show a strong positive correlation between the scores.

4.3.6. Comparison of scores of Grade 9 learners in IEB benchmarking tests with the scores in mathematics at the end of Grade 9, and scores in section B of Test 1, and Test 2

The Pearson Correlation Coefficient (r) of scores was calculated to investigate if the mathematics scores of learners in the IEB benchmarking test in mathematics at the end of Grade 9 correlated with the scores of Grade 9 learners in Mathematics at the end of Grade 9, including the scores in section B of the tests. The results are presented below in Table 10.

Table 10: Pearson Correlation Coefficient (r) and p values for IEB benchmarking test with the score in Grade 9 end of year mathematics and the scores of Test 1, and Test 2 in section B.

Pearson Correlation Coefficients Prob > |r| under H0: Rho=0 Number of Observations	
	IEB_Benchmarking_Test
Grade9_Maths_Perc	0.82537 = r <.0001 = p
Test1_SectionB_Perc	0.74335 <.0001
Test2_SectionB_Perc	0.62049 0.0016

Interpretation of the p-value:

If p ≥ 0.05, then there is no significant correlation between the two scores.

If p < 0.05, then there is a significant correlation between the two scores.

Interpretation of (r) value strength

r = 0.0 – 0.4 weak correlation

r = 0.5 – 0.6 moderate correlation

r = 0.7 – 0.99 strong correlation

Therefore, the p values show a significant correlation between the scores.

Therefore, the r values show a positive correlation between the scores.

4.3.7. Regression analysis of mathematics scores at the end of Grade 9 with the scores of Test 1, and Test 2 for sections A, and B

The Pearson correlation coefficient (r) and the coefficient of determination (r^2) were used for regression analysis to investigate if the mathematics scores of learners at the end of Grade 9 (Y) had a significant effect on the scores in section A, and B of the test. A significance level (α) of 0.05 was used. Below is a summarisation of the results in Table 11.

Table 11: Pearson Correlation Coefficient of determination (r^2) and t, and p values for Grade 9 end of year mathematics scores and Test 1, and Test 2 scores in Sections A, and B

	R-square (r^2)	t-value	Pr>|t|
Test 1 Section A percent	0.1612	2.15	0.0421
Test 1 Section B percent	0.3758	3.8	0.0009
Test 2 Section A percent	0.1600	2.14	0.0429
Test 2 Section B percent	0.3187	3.35	0.027

Interpretation of the p value:

If $p \geq 0.05$, then the maths score has no significant effect on the Life Sciences score.

If $p < 0.05$, then the maths score has a significant effect on the Life Sciences score.

4.3.8. Regression analysis of scores obtained in the IEB benchmarking test with the scores of Section B of Test 1 and Test 2

The Pearson correlation coefficient (r) and the coefficient of determination (r^2) were used for regression analysis to investigate if the score of the learners in the IEB Benchmarking test had a significant effect on the scores in section B of the test. A significance level (α) of 0.05 was used. The results of the analysis are summarised below inTable 12.

Table 12: Pearson Correlation Coefficient of determination (r^2) and t, and p values for scores of IEB benchmarking tests and scores in Section B of Test 1 and Test 2

	R-square (r^2)	t-value	Pr>|t|
Test 1 Section B percent	0.5526	5.09	<.0001
Test 2 Section B percent	0.3850	3.63	0.0016

Interpretation of the p value:

If $p \geq 0.05$, then the IEB benchmarking score has no significant effect on the Life Sciences score obtained in section B.
If $p < 0.05$, then the IEB benchmarking score has a significant effect on the Life Sciences score obtained in section B.

4.4. Discussion of Results and Findings

The results that were presented in the tables, will be discussed and interpreted, as well as their importance for this study's research hypothesis.

4.4.1. Discussion of results: distribution of variables

Table 3 showed that the p values for all the variables that were investigated was > 0.05. This indicated a normal distribution of all variables and further analysis was done to calculate the means, and standard deviations using parametric techniques.

4.4.1.1. Means of data

Table 4 illustrated the mean values of the data that was obtained. There was a large difference in the mean values of sections A and sections B for both Test 1, and Test 2. The mean value for Test 1: section A (Life Sciences theoretical content) was 63 and the mean value for Test 2: section A was 58.77. The mean value for Test 1: section B (Life Sciences questions based on mathematical skills) was 35 and the mean value for Test 2: section B was 36.77. There was also a large difference in the mean values of the Grade 9 mathematics scores (mean 58.08) and the IEB benchmarking mathematics scores (mean 33.83). The difference in mean of 24.25, places the IEB benchmarking mean more in line with the mean scores that were obtained in Test 1 and Test 2: Section B. Analysing the mean values showed little difference in the mean values for section A of Test 1 and Test 2, and the mean value of the Grade 9 mathematics scores. There was also little difference in the mean values for section B and of Test 1, Test 2, and the IEB benchmarking test scores. However, mean values between Section A and Section B are notable.

The evidence presented indicates that the noticeable difference between the means of Section A and B, as well as the Grade 9 Mathematics scores and the IEB benchmarking scores could suggest that learners studied only certain aspects for testing. However, when presented with the application of mathematical skills, they had difficulty in applying their mathematical knowledge. This would support the hypothesis that mathematical skills are poor and not integrated successfully into Life Sciences questions that are based on mathematical skills.

4.4.1.2 Comparison of section A and section B scores for Test 1, and Test 2

The t-test procedure results for the differences in the mean scores between section A and section B for Test 1 were shown in Table 5, and for Test 2 in Table 6. The p values of <.0001 showed a significant mean difference between the scores in section A and section B in Test 1, and Test 2. Therefore, the p value results support the hypothesis that poor mathematical skills can have an effect on Life Sciences performance and scores, and that mathematical skills are not well integrated into Life Sciences questions.

4.4.1.3. Comparison of the scores in sections A and sections B between Test 1 (test) and Test 2 (retest)

The t-test procedure for the differences in the mean scores in section A of Test 1 and section A of Test 2 were highlighted in Table 7. The p value was 0.1073. The t-test procedure for the differences in the mean scores in section B of Test 1 and section B of Test 2 were highlighted in Table 8. The p value was 0.4554. The p values revealed that there was not a significant mean difference of the scores in the different sections in Test 1 and Test 2. Learners achieved similar scores in Test 1 and Test 2 in each section. This evidence thus supports the reliability of the test instrument.

4.4.1.4. Comparison of scores of Grade 9 learners in mathematics at the end of Grade 9 and scores in Section A and B of Test 1 and Test 2.

The Pearson Correlation Coefficient (r) of the scores was illustrated in Table 9. The results highlighted that for Test 1 section A, and the Grade 9 Mathematics scores, there was a weak positive correlation with r = 0.40. This correlation was significant (p=0.421). For Test 1 section B, and the Grade 9 Mathematics scores, there was a moderately positive correlation with r = 0.61. The correlation between Grade 9 mathematics scores and section B, which was based on application of mathematical skills in Life Sciences, was significant (p = 0.0009). This result supports the hypothesis that poor mathematical skills can affect the performance in Life Sciences questions that are based on mathematical skills.

The results demonstrate that for Test 2: Section A, and the Grade 9 Mathematics scores, there was a weak positive correlation with r = 0.40. This correlation was significant (p=0.429). For Test 2: Section B, and the Grade 9 Mathematics scores, there was a moderate positive correlation with r = 0.564. The correlation between Grade 9 Mathematics scores and Section B, which was based on the application of mathematical skills in Life Sciences, was significant (p=0.0027). Therefore, this result supports the hypothesis that poor mathematical skills can affect the performance in Life Sciences questions that are based on mathematical skills.

