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CALCULATOR PREVALENCE IN MATHEMATICS CLASSROOMS: CASE OF EKUDIBENG CIRCUIT IN SOUTH AFRICA

Netsai Hove
Supershine University, Zambia
Emmanuel Chinamasa
Chinhoyi University of Technology

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ABSTRACT

This study influenced by the Technology adoption theory, explored the prevalence of calculators in Ekudibeng circuit mathematics classrooms in South Africa. Pragmatism guided assessment of technology adoption by allowing application of both quantitative and qualitative data analysis to portray reality. A sequential design of document analysis, a survey, lesson observations, focus group discussions and in-depth interviews was used. Empirical data was collected from a purposive sample of 154 participants, composed of 41 teachers of mathematics and 113 learners from grade 8 to 12 in Ekurhuleni South district secondary schools. A sample of 26 teachers' schemes and mathematics school syllabuses was analysed. The study found (71%) prevalence for calculator use in both public and private schools mathematics classrooms. A hypothesis test at 5% level of significance confirmed an association between gender and calculator use preference. Although all teachers reported willing to use the calculator, 54 (35%) reported, not possessing a personal calculator. Study found five calculator models in use. The majority used the SHARP model. National examinations disallowed the graphic FX-CG50 because of its perceived complexity. Calculators were used for computation of (r2) regression coefficient correlation and evaluation for logarithms and trigonometry ratios for transformation functions such $f(x) = 2\sin\theta$. Factors retarding calculator adoption include; lack of financial resources for high density public school learners, limited teacher commitment for calculator use and low teacher technical know-how of using calculator for instruction.. National examinations not emphasising use of calculators, mathematics text books do not show how calculators can be used for instruction. Study recommends use of a single calculator model as a district policy. Authoring of a teachers' handbook for the use of calculators for instruction is called for. Mathematics teachers' staff development workshop on the application of calculators is long overdue.

Key Words: Calculator, prevalence, teacher, instruction, mathematics.

1. INTRODUCTION

1.1 Background

In any country, South Africa included, the key variable in the implementation of any classroom technological innovation is the teacher. Teachers interpret the syllabus, break its' content in their schemes of work, gathers learning materials and guides the learning process. Mathematics policy makers in South Africa have not yet given calculator application in mathematics a priority. Nyaumwe (2006), fears that although learners have calculators in the classroom teachers may be side-lining their use for mathematical instruction and under-playing their contribution to national

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technology skills development. What actually takes place behind the classroom closed doors is all dependent on the mathematics teacher's level of pedagogical knowledge (Kendal and Stacey, 2002). Burke (2001) proposes that, calculators are versatile instructional tools which mathematics teachers find challenging to integrate in their classrooms. In this study, the word prevalence encompasses calculator existence (frequency) and application in mathematics teaching and learning. It is reasonable for researchers to flip the history of mathematics in South Africa after independence in 1994 as a safe springboard.

After the 1994 democratic elections and post elections in South Africa, many changes took place and the biggest change by necessity has been in the area of education. Initially, curriculum 2005 (C2005) which was driven by the Outcomes Based Education (OBE) was unveiled by the department of basic education. It was mainly characterized by cooperative group instruction which made it difficult for teachers to identify struggling learners in mathematics understanding at all levels. Outcomes-based education was introduced in 1997 to overcome the mathematics curricular dichotomy of pre-independence education. According to The Departments of Basic and Higher Education and Training (2011) Outcomes Based Education was reviewed in 2000 after the experience of its implementation
by stakeholders yielded bad results.

The Revised National Curriculum Statement (RCNS) Grades R-9 and the National Curriculum Statement Grades
10–12 was then implemented in 2002. Bjorklund (2015) speculates that, the RNCS system failed because educators did not understand it and quite often did not see the difference between C2005 and the RCNS. The result was that the implementation challenges of RCNS were the same as those of C2005. It also transpired that RCNS was highly loaded and fell short of its expectations, used vague complex terminology and inadequate training of teachers and district officials. In 2012 it was reviewed again and replaced by the Curriculum and Assessment Policy Statement
(CAPS) was rolled out in phases.

According to Carnoy, Chisholm and Chilisa, (2012) OBE is still the underlying philosophy which underpins CAPS. Currently, CAPS is the curriculum practiced in the country as a measure that redresses the inequalities and imbalances of the colonial epoch mathematics education. With effect from January 2012, a single comprehensive Curriculum and Assessment Policy Statement was developed for each subject to replace Subject Statements, Learning Programme Guidelines and Subject Assessment Guidelines in Grades R-12. The Departments of Basic and Higher Education and Training, (2011: 47) suggest that, CAPS general aims to produce learners able to:

- use critical and creative thinking in making decisions of identification and solution of problems;
- work effectively as individuals and with others as members of a team;
- manage and organize themselves in handling their activities responsibly and effectively;
- collect, analyze, organize and critically evaluate relevant data;
- use visual, symbolic and/or language skills in various modes to communicate effectively; and

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- recognize that problem-solving contexts do not exist in isolation and demonstrate an understanding and interpretation of the world as a set of related systems.

An important observation is the fact that, none of the CAPS's aims is focused on the application of technology in mathematics education. Although calculations and application skills are implicitly included, teachers did not get the use of calculators. Consequently, policy at this stage overlooked the use of calculators as instructional tools in South Africa's mathematics classrooms.

