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CALCULATOR APPLICATION FOR BIVARIATE DATA ANALYSIS: A TEACHERS' TEACHING METHODS REPERTOIRE TECHNOLOGY SUPPLEMENT

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ABSTRACT

This paper is a follow up to South Africa mathematics teachers' request for teaching methods in which calculators are applied. It explored teachers' teaching methods as a basis for the deducing teaching methods which require the application of calculator for instruction. Pragmatist philosophy facilitated the application of a combination of qualitative and quantitative research methods to enhance validity. Data was gathered from purposive sample of SHARP model EL-531 WH direct algebraic logic calculator manual analysis. This was the preferred calculator (rich source) available in the schools. Further document analysis was focused on mathematics textbooks and mathematics teaching methods. A survey of a purposive sample size (n = 49) teachers' preferred mathematics teaching methods was carried out in the circuit. Focus group discussions with mathematics teachers funnelled to group perceptions. Direct quotations for qualitative data were used to present accurate reflection of opinions from individual participants' registers. The study found that, most teachers (84%) preferred lecture and demonstration as the method for bivariate data instruction using calculators. The rationale was that it is a skills development technique which reserved teachers' mathematics expert power. Unfortunately, some teachers were not experts in calculator applications. Project method was rated lowest because teachers have low knowledge of its use. This study's participants learned how to interpret calculator manuals. This was an important contribution of the study to teacher skills development. In addition, the study's formulation of project teaching method as one of the methods which can be used to teach bivariate data using calculators was its' main contribution to teachers of mathematics. The calculator is mainly used as a motivation tool for computation. The study recommends the following teaching method: start by storytelling (Fuller-the human calculator of Virginia) is ideal. Plan the project from a problem project perspective to involve learners in solving the problem. Demonstrate the application of the calculator to check to the manual computation.

Key Words: Calculator, Bivariate data analysis, Statistics, Teaching methods.

1. INTRODUCTION

1.1 Background

Bivariate data analysis is a proper subset of predictive statistics within the field of mathematics. Sudhir and Ratnalikar , (2003:7) suggests that, the word "mathematics" is derived from the Greek word mathematica, which means "inclined to learn." The field of mathematics education and mathematics educational systems consist of many interrelated elements. A stakeholders' perception of the mathematics education system include: learners, teachers, curriculum, administrators and technology. Santos-Trigo (2007) ranks teachers as the essential element which

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activates all other elements in the system. Consequently the quality of the mathematics education mostly depends on the quality and competence of teachers and their use of technology such as the calculator.

Teachers in general and mathematics teachers in particular, have many roles. They identify the mathematics content, plan classroom activities, to instructing, motivating and guiding students. Frei (2008) reminded teachers to use effective teaching techniques and modern management skills in classroom environments in order to establish learning that can be defined as permanent changes in behaviour. Those factors which most impact students' learning and performance are not only teachers' attitudes, choice of methodology, and the content of curriculum. Christensen (1981) also included students' socioeconomic background, behaviour, personal characteristics and inclination to technology. Strong and Silver (2004) concluded by saying, effective mathematics teaching, therefore, must place equal emphasis on teachers' skills, student interests, technical environment and curriculum response to it.

Teaching mathematics is a practice related to more than one variable and other subject disciplines. According to Sullivan (2011), the primary goal of efficient mathematical teaching is to *transfer* mathematical knowledge in a way that allows students to adapt to new situations and knowledge. The word "transfer" is not appropriate, it has connotations of the teacher knows it all. Learners have nothing. In the use of calculators, learners must have the principals of mathematics and apply the calculator for computation. The story of Joseph as governor of Egypt, in Biblical history show how predictive statistics has been used to supply fundamental needs of societies such as food. Joseph had not been to school to receive the transferred knowledge. We inferred that, mathematics knowledge develops within the community. As mathematical knowledge progressed from man to machine, so did technology, with many new scientific branches emerging.
Sudhi and Ratnalikar (2003) propose that, mathematics curriculums have aimed to provide students with the fundamental mathematical skills needed for further education. This is a functional purpose where, the understanding of mathematical concepts is an essential element of the technical society where one is functioning. Besides the mathematics curriculum reflecting the technology from the society, learners must be enabled to develop their own mathematical thinking and problem-solving processes. Christensen (1981) advocate for such applied skills to be developed by project teaching methods. Projects enhance skills transfer and development from classroom to real life. Strong and Silver (2004) contend that, the chief aim of mathematics education extends beyond motivating students to learn the basic mathematics that they will need in school life. The purpose of mathematics education will be to convince learners (in the hope that they will continue to learn beyond the classroom) to adapt to the mathematical challenges which includes predictions in bivariate data that their future lives will present.

