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MATHEMATICS INSTRUCTION: PRACTICAL ADVOCACY FOR REGRESSION ANALYSIS AT A HIGH SCHOOL IN SOUTH AFRICA

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ABSTRACT
This study sought the possibility of a practical approach to the teaching of Regression analysis at a high school in South Africa. This contributes to improvement of teachers' mathematics instructional methods and enhances learners' understanding and application of regression models. The study was prompted by the observation that, generally students are underperforming in mathematics. One of the reports for Curriculum 2005, pointed out that students showed lack of understanding of regression analysis concepts. The study was guided by pragmatism research philosophy which seeks truth from intervention actions that work by solving the problem. Data collection was initiated by desk research for conceptual understanding. This was followed by surveys of a purposive sample of 33 teachers' views and lesson observations of how regression analysis concepts were taught. Document analysis and interviews helped to identify factors influencing the application of lecture methods. Error analysis was done to identify key points for corrective teaching. A group project practical approach was designed by the researcher, pilot tested at one school and evaluated by teachers who observed the video during an online lesson evaluation focus group discussion on ZOOM and BIGBLUEBUTTON platforms. The study established that, students' low levels of conceptual understanding of linear regression can be taught from a practical approach using this model: Establish students' errors through a pre-test. Introduce concepts by posing practical problems. The relevance of the task must provoke learners' emotional overtones. Use the problem to introduce concepts such as, nature of relationship, strength of relationship, coefficient of determination, regression linear model or equation and its use as a systematic mathematical method to solve the problem. Allow students to form groups of five to nine learners per group. Task them to measure and record group members' height, weight, arms' length and shoe size. Groups established mathematical models linking Weight and shoe size, weight and height, height and stretched arms' lengths. Learners' present their findings from the project to the whole school. Study encourages teachers to carry out error analysis for progression, real-life problems and develop procedural knowledge from practical activities. Satisfy students' curiosity by practical investigations of relationships for common variables like weight and shoe-size.

Key Words: Mathematics Instruction, Practical Approach, Regression Analysis.

1. INTRODUCTION
There are different views of what mathematics is and how it can be taught in schools. Hom and Gordon (2012) regard mathematics as the science of structure, order and relations which have evolved from elementary practices of counting, measuring and describing shapes of objects. This

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is a functional perception linking mathematics to its utility value. The idea of order and relations reminds us of regression analysis. Simple interest, profit and loss, speed and velocity are examples of topics taught for their utility value from South Africa's mathematics curriculum. Devlin (2012) suggests mathematics to be a science of numbers, shapes, dimensions, change and abstraction. It is a basis for understanding the world and its' technological progress. This is an accounting purpose for mathematics. In this regard, mathematics is used to explain. Its' teaching must enable learners to see mathematics in their everyday lives. This is a direct call for the current study which contributes practical teaching methods for regression analysis.

Ziegler (2012) has three dimensions of what mathematics can be. First, mathematics is coined a basic tool for life. It is everyone's survival kit for modern-day life. The use of numbers for money transactions, identification of streets and villages all need numbers. Learners need to identify the appropriate instrument in the life kit. If teachers help learners see where each tool works by applying practical methods whose tasks involve real life activities, then learning will be contextualised. This is a dimension which requires both pure and applied mathematics. High schools in South Africa emphasise the pure part by teaching procedures whose end results are single numerical answers.

According to Ziegler (2012), the second version of mathematics as a historical productive field of culture and art of designing is not talked about much in schools. Teachers draw rectangles on chalkboard instead of pointing at the door, desk top or page as a rectangle. High school teachers overshadow this historical terrain of mathematics. One can attribute the practice to the perception of a dichotomy between history as an arts and mathematics as a science subject. This study proposes that, teachers who do not teach the history of mathematics portray a limited view of the subject. They do not promote learners' emotional attitudes and appreciation of mathematics. The third but equally important concept of mathematics acknowledges mathematics as a science. It is an essentially developed active field of research and mathematics application.

Actually, arithmetic and geometry started as practical sciences serving the needs of everyday life. Sympathies for abstraction developed as soon as mathematics moved beyond the purposes for which it was initially invented. Despite that, practical applications of mathematics have never been divorced from the mathematical disciplines (arithmetic, geometry, astronomy, musical theory). In addition, many contributors to pedagogical thinking in the past 4,000 years suggest that pedagogical exercises should not leave the child inactive by preventing the learner from controlling the material. Bruner (1967) observes that instruction in mathematics though, followed the pattern of teaching the young by telling 'out of context' rather than showing 'in context'. This study subscribes to mathematics as a science, considering that correlation and regression analysis can be learned through collection of data, measuring, recording and reporting findings as solutions to practical problems.