The Departments of Basic and Higher Education and Training, (2011) emphasise that, CAPS prescribed various topics and the content areas to be covered in each grade with time allocated specifics together with the weighting
of the content areas in each phase, outcomes and relevant assessment examples. CAPS require mathematics to be taught at foundation (grades 1–3), intermediate (grade 4–6), senior (grade 7–9) and further education and training (grades 10–12) phases. Zingiswa (2017) mutes that, a top down prescribed curriculum handicaps teachers who operationalize it.

Ramatlapana and Makonye (2012) proclaim that although the teachers were free to teach the previous curricular as they saw fit, CAPS was prescriptive and demanded uniformity in implementation across the country. This prescription was enforced through inspection and a uniform examination. The results for CAPS program were counter-productive since learners' performance continued to be poor in mathematics national school assessments. Hawie (2001) also added mathematics poor performance in the Trends in Mathematics and Science Study (TIMMS) report. Moloi, (2012) further reported poor mathematics results in Southern and Eastern Africa Consortium for monitoring Educational Quality (SACMEQ) assessments. Government officials and mathematics subject advisors are able to monitor the present curriculum because the mathematics content to be taught is explicitly delimited, paced, and sequenced with prescribed mathematics textbooks that point to certain examples. Unfortunately, the methodology does not include the application of calculators. Textbooks' content is void of calculator applications.

However, Ramatlapana and Makonye (2012) argue that the said prescription restricts the mathematics teachers' professional autonomy. Feza (2014) justifies the prescription on condition that the content dilution is favoured in the country. It is expected to increase learners' performance in mathematics. Teachers of mathematics are lowly qualified to apply creative teaching methods beyond the prescription. Also a prescribed mathematics curriculum is helpful in the teaching of low achieving learners from disadvantaged socio-economic backgrounds using a more structured teacher directed instruction. In addition, systematic efforts to change the practice, attitudes and beliefs of mathematics teachers in the classroom required incremental models of change management effected through Mathematics Continuous Professional Development programs. Those programs were geared to address the quality of mathematics education, improvement of quality of mathematics teachers, numeracy and mathematics teaching in lower grade levels.

Govender, (2012) chronicles changes to the way mathematics is perceived in South Africa. Those changes include:

- In 1994, mathematics was a compulsory school subject until grade 9, and beyond that it was not compulsory. Those who registered for it at matric level did it on either higher

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or standard grade until 2007. Making mathematics compulsory at lower grades matched the quality of teachers. They were lowly qualified. The change enhanced the status of mathematics in the South African curriculum.

- In 2001 and 2002, the Outcome-Based Education (OBE) and the Common Task for Assessment (CTA) was introduced to high school learners, but was shortly discontinued due to serious challenges in terms of its implementation.
- In 2005 another curriculum change in the form of an "outcomes-based" approach was introduced. This change had a major negative impact in the learning and teaching in the GET (grades 7–9) due to the fact that it was very vague in terms of what had to be taught in different grades.

Although curriculum changes did not focus on technology application, change over the years has also affected the mathematics content to be taught in different grades. Changes involved moving content from one grade to another; removing some content and introducing new content. Recently, Technical Mathematics and Technical Science in technical schools in grade 10 was introduced in 2016. Regrettably technical mathematics introduction did not come in with technical tools like the calculator. Coupled with the change in curriculum was also the introduction of Mathematical Literacy as an alternative to be done by students who were not competent to do mathematics in the FET phase. This was done to cater for those students who could not do pure mathematics and to retain the compulsory status. This then ensures that all learners are exposed to some form of mathematics by the time they finish school. Although Amanyi and Sigme (2016) suggest that, the application of calculators motivates learners of low mathematics ability, in this case calculators were not considered a variable in the solution of learners low performance.

Spaull (2013: 23) summarised South Africa's mathematics education problem of addressing South Africa's numeracy and mathematics schooling challenge in the following points:

- although the improvement of mathematics teaching and learning in public schools will not happen fast, it must begin urgently. This gives room for the current study to contribute teaching methods.
- poor mathematics and numeracy teaching and learning in public schools accelerate private schooling wherein there is enrolment growth in private extra mathematics lessons;
- if South Africa is to be realistic about having a knowledge economy and creating more and better jobs, it will require a sustained focus on teacher and teacher-training development, particularly in mathematics teaching,
- in the interim, it is likely that the country will have growing numbers of innumerate young people, and a majority of young South Africans could be unqualified to be hired in many types of high quality work.

Spaull's (2013: 34) studies recommend focussing on these problems:

- the inefficiencies in basic education that result in escalating numbers of drop-out students from grade R-12;
- the development of early childhood and special needs mathematics education programs;
- a systemic account of public further education and training colleges on how they train mathematics teachers, together with low pass rates in higher education institutions which

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were roughly half the learners at contact education universities who start a bachelor's degree graduating while only 40 per cent of diploma learners graduate. The current study contributes the how to use calculator for teaching mathematics content.

Spaull's (2013: 34) further recommended decisions to be made on whether:

- the selection, appointment and promotion of mathematics teachers is to be based on their teaching qualities, as opposed say to the teachers' other relationships or affiliations to unions;
- consideration of whether a system of teacher rewards for learner performance in mathematics can replace a formal teaching qualifications
- the allocation of more resources to teaching in school grades with the most serious deficiencies can make the most difference to end results at grade 12 matric level; and
- how teacher complacency can be addressed in mathematics education.