4.4.1.5. Comparison of scores of Grade 9 learners in IEB benchmarking tests with the scores in mathematics at the end of Grade 9 and scores in section B of Test 1, and Test 2

The Pearson Correlation Coefficient (r) and p values for the IEB benchmarking test and the scores in Grade 9 end-of-year mathematics, and the scores of Test 1 and Test 2: Section B, were shown in Table 10. The results showed that for Grade

9 mathematics scores and IEB benchmarking test scores, there was a strong positive correlation with $r = 0.825$. This correlation was significant ($p < 0.0001$). For Test 1: Section B and the IEB benchmarking test scores, there was a strong positive correlation with $r = 0.743$. This correlation was also significant ($p < 0.0001$). For Test 2: Section B and the IEB benchmarking test scores, there was a moderately strong positive correlation with $r = 0.620$ and this correlation was significant ($p = 0.0016$).

The findings indicate that the slight difference in correlation between both Test 1 and Test 2: Section B, and the IEB benchmarking could be attributed to some learners having practised the mathematical skills required in section B, before writing Test 2. Therefore, in light of this data, the positive correlation of the scores supports the hypothesis that poor mathematical skills can affect the performance in Life Sciences questions that are based on mathematical skills.

4.4.1.6. Regression analysis of mathematics scores at the end of Grade 9 with the scores of Test 1 and Test 2 for sections A, and sections B

The Pearson Correlation Coefficient of determination (r^2) and the p values for Grade 9 end-of-year Mathematics scores, and Test 1 and Test 2 scores in sections A, and B were presented in Table 11. The results for Test 1: Section A correlated to Grade 9 mathematics scores illustrated that $r^2 = 0.1612$. Only 16.12% of the change in score in section A of Test 1 was as a result of the change in mathematics scores at the end of Grade 9, where 83.88% of the change in score of section A of Test 1 was due to other factors. The p value was 0.04 and showed that the mathematics score has a significant effect on the Life Sciences score. The results for Test 1: section B correlated to Grade 9 Mathematics scores showed $r^2 = 0.3758$. This reflects that 37.58% of the change in score in Section B of Test 1 was due to the change in mathematics score at the end of Grade 9, whereas 62.42% was due to other factors. The p value was 0.0009, which indicates that the Mathematics score has a significant effect on the Life Sciences score.

In Test 2: Section A correlated to Grade 9 mathematics scores highlighted $r^2 = 0.16$. Only 16% of the change in score in Section A of Test 2 was, because of the change in mathematics score at the end of Grade 9, and 84% of the change in score of Section A of Test 2 was due to other factors. The p value of 0.0429 demonstrated that the Mathematics score has a significant effect on the Life Sciences score. The results for Test 2: Section B correlated to Grade 9 mathematics marks showed $r^2 = 0.3187$. This reflects that 31.87% of the change in score in section B of Test 2 was as a result of the change in Mathematics score at the end of Grade 9, whereas 68.13% was due to other factors. The p value was 0.027 which suggests that the Mathematics score has a significant effect on the Life Sciences score. Hence, these results indicate support for the hypothesis, since the Mathematics score has a significant effect on the Life Sciences score. Furthermore, poor Mathematics scores can be reflected as poor scores in Life Sciences questions, where mathematical skills are required.

4.4.1.7. Regression analysis of scores obtained in the IEB Benchmarking test with the scores of section B of Test 1 and Test 2

The Pearson Correlation Coefficient of determination (r^2) and the p values of the scores of the IEB benchmarking tests, and scores in section B of Test 1, and Test 2 were presented in Table 12. The results for Test 1: Section B correlated to IEB benchmarking scores showed $r^2 = 0.5526$. This reflects that 55.26% of the change in score in Section B of Test 1 was due to a change in IEB benchmarking score, and 44.74% was due to other factors. The p-value < 0.0001 indicates that the IEB benchmarking score has a significant effect on the Life Sciences scores that were obtained in section B.

The results for Test 2: Section B correlated to IEB benchmarking scores showed $r^2 = 0.3850$. This reflects that 38.50% of the change in score in section B of Test 2 was due to a change in IEB benchmarking score, and that 61.50% was due to other factors. The p-value was 0.0016 suggests that the IEB benchmarking score has a significant effect on the Life Sciences score that was obtained in section B. Therefore, due to the evidence provided, these results support the hypothesis as the IEB benchmarking score in Mathematics has a significant effect on the Life Sciences score. Moreover, poor scores in Mathematics can be reflected as poor scores in Life Sciences questions that are based on mathematical skills.

4.4.2. Data related to the research based on scholar evaluation test questions

4.4.2.1. Fundamental research questions related to scholar evaluation tests

In order to address the first research question (*What are the consequences of bad mathematical skills on the performance of Grade 10 Life Sciences learners at a co-educational school in Welkom, Free State Province, with specific emphasis on problems related to the use of microscopes and determining relative size, and graphing skills?)*, the aim of the data analysis was to obtain p values, as well as the Pearson Correlation Coefficient with the use of quantitative models. The scores that were retrieved for Section A (Life Sciences theoretical knowledge) of the test and Section B (Life Sciences questions with mathematical skills required), showed a significant mean difference in the scores ($p < 0.0001$). When correlating the Grade 9 Mathematics final score with the score of Section B of Test 1 and Test 2, the Pearson Correlation Coefficient was 0.61200, and 0.56406 respectively. The positive correlation between the scores was also reflected in the p value of 0.0009 which indicated that the correlation was significant. This implies that a low score in Mathematics is a fairly justifiable indicator of low academic performance in Life Sciences questions that are based on mathematical skills, but this evidence does not imply causality.

The scores obtained in the IEB benchmarking test in Mathematics were also correlated to the Grade 9 final Mathematics score, and the scores in section B of Test 1, and Test 2. The Pearson Correlation Coefficients recorded were $r = 0.82537$, $r = 0.74335$, and $r = 0.62049$ respectively, thus indicating a strong positive correlation between the scores. The p values for the analysis showed $p < 0.0001$ which indicated that the correlation between the scores was significant. This means that a lower academic grade is a reasonably good predictor of weak academic achievement in mathematical skills-based Life Sciences problems however, it does not imply causation. Regression analysis using the Pearson Correlation Coefficient of determination (r^2) was also applied to the Grade 9 Mathematics scores and the scores obtained in Section B of Test 1, and Test 2. The r2 values of 0.3758 and r2 = 0.3187, illustrate a strong association between 0.0009 and 0.027 grades, and p values, suggesting that the Life Sciences score is substantially influenced by the Mathematics score. Although the scores show that poor educational achievement in Mathematics is a reasonably good predictor of academic achievement based on the mathematical abilities in Life Sciences problems, it does not indicate causation.

CHAPTER 5: CONCLUSIONS, IMPLICATIONS AND FUTURE RESEARCH

5.1. Introduction

In order to test the hypothesis of this research study (*Poor academic performance in mathematical skills among Grade 10 Life Sciences learners throughout the selected study group, has a negative effect on the academic achievement in Life Sciences with particular reference to areas concerning* microscope *use in order to determine relative size as well as in graphing skill)*, a quantitative methodological approach was adopted. Results of the written test scores were analysed statistically to determine whether or not there was a correlation between Mathematical skills and the performance of Grade 10 Life Sciences learners concerning microscope usage and graphing skills.

5.2. Realising the research objectives

The objective of this study was to investigate the relationship between poor mathematical skills and Grade 10 learners' performance in certain concepts in the field of Life Sciences, with specific focus on microscope usage and graphing skills.

