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An investigation into the impact of calculator usage on the mathematical skills of secondary school learners

by

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Declaration

I, the undersigned, declare that the dissertation, which I hereby submit for the degree Magister Scientiae at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

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Abstract

The aim of the study is to determine the extent to which secondary school learners are dependent on using calculators for performing basic calculations and operations. The purpose of the study is to obtain findings and conclusions that can be used to inform educators on the impact of learners' use of calculators on their possible tertiary studies. The study also aims to add to the body of knowledge regarding the use of calculators on secondary school level, in the South African situation in particular.

The study took place in Mpumalanga Province of South Africa. Three of the rural schools in Thulamahashe circuit of Bohlabela district namely Orhovelani High School, Bombani High School and Godide High School were selected to take part in the study. Grade 12 learners of these schools, a total of 183 learners, were involved in the study. A questionnaire was compiled from typical questions in Grade 8 to 10 school textbooks, chosen to cover a broad spectrum of basic calculations. These questions were arranged in ten categories of four questions each, later reduced to three questions each after the pilot study. The categories are: Addition and Subtraction, Multiplication, Fractions, Division, Mixed calculations, Square roots, Substitution, Exponents, Trigonometry, and Powers of Primes.

Two groups of learners were selected at each school, one group allowed to use calculators (Group WC) and the group (Group WO) not. The questionnaires were issued to both groups simultaneously during the afternoon study period at each school to avoid disturbance of the normal running of the schools. Data collected from the three schools were combined.

The analysis of the data is based on quantitative research methods. Student responses to the questionnaire are analysed quantitatively using standard statistical techniques. Results of the two groups are compared.

Results show that learners are dependent on calculators with respect to basic mathematical calculations, and particularly so in the categories of Fractions, Division, Square Roots, Exponents and Trigonometry. In the category of Addition and Subtraction and in the category of Multiplication traces of dependency is evident in calculations with larger numbers. Learners lack knowledge and skills in the categories of Exponents, Substitution and Powers of Primes. Even with calculators learners experience problems in the categories of Fractions, Substitution, Exponents and Powers of Primes.

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1.1 Background of the study

1.1.1. Introduction

This study offers an investigation into the impact that using of calculators has on the basic mathematical skills of school leaving secondary school learners. In this chapter the setting of the study is firstly presented, describing the environment in which the study was conducted, also giving a brief description of the grade 12 NSC requirements and the schooling system in general. This is followed by a general discussion of the use of calculators in schools to set the scene for the study. The problem statement is then given and the research question and sub questions are formulated. The purpose of the study is presented and the ethical considerations are discussed. The chapter concludes with a discussion on the limitations of the study.

1.1.2. Setting

South Africa consists of nine provinces. The province of Mpumalanga is situated towards the east of the country and has 545 registered schools across its cities and towns. Mpumalanga is divided into four districts namely Ehlanzeni, Nkangala, Gert Sibande and Bohlabela. Of the four districts, Bohlabela is third placed as per 2015 grade 12 final exams. Table 1.1 shows the statistics of the grade 12 pass rates for the past five years as well as the provincial averages.

Table 1.1: Grade 12 pass rates in the four Mpumalanga districts for the period 2011 - 2015

	Pass % 2011	**Pass % 2012**	**Pass % 2013**	**Pass % 2014**	**Pass % 2015**
Ehlanzeni	72.1	74	82.8	82.1	82.39
Nkangala	67.9	73	77.5	78.8	81.67
Bohlabela	**52.7**	**62.5**	**72**	**76.8**	**76.71**
Gert Sibande	65.4	69	76.4	77.1	72.62
Provincial Ave	64.8	70	77.6	79	78.63

Bohlabela district is further divided into smaller groups of school called circuits. Thulamahashe circuit, where this investigation was conducted, comprises of 11 schools. The numbers of learners and pass percentage of the schools in this circuit as of December 2015 for grade 12 are shown in Table 1.2.

Table 1.2: Grade 12 pass rates of schools in the Thulamahashe circuit

Position	Name of School	Number of learners	Pass % 2015
1	Nghunghunyana Secondary School	37	97.3
2	Magigwana Secondary School	203	95.1
3	Mafemani Nxumalo Secondary School	128	93.0
4	Mzimba Secondary School	51	92.2
5	**Bombani Senior secondary School**	**82**	**85.4**
6	Mahuvo Secondary School	56	80.4
7	Dumphies Combined School	57	77.2
8	**Orhovelani High School**	**403**	**75.9**
9	Eric Nxumalo High School	160	65.0
10	Malamule High School	81	64.2
11	**Godide High School**	**64**	**60.9**

The study took place in three of the rural schools in Thulamahashe circuit of Bohlabela district namely Orhovelani High School, Bombani High School and Godide High School and targeted grade 12 learners of this circuit, highlighted in Table 1.2.

Most learners come from a disadvataged background. These schools are situated in remote areas of South Africa where educators experience difficulties with large numbers of learners in a class and also a lack of qualified educators to teach mathematics. Villages and rural communities are difficult to reach and the physical conditions in schools are inadequate. Significant improvements in infrastructure have been observed since 1994, but many rural schools still lack clean running water, electricity, libraries and computers (Gardiner, 2008).

The requirements for the National Senior Certificate (NSC) are: A learner must take two official language subjects, provided that one of these is on Home language level. The other language subject may either be at Home or First Additional language level, provided that one of the two languages is a language of learning and teaching. A learner must take either Mathematics or Mathematics Literacy. Life Orientation is compulsory for every learner. In addition a minimum of any three other subjects must be taken. The

pass requirements for the grade 12 NCS are as follows: Obtain 40% in three subjects, one of which must be an official language at Home Language level. The other two can be any two subjects. Life Orientation must be passed with 40%. Obtain 30% in the other 3 subjects.

The first curriculum change after the 1994 political changes occurred in 1997, called Curriculum 2005 (C2005) and was revised in 2002 (Revised National Curriculum Statement, or RNCS). Given the challenging post-Apartheid conditions, as well as the short time for implementation, this was an impressive achievement of which South Africa's education system can be justly proud. Not only are all learners from grade R through to grade 12 now following the same national curriculum, but the "Class of 2008" was also the first to write the new National Senior Certificate examination (NSC). Amongst the goals of the NCS was to reduce the number of subjects, while making high cognitive demands on candidates. For example, mathematics (or mathematical literacy), as well as life orientation, became compulsory subjects for all (Chisholm, 2003).

The education system of South Africa has been revised again and in 2013 the National Curriculum Statement (NCS) has been revised to the Curriculum Assessment Policy Statement (CAPS), which has an increased emphasis on mathematics. Each and every learner is required to do mathematics from grade 4 to 9, after which a learner has an option to leave. Learners in grades 10 to 12 are required to do either Mathemetics or Mathematics literacy. Learners in South Africa start to use calculators as early as from grade 4 and use it up to grade 12. This has contributed to them possibly over relying on calculators to perform basic algebraic computations (The South African Schools Curriculum, 2012).

1.1.3. Use of calculators

In the foundation phase, that is from grade R to 3 primary learners are referred to as visual or physical learners. Having a bag of beans or counters and perhaps an abacus is the ideal. From grade R to grade 3 learners concentrate on the following three content areas without the use of calculators:

Patterns, functions and algebra: Here the learner will be able to recognise, describe and represent numbers and their relationships, and to count, estimate, calculate and check with competence and confidence answers in solving problems;

Space and Shape: Here the learner will be able to recognise, describe and represent patterns and relationships, as well as to solve problems using algebraic language and skills;

Measurements and Data Handling: Here the focus in the teaching and learning of data handling is on sorting objects and data in different ways, based on the different features of the objects.

Learners from grades 4 and 5 start to use the simple calculator and the Department of Basic Education recommends the use of the SHARP calculator among learners with all the basic keys namely plus, minus, percentages and square roots. Learners from grades 6 to 9 start to use calculators with more functions especially the one with two modes, which is Normal and Statistics. At this stage learners use calculators with direct algebraic logic (DAL) meaning that it follows the rule of BODMAS. This means they will deal with any calculations inside brackets first, then multiplication and division, then finishing with addition and subtraction. There is a fraction key, percentage key and a random function key. The statistical mode is used to find averages and standard deviations. Some advanced models of SHARP calculators used at this stage have Normal, Statistics, Drill and Table functionalities. Normal mode has new features such as the D1 - D4 keys which are short-cut keys for definable memory. It has a Write View screen, which means that you can type any calculation into the calculator as you see it in the textbook. It also has a random function, an easy to use percentage key, and a shortcut to find the hypotenuse of a right angled triangle. Drill mode allows the student to practice their basic maths calculations. There are two options in Drill mode: Math and Table. Math practices either addition, subtraction, multiplication, division or all four operations. Table mode practices a particular set of times tables in either serial order or randomly mixed. The calculator will mark each question and will give a total at the end of the question set as well the percentage of answers correct. Finally, Table mode allows the learner to put in an equation and the calculator gives back coordinate pairs which allows the student to draw a graph. Table mode can also be used to find factor pairs that are the common factors of any number in pairs. Because the table generated in this mode is unlimited students are able to access a wider range of values on the graph. From Grades 10 to 12 some extra functions used include an easy to use log button, permutations and combinations. Data stored in the statistics mode remains saved in the statistics mode so that students can access it at a later stage. All previous calculations are also stored so that if the calculator is switched off and then on again the calculation will still be on the screen. Previous calculations can be accessed by pressing the up arrow key. Some advanced models of SHARP calculators used at this stage have got six different modes: Normal, Statistics, Drill, Complex, Matrix, List and Equation. Complex mode is used to enter a quadratic or cubic equation and solve for its roots (Seartec Trading Pty Limited, 2012).

1.2 The problem statement

In South Africa learners start to use calculators in the classroom from grade 4. Most government schools, especially in the rural areas are provided with stationery by the department which includes the calculator. In general, learners are accustomed to using calculators in their schools. As these learners move to tertiary institutions such as university they are often not allowed to use a calculator and this poses a challenge to learners and may impede performance. This problem is mostly observed in students who want to advance their studies in mathematically related fields. Doing mathematics without a calculator could be a challenge for them. According to an article by the Eisenhower South West Consortium (1998), children should learn their basic facts, be able to do mental calculations, and master long division and other basic pen and paper algorithms. Mathematics is a field of study that builds on previously established concepts. A child who does not know basic multiplication (and division) will have a hard time learning factoring, primes, fraction simplification and other fraction operations, the distributive property, etc. Basic algorithms of arithmetic are a necessary basis for understanding the corresponding operations with polynomials in algebra. Mastering long division precedes understanding how fractions correspond to the repeating (non-terminating) decimals, which then paves the way to understanding irrational numbers and real numbers**.** It all connects together.

The question is whether learners are overly dependent on calculators at the cost of losing the ability to perform basic calculation without the use of calculators.

1.3 The Research question

In light of the problem statement above the main research question is formulated as follows:

To what extent are high school learners dependent on using calculators for performing basic calculations and operations?

The sub research questions are:

(1) In which of the categories of basic mathematics are students more dependent on calculators?

(2) What are the difficulties that students experience with/without calculators?

1.4 Purpose of the study

The aim of the study is to determine the extent to which learners are dependent on using calculators for performing basic calculations and operations. The purpose of the study is to obtain findings and conclusions that can be used to inform educators on the impact of learners' use of calculators on their tertiary studies. The study is also aims to add to the body of knowledge regarding the use of calculators on secondary school level, in the South African situation in particular.

1.5 Ethical considerations

To start this research I had to obtain permission from the principals of all the schools which would participate, and the Department of Education Mpumalanga. I managed to get permission from the three schools. The Department of Education has a section which deals with research so most of the principals advised me to get permission from the head office at Nelspruit. I drafted a project proposal and within a month's time the department agreed to my proposal.

1.6 Limitations of the study

The research was conducted in one of the under performing circuits in South Africa and was conducted in rural schools. If the study was conducted among different schools results may be different. Gender and age was not observed as we assumed all the learners behaved in the same way when using calculators. The research only concentrated on high school learners and did not cater for lower grades. The study is limited to the use of scientific calculators in mathematics only.

Chapter 2 Literature Review

2.1 Introduction

In my experience as a mathematics educator over an extended period, the use of calculators in the classroom is a somewhat problematic matter. On one hand you need your students to be familiar with the technology, and on the other hand you do not want your learners to rely too heavily on these devices. This is especially the case when calculators are used to perform basic operations that should be done by using skills fostered through comprehension and a measure of rote learning. With the arrival of calculators and various reform initiatives in the 1990s, more Mathematics educators began to introduce calculators in the classroom and to introduce and increase the emphasis on applications and problem-solving processes. Being freed of the labours of manual computation, it was expected that students would be able to focus on problem solving (Poe, Johnson, and Barkanic, 1992). When to use a calculator remains a problematic issue which educators must address to reap the most benefit. In trigonometry, especially in grades 11 and 12 some questions are labelled “without the use of a calculator”. Most learners in South Africa find dealing with trigonometry problems without the use of a calculator challenging.

2.2 Advantages of using a calculator

Some mathematical problems require lengthy and tedious calculations when solving and calculators could provide a speedy and accurate solution when used correctly. Muthomi, Mbugau and Okere (2011) in Meru Coutry, Kenya, found that when students use calculators they finish their work faster, it makes mathematics interesting and enjoyable, it encourages them to think and it motivates the learners. They concluded that in general the use of calculators results in better student attitude and thus enhance a learner’s mathematics self-concept which raises and maintains their motivation to learn.