These are not conclusive recommendations. What is clear from them is the fact that, none of them is focussing on the use of technology, specifically the scientific calculator in mathematics classrooms. When we peep on South Africa's neighbour, Zimbabwe for a leaf, we note that it started by policy formulation at national level.

The Science and Technology policy, according to Muchena (2003) aims to develop national scientific and technological self-reliance. This is achieved by promoting technology awareness and literacy. While no specific implementers were nominated, this study which regard mathematics as a scientific language point at the teacher. It is critical for South Africa and Zimbabwe mathematics teachers to have a national duty to develop children's use of a scientific hand-held calculator to support science and technological innovations. By including calculators in their instruction practical repertory, mathematics teachers will raise not only learners' awareness but also its application.

The government of Zimbabwe supported the Science and Technology policy by donating computers to secondary schools in 2009. Regrettably promotion of the use of calculators in schools was surpassed. One can assume that, calculators were considered cheap enough for schools to handle within their budgets. Burkhardt (1981) in Chinamasa (2012: 88) suggests that, a calculator and a computer are all technological gadgets. The dividing line between calculators and computers is blurred and fluid. For example, programmable calculators with storage and printing facilities are proper subsets of microcomputers.

Zimbabwe Schools Examinations Council (ZIMSEC) responded to the Science and Technology policy and "proliferation of scientific calculators in Zimbabwe in the mid1980s by introducing mathematics syllabus 4024 in the O-level mathematics curriculum" in 2004 for first examination in 2007 (Nyaumwe 2006: 39). Its' distinctive feature was the permitting of some candidates to use scientific calculators in national examinations. There was the option of non-calculator paper (4004). Nyaumwe (2006) also informs us that, a mathematics curriculum revision held in mid 1990s maintained but renamed the parallel curricular syllabus 4008/2 and 4028/2. Maintaining the parallel curricular was intended to allow teachers time to develop mathematics instructional skills

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in which calculators are used. It is the role of this study to find the prevalence of calculators as an indicator of teachers' preparedness for the pedagogical change. One assumes also that, schools were given time to budget for calculators.

We also need to see how the need for technology calculator was infused in the curriculum objectives in Zimbabwe. An analysis of ZIMSEC mathematics syllabus 4028/2, the calculator version shows that:

- Aim (2.6). require learners to develop ability to reason and present arguments logically. One can interpret this to mean that, learners must use pen and paper to show all working and logical arguments not copying answers from the calculator display without showing how it got it. This may not support the use of calculators in schools. Although aim (2.8). expects learners to find joy and self-fulfilment in mathematics, it does not specify how. It leaves teachers and learners open to trial and error and trial and success.
- Assessment objective (3.2) credit students for carrying out calculations and checking the correctness of their solutions. The syllabus did not say how, neither did it suggest use of calculator as a tool for checking computation accuracy. Then its' assessment objective (3.8) underscores the need for learners to provide steps and/or information necessary to solve a problem. This again suggests awarding of method marks for correct method shown, which does not promote direct interpretation of answers from the calculator.
- Syllabus 4028/2, point 4.1 clearly points out that: *the efficient use of scientific calculators with trigonometric functions is expected and strongly recommended in paper 4028/2*. Then point 4.2 reads, candidates are expected to bring their own instruments. One can assume that, it is the responsibility of candidates to buy their calculators. Hong and Thomas (2006) support learners having their own calculators for improved access and lowering of pressure on schools' departmental budgets. But this part of the syllabus point 4.2 reading, "mathematical tables will be provided in the examination" suggests positive discrimination in favour of non-calculator candidates. It does not support the use of calculators. Schools and learners can avoid costs of calculators by continuing with the non-calculator version.
- The syllabus Methodology section, point (5.0) is silent on how calculators can be used either for instruction or during examinations. Although point (5.6) reiterates the need for pupils to be taught how to check and criticise their own and another's work, it does not show how calculators come in.

These observations show that, the official national syllabus in Zimbabwe is not very keen on promoting the use of calculators in mathematics. Actually, by giving a compulsory paper 4028/1, in which calculators are not used and 50% assessment weighting for each of the two papers, ZIMSEC is trying to reduce the effect of calculators on the performance of candidates using it. The situation contradicts Amanyi and Sigme (2016) who require that, the syllabus objectives spell out how the calculators can be used to enhance learners' understanding of numerical computation and solve real life problems. Rosenstein (2002) called for a change in mathematics content and assessment methods to accommodate application of calculators. South Africa's National research coordinators' (2019), Exhibit 20, reports that, South Africa has no clear policy on the use of scientific calculators in schools.

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This study considers a calculator as a technology gadget which can be used in schools to facilitate teaching and learning of mathematics. In fact, its inclusion in the curriculum reflects technology in learners' homes such as; the calculator on their cell phone, wristwatch and every vendor's desk. Present day technological levels require daily use of skills such as estimation, problem solving, interpretation of data, predicting and applying results. Emphasis is no longer on computation. That was left for machines to do. Such a perception calls for the redefining of the mathematical skills that schools are to develop in tomorrow's adults. Computers and calculators demand a shift of teachers' mathematical skills from drill and computation to a social application of problem solving and solution application. Carey (2008) proposes knowledge based confidence building and experience with a wide range of technology. All these are teacher variables hence this study's lenses have their full beam on the secondary school mathematics teacher in the classroom.