5.3. Overview of the study

Aligning with the aims of this study (*To determine if grade 10 life sciences learners perform poorly in assessment on microscope usage and graphing due to poor maths skills)*, a test-retest, and previous mathematics test scores were used in order to quantify the levels of performance amongst Grade 10 Life Sciences learners in Mathematics, and Life Sciences test questions based on mathematical skills. Overall, the Life Sciences learners displayed notably poor mathematical skills.

The learners struggled to answer elementary, mathematically based, Grade 10 level Life Sciences questions. A low score in Mathematics is a relatively good indicator of poor academic performance in Grade 10 Life Sciences questions, with reference to microscope work and graphing that are based on basic mathematical skills. The confirmation of the ‘idea’ regarding a lack of successful fundamental mathematical skills and the application of these skills to Life Sciences was confirmed by this study. The inability of learners to construct basic graphs, calculate measurements according to scale and to manipulate simple equations to determine the size of objects, was evident from the poor results that were presented in this study. Since a well-developed mathematical foundation is essential for success in the FET phase of the Life Sciences curriculum, where up to 40% of the marks in Life Sciences tests are based on the ability to integrate mathematical concepts in real life scenarios, the findings were alarming. This evidence suggests that the implications for the future of Life Sciences in general in South Africa, may be dire.

Finally, the extent to which the fundamental mathematical skills of measuring and graphing are mastered in Grade 7 to Grade 9 is concerning, and there may be value in researching this aspect further. The positive correlation between Grade 9 mathematics scores and the Life Sciences questions based on mathematical skills, confirmed that fundamental mathematical skills did play a role in the performance of learners in Life Sciences.

5.4. Recommendations

Simply identifying the fact that Life Sciences learners perform poorly in questions that are based on fundamental mathematical skills is insufficient. The results of this study highlighted problem areas that may have implications for the teaching of Mathematics and Natural Sciences at secondary level, including Life Sciences at the FET level. Therefore, with the results of this study in mind, the following recommendations are made for future research, and for the possible improvement of learners’ skills in the application of mathematical knowledge in Life Sciences.

The first recommendation concerns the awareness of teachers regarding the mathematical skill level of learners. Teachers in Life Sciences must become aware of the problem that exists with regard to the fundamental mathematical skills of learners in Grade 10. Being knowledgeable of learners’ inability to use graphs and measuring skills at the required level, means that thorough instruction can be given on these aspects during Life Sciences. Concerning measuring, calculating and graphing skills, it is recommended that learners of Grade 7 to Grade 9 Mathematics should spend more time learning how to work with simple scale diagrams, learn how to calculate simple equations, and construct, and interpret various types of graphs. This will enable them to better understand various concepts and apply them to questions in other subjects. In addition to this, learners who choose Life Sciences as a Grade 10 subject for the FET phase should be made aware of the fact that 40% of the testing is based on fundamental mathematical skills. It is recommended that a basic Grade 9 mathematics score should be set as a minimum entry requirement for Life Sciences in Grade 10. Teachers in Life Sciences and Mathematics should compile a curriculum or learning programme that is based on the content from both Life Sciences and Mathematics. This could prevent subjects from becoming isolated, because of a lack of integration of fundamental skills across subject boundaries. In essence, there should be more extensive teaching collaboration between Mathematics and Life Sciences teachers in the lower grades. This should take the form of scaffolding in Mathematical learning as well as in the application of Mathematics in Life Sciences.

The professional development of teachers should take place in order to connect the disciplines of Life Sciences and Mathematics across school levels. Life Science learners in Grade 10 should be encouraged to view Mathematics as a foundation and fundamental requirement for Life Sciences. Such learners should know that Mathematics forms the foundation for a large proportion of the Life Sciences testing and questioning curriculum. In light of this, it is recommended that basic Mathematics tutorials should be given to learners who have poor mathematical skills, in order for them to achieve satisfactory scores in the subject of Life Sciences. Moreover, the gap between the skills that are required in Grade 10 and the fundamental mathematical skills that have been acquired at the end of Grad 9 should be bridged, so that learners are able to master the necessary skills by the end of Grade 9. Remaining with the same vein, learners in Grades 7 to 9 should be given more tasks in Natural Science that require the application of mathematics skills, regardless of the potentially challenging nature of the tasks. Additionally, a programme should be developed that prepares learners in Natural by rote, to the understanding of concepts that can be applied in many disciplines.

The above recommendations were made, because it may be possible that Grade 9 learners are educated in more difficult facets of Mathematics in order to pass the grade, and that fundamental mathematical skills that are applied across many subjects, are neglected. It is regrettably assumed that learners were taught these concepts, or are able to perform tasks that require these skills, because they are seen as being elementary. Likewise there is a possibility that Life Sciences teachers presume that the fundamental mathematical skills required in Grades 7 to 9 mathematics have been mastered by learners. It is furthermore recommended that more time should be allocated to explaining and possibly re-teaching these skills to Grade 10 learners.

5.4.1. Suggestions for further studies

Apart from the recommendations that were discussed in the previous section, the following suggestions for future studies may shed more light on the nature of the problem. Future research studies can focus on the effects of mathematical performance in Life Sciences by Grade 10 learners on a general scale, and broaden the scope of the study so it does not only include topics such as microscopy and graphing skills. Additionally, the effect of mathematical performance in Life Sciences learners in Grades 11 and 12 will also be interesting areas to explore. Another suggestion for future research endeavours, would be to explore the extent in which mathematics is taught in Grade 7 and Grade 9, concentrating on the application of skills in other disciplines such as Life Sciences.

Moreover, researchers may also focus on the amount of attention that is given to the fundamental skills of measurement, scale and graphing on primary, and secondary school level. These skills form the crux of the teaching of mathematics and can be applied in any subject. The focus of future research could explore how learners understand the aforementioned concepts and apply them to Life Sciences, and other fields of study. Other suggestions for future research studies include an exploration into teacher development regarding the integration of Mathematics and Life Sciences curriculums, which could assist the development of the skills of learners in these two subjects. In essence, the development of a curriculum that integrates the teaching of Mathematics and Life Sciences mutually. Lastly, the influence of gender in explaining mathematical skills and their application in Life Sciences questions which require mathematical skills, may be a field of research that could be studied.

5.5. Contributions to knowledge

Although research has been conducted at tertiary level on the effects of mathematical skills in the Biological sciences, the researcher suggests that this factor has been neglected on a school level, due to the fact that subjects are still traditionally viewed as distinct entities. The evidence that was presented and discussed in this study, illustrated that Mathematical scores do have an effect on Life Sciences scores in questions that require mathematical skills.

The results of this research study hope to contribute to the body of knowledge that currently exists in the field of Life Sciences, and Mathematics with regards to teaching practices at school level; and this contribution may stimulate more integration between the subjects. In addition, it is hoped that learners can improve their Life Sciences scores considerably by developing the essential mathematical skills that are required in Life Sciences; and thereby further improving these skills from Grade 10 to Grade 12. To summarise, Life Sciences learners in Grade 10 need assistance to develop adequate skills in basic Mathematics in order to interpret, and complete Life Sciences questions that are based on mathematical skills.

5.6. Conclusion

In conclusion, it has been observed historically that Grade 10 learners struggled with applying mathematical skills when answering questions in Life Sciences. Furthermore, learners who study this field of science in Grades 11 and 12 perform poorly in questions that require them to answer using basic mathematical skills. The hypothesis of this study stated that if the mathematical skills of Life Sciences learners could be significantly improved in certain areas in the field of Life Sciences, then the overall scores of learners across the FET phase would also improve significantly. Lastly, this study hoped to act as a starting point to show that poor mathematical skills has an effect on the performance of learners in Life Sciences. It is hoped that further research can be undertaken in order to address the problem of poor mathematical skills in Grade 10 learners, as well as in higher grades.