Positives and negatives on the use of calculators in the 21st century have been discussed by researchers and it seems that there is no turning back on using calculators, especially in primary and secondary levels. Brumbaugh and Rock (2001) came to the conclusion that for mathematics to be relevant to pupils’ needs and social technological demands working harder on menial tasks should be replaced by working smarter. According to Pomerantz (1997), mathematics has grown substantially in the last fifty years, and the tools available to aid mathematics learning by students have changed dramatically.

Calculators are powerful learning tools that allow students to experience the richness and value of mathematics by greatly reducing the need to execute pen and paper computations and algebraic manipulations.

Pomerantz (1997) found in a study conducted in Dallas, Texas, that calculators allow students who would ordinarily be frustrated or bored by mathematical manipulation to have access to actual mathematics itself, thus gaining a higher level of mathematical understanding rather than giving up because of tedious calculations. Appropriate use of technology and the associated pedagogy will get more students thinking and reasoning mathematically.

According to Odhiambo and Toili (2013) the use of scientific calculators is considered significant in helping to get solutions to mathematical problems. The study was prompted by continual poor performance in mathematics in the Kenya Certificate of Secondary Education examinations. Their findings show that the use of a scientific calculator positively influences students' performance in mathematics.

Baggett & Enrenfeucht (1994) from the Michigan Midwest District, USA, found that providing learners with calculators and simply teaching them how to use them is not enough. The main role of calculators is that they allow teachers to give a large variety of interesting and challenging problems, and switch the stress from teaching the mere mechanics of computations to using mathematics as a tool in solving real life problems.

According to Roberts (1980) there seems to be little doubt about the computational value associated with calculator use. Sufficient pre-training enables one to work problems more accurately, rapidly and efficiently. Calculators allow one to complete more problems per unit of time, thus in effect affording greater amounts of practice. When the discussion shifts to higher level conceptual understanding as a result of calculator use, there is less consensus as to what facts can be gleaned from the research. To those who believe that calculators should be used in the schools, the question still remains as to when such aids should be introduced.

A study by Kastberg and Leatham (2005) shows that students with more access to calculators use a wider range of problem-solving approaches and tend to attempt more problems and then obtain higher test scores. Although developing more than one representation for a mathematical object can take a

substantial amount of time, effective use of graphing calculators allows quick and easy development of and translation between representations.

A study by Salani (2013), conducted at junior secondary schools in the Tutume sub-district in the Central Educational Region of Botswana, shows that teachers appreciate the use of technology as a tool that students could rely on. Moreover, many teachers believe that the use of calculators in testing procedures could produce higher achievement scores than paper and pencil efforts, both in basic operations and in problem solving.

An analysis by Grouws and Cebulla (2000). shows that students using calculators tend to have a better attitude towards mathematics and better self-concept in mathematics than their counterparts who did not use calculators. They also found that there was no loss in student ability to perform paper and pencil computation skills when calculators were used as part of mathematics instruction.

Miles (2008) observed that students who do use calculators perform better than those students who do not use calculators on solving basic mathematics equations in eighth grade, when solving simple life skill mathematical problems.

The findings of the study by Tajudin (2011) in Malacca, a Malaysian Secondary School indicate that graphic calculator instruction enhanced students' performance and induced better levels of their cognitive awareness with less mental effort invested during learning and test phases. The study also showed that a graphic calculator strategy is instructionally more efficient and thus is superior to a conventional instruction strategy.

According to Miles (2008) a student may not need to learn certain fundamental operations and methods because the calculator will complete these calculations itself. Instead of memorizing multiplication tables for instant recall, a student can simply enter an expression into the calculator and he/she will obtain the correct answer. However, it is unlikely that these students will carry a calculator with them at all times of their lives. It is inevitable that at some point, these students will need to be able to perform mathematical operations without the use of the calculator and may be unable to do so.

2.3 Disadvantages of using a calculator

Educators in many countries do not believe that the calculator is beneficial for students for they see the dangers such as that the regular use will result in weakening of basic facts and pen and paper algorithm for computation. Use at an early age may hinder development of number concept, students will become calculator dependant, students will become more likely to accept incorrect answers from the calculator and if students use the calculator they will not learn to think (Suydam, 1980).

A study by Sneed (2014) shows that the number of students who pick up a calculator to find the answer to a multiplication problem, a skill that they should have mastered in elementary or middle school, is noticeable. The researcher himself was often required to do calculations without the use of the calculator in tests and quizzes. He always viewed a calculator as a convenience available for computational checking, complex operations (such as working with logarithms), or occasionally speeding up the process of tedious calculations. The researcher once told the students that a unit was coming up in which they would not be allowed to use their calculators to perform some of the computations. A student responded right then that her parent would be contacting the administration of the school about this arrangement.

According to Roberts (1980) educators have argued that teaching machines would merely reinforce rote memory associations rather than encourage students to solve problems creatively. While calculator use is widespread, the debate continues as to what performance and psychological benefits may accrue due to calculator utilisation.

Zheng (1992) argues that using calculators in learning mathematics may have negative effects if they are used inappropriately. Students may lack conceptual understanding and sometimes calculators deliver misleading information. Differences from conventional notation and notation used with calculators may confuse students. The negative impact of using calculators, especially graphing calculators, is very real, because calculator responses are generally numerical in nature, and students may not acquire solid conceptual understanding. Students' view of mathematics will probably be more procedural and accordingly their problem solving skills may be limited. The development of their structural view about mathematics could also be hindered. Moreover, because of its design, a calculator may deliver misleading information and create confusion in learning notation.

The study by Salani (2013) at junior secondary schools in the Tutume Sub-district in the Central Educational Region of Botswana reveals that most of the teachers expressed their lack of confidence and were incompetent in the use of a calculator in their teaching, with female teachers feeling less confident to explain the different functions of a calculator than their male counterparts. In addition, the study showed that most of the teachers believed that a calculator was a technological tool that could be useful to the students in the future. On the contrary, most teachers felt that the overuse of calculators by students could hamper the development of basic computational skills.

The data compiled by Kasnic (1977) indicate that the use of a calculator in their pilot study did not lead to improved problem solving ability among low ability problem solvers. Performance of high ability students remained high when using calculators and performance of low ability learners remained low.

Miles (2008) discovered that students do rely on calculator to do the most simple of mathematics computation; furthermore the same students do not know if the calculator derived answer is correct.

Matio (2009) found that although number handling is learnt by pen and paper at the elementary level in Finland, many students later completely forget this skill because they have got used to calculators. This does not concern so much the best 15-20% of the students, as results show in the matriculation examinations. Matio highlighted that professional users of mathematics hardly ever use them. Hence the time spent with calculators does not follow the idea that the skills obtained at school should have some practical value later.

2.4 Pitfalls of using calculators

Knowing when and how to use a calculator is an important skill. Trying to carry out complex calculations without a calculator frequently introduces numerical errors, as well as incurring a self-imposed and often excessive time penalty. However, learners need also to understand that if they are using a calculator they still must write down their working, otherwise the issue of 'one error, no marks' comes in if all they record in the answer box is the final number in their calculator (Learning Wales Publication, 2006).

Educators must not think the solution to their problems is to hand students a calculator and teach them to push buttons (Sneed 2014). Educators must be responsible enough for students' long term

betterment to require them to develop and use basic skills in an efficient and accurate manner, so that they can use that basic skill development as they move forward in their mathematics careers, where the task becomes more complex and more difficult. When students do not learn how to develop and master the basic skill sets, they are far less capable of developing and mastering more advanced skills sets. Then they will never know just how much they might have been able to achieve.

You must be able to use a calculator with confidence. It is assumed that you can carry out simple, single operations such as adding, multiplication, finding a square root and so on, but there are a number of pitfalls for the unwary if you have to carry out a sequence of operations, according to Lambert (1993). He observed that every calculator has a set of rules for which order to do some calculations, and it might not be doing calculations in the same order as you think you are instructing it. Most calculators follow the 'BODMAS' rule. If your calculator does not follow the BODMAS rule, then you must refer to your calculator handbook to see how to do these calculations.

According to Ellington (2006) there were no circumstances under which the students taught without calculators performed better than the students with access to calculator. However she observed that students receive the most benefit from graphing calculators when they have access to them during both aspects of the learning process. She recommended that teachers should decide what the role of the calculator will be in assessment when deciding when and how to use them in instruction.

2.5 Appropriate use of calculator

Appropriate use of calculators could be a way of increasing the amount and the quality of learning offered to students during the course of their mathematics education, according to Pomerantz (1997). He suggests that when used appropriately calculators enhance learning and thinking, they do not replace it. Calculators can be incorporated into curricula from kindergarten through to the university level.

Learners receive the most benefit when calculators have a pedagogical role in the classroom according to Ellington (2006). His analysis found that students in a classroom where calculators are used strategically to support and advance learning performed at a higher level on measures of operational and problem solving skills compared with students in classrooms without such calculator use.

Green (2011) mentions areas that impact positively on calculators, namely working with large numbers and working with real data. He goes on to conclude that calculators may be an appropriate tool for dealing with otherwise complicated and tedious calculations. Calculators may be used as a labour saving device allowing children to manipulate data generated in other subjects.The calculator is a tool to do calculations. So are the human mind and pen and paper. Children should be taught when to use a calculator and when mental computing (or even pen and paper) are more effective or appropriate. Choosing the right 'tool' is part of an effective problem-solving process. It is important that students learn how to estimate the result before doing the calculation. It is so easy to make mistakes when punching the numbers into a calculator. A student must not learn to rely on the calculator without checking that the answer is reasonable. A calculator should not be used to try out randomly all possible operations and to check which one produces the right answer. It is crucial that students learn and understand the different mathematical operations so they know when to use which one — and this is true whether the actual calculation is done mentally, on paper, or with a calculator.

Another appropriate way of using the calculator is through an Observe- Predict- Surpass sequence, according to Ruthven (2009). He gave an example: Suppose we wish to move pupils on from the inefficient and unreliable process of using counting on as a method of adding 10 to a number. First pupils analyse what happens when they use the calculator to add to different numbers, they then predict the results of machine calculations and finally they try to surpass the calculator, through developing sufficient speed and accuracy in the curtailed mental strategy to be able to beat someone using the machine. Ruthven (2009) also describes Result- Checking as using a calculator to review a calculation which has already been carried out. Where the calculation has been done mentally, the calculator provides a means by which a pupil can gain rapid feedback, on the direct result, but also indirectly on their mental strategy. Secondly, where a calculation has been executed on the calculator, there are important alternatives to simply repeating the same calculation. One is to reverse the calculation, working back from the result to the original data for example when a multiplication has been carried out, applying the inverse division. Another alternative is to reformulate the calculation, for example repeated addition as multiplication.

Calculators are widely used at home and in the workplace. Appropriate use of calculators in school will ensure that students' experiences in mathematics will match the realities of everyday life, develop their reasoning skills, and promote the understanding and application of mathematics. It is necessary for success in mathematics for students to master the number facts and pen and paper computation appropriate for their grade level. Students must also be proficient in mental math and estimation skills. Instruction with calculators will extend the understanding of mathematics and will allow all students

access to rich, problem-solving experiences. This instruction must develop students' ability to know how and when to use a calculator. Skill in estimation and the ability to decide if the solution to a problem is reasonable are essential adjuncts to the effective use of the calculator.

The National Council of Teachers of Mathematics (2000) recommends that all students use calculators to focus on problem-solving processes, perform the tedious computations that often develop when working with real data in problem situations, gain access to mathematical ideas and experiences that go beyond those levels limited by traditional pen and paper computation. The council also explored and experimented with mathematical ideas such as patterns, numerical and algebraic properties, and functions that reinforce skills such as estimation, computation, graphing and analysing data. Research and experience have clearly demonstrated the potential of calculators to enhance students' learning in mathematics. The cognitive gain in number sense, conceptual development, and visualization can empower and motivate students to engage in true mathematical problem solving at a level previously denied to all but the most talented.

2.6 Calculator dependency

Two decades ago Bradley, Kissane and Kemp (1996) warned of a dilemma that calculator use presents to learning with respect to dependency. Should calculators be used in courses for learning, students would not regard them as important because they are not integrated into assessment. But if calculators are integrated into learning as well as assessment there is the danger of learners becoming calculator dependent.

Wade (2002) warns about the danger that the use of ICT (Information Communication Technology) holds for developing communities. Technology cannot leapfrog the development of basic skills. Using calculators does not substitute learning of basic mathematical skills. He uses the analogy that giving illiterate people cheap books does not solve the problem of illiteracy.

Brunette (n. d.) states that calculators can create problems for students when the calculator becomes a crutch. Students become dependent on their calculators and have difficulty doing mathematics problems when they don't have a calculator available. Teachers have noticed that because of calculator dependency students tend not to simplify problems. Instead, students leave as much work as possible for the calculator. This means that the natural intuition gained when students simplify their work to make the problem easier to solve by hand is lost. These simplifying skills learned through practice in the lower grades are no longer being carried through by the student into college level math. This makes

math more challenging for students later on because they do not possess the natural intuition and skills needed to approach a hard symbolic problem and simplify.