Correlation refers to the interdependence of two continuous variables (Mukaka, 2012). According to Hinkel and Wiersma (2003), the word "co" means "two" hence correlation analysis refers to the investigation of a mutual relationship between two dependent variables. Murairwa (2016) regards correlation as some form of quantified association between two dependent sets of variables.

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Regression is the estimation of the line of best-fit to summarise the association between the variables. Murairwa (2016) considered regression analysis as a reliable method of identifying variables with an impact on a topic variable of interest to the researcher. In research Ding (2006) noted that, regression analysis is used to assess the effect of the independent variable on the dependent variable. It is the average effect across all subjects in the sample. Regression is used on the assumption that; all individual participants are drawn from a single population with common parameters. Regression analysis then can be considered to be a method of using observation (data records) to quantify relationships between a target (field record set) dependent variable and independent (covariate) variables.

Such a study can be carried out by teachers interested in generating progressive methods of enhancing the utility value of mathematics. In fact, considering mathematics as a science can enable this study to earn a qualification in mathematics and science education. Regression analysis applies practical scientific methods of data collection for predicting dependent variables in the context of learners' bio dimensions. There are three purposes for teaching correlation and regression analysis. First is to establish the nature of relationship between the variables. Second is the determination of the strengths of the variables and to facilitate the prediction of one variable when the independent variable is known.

Contextualising mathematics instruction refers to teaching methods which enable the child to decide on the application of mathematics concepts learned in class when solving real life problems. It encompasses teaching mathematics for both understanding and application. More important is its' appeals to the learner's heart (aesthetics, the nature and appreciation of mathematics beauty), the mind (cognitive development) and hand (psycho-motor) skills in a synchronised academic enterprise. The end result of learning as required by the Curriculum and Assessment Policy Statement (CAPS) calls for the solution of real world problems using understanding of practical mathematics instructional methods whose activities are carried out in the learner's environment. This study focused on satisfying learners' curiosity of discovering mathematical relationships between, say weight and shoe size.

Practical mathematics instructional methods are considered as child centred while the current mathematics teaching methods in South Africa's high schools are teacher centred. Mathematics application for concept development is muted and linked to applied mathematics and statistics. That is a limited perception for mathematics education to liberate the mind from mathematics as a content discipline to mathematics as an applied tool for day to day problems. Practical mathematics teaching methods emphasis is on the simultaneous development of the child's psychomotor and cognitive skills. This study then, contributes practical methods for mathematics statistical regression to model relationships between students' height and shoe size, height and weight, shoe size and weight as extension of grade12 statistics in South Africa's high school curricula.

Mathematics education in South African schools has been a common playground for curriculum reforms driven by politically, educational and economically motivated determinants. Such reforms are indicators of the public's lack of confidence in the country's mathematics education. Admission of low performance is shown by the experienced reduction of education standards for the past twenty years. Economic ends coupled with the conflagration of mathematical prowess and problem-solving skills for the knowledge economy resulted in mathematics being isolated as

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essential knowledge in South Africa. Thus in the post-apartheid era in the country, a redress was effected to ensure that all students are exposed to some form of mathematics by the time they complete matric.

Significant changes in the overall education system were pronounced after the 1994 democratic elections and post elections in South Africa. Biggest changes by necessity have been in the area of mathematics and science 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. Focus was on the content differentials between White learners and Black learners' schools as per examination requirement. The examination of factors contributing to low academic performance had limited attention on the teaching methods.

One of the key principles under examinations outcomes-based education is the integration of knowledge and training. Many schools of thought recognize and criticise the gulf between theory and practice in education and more broadly between education and life. Analysis of literature has shown educators' awareness of the dangers inherent in the fragmentation of knowledge between school boundaries and their lives. Alfred North Whitehead back in 1969 urged the eradication of this disconnection of subjects, which skills the vitality of the modern curriculum and the push for innovation and entrepreneurship. This suggests the need to systematically combine intellectual study with physical work and the production of goods and services. The integration of theory and practice, education and training, mental and manual labour, academic and practical work unlocks as many doors as it unites what has been artificially separated from reality in the past.

Chambliss (1971) emphasizes that the work of the head and skills of the hand will be joined in the classroom and workshop into one comprehensive method of developing harmoniously the powers of the body, mind and soul. Teachers are encouraged to develop morality in the child and train him to work hard. Such is the philosophy of implementing practical approaches in the classroom.

Departments of Basic Education and Higher Education and Training (2011) pointed out that, Outcome Based Education (OBE) was reviewed in 2000 after the experiences of its implementation by stakeholders yielding undesired results. One can conclude that, challenges arose from the fact that, it was not originated from the classroom. The Revised National Curriculum Statement (RCNS) Grades R-9 and the National Curriculum Statement Grades 10–12 was then initiated and found its way into the classrooms for implemented in 2002.