Mathematics is a discipline that deals with numbers, operations, rules and theories. Joffrey and William (2002) reveal that mathematics provides a means of communication which is clear, consistence, concise and convincing. As a result Munetsi (1994) suggest that, children are taught mathematics to acquire clear and logical thought. In real life situation, knowledge of mathematics and the related technology is *very* important. Mathematics as an academic course and as a mode of thinking begins in students' primary education and continues throughout their lifetime. Mathematics as a language of communication compels everybody to learn and use it for survival.

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Strong and Silver (2004) suggest a strong relationship between mathematical success and academic success in other courses. Changes and adaptations in other disciplines depend on the teaching-learning process facilitated by teachers in mathematics.

Focussing this study's lenses on teachers' preferences and opinions regarding pedagogical techniques in mathematics courses is important. Teachers reveal their ability to address the technical needs of students at different learning levels. The study began with a self-evaluation of the teachers' strengths and weaknesses in the use of calculators during mathematics instruction. The rationale being that, as teachers develop their teaching skills, they may help students integrate their mathematical knowledge with other activities. Ultimately it is the learners who find out what works best for their personalities and curriculum.
David (1996) endorses that, teaching as a profession is guided by principals. First, it is recommended that teachers build on children's natural interest in mathematics and on their intuitive and informal mathematical knowledge. To that end Sullivan (2011) encourage teachers to apply inquiry and exploration to foster problem-solving and mathematical reasoning. Second, teachers are expected to use both formal academic lessons and everyday activities as natural vehicles for developing children's mathematical knowledge. This requirement calls for informal teaching methods such as storytelling. Frei (2008) observes that, a mathematically rich environment is developed by practical vivid examples incorporating the language of mathematics. Third, teachers are also advised to use literature such as the history of mathematicians to introduce mathematical concepts and then reinforce them with hands-on activities such as projects. Finally, teaching is a community service in which teachers establish partnerships with parents and other caregivers in order to support children's mathematical development.

Mathematics as a common tool and language is used to define mental schemas throughout the world. Individuals who lack basic mathematical skills may face difficulties in school and social life. Teachers are called upon to overcoming such difficulties by establishing effective teaching methods and learning environment which reflects technology in the community. Achieving the functional goal depends on the employment of effective pedagogical methods

Many adults and learners harbour fear or loathing of mathematics. Unfortunately these attitudes are often reinforced by classes that present mathematics as an obscure and sterile subject. Albert (2001) proffers that learning to solve real life problems is the principal method for studying mathematics and reducing the fear of its' application. Such a notion points at problem solving as the central focus of the mathematical curriculum. Munetsi (1994) insists on mathematics enabling learners to acquire clear and logical thought. Such a commercial perspective points at mathematics as a base for scientific development and modern technology. To that end, learners must be skilled in the use of calculator as a mathematics operation technological tool. Jeffrey (2002) holds that applied mathematics now contributes directly to business, finance, health, agriculture and defence.