Roper (2014) lists calculator dependency as a potential negative consequence of using calculators in mathematics classrooms. He mentions cases of high school learners reaching for a calculator when having to divide six by three or multiply one by zero. In some schools calculators are not allowed for learners in middle school but that is not necessarily the solution. Teachers must design lessons that find a balance of dependence and avoidance of calculators.

Not everyone agrees that students become overly dependent on calculators. Pomerantz (1997) lists a number of myths of which one is that people will become so dependent on calculators that they will be rendered helpless without one. She states that the thought process required for doing mathematics can never be replaced by using a calculators. It is important that mental calculations as well as estimation and some paper work skills continue to be taught in schools, and appropriate methods for solving problems. Such skills are necessary in the mathematical process.

Karpie (2013) explores students' dependency on calculators particularly with exponents in an introductory college mathematics classroom. Two groups of students were given an assessment twice, once with and once without access to a calculator; the order of calculator access was changed with the groups. The finding is that students performed better with access to the calculator, but not significantly better.

Sneed (2014) conducted a study amongst secondary school learners in the USA to investigate the extent to which high school students use calculators to perform basic operations, and how well they actually perform those same operations without using calculators. He concludes that that availability of calculators is the prime reason for students using calculators. When students don't have a calculator available, they often think they don't need them, but when one is available they use it heavily.

Chapter 3 Methodology

3.1 Introduction

In this chapter I discuss the research methodology. I discuss the research design, process of school selection, design of the questionnaire issued to the learners, collection of the data and what data analysis techniques were used.

3.2 Research design

The study is based on quantitative research methods. Student responses to a questionnaire are analysed quantitatively using standard statistical techniques such as: Averages, frequency distributions, t-tests etc.

3.3 Designing the questionnaire

The first step was to design a questionnaire for determining the impact of the use of calculators on learners' ability to do mathematics.

Questions were obtained from Grade 8 to 10 school textbooks and were chosen to cover a broad spectrum of calculations. These questions were arranged in ten categories of four questions each, later reduced to three questions each after the pilot study. The categories cover basic calculations across a number of areas in mathematics, namely: A. Addition and subtraction, B. Multiplication, C. Fractions, D. Division, E. Mixed calculations, F. Square roots, G. Substitution, H. Exponents, I. Trigonometry and J. Powers of primes.

I first designed two questionnaires with similar questions per each category for two groups, one group responding to the questionnaire without using a calculator (WO) and the other group with using a calculator (WC). The two questionnaires were used in the pilot study and were then reduced to one questionnaire.

3.5 Pilot study

After designing the questionnaire it had to be piloted. The learners involved were grade 12 learners at Orhovelani High School. I used the science class which had 40 learners and these learners where not involved in the final study. The pilot study took two consecutive days and I used the first day to test the learners without the use of a calculator and the next day with the use of a calculator. In this pilot study I discovered that some on the learners felt that there were too many questions for the time and left without answering some of the questions. I also discovered that in the category on substitution almost none of the learners answered the question because they did not understand what had to be done. I decided to put an example at the start of the category. The same problem occurred for the category of Powers of primes and we again provided an example. After the pilot study I decided to use only one questionnaire and to reduce the number of question from 40 to 30 because the questionnaire proved to be too lengthy. Each of these categories initially consisted of four questions, which were reduced to three questions after the pilot study. The number of learners involved was 20 and the pilot study was conducted on 15 September 2015 with calculators while on 16 September 2015 the pilot was conducted without calculators.

3.4 Data collection

I chose to focus on the Thulamahashe circuit in the Bohlabela district of Mpumalanga for purposes of convenience. This is the area where I stay and it was easy for me to go around collecting data. One of the schools involved is where I work. I am familiar with the schools in this circuit and therefor was comfortable in approaching the principals for permission to do data collection there (Appendix B). The data was collected from three schools in the Thulamahashe circuit. I asked permission from all the schools in the Thulamahashe Circuit. Only three schools responded and these are namely Bombani Senior Secondary School (School A), Orhovelani High School (School B) and Godide High School (School C). I had to arrange an appointment with the principals of these schools for obtaining permission to conducting the research. The questionnaires were issued to learners during the afternoon study periods at each of the schools to avoid the disturbance of the normal running of the school. I was assisted by the teacher in charge of mathematics at each of these schools. Table 3.1 shows the statistics of the data collected. The time allocated was 30 minutes and most of the learners completed before 20 minutes. I used simple random selection to choose which learners to use or not to use the calculator.

Table 3.1: The distribution of learners in both groups WO and WC per school

Name of School	With Calculator	Without Calculator	Total
A	30	31	61
B	35	36	71
C	25	26	51

The sample at School A consists of 61 learners of which 30 learners were allowed to use calculators for responding to the appropriate questionnaire (Group WC) and 31 learners were not allowed to use a calculator (Group WO). Learners are provided with calculators by the Department of Basic Education when they are in Grade 10. By the time they reached Grade 12 many of they would have lost this instrument in some way or the instrument will be damaged. I then had to provide them with a calculator. The selection of the two groups was random. The questionnaire was administered on the 20 October 2015. The learners from this school are of mixed background, that is some come from the poor background where some leaners could not afford to buy one in the case when it is lost or damaged. At this school only one grade 12 class does Mathematics and the school had a total enrolment of 550 in 2015.

School B is one of the prominent schools in the district of Bohlabela and was chosen to be a Mathematics, Science and Technology (MST) School since 2014 starting at Grade 8, meaning that Mathematics and Physical Science is compulsory for every learner. The questionnaire was administered on 23 October 2015. The school enrolment currently stands at 1300 learners. There are four Grade 12 classes of which I chose one randomly. Most of the learners are average students and they usually perform well in all subjects but not necessarily in Mathematics and Science. A total of 71 learners participated where 35 used calculators and 36 did not. We used the same technique of random selection to divide the learners into the two groups. The third school involved in the survey was School C. The questionnaire was administered on 9 October 2015. The total enrolment of the school currently stands at 850. This school is situated again in the deep rural areas of Thulamahashe. The learners from this school are again of mixed background, that is some come from an underprivileged background

where some leaners could not afford to buy a calculator in the case when it was lost or damaged and then I had to provide one. We also used random selection to divide learners into two groups. A total of 51 learners from this school participated of which 25 used calculators whilst 26 did not.

In all three instances the two groups responded to the questionnaire at the same time.

The collected data was analysed with the assistance of Dr Lizelle Fletcher of the Department of Statistics at the University of Pretoria. For every category and each of the three questions in the category the average performances of Group WC and of Group WO were calculated. A t-tests was performed to determine if the differences in average performances between the two groups were significant. In addition a frequency distribution of responses to the questions was calculated, both for Group WC and Group WO. The frequency distributions are shown as bar charts as well.

Chapter 4 Results

4.1 Introduction

In this chapter I show the outcomes of the questionnaires for both the groups WC and WO. Bar graphs are used to give a pictorial view on the overall performance in each category. Tables are used to compare the performance per question for the groups WC and WO. I then discuss findings per each category.

4.2 Evaluation of Category A: ADDITION and SUBTRACTION (Questions 1 to 3)

The questions in this category are:

1. $17 + 25 = [\ ]$ 2. $35 - 16 = [\ ]$ 3. $812 - 79 = [\ ]$

The questions involve addition and subtraction, ranging from two digit calculations to three digit calculations. The questions increase in order of difficulty from the first to the third. The first question involves addition and the second subtraction, which could be considered as more difficult than addition and the third question involves three digit calculations as well as subtraction, which could be considered as even more difficult. Average performances (as a percentage) for the group with calculators (WC) and the group without calculators (WO) are given in Table 4.1. The questions were marked as right or wrong and a student thus scored either 1 or 0. The performance figures could therefore also be interpreted as the percentage of students who had the correct answer. This applies to all questions in the questionnaire.

Table 4.1: Average performance in Questions 1 – 3 for the two groups.

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
1.	0.98	0.95	1.117	0.266
2.	0.99	0.81	4.276	0.000
3.	0.94	0.84	2.330	0.021
Total	2.91	2.59	4.155	0.000

A t-test was performed on the results of every question to determine whether there is a difference in the average performance of Group WC and Group WO. Results indicate that the hypothesis that there is no difference between the average performances of Groups WC and Group WO in Question 1 cannot be rejected. Yet the t-test does indicate that there are statistically verified differences in the average performances of Group WC and Group WO in Questions 2 and 3.

The results indicate that for Category A: Addition and Subtraction the performance of students with calculators exceeds the performance of students without calculators in all questions. The differences increase as the difficulty of the questions increases. For three digit calculations the percentage of students who could perform the calculation without a calculator compared to those who used a calculator dropped by 10% (from 94% to 84%).

The three questions in this category are grouped together to get a performance mark for the category as a whole. The average performance of Group WC is 2.91 (out of a possible 3) compared to the average performance of Group WO of 2.59. Again the difference in averages is statistically verified by a t–test.

Figure 4.1 shows the marks distribution of Group WC and Figure 4.2 shows the marks distribution of Group WO. Figure 4.1 and Table 4.2 show that 5 of the students of Group WC had one of the answers wrong (5 of 90, 5.5%), despite using a calculator. One of the students did not have a single answer right, even though having access to a calculator.

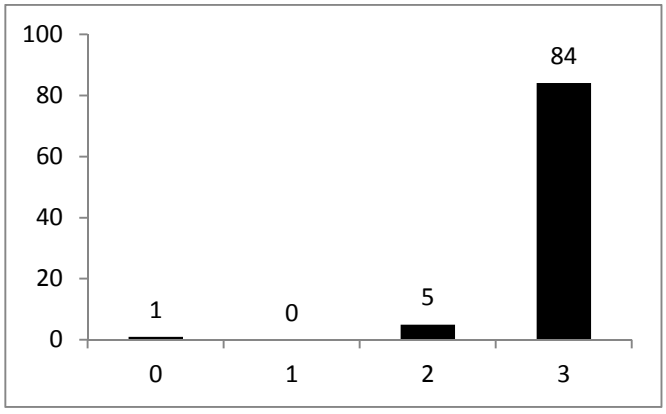

Figure 4.1: Marks distribution in Category A: Addition and Subtraction for Group WC

Table 4.2: Performance in Category A: Addition and Subtraction for Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	1	1.1	1.1
	2	5	5.6	6.7
	3	84	93.3	100.0
	Total	90	100.0	

Figure 4.2 and Table 4.3 show that there are seven students (7 out of 93, 7.5%) who could only do one of the three calculations correctly without a calculator and 24 (25.5%) who had one of the questions wrong. A total of 62 (66.7%) had all the questions right, without using a calculator.

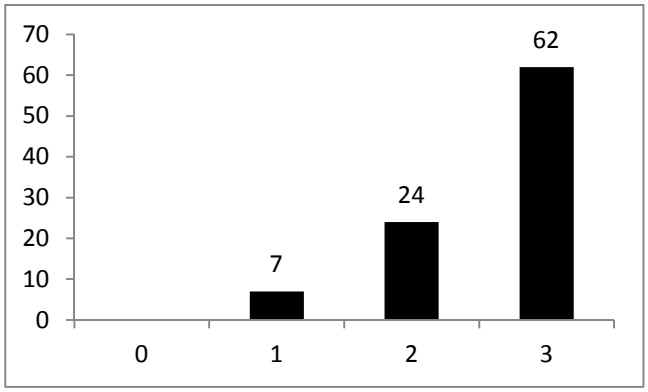

Figure 4.2: Marks distribution in Category A: Addition and Subtraction for Group WO

Table 4.3: Performance in Category A: Addition and Subtraction for Group WO

	Frequency	Percentage	Cumulative Percentage
1	7	7.5	7.5
2	24	25.8	33.3
3	62	66.7	100.0
Total	93	100.0	

Discussion: Addition and subtraction proved to be reasonably simple for both the group WC and WO. The only concern is that there is a learner who did not manage to get anything correct in the group WC. The performance overall of the group WC was higher than those in the group WO. The results show that students do not benefit greatly through using calculators for addition and subtraction and that dependency on calculators is not evident.

4.3 Evaluation Category B: MULTIPLICATION (Questions 4 to 6)

The questions in this category are:

4. $7 \times 9 = [\ ]$ **5.** $13 \times 9 = [\ ]$ **6.** $37 \times 51 = [\ ]$

In this category the questions involved multiplication. The range of the questions includes from one digit to 2 digit problems. In the first question there was a one digit by one digit multiplication. The second question involves a two by one digit calculation while the last one involves a two digit by two digit multiplication. The level of difficult increased per question. The performance of the learners is described in Table 4.4.

Table 4.4: Average performance in Questions 4 – 6 for the two groups.

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
4.	0.96	0.85	2.455	0.015
5.	0.96	0.81	3.039	0.003
6.	0.98	0.66	6.159	0.000
Total	2.89	2.32	5.189	0.000

Table 4.4 shows the results of the t-test performed on the results of the three questions, both for the groups WC and WO, in order to establish if there is a difference in performance in these two groups per question. Looking at the t-test values for all three questions, all the sigma (2 tailed) values are less than

0.05 and this shows that there are statistically verified differences in the average performance of Group WC and Group WO in questions 4, 5 and 6.