REFERENCES CITED AND CONSULTED FOR THIS RESEARCH

ACER. (2019, June 20). *ACER*. Retrieved from ACER Corporation Web Site: https://www.acer.org/au/assessment/school-assessments

Adamec, B. (2016). Infusing More Math into the Biology Classroom. *Teaching Microbiology*

AsiaSociety. (2018, July). *Understanding the World Through Math*. Retrieved from Asia Society.Org. Centre for Global Education: http://asiasociety.org/education

Bansilal, S. (2017). The Difficulty level of a national assessment of Grade 9 mathematics: The case of five schools. *South African Journal of Childhood Education*

Bergevin, C. (2010). *Integrating Mathematics into Life Science Education.* Arizona: ASMCUE.

Botha, T. (2008). *Senior Secondary Life Sciences Grade 10 Learner's Book .* Cape Town: Kagiso Education.

Bowie, M. (2008). *Life Sciences for Grade 10 Learners' Book OBE for FET.* Cape Town: Nasou.

Bowman, K., & Husbands, J. (2011). Dual Use Issues in the Life Sciences, Challenges and Opportunities for Education in an Emerging Area of Scientifc Responsibility. *CBE Life Sciences Education*, 3-7.

Cohen, J. (2004). Mathematics is Biology's next microscope, only better: Biology is Mathematics' next physics, only better. *Public Library of Science : Biology*, 80-94.

Dawson, C. (2008). *Spot On Life Sciences Learners' book Grade 10.* Sandton: Heinemann.

de Wet, P. (2017, July 14). *Why do learners struggle with maths in grades 10 - 12.* Retrieved from MacMillan Education South Africa: https://www.macmillan.co.za/news/macmillan-news/1/why-do-learners-struggle-with-maths-in-grades-1012/93

Dornette, P. (2018, March 15). *Improving Students' Maths Skills for Science Class.* Retrieved from Carolina: http://www.carolina.com

Education, D. o. (2011). *Curriculum Assessment Policy statement (CAPS) Grade 7 - 9 Mathematics.* Pretoria: Government Printing Works.

Education, D. o. (2011, April). *National Curriculum Statement (NCS) Further Education and Training (FET) phase Grade 10 - 12 Life Sciences.* Pretoria: Government Printing works. Retrieved from Further Education and Training (FET) Phase: http://www.education.gov

Essays, U. (2017, June 12). *Education in South Africa : Mathematics and Scientific Performance.* Retrieved from UK Essays: www.ukessays.com/essays/education/poor-performance-in-maths-and-science-education-education-essay.php?vref=1

Fellabaum, J. (2011). Mathematics in Life Sciences: Developing a Best Practice. *ASQ Advancing the STEM Agenda in Education, the Workplace and Society*, 19-23.

Furner, J., & Kumar, D. (2007). The Mathematics and Science Integration Argument : A stand for Teacher Education. *Eurasia Journal of Mathematics, Science & Technology Eduation*, 185-189.

Galloway, C. (2010). Vygotsky's Constructivism. In M. Orey, *Emerging Perspective on Learning, Teaching and Technology* (pp. 48-49). Georgia: University of Georgia, USA.

Gerber, J. N. (2017). *National Assessments to be replaced - Motshekga.* Cape Town: News24.

Gross, L., Brent, R., & Hoy, R. (2004, July 01). The Interface of mathematics and biology. *Cell Biology Education*, pp. 85-92.

Hester, S. (2014). Integrating Quantitative Thinking into an Introductory Biology Course Improves Students' Mathematical Reasoning in Biological Contexts. *CBE - Life Sciences Education*, 54-64.

Hwang, A.-S. (1996). Positivist and Constructivist persuasions in instructional development. *Instructional Science*, 343-356.

Jungck, J. (2012). Mathematics make Microbes Beautiful, Beneficial, Bountiful. *Advances in Applied Microbiology*, 37-80.

Karsai, I., & Kampis, G. (2010, September 01). The Crossroads between Biology and Mathatics : The Scientific Method as the Basics of Scientifc Literacy. *BioScience*, pp. 632-638.

Leonard, B. (2007). Integrative Learning as a Developmental Process: A grounded theory of College Students Experiences in Integrative studies. *DRUM - University of Maryland*, 24-25.

Leonard, J. B. (2012). Integrative learning - A Grounded Theory. *Issues in Integrative Studies*, 48-74.

MacMillan. (2018). *Why do Learners struggle with maths in grade 10 - 12?* Midrand: MacMillan.

Madlung, A., Bermer, M., Himelbau, E., & Tullis, A. (2011). A study asssessing the Potential of Negative Effects in Interdisciplinary Math - Biology Instruction. *CBE - Life Sciences Education*, 43-54.

Marder, M. (2017). A Problem with STEM. *CBE - Life Sciences Education*, 2 - 9.

McLeod, S. (2018). *Lev Vygotsky- Developmental Psychology.* Retrieved from Simply Psychology: https://www.simplypsychology.org/vygotsky.html

Mwakapenda, W., & Dhlamini, J. (2010, July 30). Integrating Mathematics and Other learning Areas : Emerging Tensions from a Study involving Four Classroom teachers. *Pythagorus*, pp. 22-29.

Osborne, J. (2007). Science Education for the Twenty First Century. *Eurasia Journal of Mathematics, Science & Technology Education*, 173-184.

Ozgun-Koca, S. (2001). The Graphing Skills of Students in Mathematics and Science Education. *ERIC Digest for Science Mathematics and Environmental Education Columbus*, 16-20.

Padayachee, K. (2016). *Guidelines for writing a Research Proposal.* Pretoria: UNISA.

Peschl, M. (2001). Constructivism, Cognition, and Science - An investigation of its Links and Possible Shortcomings. *Foundations of Science*, 125-161.

Preethlall, P. (2010). *Study & Master Study Guide 10 Life Sciences 2nd Ed.* Cape Town: Cambridge University Press.

Quinnel, R., Thompson, R., & LeBard, R. (2012). Academic numeracy in Life Science learning : Challenging perceptions. *The Higher Education Academy - STEM*, 22-30.

Ross, K. (2017, February 27). *Maths Skills in GCSE Biology*. Retrieved from My GCSE Science: https://www.my-gcsescience.com/maths-skills-gcse-biology/

Simon, M. (2011). *Assumptions, Limitations and Delimitations.* Retrieved from Dissertation success: http://www.dissertationrecipes.com

Skaalvik, S. (2006). Self-concept and self-efficacy in mathematics: relation with mathematics motivation and achievement. *ICLS '06 Proceedings in the 7th international conference on Learning sciences* (pp. 709-715). Indiana: Bloomington.

Sorgo, A. (2010). Connecting Biology and Mathematics : First prepare the Teachers. *CBE Life Sciences Education*, 196-200.

South African Government. (2013, October 29). *Parliamentary Monitoring Group*. Retrieved from Government Quality Assurance: https://pmg.org.za/committee-meeting/16677/

Suurtaam, C. (2011). Developing Mathematics Classroom Practices: The role of coherence and collaboration. *Journal of Education Research*, 335 - 359.

Suurtamm, C. (2011). Developing Mathematics classroom practices : The role of coherence and collaboration. *Journal of Education Research, Vol.*, 335-359.

Tariq, V. (2004). Numeracy, mathematical literacy and the life sciences. *MSOR Conections*, 25-29.

Tariq, V., Stevenson, J., & Roper, T. (2005). Maths for Biosciences:towards developing an innovative e-learning resorce for post GCSE students. *University of Central Lancashire Connections*, 39-43.

Tikhonov, M. (2016). Opinion: Mircobiology Needs More Math. *The Scientist Magazine*, 50-53.