Good mathematics teaching with appropriate instruments opens students' doors to different careers. Predictive statistics enables informed decisions for any business operation and national commercial ventures. According to Hennich, Motenda and Smaldino (1996) a technological economy calls for technically literate people able to read technical manuals. Regrettably mathematics is taken as a very difficult subject by majority of the learners. This paper

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tags students' negative attitude to mathematics on teachers and their teaching methods. Many people do not have the necessary mathematical skills to apply to real life situations when they leave primary school. Most learners do not get the opportunity to develop their mathematical abilities without teachers' initiatives. As such mathematics competency deficit reflects a default mathematics teaching. It is a general view that children learn mathematics better if their abilities, needs, interest and technology are taken into account when planning teaching and evaluating maths lessons.

Teaching of mathematics can be interesting if the appropriate technology is used. For example, the assigning of computation to mathematics calculators frees learners from fear of failing due to computation errors. Different people have explained learners' poor performance in mathematics from different angles in South Africa. Some attribute it to poor teaching methods. Others argue that lack of teaching and learning resources during the course of learning is the cause. This paper focuses its' investigative lenses on the application of technology.

In most cases teachers accept the burden of learners' poor performance on their shoulders. That acceptance renders them rich sources for this study's problem of incompetent use of calculators. Teachers are known for working tirelessly to make sure that they complete the work in the syllabus. Such a focus on content and not pedagogy and its tools yields less good fruits. This paper assumes that computation rules in all mathematics application, hence it will affect learners output if not corrected by use of calculators. This has prompted the researchers to explore possible use of calculators for bivariate data analysis as a strategy to improve teachers' teaching methods as guided by different theories of educational pedagogy.

Pedagogical theories

Pedagogical theories explain different ways in which children learn as a guide to the processes of teaching and learning in the classrooms. Behaviourist theorists such as Jeanne (2003) define learning as a relatively permanent change of behaviour due to experience. Behaviourists focus on external observable behaviours whose indicators can be objectively measured and evaluated. Mathematics learning then, can be seen in terms of the observable responses that learners give and the environmental stimuli that influence how those responses change over time. Teachers are advised to measure successful use of calculators in the form of correct keys pressed and correct answer given. Estimation of changes over time requires predictive models such as regression linear analysis.

Piaget proposed the Cognitive psychologists theory in 1930. It examines the learning process that takes place in the learner's mind. Sousa (2006) explains cognitive psychology as a study of how the learner's brain processes information into knowledge. During the application of calculators, teachers are encouraged to facilitate learners' mental computation process by approximating the accuracy of the answer from the calculator. Hennich, Motenda, and Smaldino (1996) suggested that, technology learners' attention can be harnessed by use of calculators. That is the motivation role of the calculator. Use of real life examples and problems in projects facilitates variable identification and perception. The idea of getting a correct answer due to calculator computation motivates learners.

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According to social cognitive theorists, like Bandura (1977a), people learn through social interactions by observing and imitating those around them. This suggests use of group work for project tasks. Biehler and Snowman (1997) observes that during group interaction, each group member construct his/her one's own understanding. In a lesson on the use of calculators to solve mathematics problems each be encouraged by others and shown which keys to operate. Consequently, Kluwe, Haider and Misiak, (1990) encourage learning by doing in groups. Socialisation is promoted and used for learning.

Teaching strategies for helping to process and learn classroom calculator application include showing how it relates to prior knowledge. Concepts must be presented in an organized fashion, asking pupils to draw inferences, providing mnemonics for seemingly "meaningless' pairs and lists. Hennich, Motenda and Smaldino (1996) suggest starting by familiarising with the calculator, identification of key and their functions before their operations.

Retrieving information from long term memory appears to be a process of following pathways of associations. Students' attempts at retrieving what they have learned are more
likely to be successful if children have learned classroom subject matter to mastery. Linking content with numerous things they know is critical for facilitating recall and flexible application. One method of enhancing it is by practice, if they use it frequently and if relevant retrieval cues are present in their environment, learners can succeed.
According to Jeane (2003) students cognitive process will differ in part as a function of their cultural backgrounds, English proficiency, and any special educational needs that they might have. For calculator instruction demands that, learners learn the language of mathematics and calculator manual before operation. At one time or another, all students are likely to have difficulty in processing and learning classroom subject matter. By considering and fostering the specific cognitive processes involved in effective learning, teachers can help all students achieve classroom success. It is therefore, essential to investigate different teaching methods which can include appropriate technology such as the calculator. This paper investigates calculator application in problem solving, inquiry based teaching in the context of a project.