According to Bjorklund (2015) the RNCS system failed because the 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. Weaknesses in the change process include these: first, RCNS was highly loaded and fell short of its expectations. Second, it used vague complex terminology. More important is that, training of teachers and district officials was inadequate. One overshadowed factor was that, teacher involvement was limited to implementation of the literary imposed teaching methods. There was limited room for teacher creativity since all methods were spelt out in the curriculum. Well, one can understand that, how much freedom teachers are given in curriculum design depends on the teachers' level of competencies.

After being implemented for ten years RCNS was reviewed in 2012, found inadequate and replaced by the Curriculum and Assessment Policy Statement (CAPS) which was rolled out in all phases. Carnoy, Chisholm and Chilisa's (2012) evaluation suggests that, OBE is still the underlying philosophy underpinning CAPS. Currently, CAPS is the curriculum being implemented in the country as a measure that redresses the inequalities and imbalances of the past in 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 Education and Higher Education and Training, (2011: 121) points out clearly that, CAPS aims to produce learners that are 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, analyse, organize and critically evaluate relevant data;
- use visual, symbolic and or language skills in various modes to communicate effectively; and
- 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.

These attributes were the motivating pillars for this study's application of project teaching which harness mathematics concepts of estimation and regression analysis in South Africa. Most important, is the study's teaching methods which have the ability to link practical application of mathematics with real life activities of measuring, recording and reporting in groups. Stanton (2001) proposes the following teaching method for correlation and regression: first reviewing Galton's heredity problems. This may not appeal to those South African students who dislike agriculture. The practical work starts by plotting data points and fitting line of best-fit by hand. The action develops learners' motor skills. Teacher is encouraged to demonstrate that, Pearson's (r) is the most accurate prediction of Y, score

Howie (2012) reports that, curriculum blinkering was evidently reflected from national school assessments and also in the Trends in Mathematics and Science Study (TIMMS) together with Southern and Eastern Africa Consortium for monitoring Educational Quality (SACMEQ). Moloi (2012) assured stakeholders that, Government officials and mathematics subject advisors are able to monitor the present curriculum. This is because the mathematics content to be taught is explicitly delimited, paced and sequenced with prescribed mathematics textbooks which provide certain examples.

However, Ramatlapana and Makonye (2012) argue that although a centralised curriculum ensured resources availability, the said prescription restricts mathematics teachers' professional autonomy. However, the curriculum is preferred in the country because it is helpful in the teaching of low achieving learners from disadvantaged socio-economic backgrounds using a more structured

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teacher directed instruction. In addition, the curriculum enhances systematic efforts to change the practice, attitudes and beliefs of mathematics teachers in the classroom. Teachers' and students' learning outcomes and familiarisation with the implementation of the curriculum are facilitated 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: 67) suggests the following mathematics education implementations strategies:

- In 1994, mathematics was a compulsory subject until grade 9, and beyond that it was optional. Those who registered for it at matric level did it on either higher or standard grade until 2007.
- 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 curriculums change in the form of an "outcomes-based" approach was introduced. This change had a major impact in the learning and teaching in the General Education and Training phase (GET), (grades 7–9) due to the fact that it was very vague in terms of content to be taught in different grades.

So far mathematics curriculum changes involved moving content from one grade to another, removing some content and introducing new content. There is limited focus on teachers' teaching methods although they form a strong coupling in the system. Recently, Technical Mathematics and Technical Science in technical schools in grade 10 from 2016 were introduced. These two require more mathematics application rather than recall. Teaching methods demand students' involvement of the hand and mind in the learning process. Such observations funnel to the conclusion that mathematics curriculum evaluation and change in South Africa is a continuing process. Coupled with the change in curriculum was also the introduction of Mathematical Literacy as an alternative to be done by students who were considered not competent to do mathematics in the Further Education Training phase. This was done to cater for those students who could not do pure mathematics and to retain the compulsory status. Such changes ensured that all learners are exposed to some form of mathematics by the time they finish school.

The Education minister's, (Motshekga, 2013) observation noted that "South Africa is significantly under performing in education in general, particularly mathematics teaching and learning. Mathematics teaching is often poor quality, with teachers not able to answer questions in the curriculum they are teaching, one indicator of the challenge. Often national testing is misleading as it does not show the major gap at lower grade levels." The comment is a direct attack on teachers' content knowledge levels. The current study is consent with teachers' pedagogy levels which promote mathematics understanding. It assumes that, teachers have the content of correlation and regression analysis to be able to teach it.