Tiwari, M. (2012). A Mathematical applications into the cells. *Journal of Natural Science, Biology and Medicine*, 19-23.

UNISA. (2016). *Policy for Reseach Ethics.* Pretoria: UNISA.

van Staden, S. &. (2017, July 14). Differences in the quality of school-based assessment: Evidence in Grade 9 mathematics achievement. *Pythagorus, 38(1)*, pp. 67-77.

Van Tonder, A. (2010, October). *Unisa archives.* Retrieved from UNISA.

Van Wylen, D., Abdella, R., Dickinson, S., Engelbrecht, J., & Vandiver, R. (2017). Interdisciplinarty: The Right people, A supportive place, and a Program emerges. *CBE - Life Sciences Education*, 13-21.

APPENDIX A
LIFE SCIENCES ASSESSMENT – GRADE 10

DATE : ………………………………………………….

TIME : 2 HOURS

MARKS : 100

NAME :
……………………………………………………………………………………………

Instructions :

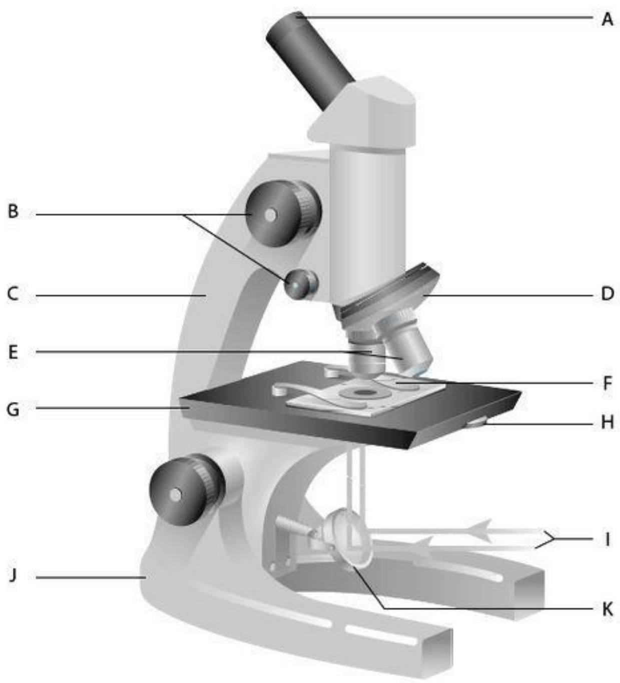
1. Answer all the questions in the spaces provided on this question paper.
2. This assessment consists of two sections, section A and section B. Answer both sections to the best of your ability.
3. Show all calculations.
4. Use of a scientific calculator is permitted.
5. Write neatly and legibly, and use a ruler for straight lines.

MARKS SECTION A /50	
MARKS SECTION B/50	
TOTAL MARKS /100	

LIFE SCIENCES ASSESSMENT : SECTION A - GRADE 10

Answer all the questions in the spaces provided

QUESTION 1



http://data.allenai.org/tqa/the_microscope_L_0362/

1.1. Provide labels for the structures labelled A, B, E, G and K (5)

A.

B.

E.

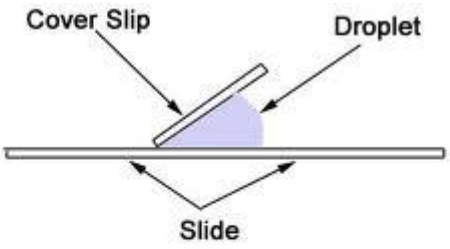
G.

K.

1.2. Explain the function of the part labelled K. (2)

1.3. Discuss three procedures to be followed for the correct care and handling of the microscope. (3)

1.4. The figure below shows one of the steps in making a wet mount slide to be viewed under the microscope.

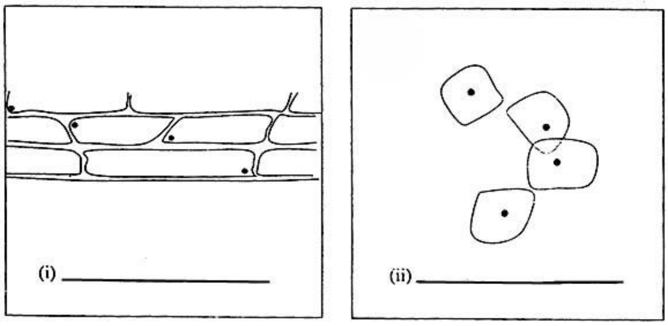


http://www.mccc.edu/~natalep/Lab1-6slides.htm.

1.4.1. Explain in five (5) simple steps the procedure that you would follow for making a wet mount slide of onion cells to view under the light microscope.(5)

1.4.2. Question 1.4.2 adapted from Study & Master Study 10 Study Guide Life Sciences pg 59 (2011)

A grade 10 learner submitted the following drawings of animal cells and plant cells which he viewed under a light microscope. He forgot to label the drawings or to write a caption for them.



ttp://www.google.co.za/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwi2ndytg9ndAhWbE4gKHfPBDooQjRx6BAgBEAU&url=http://oldschool.com.sg/module/PublicAccess/action/Wrapper/sid/9595afb87c8cf767f034c3ae53e74bae/cmbn_id/431/coll_id/1121&psig=AOvVaw3GTZ6bfKYkrx6RTXeevdXL&ust=1538063530388629

1.4.2.1. Provide labels for drawing (i) and drawing (ii) (2)

(i)

(ii)

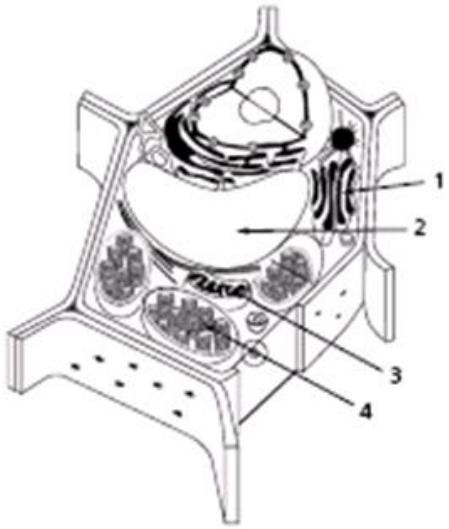
1.4.2.2. Tabulate two visible differences between cells (i) and (ii). (2)

1.4.2.3. Why do you think the learner did not put in structures like chloroplasts and mitochondria. (1)

[20]

QUESTION 2

The diagram below shows a section through a cell. Various organelles have been labelled.



https://www.proprofs.com/quiz-chool/story.php?title=3rd-block-group-2_1.

2.1. Provide labels for the organelles labelled 1 to 4. (4)

1.

2.

3.

4.

2.2. Is this cell an example of a prokaryotic or a eukaryotic cell? Give a visible reason for your answer. (2)

2.3. On the drawing, label the cell nucleus clearly. (1)

2.4. Provide the functions of each of the parts 2, 3 and 4. (3)

2.

3.

4. **[10]**

<u>QUESTION 3</u>

Question 3 adapted from Senior Secondary Life Sciences Grade 10 Learner's Book pg 150 (2008)

Read the extract below and answer the questions which follow:

"CANCER : WHEN CELL DIVISION GOES WRONG

In humans and animals there is a control system to stop cells from dividing too often. Cell division takes one or two hours, and then cells normally grow for many hours. When they reach a certain size, the cells start to divide.

If this control system breaks down in a part of the body, the cells will divide over and over again in an uncontrolled way. This results in the formation of a mass of cells that have no function. This mass of cells is called a tumour. A tumour can be either benign or malignant. A benign tumour is enclosed in a capsule, and it stays in one place without harming the surrounding organs. In a malignant tumour the cells are spread around the body by the circulating blood, forming new tumours in other parts of the body. A tumour that spreads through the body is called a carcinoma (cancer).