Literature argues for the teacher's disposition to the use of calculators for mathematics instruction from different angles. Nyaumwe (2006: 41) emphasises that, successful integration of calculators in the mathematics classroom requires correct teacher orientations. For an effective orientation to be planned at district level there is need for this study to establish the prevalence of calculator application in Ekudibeng circuit 5, secondary schools. It is a training needs analysis for the improvement of mathematics instruction in the circuit.

Newhouse (1998) in Chinamasa (2012: 90) discloses that, even teachers in Australia were against the adoption of technology in their classrooms although they had the technological gadgets and skills to use them. Andrew (1995) reports teachers who wanted mathematics calculators to be banned from Australian classrooms. They were convinced that calculators do not contribute to children's learning. These studies did not spell out factors which contributed to such teachers' disposition. A clear inference is that, a group of teachers who subscribe to those technology denials do not promote the prevalence of calculator application in mathematics classrooms for instruction.

Haylock (2004, p 21) attributes the source of teacher resistance to technology in their classrooms to "misconceptions that calculators think" for the child. The calculator provides answers like a magic box. Carey (2008), calls such beliefs unfounded myths. They include such claims as: calculators make students too lazy and dependent to be able to do their real life computational demands. Some teachers consider learners' transcribing answers from the calculator as cheating. Teachers who contribute to these "misconceptions" about calculators cannot promote the prevalence of calculator applications in mathematics without a strong re-orientation and supporting program. Such a need calls for the current study which contributes calculator instructional methods for mathematics.

Teachers' misconceptions can be reduced by clarification facts such as: calculators are machines which were programmed to act in a particular fixed way. They cannot think and replace learners' knowledge of mathematics concepts and facts. Since a calculator is a computer, its' role is to carry out the mathematics computations. That is not important knowledge in today's technological world which demands application. What is critical is knowledge of what to input (as demanded by the question), how to input it and what keys to press for the answer. In fact, using calculators require advance knowledge of a systematic mathematics problem solution schema. The following mental processes were identified by Haylock (2004) in Chinamasa (2012: 91):

- Identification of what is given (contextual analysis) in the problem and what is required. Such is a brain storming exercise which learners can carry out in groups or as individuals.
- Thinking of alternatives for the solution (combination of given variables) to get what is required. Here group discussions and evaluation of alternatives is critical.
- Carrying out the computation using the calculator requires identification of the keys, decision of their operation sequence and the estimation of the solution.
- Evaluation of the solution appropriateness in the context of the problem is a critical motivating step for children.

It is clear then, that more than (75%) of problem solving process is a mental activity which survives on mathematical knowledge. Actually, application of calculators develops problem solving skills. Learners can only realise such a benefit if teachers are aware of methods for developing cognitive skills facilitated by using the calculator for instruction.

Reznichenko (2007: 6) suggests that, calculators as cognitive support instruments can; (a) support both cognitive and meta-cognitive processes requiring more than nine mind spaces. (b) shares cognitive loads by supporting lower cognitive skills and leaving resources for higher order cognitive demands. (c) allows learners to engage in cognitive activities that could otherwise be unreachable for them. (d) facilitates learner generation and testing of hypothesis in real life contexts. The end results of these benefits include students' development of positive attitudes to mathematics as a life supporting endeavour.

Niess (2006, 200) supports the application of calculator in mathematics for the following reasons: a) they are motivating tools for those learners with computational limitations. (b) they are good at developing number senses in children. (c) they establish mathematical number patterns and relations. (d) they are a direct response to national standards. (e) technological knowledge and skills enhance mathematics application. (f) calculators improved students' interest, performance and confidence in mathematics. These merits can only be realised if the calculator prevalence is high and teachers are using them for instruction.

Statement of the Research Problem

There is limited documented knowledge of the prevalence of calculators in South Africa's mathematics classrooms. The knowledge gap makes it difficult for contextualised planning of technological skills development intervention for the circuit schools calculator technology implementation. South Africa's National research coordinators' (2019), Exhibit 20, reports that, South Africa has no clear policy on the use of scientific calculators in schools. In Zimbabwe Nziramasanga's (1999) commission reported that, teachers and parents are sceptical about the use of calculators in mathematics classrooms. The commission expressed fear of a possible danger arising from schools mathematics failure to train learners to use calculators as life tools. Nyaumwe and Bapoo (2004) found pre-service mathematics teachers keen to participate at a graphic calculators' workshop. They were motivated by the need for technological knowledge and its use in the classroom. Chinamasa (2012) found that (56%) of stakeholders were for the use of calculators at primary school. Teachers had reservations based on limited exposure to calculators and how they are used for teaching. Amanyi and Sigme (2016) concluded that, teachers have

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positive perceptions towards use of calculators for mathematics instruction, hence can integrate them in mathematics teaching and learning. It is the purpose of this study then, to explore the prevalence of scientific calculator use for mathematics instruction in Ekurhuleni district secondary schools in South Africa.