The government opted to define the set of values for the teaching and learning of Mathematics in the South African context. It was also acknowledged that in education, the country was doing well in terms of providing access to some mathematics studying and equity, but quality of teaching raised eyebrows. Mostly, the underperformance was visible in the public sector schools that form

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about 80% of schooling in the country. This study can only contribute part of the solution to students' underperformance in mathematics by suggesting a practical method for teaching mathematics correlation and regression analysis in South Africa.

Mathematics under-performance crisis has recently worsened as the department of education has decided to progress learners who do not meet the minimum mathematics requirements for progression to the next grade in the senior phase, grades 7–9. Parker (2006) claims that the progression of learners who fail mathematics compromises the country's future quality of human capital and economic growth. Zingiswa, (2019) focused the solution on teachers' teaching abilities. He proposed that under qualified mathematics teachers, those who had done standard grade mathematics can be subjected to an intense compulsory in-service mathematics teacher training process. In this way mathematics teachers would be equipped with both pedagogical knowledge and mathematics content for teaching the subject.

In the past decade, Venkat et al.(2009) declares that the number of students seeking to become senior secondary teachers of mathematics in schools has not kept pace with demand. Teaching is unable to compete with the status, remuneration and prestige of other expanding career options in science and technology, given the small pool of successful candidates in matric mathematics. The shortage of mathematics teachers is associated with the fact that South Africa's apartheid policies deliberately underdeveloped the mathematics education system. In 1994 South Africa inherited high school teachers of mathematics whose highest qualifications were diplomas as opposed to degrees. They were underprepared to handle the content of the changed mathematics curriculum. This legacy remains intact and must be addressed for any reversal of the past and for substantial improvements in providing learners with adequate and appropriately qualified mathematics teachers.

Under qualified mathematics teachers require mathematical knowledge and skills promised in the current CAPS curriculum. Parker (2006: 17) notes that approximately 20% of grade 10–12 mathematics teachers are professionally unqualified and of those that are qualified, still only 21% have some university level courses. In addition, there is also evidence to the fact that qualified mathematics teachers in the system are either not teaching mathematics or not teaching it at the level at which they are qualified.

Moloi (2012), for example, argues that quality mathematics teaching in South Africa will continue to be a phantom unless:

- there is a quality teacher education that refreshes teachers' competencies;
- teachers make efforts to understand how their learners think and learn, and recognize the learning experiences of their learners; and
- Teachers' are given the necessary support by the Education Systems around the World authorities. The proposal is anchored on teacher development because the teacher activates all teaching and learning in classrooms.

Moloi (ibid) did overlook the role of the mathematics teacher as an action researcher seeking practical methods to promote students' understanding of mathematics.

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Research on Mathematics education in South Africa

The changing landscape of post-apartheid South Africa called for research themes exploring mathematics education to include assessment, issues of language, aspects of radical pedagogy and progressive classroom practices. Ethno mathematics deserved special inclusion because mathematics teaching and learning is a cultural activity. Nonetheless, it would be of interest to see how all stakeholders understand the connections between curriculum research, reform, policy and practice in mathematics education.

Adler et al (2016) report a considerable increase in primary mathematics education over the past decade. This could be a response to South African mathematics education registered challenge wherein learners' performances at all levels, and teachers' specialized mathematical knowledge was significantly low. The Centre for Development and Enterprise (CDE) is one of South Africa's leading development think tanks, focusing on vital national development issues and their relationship to economic growth and democratic consolidation. Spaull (2013) who compiled the CDE report assert that despite some improvement, South Africa is still significantly underperforming in mathematics education. The data collected points to indicators on school performance and teaching reveal largely unacknowledged poor teaching of mathematics in the majority of schools. The most recent report from the Head of the Department of Basic Education's National Education Evaluation and Development Unit (NEEDU) (2014), argues that poor learner performance in most schools is largely due to the poor subject knowledge of teachers, especially in mathematics.

The government official remarks that low student achievement is accounted for by teacher complacency. Specifically, the appointment of mathematics teachers not on merit resulted in incompetent teachers being in charge of classes. Spaull (2013: 17) proposed four points that can be borne in mind when addressing South Africa's numeracy and mathematics schooling challenge:

- although the improvement of mathematics teaching and learning in public schools will not happen fast, it must begin urgently;
- poor mathematics and numeracy teaching and learning in public schools accelerate private schooling where in 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, and
- it is likely that the country will have growing numbers of innumerate young people. The majority of young South Africans are unqualified to be hired in many types of high quality work.

Currently (2021) under performance in mathematics is still a perennial issue in South Africa's schools. The Department of basic Education as a way of trying to address underperformance in mathematics recommended active and critical learning classroom instructions, which encourages and involves active and critical approaches to learning. While recommendations are based on examination results, teachers will continue with rote and uncritical learning of given mathematics procedures (Basic Education Curriculum and Assessment Policy Statement (CAPS) Mathematics Senior Phase, 2011:4).