Results show that in the category of Multiplication, the learners using calculators perform better than those without using a calculator. As we move from one by one digit multiplication to two by two digits the performance of those without using calculators drop from 85% in question 4 to 66 % in question 6. Question 6 proved to more difficult to those without using a calculator, which is expected but actually is the opposite to those using a calculator as they scored the highest percentage of 98% in this category.

The total score for the three questions were also observed. The group with calculators managed to obtain 2.89 of the possible 3 and the group without calculators obtained 2.32. Again the difference in total averages is statistically verified. Learners performed better when using this instrument.

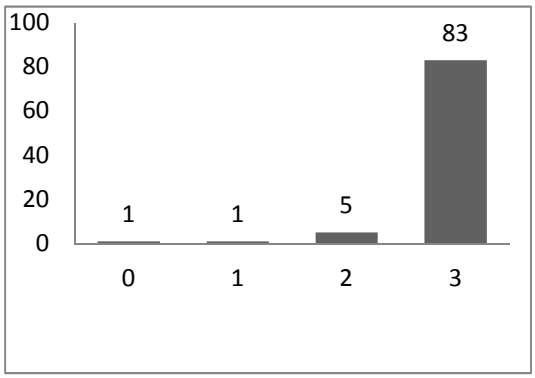

Figure 4.3: Marks distribution in Category B: Multiplication for Group WC.

Table 4.5: Performance in Category B: Multiplication for Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	1	1.1	1.1
	1	1	1.1	2.2
	2	5	5.5	7.7
	3	83	92.2	100.0
	Total	93	100	

Figure 4.3 and Table 4.5 represent the marks distribution in the Group WC. Only one leaner in Group WC did not manage to get a correct answer of multiplying a one by one digit question despite using a calculator and 92.2% managed to get everything correct.

Table 4.6 shows that 62.4% of learners managed to get everything correct for the Group WO, which is almost 30% less than that in the group WC. Of the group WO just over 20% of learners only had one question right and 5.3% had no answer correct.

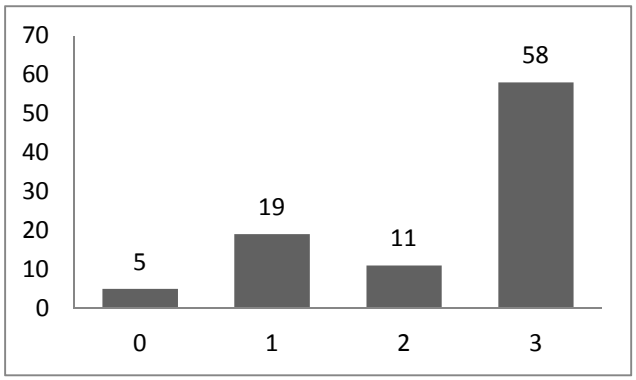

Figure 4.4: Marks distribution in Category B: Multiplication Group WO

Table 4.6: Performance in Category A: Addition and Subtraction for Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	5	5.3	5.3
	1	19	20.4	25.7
	2	11	11.8	37.5
	3	58	62.4	100.0
	Total	93	100.0	

Discussion: These results show that learners are proficient in multiplication of single digits with or without the use of a calculator. More than 85% in both the groups had the first question correct which involve multiplying single digits. As we move on to the second question the performance started to change as those with calculator maintained their performance, while for those in the group WO the

performance started to decrease. As we move to a multiplication of a two digit number by another two digit number the difference in performance starts to increase greatly. Although calculators do not offer a general advantage to learners when multiplying single digit numbers it definitely does so for multiplying double digit numbers.

4.4 Evaluation Category C: FRACTIONS (Question 7 to 9)

The questions in this category are:

7. $\frac{1}{2}+\frac{1}{4}=[\ ]$ **8.** $\frac{\frac{1}{10}}{2}=[\ ]$ **9.** $\frac{1}{5}+\frac{1}{5}=[\ ]$

In this category the questions involve addition and division of fractions. Questions 7 and 9 involve addition of fractions and question 8 involves division of a proper fraction by a single digit. The average performance for both groups WO and WC are summarised in Table 4.7.

Table 4.7: Average performance for Questions 7-9 for Groups WO and WC

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
7.	0.76	0.19	9.694	0.000
8.	0.52	0.20	4.703	0.000
9.	0.78	0.17	10.269	0.000
Total	2.08	0.57	10.484	0.000

To determine whether there is difference in average performance between the performance of Group WC and Group WO a t-test was performed. All the Sigma (2 tailed) values were below 0.05 which indicates that there is a statistically significant difference in all three average performances. Question 8 appears to be a difficult question even to the group using calculators as they have an average performance of 52%, with the group without calculators only scoring 20%. Even with calculators, little more than half of the students could do the calculation correctly. For question 9 more than 75% of

students using calculators could perform the calculations correctly compared to less than 20% of the group without calculators.

When the three questions are grouped together, it is very clear that learners in the Group WC performed considerably better that than those in the Group WO, although the general performance in the group WC is not strong. The group WC had 2.08 of the possible 3 (69%) and the group WO had 0.57 of the possible 3 (19%). The t-test verified that the difference in average performance is statistically significant.

Figure 4.5 shows the distribution of marks for the Group WC and Table 4.8 shows the mark performance on each question in the Group WC. A total of 14.4 % of the group with calculators did not manage to get any answer correct and only 46% had everything correct.

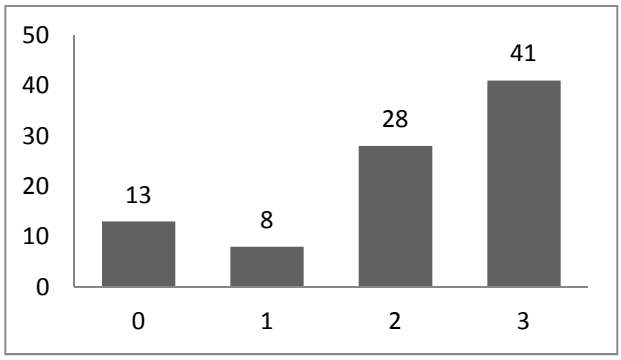

Figure 4.5: Marks distribution in Category C: Fractions Group WC

Table 4.8: Performance in Category C: Fractions Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	13	14.4	14.4
	1	8	8.8	23.2
	2	28	31.1	54.6
	3	41	45.6	100.0
	Total	90	100.0	

Figure 4.6 shows the distribution of marks for the Group WO and Table 4.9 shows the mark performance on each question in the Group W0.

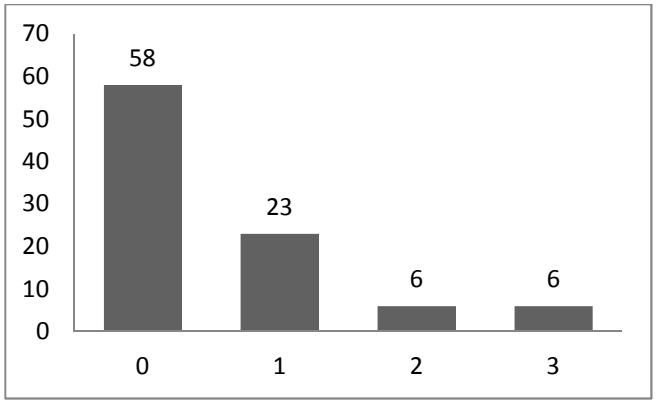

Figure 4.6: Marks distribution in Category C: Fractions Group WO

Table 4.9: Performance in Category C: Fractions Group WO

		Frequency	Percentage	Cumulative Percentage
Valid	0	58	62.3	62.3
	1	23	24.7	87
	2	6	6.4	93
	3	6	6.4	100.0
	Total	93	100.0	

For the group WO 62% of the learners did not get any answer correct (58 out of 93). Only 6 learners out of 93 had all the answers correct, that is 6.4 %. A percentage of 12.8 % managed to get two or more questions correct in this category.

Discussion: This category proved to be a severe challenge to the learners in the group WO. It is clear that learners have a problem in performing basic fraction calculations. Although the performance of the Group WC was much better than that of Group WO, one would have expected learners in group WC to perform better. A calculator which has a function of division should have assisted leaners in the group WC although most of the leaners failed to answer the second question which needed some special knowledge of the use of a calculator. It is disconcerting that such a large percentage (62.3%) of learners could not perform fraction calculations at all without a calculator. Dependency on calculators is evident.

4.5 Evaluation Category D: DIVISION (Questions 10 to 12)

The questions in this category are:

10. $-75 \div (-15)$ **11.** $\frac{72}{8} = [\ ]$ **12.** $\frac{306}{17} = [\ ]$

The questions in this category involves division. The first question is to divide two negative two digit numbers. The second question involves a simple division problem written in the form of numerator and denominator of a two digit value in the numerator with a one digit value in the denominator which is its factor. The last question involve division of a three digit number as the numerator by a two digit number as the denominator. Long division is required if a calculator is not used. The denominator is a factor of the numerator. The results are given in the table below.

Table 4.10: Average performances for Questions 10-12 for Groups WO and WC

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
10.	0.83	0.43	6.204	0.000
11.	0.97	0.71	5.038	0.000
12.	0.96	0.54	7.412	0.000
Total	2.39	1.41	7.595	0.000

A t-test was performed to see whether there is a significant difference in the average performance of learners in the two groups WO and WC. The results indicate that there is a significant difference in the average performance of learners in the two groups in all the questions.

In the division category students in group WC performed better than the group WO. In the group WC 83% managed to answer the first question correctly. More than 96% of the leaners in this group managed to get the second and third question correct. For the group WO 71% of the leaners had the second question correct and 43% and 54% had the first and third questions correct, respectively.

When the results of the three questions are combined, group WC obtained 2.39 of the possible 3 (80%) and the group WO obtained 1.41 of the possible 3 (47%). A t-test verified that the difference in averages is significant.

Figure 4.7 and Table 4.11 below show the marks distribution of group WC. A total of 46.7 % (42 out of 90) managed to get all the 3 questions correct and 2.2% did not manage to get anything correct even when using a calculator.

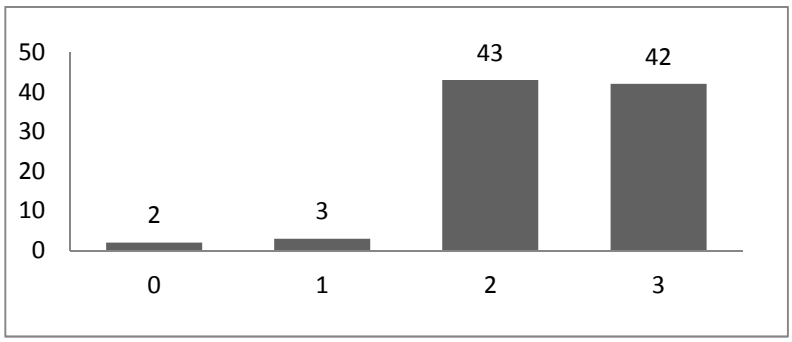

Figure 4.7: Marks distribution in Category D: Division Group WC

Table 4.11: Performance in Category D: Division Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	2	2.2	2.2
	1	3	3.3	5.5
	2	43	47.8	53.3
	3	42	46.7	100.0
	Total	90	100.0	

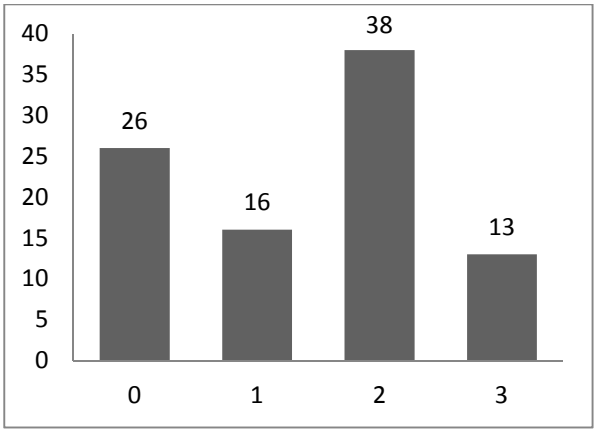

Figure 4.8 Marks distribution in Category D: Division Group WO

Table 4.12: Performance in Category D: Division Group WO

		Frequency	Percentage	Cumulative Percentage
Valid	0	26	28	28.
	1	16	17.2	45.2
	2	38	40.9	86.1
	3	13	13.9	100.0
	Total	93	100.0	

Figure 4.8 and Table 4.12 show the marks distribution of the Group WO. Only 13 learners (13.9%) managed to get everything correct. For this group 28% did not get anything correct while 40.9 % managed to get two of the three questions correct which is close to the 47.7 % of group WC who had two questions correct. Almost half of the learners (45.2 %) in this group (WO) managed to get at most one question correct.

Discussion: Division questions seem to be easy for learners when using calculators. In the calculator the function of numerator and denominator is readily available and a learner just need to enter the values and the calculator does the job, especially for the second and third questions. The first question involves negative values. Most leaners are reluctant to work with negative values and so some leaners may have punched the values in wrongly explaining why the performance was 14% less than for the second and third question.

Doing division without a calculator appears to be problematic. The average score over the three questions is considerably lower for the group WO (1.41) compared to group WC (2.39). Learners are in

general not competent in performing division calculations without a calculator and dependency on calculators is indicated.