Research Questions:

a) What is the prevalence of calculators for mathematics instruction in Ekurhuleni district?

b) How are the calculators being used in mathematics classrooms?

c) What factors influence calculator prevalence in secondary schools in Ekurhuleni district?

d) What can be done to improve the prevalence of calculators in Ekurhuleni district secondary schools?

Hypothesis:

The study is guided by the following pair of statistical hypothesis:

H_0: There is no Association between gender and calculator application preference.

H_1: There is an Association between gender and calculator application preference.

Significance of Study

This study is important in that, it contributes teacher pedagogical support material for the teaching of mathematics. It is also a needs analysis providing a basis for planning technology adoption and quality teaching improvement interventions. Researchers also use it as a technology adoption monitoring and evaluation activity. By participating in this study, teachers' and learners' awareness of calculator use in mathematics classes is raised. More important is the realisation of the fact that, skilful application of calculators for instruction can improve learners' performance. Insight into the prevalence, factors contributing to the way teachers and learners are using calculators become targets for staff development initiatives. They contribute content for mathematics teachers' staff development in the district and districts with similar initiatives (improving calculator use in the mathematics class).The study contributes literature on calculator use in secondary schools.

2.METHODOLOGY

Research Design

This study was guided by the pragmatism research philosophy which facilitated the assessment of technology adoption as an inevitable intervention. Data collection by method triangulation is enhanced when using pragmatism. A serial data collection through survey, lesson observation, focus group discussions and interviews parallel to continuous document analysis dominated fieldwork research design. Pragmatism is used as a prologue to interventions in social science research. This study zips to a case study whose data presentation is mainly but not entirely qualitative in nature. According to White (2005: 56), a case study is a type of qualitative research in which the researcher explores a single entity (calculator prevalence) bounded by time and activity (calculator usage) and collects detailed information by using a variety of methods (survey, interviews, observation and document analysis). Mhlanga and Ncube (2003: 70) note that case studies examine a social unit (mathematics teachers and learners in a district) as a whole. Researchers settled for the case study after considering that, case studies employ multiply data

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collection methods. It calls for the researcher's physical presence in the field. The presence allows researchers to use the environment and their knowledge of participants for data interpretation.

Population and Sampling

The main population for this study was composed of all mathematics secondary school teachers and learners in schools registered in the Ekurhuleni district in South Africa. Teachers are key variables to the use of calculators for mathematics instruction. They decide what mathematics is to be taught, seek resources for it and decide how to teach it. In this case, they can use or ignore the use of calculators in their teaching of mathematics. Learners are rich sources of what actually happens (the hidden and real curriculum). They experience the need for calculators when exposed. Since South Africa has no specific policy on calculator use in mathematics, syllabus requires learners to provide their own materials (calculators). So they become rich sources for factors related to resourcing.

Other none-human populations considered in this study include these documents: continuous assessment, teachers' schemes and textbooks. These constitute the official guide for what is worthy knowledge in mathematics in South Africa (intended curriculum). Specifically, the syllabus showed content, methodology and assessment criterion for the use of calculators in mathematics classes and national examinations. The second set of documents included mathematics teachers' scheme books. These show calculator activities that teachers plan for the class. More important was their evaluations. There was no need for rigorous validation of these documents. Researchers were satisfied by them being the current (2022) documents in use. The head's school stamp was adequate for us to regard the document as valid. The actual scientific calculators which were found in the schools were also rich sources.

Sampling was purposive. The population was finite and grouped in schools. The inclusion criterion was having knowledge of calculator use (rich source), being available when researchers visited the school and willing to contribute to the study through the survey, focus group discussion or interview. In qualitative case studies, whose purpose is to understand, sample size does not matter. White (2005) can settle for single detailed case for understanding. Sampling is continued until researchers notice that, they have reached a variable saturation point.

Instruments

Field work method triangulation was composed of survey, lesson observation, focus group discussion and interviews. The main instrument for the survey was a questionnaire designed by the researchers for this study. It captured participants' possession of calculator, its' model, what they used it for and how they used it. Open ended questions captured participants' examples and insights. A key question asked for an illustration of a formal lesson that they had on the use of the calculator.

The lesson observation guide focused group discussions on the essentials for the analysis of observed demonstration lesson on calculator application as a pedagogical instrument in mathematics. The observation guide directed researchers' lenses on calculator use. We recorded when calculators were introduced in a lesson and for what purpose. Teacher and Learners' activities were valuable actions for the study's observation. Another instrument was a document

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analysis guide. It focused researchers on syllabus and schemes objectives, activities and evaluations.

Data Collection

Data collection was embedded in reading literature for a comprehensive understanding of the problem and its manifestations. This stage facilitated variable identification and instruments structuring. Permission was sought and granted by Ekurhuleni District schools Inspector and all school heads of secondary schools in the district. This was a critical ethical consideration enhancing an official buy-in for the study, mobilisation of support and study co-ownership. Researchers visited each school in the district education vehicles as part of the inspectors' routine visits. Questionnaires were distributed to teachers and pupils. These were collected from the school principal's office after three days. School principals' cooperation was critical in ensuring a high response rate. Volunteering teachers were visited at their school for their schemes of work, lesson observations and interviews. Video recorded lessons on the use of calculators in mathematics were beamed for teachers' focus group discussions.