Statement of the Research Problem

There is limited documentation of mathematics teachers' teaching methods using calculators for bivariate data analysis. Their teaching methods when using calculators are usually questioned by stakeholders. Society has calculators whose place in the mathematics classroom is doubted and has no official statement in South Africa. In this respect, it is therefore imperative that a study is conducted to investigate methods of teaching mathematics using calculators.

Research Questions

The study sought answers to the following pertinent mathematics education pedagogical questions:

1. What teaching methods are teachers using calculators in mathematics?
2. What are teachers' concept of a mathematics teaching and learning project?
3. How can teachers use calculators for bivariate data analysis?

Research Objectives

The study intents to:

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1. Identify teaching methods in which teachers can use calculators.
2. Present teachers' concept of a mathematics teaching and learning project.
3. Suggest teaching methods which use calculators for bivariate data analysis.

Significance of the Study

The study deserves recognition for the following considerations:

1. Study findings contribute part of the solution to the problem of limited calculator use in mathematics classroom as a result of teachers' low calculator operation skills. This is a critical stage in the curriculum reflections of the community.
2. Study contributes literature on calculator operations, which teachers can add to their mathematics teaching methods repertoires.
3. Participants learn to read calculator manuals, develop calculator instruction methods and learn calculator operation skills.

Research Methodology

Research design

The study was guided by the pragmatism research philosophy. Pragmatism is ideal for studies which examine the suitability of an intervention such as the inclusion of calculators in mathematics instruction. Variables are both quantitative and qualitative, that aspect compels the study to resort to pragmatism to facilitate the combined application of both qualitative and quantitative data collection methods. Eshiwani (1982) encourage researchers in education to apply pragmatism so that the strength of qualitative methods covers up for the weaknesses of quantitative methods. The research design was a sequence of document analysis covering calculator manual and mathematics textbooks. That was followed by a survey of teachers' mathematics teaching methods. Focus group discussions culminated into teaching notes showing how calculators can be applied in bivariate data analysis.

Instruments

The study used two instruments. None human instruments were calculator manuals from the manufacturers of SHARP scientific calculators. These were readily available in each new calculator box. They are included by the manufacturer to enable users to operate the calculator, hence rich sources of the "how" to use it. Mathematics text- books mainly Solomon (1996) and Crawshaw and Chambers (2001) provided the content and teaching methods. They are in use and needed no validation. The questionnaire was the main instrument for survey. Teachers are literate to comprehend questions in English and record their views. It was designed by researchers for the purpose. A focus group discussion guide captured common teaching methods and their rationale.

Data Collection

Data was collected from purposive samples of calculator manuals, textbooks and teachers. The inclusion criterion was being rich sources of the variable (how to operate a scientific calculator), available and accessible to the researchers and participants.

Document analysis of the manuals was carried out by a group of five teachers and five grade 12 learners. These managed to deduce and structure the calculator communicative operation presented on findings. The questionnaire was send to schools in the cluster. Forty-nine (49) teachers who

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participated in the focus group discussion workshop returned the questionnaires. Focus group discussion was dominated by answering the questions:

1. What teaching methods facilitate the use calculators?
2. What do you use the calculator for?
3. How can we apply calculators to teach bivariate data analysis?

Groups presented their findings. Researchers identified common points and summarised them. Outlier points were discussed for content enrichment.

2.FINDINGS AND DISCUSSION

Data presented is from forty-nine teachers who participated at the workshop. That is statistically, a large sample for the variables to be normally distributed and findings can be generalised within a (95%) confidence interval.