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The South African Annual Teaching Plan (ATP for 2021) week 25, 2 to 6 August has this content for Correlation and Regression: *Use statistical summaries, scatter plots, regression line and correlation to analyse and make **meaningful comments** on the **context** associated with given bivariate data, including interpolation, extrapolation and decision on skewness.* Key words which demand understanding are “meaningful comments” and “context” which require learners’ understanding of concepts from practical everyday activities in their real-life situations, not merely computations to get the correct answer. Unfortunately, it does not suggest any teaching methods. The omission calls for the current study, a practical advocacy for correlation and regression analysis.

2.STATEMENT OF THE RESEARCH PROBLEM

There are limited mathematics teaching approaches which apply practical activities to develop correlation and regression analysis concepts for application in grade 12. Despite the suggested strength of a 'hands-on' approach, learning in secondary school mathematics classes has become abstract and analytic. Teachers expose students to formulas and procedures leading to one correct answer for the question. Students lack the opportunity to act and learn from their educational experiences. Major topics such as correlation and regression analysis are taught in theory. Students are provided formulas and exercises in which they substitute figures to get answers. Teaching procedural knowledge perpetuates rote learning at the expanse of application. Procedural knowledge out of real life context is nothing more than learning for examinations rather than the predictive and social communicative function of mathematics. This contradicts the development of students’ manipulative, cognitive and problem solving skills. In fact, teacher centred teaching methods alienates students from their local environment by focusing them on book information. Students consider mathematics as a school subject and not content activities in which they survive.

Limited consideration was given to the actual classroom teaching methods. Attempts to examine classroom discourse were confined to evaluations of the implemented solutions identified for improving efficiency in teaching and learning of mathematics. There is scant work on solutions linking practical work with the teaching of mathematics content. The role of the current study is to provide a practical teaching method for grade 12 mathematics based in the context of regression analysis hence appropriate for a mathematics and science education degree.

Main Research Question

This study intent to answer the fundamental question which worries teachers who are serious about their work: *What practical teaching methods can be used to teach mathematics content for predictive regression analysis?*

Research Questions

Solutions to the main research question are synthesised from answers to the following questions:

1. What difficulties do learners show in correlation and regression analysis?
2. What teaching methods are being used to teach regression at grade 12 in South Africa’s Kopano high schools educational circuit?
3. What factors influence teachers’ teaching methods for regression analysis?
4. What practical teaching methods can be used to teach regression analysis at grade 12 levels?

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Study Objectives:
This study then intent to:

1. Infer learners' errors on correlation and regression analysis problems.
2. Deduce teaching methods that are being used to teach regression analysis at grade 12 in South Africa's high schools?
3. Establish factors influencing teachers' teaching methods for regression analysis?
4. Suggest a teaching model for regression analysis which can be applied in real life setting in any school.

Significance of the study
This study deserves significant recognition from the fact that: its findings improve the practice of teaching. It specifically contributes teaching methods and teaching materials for practical activities to improve their teaching of mathematics. This is important contribution of practical teaching methods which teachers can use for estimation and hypothesis testing in the context of maize yield in South Africa. This method links mathematics to real life. The method develops students' understanding of mathematics content and its' application. Findings also add a significant part of teacher support in the implementation of CAPS curriculum.

It is an important contribution to literature on mathematics teaching methods for South African teachers. More important for teachers, is the fact that, this study raises participating teachers' awareness of teachers' contributions to curriculum implementation through research. It is a rich source of teacher-researcher insights for further action research in mathematics curriculum implementation. The study's ripple effects are based on the rationale that, redressing instructional techniques for teachers on one hand will be addressing learners' problem of under achievement in mathematics. Participating students developed researching skills which they will apply in their real lives. Also specifying strengths and weaknesses of the current mathematical instructions may provide useful data for educational authorities as a planning basis to solve the current issue of teacher staff development and students' underperformance in mathematics.

3.METHODOLOGY

Research Philosophy and Design
This study whose purpose is to explore the possibility of a practical instructional intervention for correlation and regression was guided by pragmatism research philosophy. Kothari (2004) suggests that, pragmatism believes in true knowledge as that which works by solving the problem. It is a solution seeking philosophy. Since the study had several variables, pragmatism became handy for facilitating the application of mixed methods (Bazeley, 2018).

The study applied a mixed methods descriptive research design in two parts, non-empirical (literature) and empirical investigation (fieldwork). This was influenced by Punch (2006: 17) model of research design. According to Huberman and Miles (2002), exploratory studies are guided by research questions rather than hypothesis required for confirmatory studies. The design allows the in cooperation of literature as data and bench marks for the empirical (instructional model) stage.