Data Analysis and Presentation

Data analysis started by screening questionnaires for completeness and answering of key research questions. This was followed by coding responses according to research question themes (calculator availability, model, how it is used, factors, any calculator lesson taught in mathematics). Analysis of syllabus and schemes was done and findings recorded under calculator topics, objectives, activities and evaluation. Data presentation depends on the nature of the variable. Calculator model frequency and mathematics topics are quantitative discrete variable. They are presented on bar graphs to show the distribution of the single variable. Data for a none-parametric test was collected by frequencies of calculator preferences. Data from document analysis, interviews and observations is qualitative. It is presented in tables with direct quotations to enhance the presentation of reality.

3 .FINDINGS AND DISCUSSION

3.1 Calculator Prevalence

Findings presented in this study were analysed from purposive sample of 154 participants, composed of 41 teachers of mathematics and 113 learners from grade 8 to 12 in Ekurhuleni South district secondary schools. Seventeen (17) observed lessons, interviews, thirteen (13) mathematics teachers' schemes were analysed for calculator prevalence and instructional content. Out of 154 respondents, 109 reported that they had calculators which they use for mathematics. This was a (71%) calculator prevalence rate.

Fifteen (15) mathematics teachers had no personal calculators. Participants had five calculator models namely : Kenko S.U.P.E.R. (KK-82MS), *Scripto* 925 Scientific calculator, SHARP (EL-531WH) with D.A.L, JOINUS (JS-82MS-3) and Casio (FX-CG50) graphic calculator. Out of the 109 calculators seen in schools, only 17 (16%) had their manuals. We concluded that, limited consultation of the calculator manual contributed to their underutilisation in mathematics. Teachers and learners confined themselves to the primary basic operations (+,-, x and ÷).
Calculators were distributed as shown in Figure 1, below. The majority (37%) had the SHARP (EL-531WH) model.

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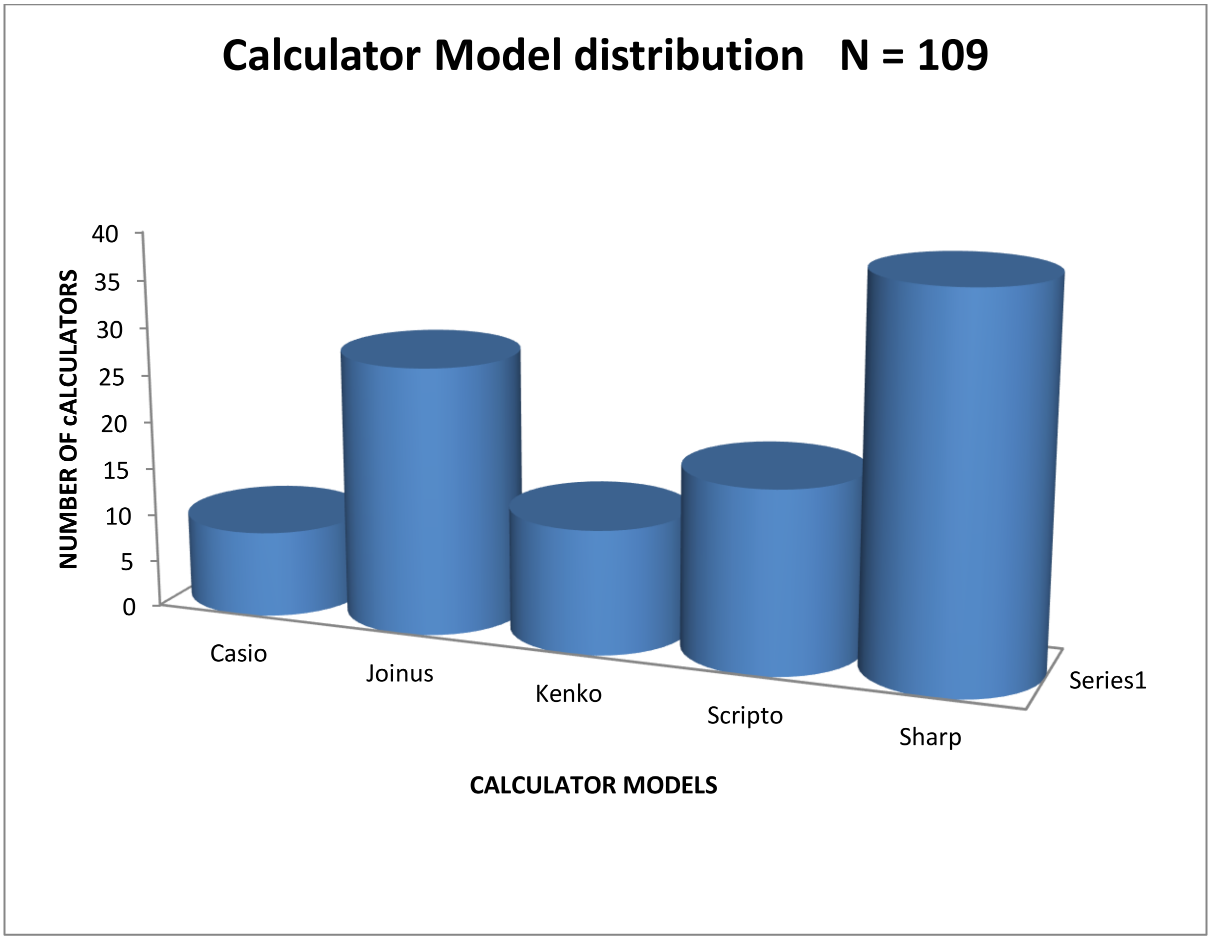

Asked why most of them have the SHARP (EL-531WH) model:
Teacher X, said: *These Sharp calculators are commonly available in shops and Supermarkets*.
Student D, said: *They are the cheapest scientific calculators*
These responses support Nyaumwe (2006) who refuted the cost of calculators as a factor for their non-use in schools.