Cancer cells tend to affect normal cells depriving them of food. There are many kinds of cancers that can form in different parts of the body. For example, cancers can grow in the brain, mouth, throat, pancreas, liver, lungs, colon, breasts and prostate gland.

There may be various reasons why cells become cancerous. Carcinogens are substances that can trigger cells to start dividing in an uncontrolled way. Contact with carcinogens should be avoided.

The best treatment for cancer is early diagnosis, followed by surgical removal of the tumour. Tumours can also be successfully treated with anti-cancer *drugs (chemotherapy) or with electromagnetic currents (radiotherapy). Some people believe in using medicinal plants to assist with cancer treatment."*

3.1. Name the process by which cell division occurs in body cells. (1)

3.2. Explain two ways in which cancer cells are different from normal body cells. (2)

3.3. Discuss a possible effect that a tumour may have on the body if it is not removed or treated. (1)

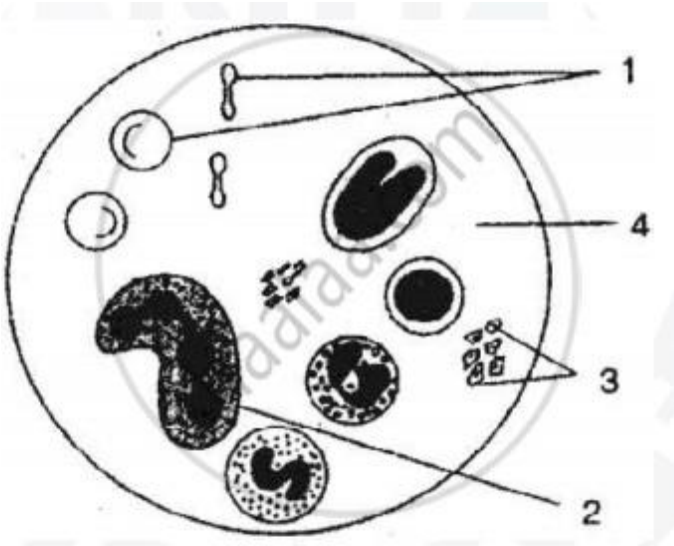
3.4. Name any two carcinogens and for each, mention the part of the body most likely to be affected. (4)

3.5. Discuss two methods of treating cancer. (2)

[10]

<u>QUESTION 4</u>

The diagram below shows microscopic view of a blood smear to show the composition of blood. Study the diagram and answer the questions below.



https://www.shaalaa.com/question-bank-solutions/circulation-blood-given-below-diagram-human-blood-smear-study-diagram-answer-questions-that-follow-name-components-numbered-1-4-mention-two-structural-differences-between-parts-1-2-name-soluble-protein-found-part-4_19685

4.1. Identify the structures numbered (1). (1)

4.2. What is the shape of these structures? (1)

4.3. Name two important functions of these structures. (2)

4.4. Identify the part numbered (2). (1)

4.5. Name three dissolved substances found in this part. (3)

4.6. Which numbered part: (2)

i) plays a role in the clotting of blood by releasing clot-initiating factors

ii) has a life span of about 10 days.

[10]

<u>LIFE SCIENCES ASESSMENT : SECTION B – GRADE 10 :</u>

Answer all questions in the spaces provided.

<u>QUESTION 1</u>

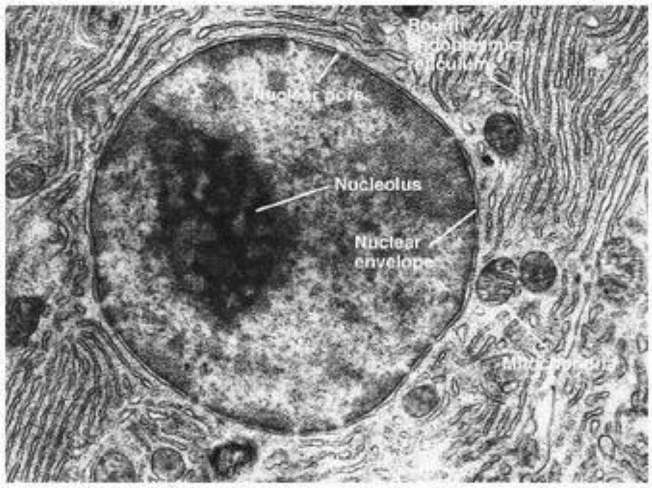
Questions 1.1, 1.2 adapted from Spot On Life Sciences Grade 10 (2008) pgs 102, 106

1.1. The magnification of a microscope = magnification of the top lens (eyepiece) x magnification of the objective lens. Complete the table below by finding the values of a - c. (3)

Eyepiece lens	**Objective lens**	**Overall magnification**
10x	40x	a)
b)	40x	1000x
20x	c)	800x

1.2. The length of a cell organelle on a transmission microscope had the following dimensions: length 60mm, width 40mm. The magnification of the microscope when the photo was taken was 20 000X. Calculate the actual length and width of the organelle in micrometres. Show calculations. (5)

1.3. Figure 1 shows a section through a cell nucleus magnified 5 700x



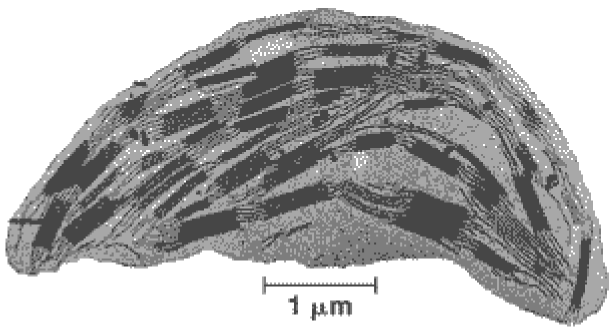
https://www.haikudeck.com/animal-cells-uncategorized-presentation-TpxdkMP7nF

Figure 1 : Section through the nucleus of a cell

1.3.1. Calculate the actual length and the width of the nucleus in mm. Show calculations. (5)

1.3.2. From the measurements you have worked out, draw a suitable scale line that can be placed on the micrograph. (2)

1.4. Figure 2 shows a micrograph of a chloroplast.



↑ ↑

X Y

Figure 2 : Chloroplast of a plant cell

1.4.1. Calculate the magnification of Figure 2 shown above using the formula for magnification. (Mag = size of image/size of object). Use the length X-Y as the length of the chloroplast. Show calculations. (5)

[20]

QUESTION 2

Question 2 adapted from Life Sciences Grade 10 OBE for FET (2008)

2.1. A cell consists mainly of the following elements:

Hydrogen (H) 59%
Oxygen (O) 25%
Carbon © 11%
Nitrogen (N) 4%
Others such as Phosphorous (P) and Sulphur (S) 1%

Draw and fully label a pie chart to show the composition of the cell as provided above. Show all calculations. (10)

[10]

QUESTION 3

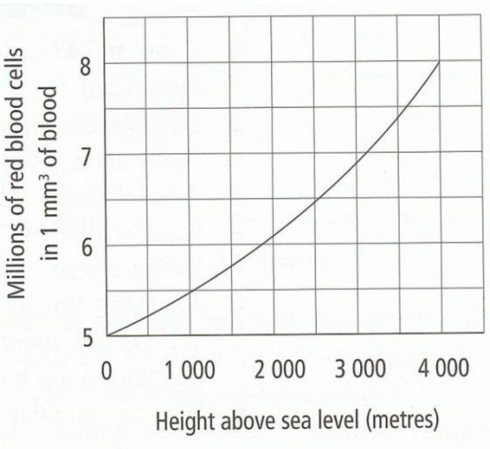
3.1. The table below shows the percentage number of cancer cells found in various regions of the body of a patient who underwent cancer testing.