Population and Sampling

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The population of this study is in two categories, human and material. The material population was composed of school curriculum documents which revealed what South Africa considered as worth mathematics knowledge. Teachers' schemes of work, show their understanding and interpretation of national syllabus. Text-books exhibit what learners are exposed to and how they are required to learn it. Researchers used purposive samples of them. The inclusion criterion as required by White (2005), was being rich sources of the content and available. Since these were documents in use officially in schools, there was no need to carry out rigorous validation expected by Mustafa (2010).

The human population was composed of teachers and learners in Kopano high schools circuit. A purposive sample of 33 teachers participated in this study's survey. Their inclusion criterion was being teachers of mathematics who have taught regression analysis at some point, being available and willing to participate in the survey. The total number of grade 12 learners at one school (N= 46), is known hence probability sampling was appropriate to save resources. The variable, knowledge of regression analysis was expected to be uniform since they were taught regression analysis prior to the study activities. Simple random sampling of participants was done to allocate learner participants into experiment and control group.

Data Collection

Data collection started by seeking permission from schools' responsible authority. Desk research was carried out by analysing curriculum documents and studies on mathematics performance in South Africa. A questionnaire capturing teaching methods used for regression analysis and factors influencing their use was structured by researchers for this study. The questionnaire was pilot tested to improve its reliability. Creswell (2009) advised researchers to delete questions not responded to during the pilot test.

The principal researcher administered the questionnaire to 33 teachers of mathematics who were at a circuit workshop in May 2020. Although this was an intact group, it was the richest purposive sample for this study. Collecting data from mathematics teachers who were at a workshop for a week facilitated a high response rate and reduced travel expenses. Analysis of data was done by researchers.

Grade 12 class at for the selected secondary school in 2020 had 46 students. They were taught regression analysis by their teacher (not the researcher). A pre-test was designed and administered to identify learners' errors on correlation and regression analysis and determine the students' possible level of performance on the subject.

The principal researcher structured the practical approach mathematics instructional model and discussed it with teachers at his school for improvement.

The Intervention: The researcher organised lessons off-session.

Lesson Introduction Problem: How can we approximate the possible Exam mark for a student who does not write the final examinations due to illness?

Class Discussion: class suggests possible estimations, their strengths and weaknesses in terms of validity and reliability.

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Teacher: leads students to review Regression analysis purpose (mainly approximation, prediction). The main concepts (nature of linear co-relationship -from scatter diagram, strength of relationship- from Pearson's Co-relation coefficient (r), Coefficient of determination (r^2), Mathematical regression model and its' application)

Activities: Learners formed 4 groups each of 8, 8, 9 and 9 learners. They collected the following data for each group member: Age, Shoe size, weight, height, stretched out arms' length.

Tasks: Group A *formulate a mathematics model for the relationship between* ***Age*** *and* ***Shoe size***

Group B *formulate a mathematical model for the relationship between* ***weight*** *and* ***shoe size***

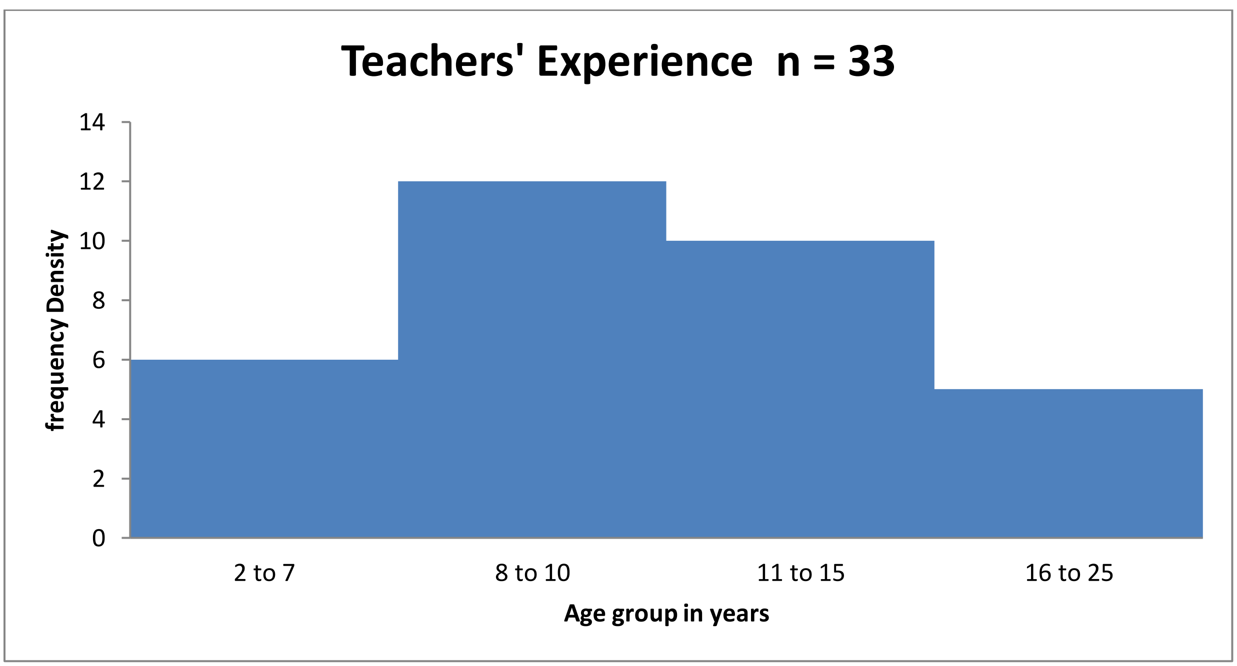
Group C *formulate a mathematical model between* ***height*** *and* ***stretched arms' length***.