4.6 Evaluation Category E: MIXED CALCULATIONS (Questions 13 to 15)

The questions in this category are:

13. $\frac{\frac{1}{3}+\frac{1}{5}}{2}=[\ ]$ **14.** $\frac{1}{2}\div 5=[\ ]$ **15.** $-\frac{6}{7}+3=[\ ]$

This set consists of mixed questions involving addition, subtraction and division of whole numbers, and fractions. The first question involves addition of two fractions and division by an integer. The second question involves division of a fraction and an integer and the last question involves addition of a fraction and an integer. The average performances for these questions are given in table 4.13.

Table 4.13: Average performance for Question 13-15

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
13.	0.83	0.43	6.204	0.000
14.	0.83	0.40	6.748	0.000
15.	0.70	0.18	8.195	0.000
Total	2.37	1.01	8.794	0.000

The t-test results indicate that there is a statistically significant difference in average performance of learners in the groups WC and WO for all three questions. For questions 13 and 14 around twice as many learners of Group WC could perform the calculations correctly than of Group WO. For question 15 only 18% of learners of Group WO could perform the calculation correctly compared to 70% of group WC.

When combining the three questions in this category we can see the average performance of group WC is 2.37 out of 3 (79%) compared to 1.01 (34%) for group WO. Again the difference in averages is statistically verified by the t-test.

Figure 4.9 and Table 4.14 show the marks distribution of the group WC and Figure 4.10 and Table 4.15 show the mark distribution of the group WO. For group WC 61.1% of the learners managed to get everything correct and 8.9% did not manage to get anything correct even though having access to a calculator.

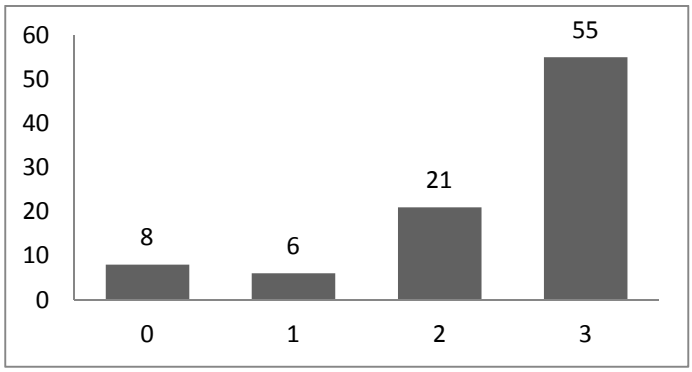

Figure 4.9: Marks distribution in Category E: Mixed Questions Group WC

Table 4.14: Performance in Category E: Mixed Questions WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	8	8.9	8.9
	1	6	6.6	15.5
	2	21	23.3	38.8
	3	55	61.1	100.0
	Total	90	100.0	

Figure 4.10 and Table 4.15 show that only 15% of learner's (14 of 93) of group WO managed to get all three questions correct. From this group 47.3% learners (44 out of 93) did not manage to get any question correct.

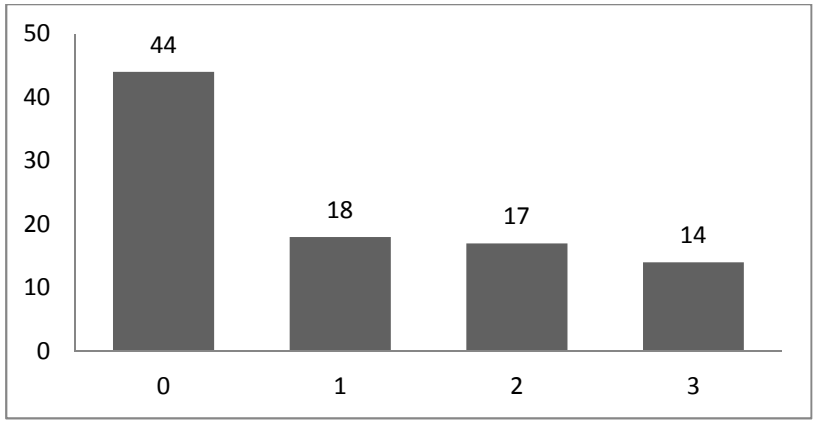

Figure 4.10: Marks distribution in Category E: Mixed Questions Group WO

Table 4.15: Performance in Category E: Mixed Questions WO

		Frequency	Percentage	Cumulative Percentage
Valid	0	44	47.3	47.3
	1	18	19.4	66.7
	2	17	18.3	85
	3	14	15.0	100.0
	Total	93	100.0	

Discussion: The results of this category are disconcerting. Of particular concern are the results of Question 15 that involve subtraction of an integer and a fraction. The fact that only 18% of learners could perform this basic calculation without the aid of a calculator indicates a lack of basic skills. The low performance figures in the other two questions support this finding. In this category where calculations with fractions are tested a dependency on calculators is evident.

4.7 Evaluation Category F: SQUARE ROOTS (Questions 16 to 18)

The questions in this category are:

16. $\sqrt{81} = [\ ]$ **17.** $-\sqrt{625} = [\ ]$ **18.** $\sqrt{0.0049} = [\ ]$

In this category are questions involving square roots. The questions involve finding the square roots of perfect squares. The level of difficulty increases as we move from the first question to the last question. The first question is about finding the square root of a two digit perfect square. The second one is about finding the square root of a three digit perfect square but also involving a negative sign outside the square root. The last question is about finding the square root of a decimal number.

Table 4.16: Average performance for Questions 16-18

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
16.	0.97	0.73	4.711	0.000
17.	0.84	0.42	6.621	0.000
18.	0.90	0.47	6.998	0.000
Total	2.71	1.62	8.036	0.000

For question 16 the results show that both the groups WC and WO had fairly high percentages of 97% and 73%, but even so the t-test results indicate that there are statistically verified differences in performance in all the three questions. Yet, it also has to be pointed out that 27% of the learners without a calculator could not find the square root of 81.

For question 17, involving a three digit number the group WC shows an average performance of 84% compared to 42% for group WO. For group WC, and perhaps in both groups, the confusion could have been whether the minus sign is taken to be inside the square root (impossible) or outside. Finding the square root of a decimal was also challenging to learners in group WO as only 47% could perform the calculation correctly compared to 90% of the other group WC. The three questions combined show an average of 2.71 out of the possible 3 (90%) for group WC and 1.62 (54%) for group WO. A t-test verifies that the difference is significant.

Figure 4.11 and Table 4.17 show the distribution of marks for the group WC. It shows that only one learner in this group did not manage to get any question correct. A total of 71 out of 90 learners (78.9 %) managed to get everything correct.

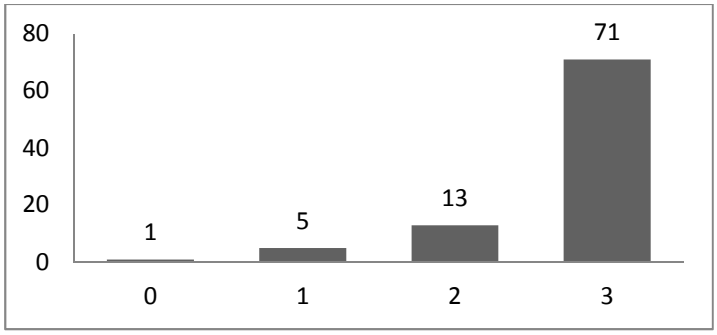

Figure 4.11: Marks distribution in Category F: Square Roots Group WC

Table 4.17: Performance in Category F: Square Roots Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	1	1.1	1.1
	1	5	5.6	6.7
	2	13	14.4	21.1
	3	71	78.9	100.0
	Total	90	100.0	

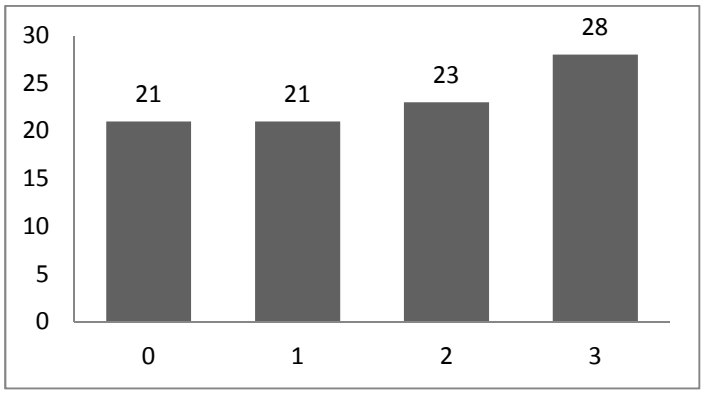

Figure 4.12: Marks distribution in Category F: Square Roots Group WO

Table 4.18: Performance in Category F: Square roots Group WO

		Frequency	Percentage	Cumulative Percentage
Valid	0	21	22.6	22.6
	1	21	22.6	45.2
	2	23	25.6	70.8
	3	28	30.1	100.0
	Total	93	100.0	

Figure 4.12 and Table 4.18 show the marks distribution for the group WO. A total of 21 learners (22.6%) did not get anything correct. Only 28 learners (30.1%) managed to get all the questions correct in this category.

Discussion: The overall performance of the group WC in this category is high and shows a proficiency in using a calculator. The square root is a readily available function on the calculator and you just need to put a value in and the answer comes on the screen. As far as square root calculations for the learners without calculators are concerned it is clear that the learners can barely perform simple calculations such as finding the square root of 81. If the question demands more advanced skills and understanding the majority of students falter. The difference in performance between learners who use calculators and those who do not is evident and of concern. There is an indication of dependency on calculators.

4.8 Evaluation Category G: SUBSTITUTION (Questions 19 to 21)

The questions in this category are:

Evaluate if $a=5, b=-6, c=-3$ **e.g.** $abc=5\times(-6)\times(-3)=90$

19. $\frac{b}{6}=[\ ]$ **20.** $(a+b)+\frac{c}{3}=[\ ]$ **21.** $\frac{ab}{ac}=[\ ]$

Questions 19, 20, 21 involve substitution. In the first question a single value has to be substituted into a fraction. The second question involves addition of two values in brackets then adding to it a fraction; three substitutions need to be made. The last question involve multiplication of two values both in the numerator and denominator, of which one factor can be cancelled. The level of difficulty ranges from less difficulty to more difficulty questions. A t-test was performed and the results are described in Table 4.19.

Table 4.19: Average performance for Questions 19-21

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
19.	0.48	0.22	3.858	0.000
20.	0.43	0.11	5.284	0.000
21.	0.43	0.18	3.784	0.000
Total	1.94	0.51	4.674	0.000

In all three questions there is a significant difference in the average performance of Groups WC and WO as verified by t-tests, although for both groups the performance is low.

The results indicate that in this category the average performance in both the groups for every question was less than 50%. Although we can say that the performance of learners with calculators exceeds the performance of the ones not using the calculator, only 48% of the group WC managed to get the first question correct. In the group WO only 22% for the first question and lees than that for the other two questions. The results combined show the average for Group WC is 1.94 out of the possible 3 (65%) compared to 0.51 of the possible 3 (17%) for the group WO.

Figure 4.13 and Table 20 show the distribution of marks in the group WC. A total of 45 learners (50%) did not get anything correct and only 37.7% had everything correct (34 of the 90).

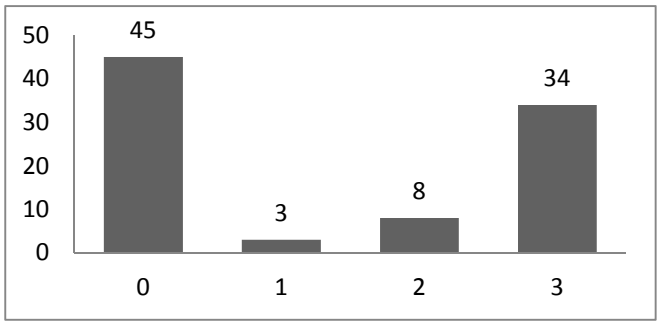

Figure 4.13: Marks distribution in Category G: Substitution Group WC

Table 4.20: Performance in Category G: Substitution Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	45	50	50
	1	3	3.3	53.3
	2	8	8.9	62.2
	3	34	37.8	100.0
	Total	90	100.0	

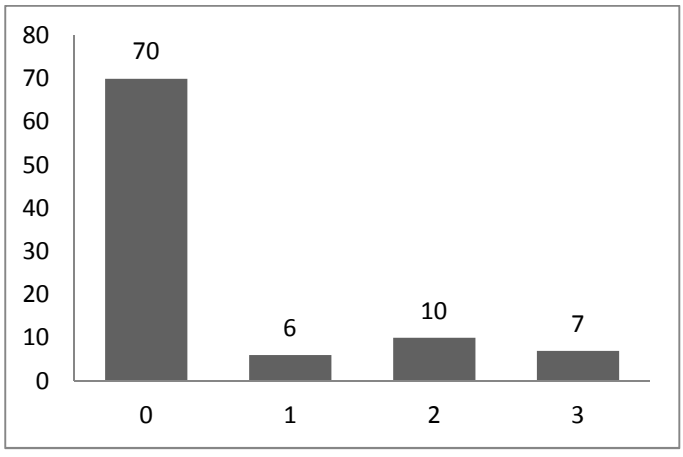

Figure 4.14: Marks distribution in Category G: Substitution Group WO

Table 4.21: Performance in Category G: Substitution Group WO

		Frequency	Percentage	Cumulative Percentage
Valid	0	70	75.6	75.6
	1	6	6.5	82.1
	2	10	10.8	92.9
	3	7	7.5	100.0
	Total	93	100.0	

Figure 4.21 and Table 4.21 show the mark distribution in the group WO. It shows that 70 learners (76%) did not get anything correct. In this group 7 (7.5%) of the learners managed to get all three questions correct. Table 4.21 shows that 6.5% had only one of question correct.