Participants' Age distribution n = 49

STEM	LEAF
1	8 9
2	0 0 1 3 5 7 8 9
3	0 1 3 3 3 3 3 6 7 7 7 8 8 9 9 9
4	1 2 3 4 4 6 7 7 8 9 9 9
5	0 3 4 5 6 7 8 8 9 9
6	
7	3

Key: 8 | 8 = 88

The participants are all adults, above 18 years. They are mature to suggest teaching methods which can be relied upon. The modal age is 33. There is one outlier who is 73 years old. The outlier is teaching at a private college where the government retirement age of 60 years may not be observed and enforced. He is a very rich source of teaching methods. The quartiles are such that: $Q_2 - Q_1 < Q_3 - Q_2$, revealing that, the age distribution is negatively skewed. There are more older teachers in this cluster. These are less inclined to use the calculator. One of them said she attended the workshop to learn how to use the calculator.

Distribution of Calculator use and Teaching methods n = 49

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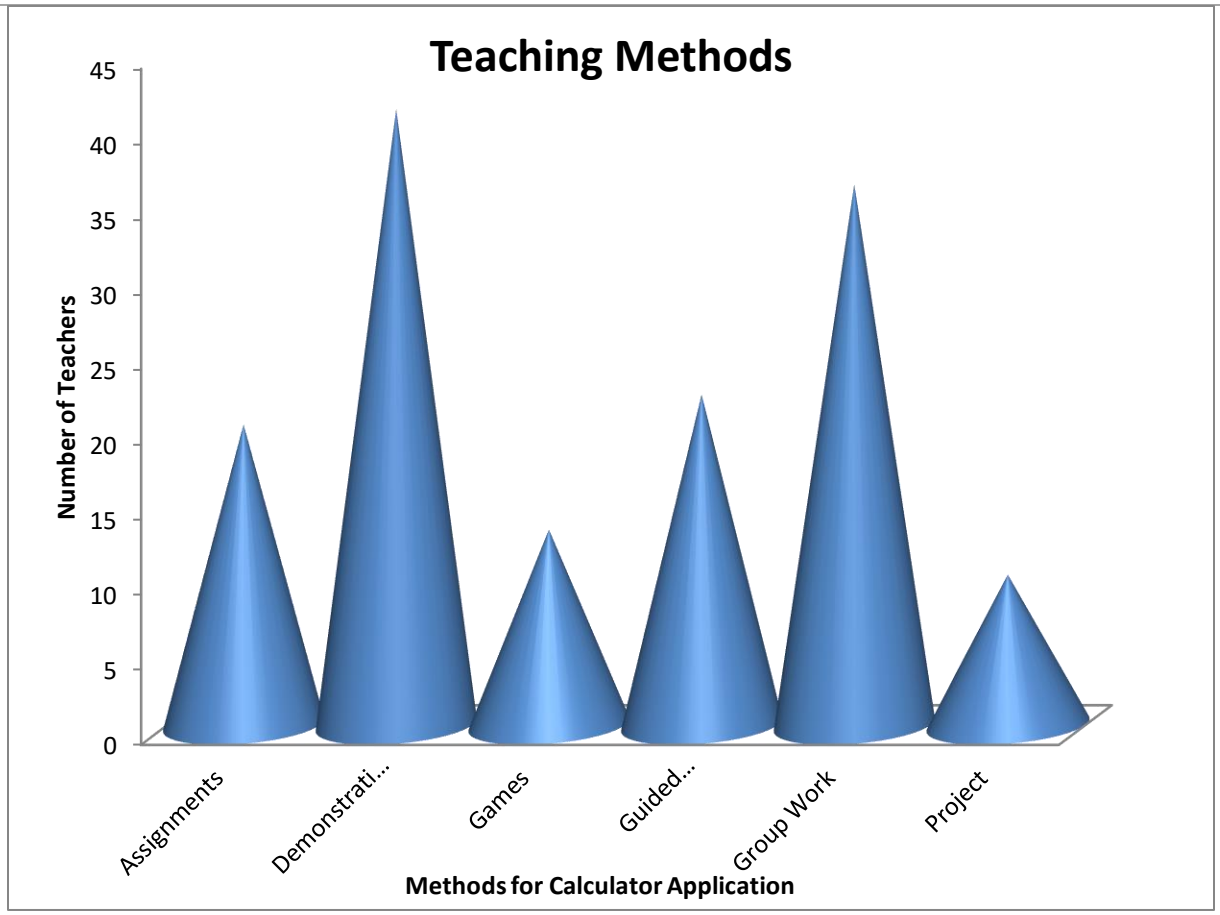