Group D *formulate a mathematical model between* ***height*** *and* ***shoe size***

Groups presented their findings to the school community during an afternoon session as part of their projects. Group competition quiz focussing on application of correlation and regression in social, business, commerce and transport was one of the activities. A post-test was administered eight weeks after the pre-test scored and recorded. Teachers' evaluation of the model was done during an online focus group discussion.

4.RESULTS AND DISCUSSION

Findings for this study were contributed by 33 mathematics teachers and 34 grade 12 learners. These samples were statistically large for any variable to be normally distributed. The findings can be generalised to similar high school situations with minimal adaptions.



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The table shows that; the majority of teachers are in the (8 to 10) years' experience group. Their experience average age is 11.13636364 ≈ 11years. They are senior enough for their survey contributions and model evaluation to be relied upon. The visual impression is that of a positively skewedness distribution which support Motshekga (2013) who observed that, mathematics teacher qualification was low in South Africa's high schools.

Surveys and lesson observations revealed that, the majority of teachers taught correlation and regression analysis through teachers' lecture methods. They raised these facts in support of the teacher lecture methods for correlation and regression. It was the main method used at teacher training colleges. It is the main method for focussing learners on examinations requirement.

Teacher N, explained that: *In South Africa, schools are ranked and rated on the performance of their learners in national examinations. Therefore, teachers have to drill their learners to produce model answers. It is critical especially for foreign teachers to have high passes for their contracts to be renewed.*

Teacher T, supported N by saying*: School principals and subject advisers want learners to pass mathematics in external examinations so that they avoid accountability and trapping of schools under their administration. This forces mathematics educators to drill learners for examinations instead of teaching them for mental development and life utility values which involve the head, heart and hand.*

We concluded that, centralised curriculum with uniform examinations for different schools and different learners compelled teachers to use uniform (lecture) teaching methods.

Learners' Errors (Correlation and Regression analysis)
Qualitative analysis of students' scripts for the pre-test revealed that students:

- ✓ Operated at process level conception. They focused on getting the answer.
- ✓ Lacked conceptual logical reasoning. They could not explain the link between the scatter diagram findings and Pearson's correlation coefficient, for example a high/strong or positive correlation and R= 0.56 (positive value).
- ✓ Could not suggest contextualised qualitative justification for their answers. For example, why heavier students tented to have larger she sizes (positive correlation).
- ✓ There was no consistency in their reasoning. For example, low Pearson's correlation coefficient (R = 0.023) and possibility of a line of best-fit.
- ✓ Numerous algebraic and computational errors, particularly on the computation of sums of squares.
- ✓ Low proficiency in symbolic manipulations. They could not realise that, The formula for the gradient, **b** $=\dfrac{\sum xy-(\sum x)(\sum y)}{n\sum x^2-(\sum x)^2}$ was derived from that of Pearson's correlation. Most of them got their values of (b) by substitution.