Body region tested	**% cancer cells**
Lungs	78
Oesophagus	53
Pancreas	24
Kidney	15
Liver	87

Draw and fully label a suitable graph from the data provided in the table. (10) **[10]**

QUESTION 4

The graph below shows the number of red blood cells per $1mm^3$ at various heights above sea level (altitude).



4.1. How many red blood cells are found in $1mm^3$ of blood at 2 500m. (2)

4.2. What is the difference in the number of blood cells found in $1mm^3$ of blood at the highest and lowest altitudes on the graph. Show calculations. (3)

4.3. Describe the relationship that exists between the number of red blood cells per mm^3 and the height above sea level. (2)

4.4 Calculate how many red blood cells there would be in 1 litre of a persons' blood if they live at an altitude of 1000m. Show calculations. (3)

[10]

APPENDIX B

PARTICIPANT INFORMATION SHEET

Ethics clearance reference number: 2018_CGS/ISTE+008
Research permission reference number (if applicable): N/S

12 March 2019

Title : THE EFFECTS OF POOR MATHEMATICAL SKILLS ON GRADE 10 LEARNERS' PERFORMANCE IN CERTAIN CONCEPTS IN LIFE SCIENCES – A CASE STUDY FOCUSSING SPECIFICALLY ON MICROSCOPE USAGE AND GRAPHING SKILLS

Dear Prospective Participant

My name is Mandy de Vries and I am conducting research with Prof. H.I Atagana, a professor in the Department of Mathematics, Science and Technology in Education towards an MSc in Life Sciences Education at the University of South Africa. We are inviting you to participate in a study entitled THE EFFECTS OF POOR MATHEMATICAL SKILLS ON GRADE 10 LEARNERS' PERFORMANCE IN CERTAIN CONCEPTS IN LIFE SCIENCES – A CASE STUDY FOCUSSING SPECIFICALLY ON MICROSCOPE USAGE AND GRAPHING SKILLS.

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to identify if performance in life sciences amongst grade 10 learners in the areas of microscope usage and graphing, can be improved with better integration and improved competencies in basic mathematical skills. It is hoped that the results of the study will be able to make a significant contribution to life sciences education, not only within the school where this study is to be carried out, but also nationally. The study hopes to suggest strategies amongst life sciences teachers and math teachers at school level in order to integrate subject content so that learners may be able to have improved performance in life sciences.

WHY AM I BEING INVITED TO PARTICIPATE?

This study will be conducted as a case study. There will be 30 – 40 participants. The participants for this research will be all the grade 10 life sciences learners, both boys and girls, in an independent secondary school in the town of Welkom in the Free State province. The participants will be aged between 14 and 17 years and will be English speaking. The language of learning, teaching and testing is English. No sampling will take place as all the grade 10 life sciences learners in the school will form the population of the study. These participants have been selected as the researcher has identified, through situated experience, that grade 10 learners have difficulty in answering questions on microscope usage and graphing that are based on mathematical skills.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

Participants will not be required to perform any activities outside of what is required in the normal life sciences curriculum and school situation. The study involves a written, two hour test that will be completed during the normal school day under test conditions. The test date and any content that must be studied in order to answer the test, will be given at least two weeks prior to the testing. A retest will be done two weeks after the first test under the same conditions.

The test will comprise two sections. The first section will contain questions based on the theoretical knowledge of the microscope and the skills pertaining to the use of the microscope. The second section will contain questions relating to the application of simple mathematical skills that are required when using the microscope, as well as the skills of graphically presenting data in a life sciences context. The questions in the test will be in accordance with the knowledge and skills required by pupils at a grade 10 level according to the Curriculum and Assessment Policy (CAPS) for the Further Education and Training Phase (FET) for grade 10 life sciences.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

This study is seen to be of significant benefit to the grade 10 life sciences learners, as it has the potential to focus on improving the mathematical skills of grade 10 life sciences learners in a focused way, which will have a directly positive impact on their life sciences results.

ARE THEIR ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

This research is classified as a low risk research. The potential for harm is low. There is the potential for minor inconvenience and discomfort. This is not in excess of what would normally be experienced in the school testing situation.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You have the right to insist that your name will not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research. Your answers scripts will be given a code number or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

Records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

While every effort will be made by the researcher to ensure that you will not be connected to the information that you share during the case study, I cannot guarantee that other participants in the case study group will treat information confidentially. I shall, however, encourage all participants to do so. For this reason I advise you not to disclose personally sensitive information in the case study.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a minimum period of five years in a locked cupboard at St Dominic's College High School, Welkom. Electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After the minimum period of time, hard copies will be shredded and/or electronic copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programme.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

No payment or compensation will be given to participants.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Research Ethics Review Committee of the Institute of Science and Technology Education and the Research Permission Sub-committee of the Senate Research and Innovation and Higher Degrees Committee (RPSC), UNISA. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Mandy de Vries on 057 352 3905 or mdevries@dominic.co.za . The findings are accessible for 12 months.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact Mandy de Vries on 057 352 3905 or mdevries@dominic.co.za.

Should you have concerns about the way in which the research has been conducted, you may contact Prof H.I. Harrison on 012-337-6129 or atagahi@unisa.ac.za. The Ethics Review Committees (ERCs) within the Unisa context are constituted by the Senate Research and Innovation and Higher Degrees Committee of the University, and has been authorized to carry out ethical review of research. You may contact Prof Padayachee at padayk@unisa.ac.za if you have any ethical concerns.

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

Mandy de Vries

APPENDIX B2

PARENT INFORMATION SHEET

Ethics clearance reference number: 2018_CGS/ISTE+008
Research permission reference number (if applicable):

12 March 2019

Title : THE EFFECTS OF POOR MATHEMATICAL SKILLS ON GRADE 10 LEARNERS' PERFORMANCE IN CERTAIN CONCEPTS IN LIFE SCIENCES – A CASE STUDY FOCUSSING SPECIFICALLY ON MICROSCOPE USAGE AND GRAPHING SKILLS

Dear Parent/Guardian of Prospective Participant

My name is Mandy de Vries and I am conducting research with Prof. H.I Atagana, a professor in the Department of Mathematics, Science and Technology in Education towards an MSc in Life Sciences Education at the University of South Africa. We are inviting your child/ward to participate in a study entitled THE EFFECTS OF POOR MATHEMATICAL SKILLS ON GRADE 10 LEARNERS' PERFORMANCE IN CERTAIN CONCEPTS IN LIFE SCIENCES – A CASE STUDY FOCUSSING SPECIFICALLY ON MICROSCOPE USAGE AND GRAPHING SKILLS.

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to identify if performance in life sciences amongst grade 10 learners in the areas of microscope usage and graphing, can be improved with better integration and improved competencies in basic mathematical skills. It is hoped that the results of the study will be able to make a significant contribution to life sciences education, not only within the school where this study is to be carried out, but also nationally. The study hopes to suggest strategies amongst life sciences teachers and math teachers at school level in order to integrate subject content so that learners may be able to have improved performance in life sciences.

WHY IS MY CHILD BEING INVITED TO PARTICIPATE?

This study will be conducted as a case study. There will be 30 – 40 participants. The participants for this research will be all the grade 10 life sciences learners, both boys and girls, in a private independent secondary school in the town of Welkom in the Free State province. The participants will be aged between 14 and 17 years and will be English speaking. The language of learning, teaching and testing is English. No sampling will take place as all the grade 10 life sciences learners in the school will form the population of the study. These participants have been selected as the researcher has identified, through situated experience, that grade 10 learners have difficulty in answering questions on microscope usage and graphing that are based on mathematical skills.