Discussion: This category appears to be difficult for all the learners. Learners were perhaps not familiar with this type of substitution questions, which is worrying since the skills required are imperative for further studies. The problem seems to be a lack of conceptual understanding for which calculators were of little use. This shows lack of understanding of mathematics. Learners need to be proficient in basic substitutions.

4.9 Evaluation Category H: EXPONENTS (Questions 22 to 24)

The questions in this category are:

22. $\frac{5^5}{5^2} = [\ ]$ **23.** $\left(3^2+4^2\right)^{\frac{1}{2}} = [\ ]$ **24.** $\left(2^2\right)^3 = [\ ]$

In this category learners where tested on how to simplify exponents. The first question involves division of exponents with the same base. The second question was more difficulty as it involves multiplication of exponents and a further exponent. The last question involves multiplication of exponents.

Table 4.22: Average performance for Questions 22-24

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
22.	0.44	0.13	4.990	0.000
23.	0.56	0.22	5.015	0.000
24.	0.80	0.34	6.993	0.000
Total	1.80	0.69	7.469	0.000

To determine whether there is a significant difference in the average performance of learners in the Groups WC and WO a t-test was performed. The t-test does indicate that there was enough evidence statistically that the average performance of those in the group WC exceeds that of the group WO in all the questions in this category.

The first question seems to be simple but showed the worst performance, namely that 44% of group WC and 13% of group WO could answer the question correctly. The last question showed an average performance of 80% for group WC but for the group WO only 34%, 44% less than for Group WC. The three questions in this category grouped together showed an average of 1.80 for the group WC of the possible 3 (60%) and 0.63 for the group WO (21%). Again the differences in averages are statistically verified by the t-test.

Figure 4.15 and Table 4.23 show the mark distribution of the group WC. Figure 4.15 shows that 33 of the possible 90 learners (36.7%) managed to get all the questions correct. A total of 13 of the learners (14.4%) did not manage to get anything correct although having the privilege of using calculator.

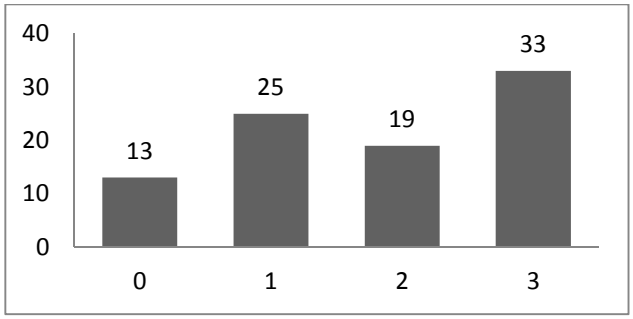

Figure 4.15: Marks distribution in Category H: Exponents Group WC

Table 4.23: Performance in Category H: Exponents Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	13	14.4	14.4
	1	25	27.8	42.2
	2	19	21.1	63.3
	3	33	36.7	100.0
	Total	90	100.0	

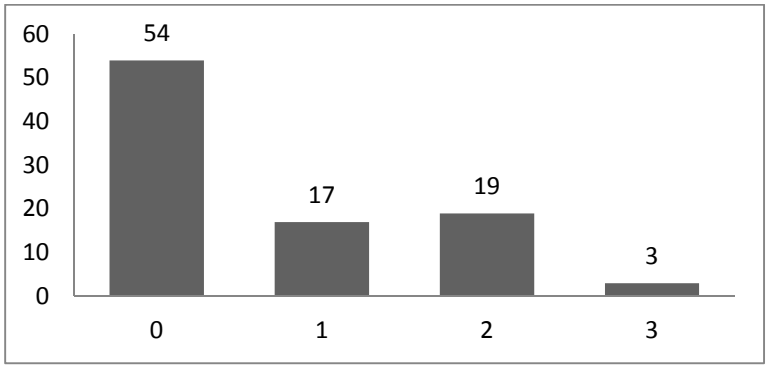

Figure 4.16: Marks distribution in Category H: Exponents Group WO

Table 4.24: Marks distribution in Category H: Exponents Group WO

		Frequency	Percentage	Cumulative Percentage
Valid	0	54	58.1	58.1
	1	17	18.3	76.4
	2	19	20.4	96.8
	3	3	3.2	100.0
	Total	93	100.0	

Figure 4.16 and Table 4.24 show the mark distribution for the group WO. Of the WO group 54 (58.1 %), that is more than half of the learners did not manage to get anything correct. Only 3 of the 93 learners (3.2%) managed to get all the three answers correct without using a calculator. The second question seemed to be difficult for both the groups. Only 3.2% had all three questions correct.

Discussion: The performance of group WC far exceeds the performance of group WO. Exponents form an important part of tertiary mathematics and it appears that learners are not grounded in the concepts involved with exponents. Learners have difficulty in performing basic calculations without a calculator. Even with a calculator the performance is not particularly good, which again points to a lack of conceptual understanding.

4.10 Evaluation Category I: TRIGONOMETRY (Questions 25 to 27)

The questions in this category are:

Evaluate the expressions below

25. $\sin 90^0 = [\ ]$ **26.** $\tan(-45^0) = [\ ]$ **27.** $\cos 120^0 = [\ ]$

In this category of basic trigonometry most of the learners need to recall values from memory if working without calculators. The first question is deemed as easy and even without recall of the exact value a

learner could sketch the sine graph to find the solution. The second question requires of the student to know the basic behaviour of the tan function, and how to deal with the negative angle. This question was more challenging than the first one. The last question was again more challenging as it requires of a learner to be able to calculate the cosine of an obtuse angle.

Table 4.25: Average performance for Questions 25-27

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
25.	0.86	0.55	4.809	0.000
26.	0.80	0.40	6.061	0.000
27.	0.70	0.24	7.058	0.000
Total	2.36	1.18	6.980	0.000

The results as given in Table 4.25 indicate that there is a significant difference in performance in performance of all the trigonometry questions as verified by the t-test.

In the trigonometry category the average performance of the learners in the group WC far exceeds that of the group WO. The difference in performance increases as the difficulty of the questions increases. Performance decreased from 86% to only 70% for the group WC and from 55% to 24% (less than half of 55%) for the group WO. The three questions combined together show an average performance of 2.36 out of a possible 3(79%) for the group WC and 1.18 of the possible 3 (39%) for the group WO.

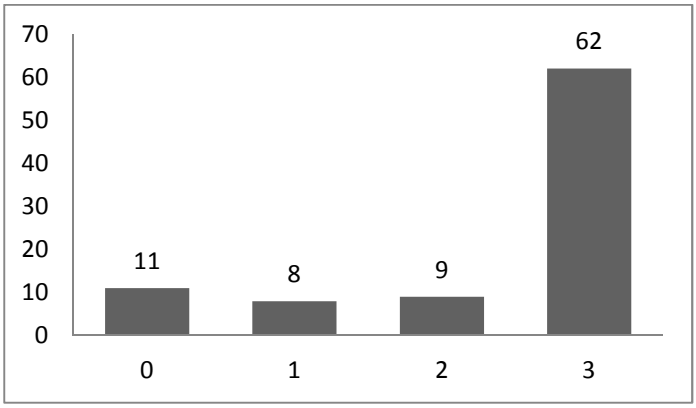

Figure 4.17 Marks distribution in Category I: Trigonometry Group WC

Table 4.26: Performance in Category I: Trigonometry Group WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	11	12.2	12.2
	1	8	8.9	21.1
	2	9	10	31.1
	3	62	68.9	100.0
	Total	90	100.0	

Figure 4.17 and Table 4.26 show the mark distribution in the group WC. A total of 62 of the 90 learners (68.9%) managed to get everything correct. Only 11 learners (12.2%) did not manage to get anything correct while using a calculator.

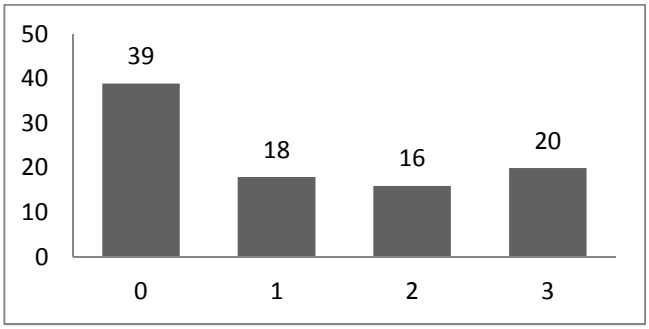

Figure 4.18: Marks distribution in Category I: Trigonometry Group WO

Table 4.27: Performance in Category I: Trigonometry Group WO

		Frequency	Percentage	Cumulative Percentage
Valid	0	39	41.9	41.9
	1	18	19.4	61.3
	2	16	17.2	78.5
	3	20	21.5	100.0
	Total	93	100.0	

Figure 4.18 and Table 4.27 show the mark distribution for the group WO. A total of 39 of the 93 learners (41.9%) did not have anything correct. Only 20 learners (21.5%) managed to get all three questions right without the use of a calculator.

Discussion: In the topic of trigonometry it is easy for a learner using a calculator to get all the solutions correct. The calculator functions are readily available to use and this must be a contributory factor in many leaners managing to get every answer correct. A learner in the group WO will need to understand special angles and how to deal with the trigonometric values of a special angle. Only 20% of learners without a calculator managed to get all the answers correct. At tertiary level students are expected to do trigonometry without the use of a calculator and the performance as witnessed in these questions would not be adequate. This category renders disconcerting results and indicates dependency on calculators.

4.11 Evaluation of Category J: POWERS OF PRIMES (Questions 28 to 30)

The questions in this category are:

Write as exponents or as powers of primes e.g. $16 = 2^4$

28. $125 = [\ ]$ **29.** $\frac{1}{32} = [\ ]$ **30.** $0.001 = [\ ]$

Powers of primes are involved in this category. A learner is required to know how to factorize a number into a product of primes. The first question was on a simple three digit number that had to be written as a power of primes. The second question needed more thinking as the value which needed to be expressed as a product of prime was in the denominator of a fraction. The last question was more difficult as it involved a decimal number. The questions where arranged in hierarchy of difficulty.

Table 4.28: Average performance for Question 28-30

Question	Group WC (N=90)	Group WO (N=93)	t-test values	
			t	Sigma (2-tailed)
28.	0.51	0.32	2.619	0.010
29.	0.29	0.06	4.121	0.000
30.	0.21	0.01	4.495	0.000
Total	1.00	0.40	4.622	0.000

A t-test was performed on both the groups WO and WC and the results are as shown in Figure 4.28. The results in question 28 indicate that there may be no difference in averages on a 1% confidence level. The group WO results show an average performance of 6% and 1% in questions 29 and 30, respectively. For the three questions combined the group WC managed to score only 1 out of the possible 3 (33%) and the group WO showed an average performance mark of 0.4 out of the possible 3 (13%), both very low.

Figure 4.19 and Table 4.29 show the mark distribution for the group WC. From the figures below we can see that none of the learners managed to get all the three questions correct. Many learners managed to get only one correct answer only (39 out of 90, 43.3%). A fairly large group of learners (24 out of 90, 26.7%) did not get anything correct despite using a calculator

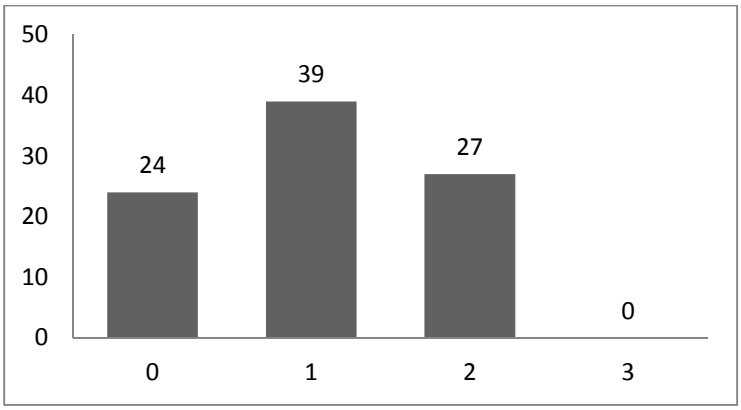

Figure 4.19: Marks distribution in Category J: Products of Primes WC

Table 4.29: Performance in Category J: Products of Primes WC

		Frequency	Percentage	Cumulative Percentage
Valid	0	24	26.7	26.7
	1	39	43.3	70
	2	27	30	100
	3	0	0	100.0
	Total	90	100.0	

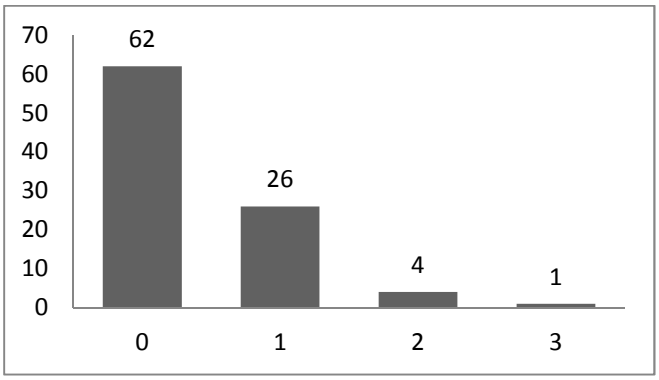

Figure 4.20: Marks distribution in Category J: Products of Primes WO

Table 4.30: Marks distribution in Category J: Products of Primes WO

		Frequency	Percentage	Cumulative Percentage
Valid	0	62	66.7	66.7
	1	26	28	94.7
	2	4	4.3	99
	3	1	1.1	100.0
	Total	93	100.0	

Figure 4.20 and Table 4.30 show the mark distribution for the group WO. Most of the learners (62 out of 93, 66.7%) did not get anything correct. In this group only one learner managed to get all the questions

correct without using a calculator. A total of 26 learners (28%) had only one correct answer. A large percentage of 94.7% had nothing or only one answer correct.