The majority (84%) proposed the teaching of bivariate data analysis using lecture and demonstration method. The rationale being that, a teacher needs to lecture to learners for content understanding. Then the teacher proceeds to demonstrate the application of calculator after the mathematics content is understood. These findings on high lecture and demonstration method preference, support Hamacheck (1995) who declared that, academic subjects like mathematics that have structural information, develop skills and languages require direct teaching. Lecture method is also supported by infrastructures such as lecture-rooms, learners' desk arrangements and resources.

The least (20%) considered method was the project method. Teachers explained that, although they used continuous assessment in South Africa, they were not well versed with the project method. They likened it to discovery learning.

Characteristics of Teaching and Learning project

1. There must have a mathematics teaching and learning purpose.
2. Can be posed as a problem requiring mathematics skills application
3. Must have educational activities promoting the attainment of mathematics teaching and learning
4. Can be done in groups for cooperative learning and peer teaching.
5. Should have embedded motivation for achievement of objectives within the process.
6. Evaluation must be done by individual members to promote group ownership of solution.

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Example:

Aspect	Illustration	Pedagogics Comment
Problem	-What is the relationship between the weight of an individual and his/her shoe size? -What can be the shoe size for an individual whose weight is 62.7 kgs	- curiosity based - participants are readily available
Objectives	Learners should be able to: -measure the weight of group members -survey members' shoe sizes -deduce and apply mathematics correlation models to analyse bivariate data -Apply model to predict outlier sizes	Multiple skills developed -measurement -approximation -interview -computer use for diagrams -data analysis
Organisation	Group work (5 to 10 participants)	-Promote cooperative learning
Duration	At least two weeks or three weeks	-must not be too long
Teaching Method	Apply lecture and demonstration method to: -teach the theory (scatter plot and its interpretation, Equation of regression and application) -Teach calculator application (show essential keys, present the operation order for statistics mode, provide calculator communication for motivation	Calculator operation is a skill involving: -cognitive learning schemas -psychomotor skill -hand eye coordination -social interaction
Results	Group members present (process and findings)	-communication skills

Teachers' Group K, Solution

Teacher	M	E	X	G	K	T	L	S	D	B
Weight	46,5	54,2	76,5	85,3	72,8	93,1	120,3	88,1	67,3	56,1
Shoe Size	3	4	5	8	6	7	7	6	8	7