WHAT IS THE NATURE OF MY CHILD/WARD'S PARTICIPATION IN THIS STUDY?

Participants will not be required to perform any activities outside of what is required in the normal life sciences curriculum and school situation. The study involves a written, two hour test that will be completed during the normal school day under test conditions. The test date and any content that must be studied in order to answer the test, will be given at least two weeks prior to the testing. A retest will be done two weeks after the first test under the same conditions.

The test will comprise two sections. The first section will contain questions based on the theoretical knowledge of the microscope and the skills pertaining to the use of the microscope. The second section will contain questions relating to the application of simple mathematical skills that are required when using the microscope, as well as the skills of graphically presenting data in a life sciences context. The questions in the test will be in accordance with the knowledge and skills required by pupils at a grade 10 level according to the Curriculum and Assessment Policy (CAPS) for the Further Education and Training Phase (FET) for grade 10 life sciences.

CAN MY CHILD/WARD WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and your child/ward is under no obligation to consent to participation. If he/she does decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. Your child/ward is free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

This study is seen to be of significant benefit to the grade 10 life sciences learners, as it has the potential to focus on improving the mathematical skills of grade 10 life sciences learners in a focused way, which will have a directly positive impact on their life sciences results.

ARE THEIR ANY NEGATIVE CONSEQUENCES FOR MY CHILD/WARD IF HE/SHE PARTICIPATES IN THE RESEARCH PROJECT?

This research is classified as a low risk research. The potential for harm is low. There is the potential for minor inconvenience and discomfort. This is not in excess of what would normally be experienced in the school testing situation.

WILL THE INFORMATION THAT MY CHILD/WARD CONVEYS TO THE RESEARCHER AND HIS/HER IDENTITY BE KEPT CONFIDENTIAL?

Your child/ward has the right to insist that his/her name will not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about their involvement in this research. Your child/ward's answer scripts will be given a code number or a pseudonym and he/she will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

Records that identify participants will be available only to people working on the study, unless you give permission for other people to see the records.

A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

While every effort will be made by the researcher to ensure that participants will not be connected to the information that is shared during the case study, I cannot guarantee that other participants in the case study group will treat information confidentially. I shall, however, encourage all participants to do so. For this reason I advise all participants not to disclose personally sensitive information in the case study.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your child/ward's answers will be stored by the researcher for a minimum period of five years in a locked cupboard at St Dominic's College High School, Welkom. Electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After the minimum period of time, hard copies will be shredded and/or electronic copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programme.

WILL PARTICIPANTS RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

No payment or compensation will be given to participants.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Research Ethics Review Committee of the Institute of Science and Technology Education and the Research Permission Sub-committee of the Senate Research and Innovation and Higher Degrees Committee (RPSC), UNISA. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Mandy de Vries on 057 352 3905 or mdevries@dominic.co.za . The findings are accessible for 12 months.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact Mandy de Vries on 057 352 3905 or mdevries@dominic.co.za.

Should you have concerns about the way in which the research has been conducted, you may contact Prof H.I. Harrison on 012-337-6129 or atagahi@unisa.ac.za. The Ethics Review Committees (ERCs) within the Unisa context are constituted by the Senate Research and Innovation and Higher Degrees Committee of the University, and has been authorized to carry out ethical review of research. You may contact Prof Padayachee at padayk@unisa.ac.za if you have any ethical concerns.

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

Mandy de Vries

APPENDIX C

CONSENT TO PARTICIPATE IN THIS STUDY

2018_CGS/ISTE+008

I, __________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty.

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the quantitative scores of the written test based on microscope work and graphing.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname………………………………………… (please print)

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

Researcher's Name & Surname: Mandy Joy de Vries………………(please print)

Researcher's signature… .Date…12 March 2019

APPENDIX C2

PARENT/GUARDIAN CONSENT TO ALLOW A MINOR TO PARTICIPATE IN THIS STUDY

2018_CGS/ISTE+008

I, ___________________ (Parent/guardian), of ______________________ (print full name) confirm that the person asking my consent to allow _________________________ to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and agree that ___________________________________ can participate in the study.

I understand that his/her participation is voluntary and that he/she is free to withdraw at any time without penalty.

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that ____________________ participation will be kept confidential unless otherwise specified.

I agree to the recording of the quantitative scores of the written test based on microscope work and graphing.

I have received a signed copy of the informed consent agreement.

Parent/Guardian Name & Surname………………………………………… (please print)

Parent/Guardian
Signature…………………………………………….Date…………………

Researcher's Name & Surname: Mandy Joy de Vries……………

Researcher's signature… Date…12 March 2019

APPENDIX D

Request for permission to conduct research at St Dominic's College High School, Welkom

THE EFFECTS OF POOR MATHEMATICAL SKILLS ON GRADE 10 LEARNERS' PERFORMANCE IN CERTAIN CONCEPTS IN LIFE SCIENCES – A CASE STUDY FOCUSSING SPECIFICALLY ON MICROSCOPE USAGE AND GRAPHING SKILLS

2 October 2018

Mr S. Gaffney

St Dominic's College High School, Welkom

057-352-3905: sgaffney@dominic.co.za

Dear Mr Gaffney

I, Mandy Joy de Vries, am doing research with Prof. Harrison Atagana, a professor in the Department of Mathematics, Science and Technology Education, towards an MSc in Life Sciences Education at the University of South Africa. We are inviting you to participate in a study entitled "THE EFFECTS OF POOR MATHEMATICAL SKILLS ON GRADE 10 LEARNERS' PERFORMANCE IN CERTAIN CONCEPTS IN LIFE SCIENCES – A CASE STUDY FOCUSSING SPECIFICALLY ON MICROSCOPE USAGE AND GRAPHING SKILLS".

The aim of the study is to indicate that poor mathematical skills amongst Grade 10 Life Sciences learners have a negative impact on their academic performance in areas of microscope skills and graphing which require the direct application of certain basic maths skills. It further hopes to identify and suggest strategies to improve the mathematical skills required by Grade 10 Life Sciences learners in order for them to achieve better academic performance in Life Sciences.

Your school has been selected because the researcher is familiar with the teaching and learning environment and your school actively promotes 21st Century teaching skills which are envisaged to be implemented to a greater degree if the hypothesis is shown to be valid.

The study will entail the Grade 10 Life Sciences learners of 2019 undertaking a written test which will assess both biological knowledge and mathematical skills in the field of microscope work and graphing. There will be a re-test to ensure the validity and reliability of the instrument used. The results of these tests will be compared to the maths marks achieved by learners at the end of grade 9 (2018). A correlation of results will be done using statistical analysis.

Due consideration will be given to ensure that the ethics involved in the research are maintained. Participants will be informed of all aspects of the research, they will voluntarily sign an agreement to participate in the research, and letters of parental consent will be obtained. The personal identity of the learners and individual learner scores will not be disclosed.

The benefits of this study are that the Life Sciences and Mathematics departments can develop teaching strategies to better integrate content in order for the Life Sciences learners to achieve better results in the areas of microscope work and graphing. It is hoped that with an improvement of maths skills, which account for 30% of the senior Life Sciences exam papers, that there will be a significant improvement on the life sciences marks in Grade 10 and subsequently, Grades 11 and 12.

The potential risks of harm in this study are very low. There is the potential for minor emotional discomfort or inconvenience, but this will not be in excess of that which is required on a normal daily basis in the school situation and these effects can be easily negated by the researcher.

The feedback procedure will entail the school being informed of the statistical analysis results which may indicate that the hypothesis is valid.

Yours sincerely

M.J. de Vries

Life Sciences Educator and Researcher