Discussion: The questions in this category appear to be difficult for both the groups. A learner needed to know the laws of exponents and a calculator would not be of much use. No one managed to get everything correct in the group WC and a single leaner in the group WO had everything correct. This may suggest that this topic was not well understood by the learners. It is a difficult topic to understand and it is a difficult topic for educators to teach learners. The extremely low performance of learners, especially those without calculators, does not bode well for those venturing into tertiary studies.

Chapter 5 Discussion and Conclusions

In this chapter I answer the research question and sub questions. The research question as formulated in Chapter 1 is as follows:

To what extent are high school learners dependent on using calculators for performing basic calculations and operations?

The sub research questions are:

(1) In which of the categories of basic mathematics are students more dependent on calculators?

(2) What are the difficulties that students experience with/without calculators?

Firstly, in all categories the total performance score for learners with calculators was statistically verified to exceed the performance score of learners without calculators as shown in Chapter 4. This result in itself is not unexpected as it stands to reason that learners would benefit from using calculators when performing basic mathematical calculations. Yet, in many categories the performance of learners using calculators far exceed that of learners not using calculators which does signal a dependency of calculators. What does emerge is that dependency on calculators is more evident in certain categories than others.

Answering the first sub question: In which of the categories of basic mathematics are students more dependent on calculators?

In order to answer the first sub question we consult Table 5.1 that gives the total scores for groups WC and WO as percentages for every category with the mark out of 3 given in brackets as well as the percentage differences. In addition, the percentage difference relative to the score of Group WC is given, called the Relative difference.

Table 5.1: Total scores in the different categories

Category	Total score of Group WC	Total Score of Group WO	Percentage difference	Relative difference (to WC)
A. Addition and Subtraction	97% (2.91)	86% (2.59)	11%	11%
B. Multiplication	96% (2.89)	77% (2.32)	19%	20%
C. Fractions	69% (2.08)	19% (0.57)	50%	72%
D. Division	80% (2.39)	47% (1.41)	33%	41%
E. Mixed calculations	79% (2.37)	34% (1.01)	45%	57%
F. Square roots	90% (2.71)	54% (1.62)	36%	60%
G. Substitution	65% (1.94)	17% (0.51)	48%	25%
H. Exponents	60% (1.80)	23% (0.69)	37%	62%
I. Trigonometry	79% (2.36)	39% (1.18)	40%	51%
J. Powers of primes	33% (1.00)	13% (0.40)	20%	61%

From Table 5.1 it can be seen that there are only three categories for which the percentage difference between the performance of Group WC and Group WO is less than or equal to 20%. These categories are Addition and subtraction, Multiplication and Powers of primes. In the category of Addition and subtraction and in the category of Multiplication the percentage differences are less than 20%. The conclusion is that the category of Addition and subtraction and the Category of Multiplication do not give reason for concern on dependency on calculators. The category of Powers of primes shows poor performance in both categories and it is clear that using a calculator for this type of calculation is not particularly beneficial. For calculations with larger numbers there are indications of dependency on calculators.

Categories in which learners with calculators performed well (>79%) but learners without calculators performed relatively poorly (<45%) are Division, Mixed calculations, Square roots and Trigonometry. In the Division category learners without calculators only score 47% on average (compared to 80% with calculators); for the Mixed Calculations category only 34% (compared to 79% with calculators); in the Square roots category only 54% (compared to 90% with calculators) and in the Trigonometry category

only 39% (compared to 79% with calculators). These categories are then identified as categories in which learners are dependent on calculators.

The category of Fractions is the category that shows the biggest difference (50%) between learners with calculators and learners without calculators. Other categories with differences that exceed 40% and that could be considered as particularly large are Mixed Calculations (45%), Substitution (48%) and Trigonometry (40%). These large differences also point to dependency on calculators.

Perhaps a better measure for a difference in performance is the percentage difference relative to the score obtained by the group with calculators. The categories that emerge are Fractions (72%), Mixed Calculations (57%), Square roots (60%), Exponents (62%) and Trigonometry (51%). The category of Powers of primes show a relative difference of 61% but the scores for students both with and without calculators are low and the result points to a general lack of expertise in this topic and not so much to a dependence on calculators.

Of concern is that both groups experienced difficulties in the categories of Fractions, Substitution, Exponents and Powers of primes, where the performance score of the learners with calculators was less than 70% and the performance of learners without calculators considerably less than that. (The cut off percentage of 70% is chosen arbitrarily but is based on the premise that it can be expected of learners who are proficient in using calculators that at least 70% of them should be able to do basic mathematical calculation correctly when using a calculator). In the Fractions category learners with calculators showed an average score of 69% that decreased to 19% for learners without calculators. In the Substitution category the score of 65% for learners with calculators decreased to 17% for learners without calculators. In the category of Exponents the score of 60% for leaners with calculators decreased to 23% for learners without calculators and in the category of Powers of primes the very low score of 33% for leaners with calculators decreased even further to 13% for learners without calculators. The concern regarding the underperformance for both groups but particularly for the group without calculators is based on the fact that the skill of substitution and the knowledge of exponents as well as being able to decompose a number in its prime factors are important if a learner wants to pursue tertiary studies. Working with fractions is a fundamental skill and proficiency is vital in further studies. The finding that learners with calculators do not perform in these categories (and learners without calculators even worse) shows that learners have not truly mastered the skills required in these topics in general.

Answering the second sub question: What are the difficulties that students experience with/without calculators?

In Table 5.2 the average total performance scores are given over the ten categories and for both groups.

Table 5.2: Average total performance scores

Total for Group WC (30)	Percentage for Group WC	Total for Group WO (30)	Percentage for Group WO
22.45	75%	12.3	41%

We first investigate problems experienced by learners when using calculators. In none of the categories and none of the questions a 100% performance was achieved, either with or without using calculators as can be seen from Table 5.1. Table 5.2 shows that the average total performance score for the Group WC is 75%. This score is lower than expected for students performing basic mathematical calculations with the aid of a calculator. This finding could indicate that there are some problems in using calculators. The fact that so many learners have lost or damaged calculators may have an influence on their ability to use the calculator. It could indicate that learners do not know how to operate some function keys on the calculators or are out of practice.

Questions that involved addition and multiplication were clearly easy for learners using calculators where learners scored 97% and 96%, respectively. It is also clear that when working with square roots, which involves straight forward operations on a calculator learners are proficient (scoring 90%) but where a sequence of operations are involved such as in the Fractions category performance drops (69%).

When comprehension of the problem is required rather than just straight forward calculations learners experience problems even when using a calculator as is clear from the performance of the group WC in the categories of Substitution (65%), Exponents (60%) and Powers of primes (33%), as can be seen from Table 5.1.

We now turn to problems experienced by learners not using calculators.

The categories in which learners without calculators obtained low scores (<50%) are Division (47%), Trigonometry (39%), Mixed calculations (34%), Exponents (23%), Fractions (19%) and Powers of Primes (13%).

As expected, for the more difficult problems per category, the performances are poorer. For example, multiplying and dividing three digit numbers show lower scores than for single of double digit numbers. In questions that involve square roots of two or more digits that are perfect squares, scores are also lower. A learner can easily use a square root key on a calculator and get the correct answer, but in the absence of calculators learners perform poorly when having to find a square root of a three digit perfect square. This suggests dependency on calculators.

In the category of Substitution leaners did not manage to interpret what was required of them to do although an example was there for them. The category of Fractions was problematic. This finding points to a lack of skills, either because of under exposure to this type of problem or a lack of understanding of what is expected.

Given questions that involve trigonometry, it was clear that a learner could easily use a trigonometry function key and get a correct answer, but in the absence of calculators learners performed poorly. In the absence of the device leaners do not have other ways of calculating special angles. This again suggests dependency on calculators.

The problems experienced in doing exponents seem to be due to a lack of knowledge and a lack of comprehension of the basic exponent laws. This conclusion is justified through learners showing a low performance score of 13% for performing the simple calculation $\frac{5^5}{5^2}$. Similarly, it can be concluded that a lack of knowledge of the basic laws of fractional computations is evident in the Fractions category where learners scored 19% and 17%, respectively, for performing the calculations of $\frac{1}{2}+\frac{1}{4}$ and $\frac{1}{5}+\frac{1}{5}$.

The results of the Powers of primes category render the conclusion that there is a lack of skills in doing this type of problem. Only 6% of learners could write $\frac{1}{32}$ as 2^{-5}.

The overall conclusions are:

- Learners are dependent on calculators with respect to basic mathematical calculations, and particularly so in the categories of Fractions, Division, Square Roots, Exponents and Trigonometry. In the category of Addition and Subtraction and in the category of Multiplication calculator traces of dependency are evident in calculations with larger numbers.
- Learners lack knowledge and skills in the categories of Exponents, Substitution and Powers of Primes.
- Even with calculators learners experience problems in the categories of Fractions, Substitution, Exponents and Powers of Primes.

Returning to the literature, the results of our study show a disagreement with Grouws and Cebulla (2000). who maintain that there is no loss in student ability to perform paper and pencil computations when calculators are used as part of mathematics instruction. We also disagree with the study of Karpie (2013) who found that when working with exponents students performed better with access to the calculators, but not significantly better. We do agree with Sneed (2010) who states that educators must be responsible enough for students' long term betterment to require them to develop and use basic skills in an efficient and accurate manner. We also agree with Brunette (n. d.) who states that calculators can create problems for students when the calculator becomes a crutch.

Future research and recommendations.

This research was conducted on a small group of learners from a specific district in Mpumalanga. I would recommend future researchers to conduct similar research on a larger population of learners. The study could be confined to School A only, a top performing school, to determine whether results improve.

The study focuses on secondary school learners. As a follow up study experiences should be investigated of first year students at university who are restricted from using calculators in tests and examinations.

It is recommended that results of this study are communicated to the schools involved and to a wider community.

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Addendum A: Questionnaire

Candidate Number: _____ Grade:_____ Male/Female:_____Age:_____

Instruction to candidate:

1. **PLEASE INDICATE TIME TAKEN TO COMPLETE ALL THE TASKS.**
2. **ONLY INDICATE YOUR CANDIDATE NUMBER WHICH YOU WILL BE PROVIDED BY THE INVIGILATOR.**
3. **PROVIDE YOUR ANSWER IN THE PROVIDED BOX. THE SPACE BELOW MAY BE USED FOR CALCULATION.**
4. **NO CALCULATOR ALLOWED.**

SECTION A

Addition and subtraction

1. $17+25=$	2. $35-16=$	3. $812-79=$

SECTION B

Multiplication

4. $7\times9=$	5. $13\times9=$	6. $37\times51=$

SECTION C

Fractions

7. $\frac{1}{2}+\frac{1}{4}=$	8. $\frac{\frac{1}{10}}{2}=$	9. $\frac{1}{5}+\frac{1}{5}=$

SECTION D

Division: Evaluate

10. $-75\div(-15)$	11. $\frac{72}{8}=$	12. $\frac{306}{17}=$

SECTION E

Mixed questions

13. $\frac{\frac{1}{3}+\frac{1}{5}}{2}=$	14. $\frac{1}{2}\div 5=$	15. $-\frac{6}{7}+3=$