Main purposes of using teacher lecture methods that teachers reported to have considered include introducing new material, illustrate applications of rules, principals and procedures. Lecture

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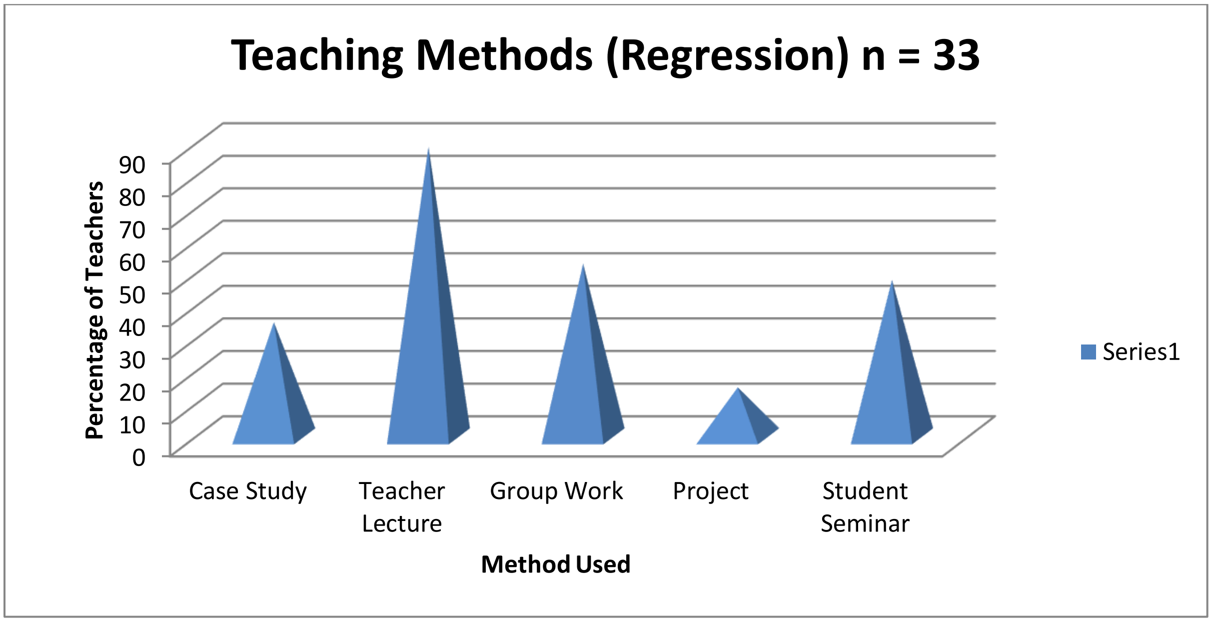
method was also appraised for saving time and allowing teacher flexibility. Teachers preferred it for preserving teacher expert power. Demonstration, discussion and assignments can be combined.



Project method was not popular mainly due to the fact that, it wastes time. Teachers are not keen to take time planning it. In addition, project and practicum instruction were discouraged because of these factors: students must have adequate content knowledge to be able to apply in a project. The teaching process must be reflective. Instructional methods must be contingent with the task, problem and quality of students. Teachers claimed that, these were not possible to care for their large classes. For maximum results there is need for teamwork for both teachers and learners.

Students' performance (Pre and Post-Test Results)

Test	n	$\bar{x}$	S_x	Range
Pre-Test	46	56	5.342	28
Post-Test	46	67	2.3561	13

The descriptive comparison in the table, shows that: students did better in the post-test

($\bar{x}_1 = 56 < \bar{x}_2 = 67$). Also students' performance in post-test was more consistent

($S_{x2} = 2.356 < S_{x1} = 5.342$). The range for pre-test is wider that of the post-test implying that, students' performance in post-test was more concentrated around the centre.

5.CONCLUSION

The purpose of the study was to enhance learners' understanding of correlation and regression analysis by developing a literature and empirical evidence informed instructional intervention model. The study recommends the following model in the form of lesson activities;

1. Carry out error analysis to determine learners' level and misconceptions to correct.
2. Introduce the concept of correlation and regression analysis in the form of a problem requiring prediction.
3. Allow students to find alternative solutions in groups.
4. Let them test their solutions using hypothetical figures.
5. Teacher can introduce correlation and regression as more accurate methods.
6. Students identify different situations in which relationships of dependent variables can be modelled using correlation and regression analysis
7. Demonstrate: a) Use of scatter plot as instrument to establish nature of correlation.
   b) comment emphasise the general and specific interpretation of answer
   c) Introduce Pearson's coefficient correlation as the quantitative value of the strength of the relationship between the variables. Also the value of (r^2) the coefficient of determination and its interpretation as possible contribution of the dependent on covariate variable.
   d) Lead students to the structuring of the equation of regression.

7. Let learners form groups, collect data on each member's height, weight, shoe sizes, stretched arms' lengths. Assign each group to establish regression models for the correlation between any two variables.

8. Groups present their reports to the school.

There are four implications for teachers of mathematics:

1. Carry out error analysis for almost all their mathematics topics. A single summative diagnostic test problem can help.
2. Record common error from each topic and discuss them with colleagues during staff development meetings.
3. Use real-life problems to develop mathematical concepts for understanding.
4. Develop procedural knowledge from practical activities.

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