The teacher's response did not focus on its' utility values, such as the statistical functions. It raised doubt whether that teacher used it for mathematical teaching and learning.

Only three students had the Casio (FX-CG50) graphic calculators. Asked why they bought that model.
Student B, said: *This was bought for me by a brother. Unfortunately, I do not know how to use it. My teacher cannot also use it. I will have to sell it and buy another.*
Student T, said: *This type of calculator was disallowed by my teacher. She explained to me that, it is not accepted for examinations. They said it shows all graphs, and you just copy.*

We tallied these sentiments with the assessment objectives which credit showing of working. This could be the point that the teacher wanted to stress. Unfortunately in this case, the official curriculum as expounded in the syllabus has barred learners from using advanced technology because they are unable to use it themselves. This is one of the official limitations of CAPS prescriptive education program.

An education officer supported the student by saying, such calculators puts this candidate at an advantage over others during national examinations. He further pointed out that under graphs; the syllabus emphasis is on practical drawing. For example we were referred to these assessment objectives syllabus point(6.5) Graphs and Variation

Table 1: Content and Objectives for Graphs and Variation

Content	**Objectives**
6.5.1. Coordinates	Use Cartesian coordinates to interpret and infer *from graphs* and to *draw graphs from given data*
6.5.2. Kinematics	*Draw and interpret* velocity, displacement-time *graphs*
6.5.3. Variation	*Draw and interpret graphs* for partial, direct, inverse variation
6.5.4. Functional graphs	*Draw and interpret graphs* given functions Solve simultaneous equations *graphically* Estimate gradient of curve *by drawing tangents* to curve
6.5.4.Area under a curve	Estimate area by *counting squares*

Yes, we agreed that, the syllabus is still prescribing the physical drawing skills not the form of the graph as shown by the graphic calculator. We deduced that, one of the sources of variation between teachers' continuous assessment and national assessment is the fact that, during continuous assessment a student can be guided by the calculator which will be absent during the national examinations.

We also noted that summative Norm-referenced national examination which is used for screening learners is a limitation to innovation. We concluded that, the national assessment models have not yet changed to allow technology application in education. Specifically, it currently does not allow graphic calculators to be used in mathematics at secondary school level. This finding contradicts Amanyi and Sigme (2016) who require syllabus objectives which use calculators to enhance understanding of numerical computation and solve real life problems.

Analysis of calculator prevalence by Gender revealed that, 67(61%) Female participants had their own calculators. One student reported that at form one level, everybody had a calculator. Boys either lost or sold their calculators because their seemingly obsoleteness. They (boys) survived by borrowing calculators when they needed them.

We inferred that, girls were more careful at keeping their calculators. Another perception was that, they kept them securely because to them (girls), calculators provide a lifeline in mathematics. They were used as critical computation tools for mathematics learning. A hypothesis test of association confirmed an association between gender and calculator preference. More female students preferred calculators than males. One implication for mathematics class management instruction is that, if possible the teacher can have a gender mixed grouping so that they share the limited calculators and their use.

Since each calculator has its unique features and is programmed differently, it is not possible for teachers to know them all and assist each student as per student's calculator model. We strongly recommend the use of one calculator model per school, so that teachers can support learners more effectively.

3.2 Calculator Usage in mathematics

Respondents did not supply any example of a lesson on the use of calculators. This suggested that, no teacher taught learners how to use calculators in mathematics. None of the 17 teachers whose schemes of work was analysed had a lesson scheduled for the use of the calculator. Interviews showed that, they took it for granted that learners know how to use calculators. None of them had also schemed as assumed knowledge, checking of learners' calculator skills.

We inferred that, while teachers saw pupils using calculators, they did not accord learners' calculator operation skills an equal weighting to that of the mathematics content that they were teaching. On the contrary, learners were taught how to use logarithm tables before they used them.

We recommend that, calculator skills be done as an introduction for all lessons in which the calculator is applied. For example, identification of the square- root ($\sqrt{\ }$) sign, on the calculators' keys must be done as part of the introduction for solving quadratic equations using the formula. The meaning of an Error 2, response for say, $\sqrt{-13}$ must be explained and may be used for the introduction of complex numbers. Learners must try evaluating the square-roots of at least five numbers including 2 negative numbers as a lesson introduction.

Figure2: Topics in which teachers Required Calculators N = 17

Topic	Frequency																
Quadratic Equations	x	x	x	x	x	x	x	x	x	x	x						
Consumer Arithmetic	x	x	x	x	x	x	x	x									
Mensuration	x	x	x	x	x	x	x	x	x	x	x	x	x				
Trigonometry	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sequences	x	x	x	x	x	x	x	x	x								

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Matrices	x	x	x	x	x	x											
Statistics	x	x	x	x	x	x	x	x	x	x	x	x					
Transformation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Graphs	x	x	x	x													

The dot plot shows that, all (17) teachers whose scheme books were analysed recorded calculator for a teaching learning aid for trigonometry. Calculators were also required for mensuration and quadratic equations. Only three teachers indicated calculators as a teaching aid for matrices.