SECTION F

Square roots

16. $\sqrt{81} =$	17. $-\sqrt{625} =$	18. $\sqrt{0.0049} =$

SECTION G

Substitution

Evaluate if $a = 5, b = -6, c = -3$ e.g. $abc = 5 \times (-6) \times (-3) = 90$

19. $\frac{b}{6} =$	20. $(a+b) + \frac{c}{3} =$	21. $\frac{ab}{ac} =$

SECTION H

Exponents

22. $\frac{5^5}{5^2} =$	23. $(3^2 + 4^2)^{\frac{1}{2}} =$	24. $(2^2)^3 =$

SECTION I

Trigonometry

Evaluate or and simplify the expression below

25. $\sin 90^0 =$	26. $\tan(-45^0) =$	27. $\cos 120^0 =$

SECTION J

Write as exponents or as products of primes, example $16 = 2^4$

28. $125 =$	29. $\frac{1}{32} =$	30. $0.001 =$

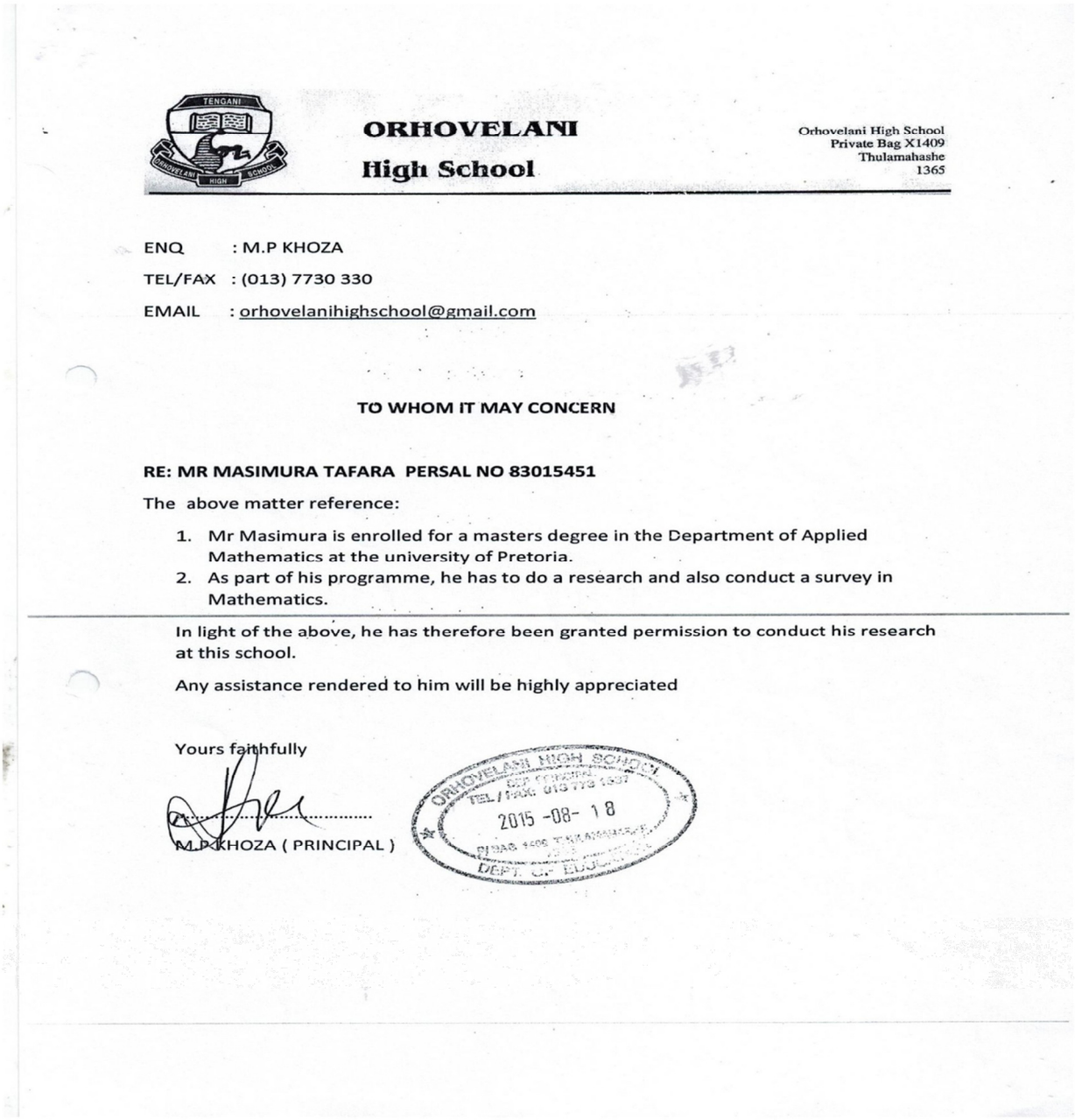
TIME TAKEN TO COMPLETE ALL THE TASKS:_____

SIGNATURE:_____DATE:_____

THANK YOU FOR YOUR CONTRIBUTION

REGARDS
MASIMURA TAFARA

Addendum B: Letters of consent



ORHOVELANI
High School

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Thulamahashe
1365

ENQ : M.P KHOZA
TEL/FAX : (013) 7730 330
EMAIL : orhovelanihighschool@gmail.com

TO WHOM IT MAY CONCERN

RE: MR MASIMURA TAFARA PERSAL NO 83015451

The above matter reference:

1. Mr Masimura is enrolled for a masters degree in the Department of Applied Mathematics at the university of Pretoria.
2. As part of his programme, he has to do a research and also conduct a survey in Mathematics.

In light of the above, he has therefore been granted permission to conduct his research at this school.

Any assistance rendered to him will be highly appreciated

Yours faithfully

M.P KHOZA (PRINCIPAL)

ORHOVELANI HIGH SCHOOL
2015 -08- 18

GODIDE HIGH SCHOOL

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Cell: 082 0954 165

Godide high school
Private bag x1307
Thulamahashe
1365

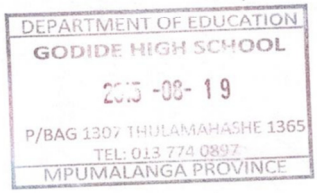
BOHLABELA DISTRICT
THULAMAHASHE CIRCUIT

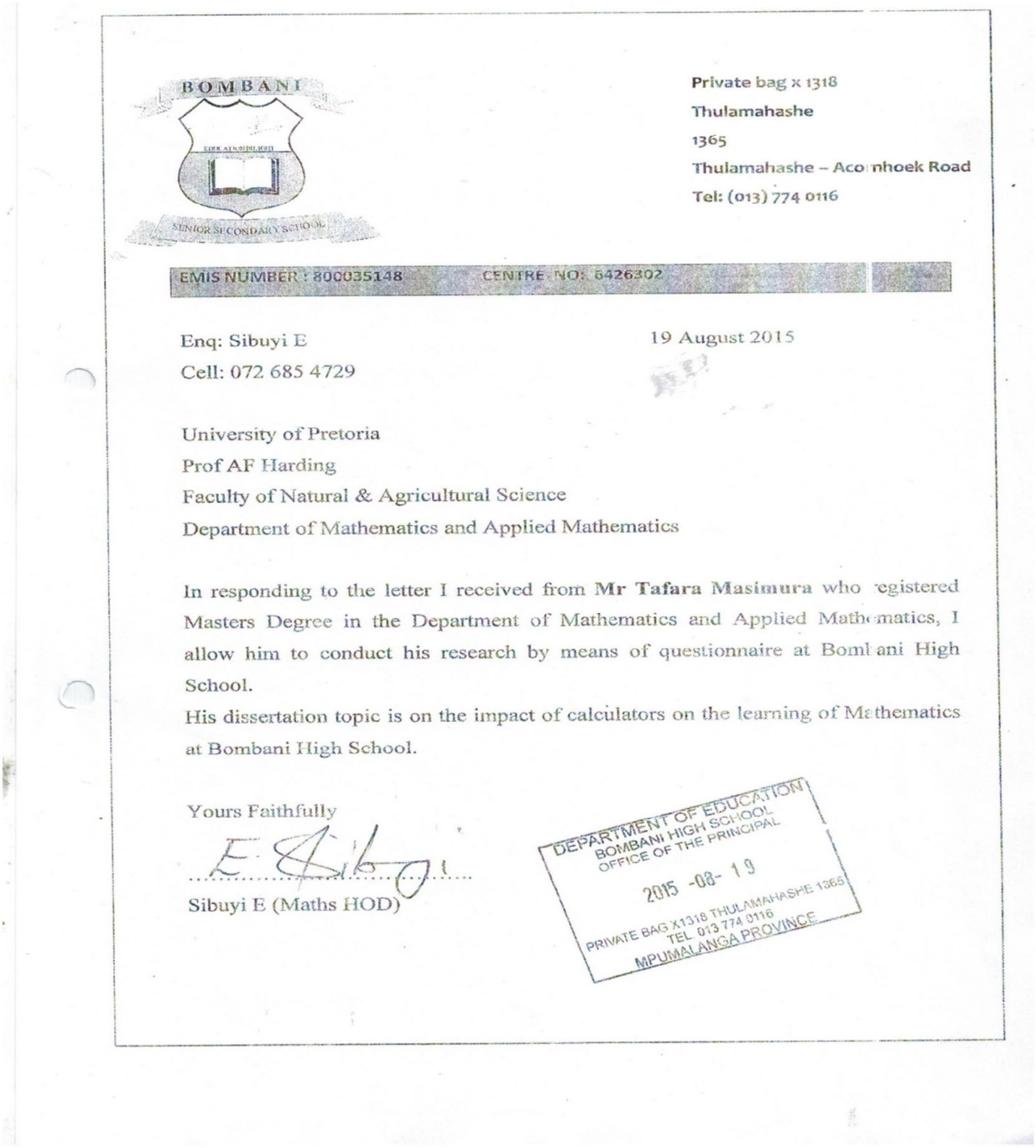
TO WHOM IT MAY CONCERN

We have allowed your student, Mr Masimura Tafara, student number 14438152, to carry out his research at our school.

Yours Truly

Tibane BP





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EMIS NUMBER : 800035148 CENTRE NO: 6426302

Enq: Sibuyi E
Cell: 072 685 4729

19 August 2015

University of Pretoria
Prof AF Harding
Faculty of Natural & Agricultural Science
Department of Mathematics and Applied Mathematics

In responding to the letter I received from **Mr Tafara Masimura** who registered Masters Degree in the Department of Mathematics and Applied Mathematics, I allow him to conduct his research by means of questionnaire at Bombani High School.
His dissertation topic is on the impact of calculators on the learning of Mathematics at Bombani High School.

Yours Faithfully

E. Sibuyi

Sibuyi E (Maths HOD)

DEPARTMENT OF EDUCATION
BOMBANI HIGH SCHOOL
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2015 -08- 19
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MPUMALANGA PROVINCE

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Natural & Agricultural Science
Department of Mathematics and Applied Mathematics
14 August 2015

Re: Tafara Masimura Student number: 14438152

Mr Masimura is enrolled for a masters degree in the Department of Mathematics and Applied Mathematics at the University of Pretoria, an MSc (Mathematics Education). His dissertation topic is on the impact of calculators on the learning of mathematics, both at secondary school level and on first year university level.

For the purpose of research for the degree Mr Masimura will need to conduct a survey by means of a questionnaire on both secondary and tertiary students. Results will be reported on anonymously. As supervisor of Mr Masimura I request cooperation from authorities involved.

Yours sincerely

Prof AF Harding
Professor in Mathematics

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Republic of South Africa

Tel:
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Email address
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The Head of Department
Mpumalanga Department of Education
Private Bag X11341
Nelspruit (1200)
Date: 08 March 2016
Dear Sir/ Madam

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN SOME OF YOUR SCHOOLS IN THULAMAHASHE CIRCUIT

The above matter bears reference,

1. I, **Tafara Masimura**, a Master of Science Education with the University of Pretoria hereby request to conduct a research in some of your schools that will meet the requirements of the sampling technique that will be used in the study.

2. The title of my research study is: **The impact of calculators on the learning of mathematics both at high school and first year students at University of** and has been chosen by my Supervisor. See latter attached.

3. The study will use a quantitative data design using a questioners where data will be collected from selected schools.

4. The ethics policy of the University of Pretoria requires that I get permission from the Department of Education to be able conduct this research.

5. The Department of Education will benefit from this study by getting information about ways to support our learners on better ways of using technology.

6. When the study has been completed, a copy of the report will be made available to the Department of Education.

7. I have attached a request from my Supervisor.

I hope you will find this in order.

Regards

Tafara Masimura (0715018931, 0787901016)
Email tafaramasimura13@gmail.com

education
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Litiko le Temfundvo, Umnyango we Fundo | Departement van Onderwys | Ndzawulo ya Dyondzo

Mr. T. Masimura
Department of Mathematics and Applied Mathematics
University of Pretoria
Pretoria
0001

RE: APPLICATION TO CONDUCT RESEARCH: MR. T. Masimura

Your application to conduct research was received. The title of your study reads: "*The impact of calculators on the learning of mathematics both at high school (grade 12) and first year students at University of Pretoria.*" I trust that the aims and the objectives of the study will benefit the whole department in particular the learners and the teaching of mathematics in our schools. Your request is approved subject to you observing the provisions of the departmental draft research policy which is available in the departmental website. You are also requested to adhere to your University's research ethics as spelt out in your research ethics document.

In terms of the attached draft research policy data or any research activity can only be conducted after school hours as per appointment. You are also requested to share your findings with the relevant sections of the department so that we may consider implementing your findings if that will be in the best interest of the department. To this effect, your final approved research report (both soft and hard copy) should be submitted to the department so that your recommendations could be implemented. You may be required to prepare a presentation and present at the department's annual research dialogue.

For more information kindly liaise with the department's research unit @ 013 766 5476 or a.baloyi@education.mpu.gov.za.

The department wishes you well in this important project and pledges to give you the necessary support you may need.

MRS MOC MHLABANE
HEAD OF DEPARTMENT
14, 4, 16
DATE

MPUMALANGA
THE PLACE OF THE RISING SUN