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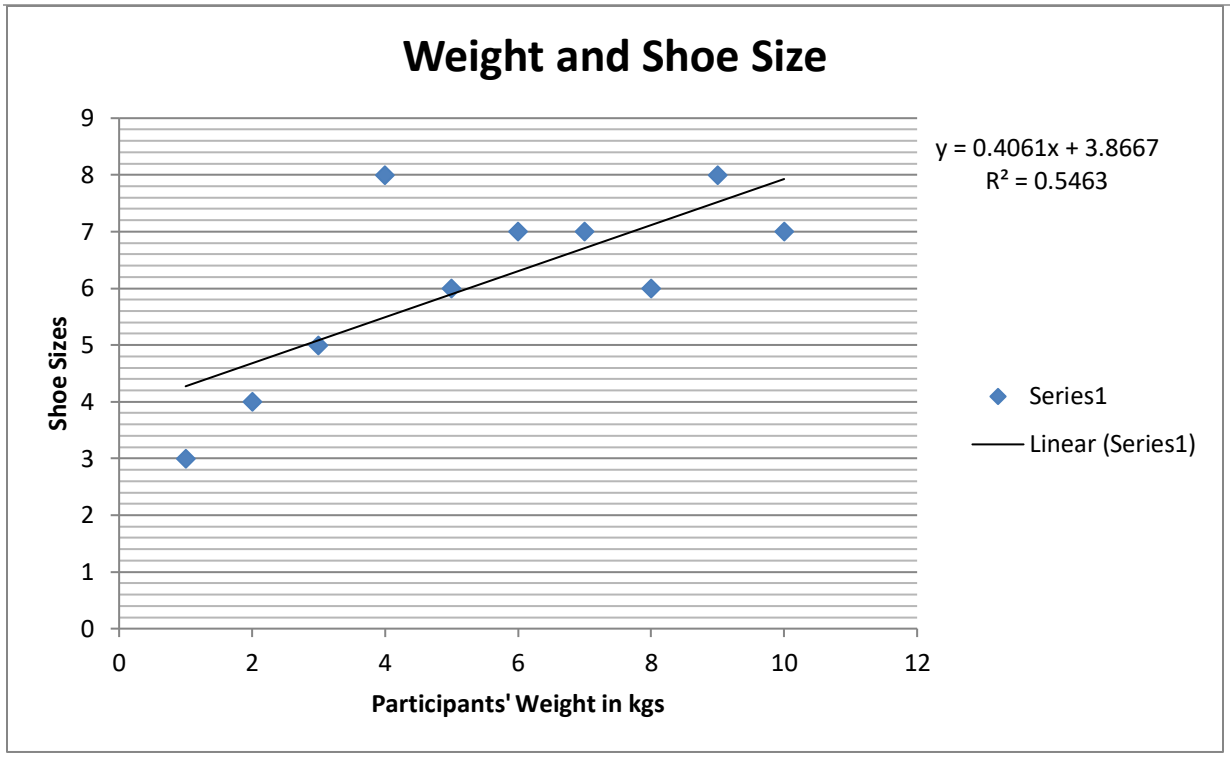

Learners were asked to verify the equation given by the computer using the calculator. The calculator table of operation below was generated.

Calculator Interactive Operation table

Operation (input) ON: Mode [1:1]	Screen Display (Calculator output) Stat 1
46.5 [STO] 3 [M+] 54.2 [STO] 4 [M+] 76.5 [STO] 5 [M+] 85.3 [STO] 8 [M+] 72.8 [STO] 7 [M+] 93.1 [STO] 7 [M+] 120.3 [STO] 7 [M+] 88.1 [STO] 6 [M+] 67.3 [STO] 8 [M+]	46.5, __ DATA SET = 1 54.2, __ DATA SET = 2 76.5,__ DATA SET = 3 85.3,__ DATA SET = 4 72.8,__ DATA SET = 5 93.1,__ DATA SET = 6 120.3,__ DATA SET = 7 88.1,__ DATA SET = 8 67.3,__ DATA SET = 9

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56.1 [STO] 7 [M+]	56.1,__ DATA SET = 10
2NDF: RCL Σx = RCL Σy = RCL Σxy = RCL Σx^2 = RCL Σy^2 = RCL r = RCL a = RCL b =	720.2 61 4811.5 62 105.88 397 0.531659434 (strong positive correlation) 3.029941077 0.040384884 (positive correlation)
Equation of Regression: y = When x = 62.7: y = y = y = The participant buys shoe size 6	0.04x + 3.03 0.04 (62.7) + 3.03 2.508 + 3.03 5.538

3.CONCLUSION

The study concluded that, bivariate data analysis can be taught by a serial combination of: lecture and demonstration to develop the mathematics understanding. This is followed by a a project problem assignment. The calculator can be introduced as a checking and motivation instructional tool. We recommend training of teachers in authoring teaching notes on the use of calculators in mathematics. These can be shared during cluster staff development workshops.

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