Table 2, shows how the calculators were applied.

Topic	Content	Examples for Calculator
Quadratic Equations	Solution using formula	Finding Square-roots $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ Identification of imaginary roots, calculator says Error 2
Consumer Arithmetic	Water and electricity bills, Bank accounts	Computation of costs, Calculations of percentages (interests)
Mensuration	Lengths and Area of sectors Volume of pyramids cylinders Area of triangles	Evaluation of formula values $A = \frac{1}{2} ab \text{ Sin } \theta$ $e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots,$ $-\infty < x < \infty$
Trigonometry	Ratios	Numerical value of say, tan θ
Statistics	Computation of measures of central tendency	Computation of mean $= \frac{357}{13}$, the division
Matrices	Calculation of determinants	Numerical values for directed numbers

Table 2 examples show that calculator use was limited to the four basic operations and computation. In matrices and consumer arithmetic, calculators were used for addition and subtraction. For trigonometry and mensuration, calculators were used for the numerical values of trigonometric ratios and the multiplication. In fact, they were taken as replacement for logarithm tables. Some students who had calculators also used logbooks for trigonometry ratios. We deduced that, calculators in this respect were used for addition of decimals.

While the calculator has the statistics mode for computing the mean, variance and standard deviation, learners were not taught to use them. When one teacher was quizzed on why they did not show students how to compute mean directly from the calculator, the teacher said that he wanted students to show their working so that they get method marks. As a national examiner in mathematics, the teacher drills students to maximise marks by presenting every part of an answer that national examiners award marks for.

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We inferred that, mathematics teachers are teaching for examinations more than learners understanding of mathematics concepts. Such a perception (teaching for examinations) violates the achievement of learner understanding of mathematics for higher levels. Such teachers require mind set re-orientation.

3.3 Factors promoting calculator prevalence

The following factors were considered as promoting the prevalence of calculators in secondary schools in Zimbabwe:

- The National Science and Technology policy calls for mathematics educators to contribute by teaching learners how to use calculators in mathematical situations in their day-to-day lives.
- The presence of national board examinations is a direct provocation for both teachers and learners of mathematics to learn how to use the calculator in mathematical tasks in class and their every-day lives.
- The school environment (authorities, teachers and students) have a positive disposition to the application of calculators in mathematics. Teachers allow students to bring calculators in their classrooms.
- Parents are keen to apply technology and can buy calculators for their children.
- Teachers who participate in the marking of national examinations can influence the scoring of examination answers to reward students who show ability to use calculators.

3.4. Factors affecting Calculator Prevalence

- National examinations have not yet accommodated calculators in their assessment models. Teachers who are oriented to teaching mathematics for students to pass examinations concentrate on the use of pen and paper solutions which show each stage of working to gain method marks.
- Teachers who allow students to use calculators during continuous assessment are at a better position for influencing their application in national examinations.
- National mathematics syllabuses which emphasise the use of physically drawn graphs compel teachers and students not to use graphical calculators. Actually, graphs are now being drawn by computers in the real world. So such a syllabus, textbooks and teachers are equipping learners with obsolete skills. Shame!!
- Mathematics textbooks used in secondary schools have nothing on how to use the calculators.
- Teachers' colleges did not teach students how to use calculators. The ripple effect is that, teachers cannot apply calculators for instruction in mathematics. They have limited knowledge of how the calculator works, what it can and cannot do and how to use it to develop students' understanding of mathematics.

Recommendation to Improve Calculator Prevalence

Calculator prevalence (availability and use) can improve if the following recommendations are implemented:

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a) The district can set a policy which advocates for the use of one model of calculator in its schools. The district can ask the company to donate calculators for those students who cannot afford.
b) District Education Officer, recruit experts on a part-time contract to write modules on how to use the
calculator for different topics in the syllabus.eg. Teacher A writes a chapter on sequences, Teacher B writes on Correlation and regression and teacher Z can present this for *Statistics probability*

Expectation E(X) = np and Variance, Var (X) = npq

$$(x+a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$$

$P(X = x) = {}_nC_x . p^x . q^{(n-x)}$

Where: $nCx = \dfrac{n!}{x!(n-x)!}$ for example, ${}_7C_5 = \dfrac{7!}{5!(7-5)!} = \dfrac{1.2.3.4.5.6.7}{1.2.3.4.5.1.2} = 21$

Calculator can do this calculation. ***[7], [2ndF], [nCr], [5] [=]***
Calculation of p to the power x, [p], [y^x],[x]
for example $(0.7)^3$ = (0,7)[y^x][3] = 0,343.

c) District officer mounts workshops to teach their mathematics teachers how to use calculators in mathematics
classrooms. Each teacher can be given a school handbook on how to use the calculator.
d) Lesson observations by District Schools Inspector can focus on the use of calculators in mathematics
Instruction and teacher promotion credit be raised for those teachers inculcating technology application.
e) Teachers whose lessons on calculator use are good, can be resource persons for their cluster of secondary schools. They can present the good lessons for others to learn.

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