Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.7, No.21, 2016

The Effects of the use of Microsoft Math Tool (Graphical Calculator) instruction on students' performance in linear functions

Philip Siaw Kissi[1*], Opoku Gyabaah[2] and Sampson Kwadwo Boateng[3]
1. Management Information System Department, Cyprus International University, North Cyprus
2. Regent University College of Science and Technology, Accra - Ghana
3. Concordia University, College of Education, Portland – Oregon, USA
* Corresponding Author

Abstract
The aim of the study was to investigate the effect of Microsoft Math Tool (graphical calculator) on students' achievement in the linear function. The study employed Quasi-experimental research design (Pre-test Post-test two group designs). A total of ninety-eight (98) students were selected for the study from two different Senior High Schools (SHS) in Accra, Ghana. The two schools were categorized as control group of forty-eight (48) students and experimental group of fifty (50) students. The analysis of data was done using independent t-test with alpha value (α) = 0.05. Pre-test assessment conducted at the beginning of the study shown no significant difference, t (95.720) = -0.441, p = 0.660 between the control and experimental groups. This indicated that the two groups were homogeneous. The experimental group received teaching instruction using the graphical calculator while traditional lecture method was used to teach the control group by the same instructor. Results revealed that there was significant differences, t (96.000) = -6.984, p = 0.00 in students' performance between control and experimental. This suggested that mathematics teachers and curriculum or textbook developers should introduce the use of the graphical calculator to improve students' performance in mathematics education, particularly linear and quadratic functions.
Keywords: Linear function, graphical calculator, technology, theory, mathematics

1. Introduction

Students all over the world need proper education in mathematics that could better their lives and their nation as a whole. This may be attained when teaching methods go far from the frequent use of face to face teaching that is found in most classrooms particularly in Africa. Teachers as a backbone of education need to adopt new ways to design conducive and interactive learning environment that may motivate and engage students to have a better understanding of concepts. Technology such as software calculators, hypermedia, web-based collaboration and mobile tools, open-source software and the rest have been proven as one of the best innovative tools that could assist teachers to achieve this expectation.

Despite the positive impact of technology in classroom instructional delivery, many mathematics teachers continue to rely on the traditional method where students are given lectures in class and expected to read textbooks for a better understanding of mathematical knowledge (Deslaturiers, Scheley & Wieman, 2011; Stošić, 2015). This approach has influence students to memorise facts in isolation and methods during mathematics lessons without conceptual understanding (Bouman & Meiners, 2012). Students require a collaborative learning environment that could enable them to explain, interpret, infer, compare and exemplify the concept of mathematics (Ministry of Education Science and Sports, 2007). Integration of technology would make teachers more productive and competent to design appropriate teaching. Proper instructional design use in classroom teaching engages the attention of students on the main idea without interfering by any other factors (Goldenberg, 2000).

Many students particularly in Africa, who learn linear functions in a traditional manner, find it difficult to connect a function and its graph (Elliott, Hudson, & O'Reilly, 2000). Technology provides mathematics teachers' opportunity to prepare learning environment that improves students understanding of learning mathematics concepts. For instance, integration of graphing calculator encourages students to get a deeper understanding of concepts in mathematics especially linear function (Tarmizi, Ayub, Bakar & Yunus, 2008).

1.1 Statement of the problem

Most topics in mathematics obtain their basis from the linear function which is related to several disciplines in the field of mathematics education. Many teachers still use the traditional method to teach mathematics particularly linear function where students are required to read the textbook at their own pace after class (Mousel, 2013). This improper way of instruction has resulted in students' difficulty and misunderstanding of the concepts of linear function such as finding gradient, y-intercepts, drawing and interpretation (Birgin, 2012). It is therefore, imperative to investigate the effect of graphical calculator on students' achievement in linear function studies.

1.2 Aim of the study

The aim of the study was to investigate the effects of Graphical calculator on students' performance in linear function.

1.3 Specific objective of the study

The specific objectives of the study were:

1. To investigate the effect of students using graphical calculator to draw graph of linear function.
2. To investigate the effect of graphical calculator on students understanding of gradient and y-intercept of linear function.

1.4 Hypothesis

There is no difference in linear function performance of students between control and experimental groups after the post-test.

2. Literature review

The study seeks to improve students' conceptual understanding in linear function using a technological tool called graphical calculator. It is therefore important to understand the fundamental theories and literature that discuss students understanding particularly in mathematics.

2.1 Pirie and Kieren theory of students' mathematical understanding

Pirie and Kieren (1989) explain that the growth of understanding is not in linear form, but through a movement which is surrounded by eight levels. They claim that understanding of mathematics is a process that occurs by a thoughtful passage between these levels of complexity. The levels describe the growth of understanding by an individual for a specified topic. It has structures that relate action of students in a diversity of situations, tracing the movement of back and forth of understanding activities among the levels. These activities enable students to examine, form and gather concepts. The following are the eight levels of Pirie and Kieren (1994) growth of understanding mathematics and how it relates to this study as in figure 1.

Primitive Knowing: This is the innermost part of the level which encloses all the prior knowledge of a student outside the topic specifically, the knowledge that could grow in the new topic being taught. Pirie and Kieren (1994) assert that the growth of understanding of any mathematical concept starts at this level. For instance, students' previous knowledge of plotting x-y coordinate may signify Primitive Knowing for the linear graph.

Image making: This is any idea that may form by the student through engagement of various activities about the discussed topic. These activities could enable them to form an image or idea of the topic. For example, drawing of a linear graph with specific examples might help the student to develop images.

Image having: This is a mental construction of students about a topic without tied to certain activities. The students are now capable of carrying with their mental plan for these image making activities and use them consequently. For instance, students know that $y = x +1$ yields a straight line without drawing the graph.

Property Noticing: This is the level where students may connect or combine images to construct relevant properties. The images of the student are examined for a particular or appropriate property. For example, students know that linear graph $y = x$ pass through the centre (0, 0) because if $x = 0$ then $y = 0$.

Formalising: This is the level where students make generalisation of the method from the topic. For instance, the student may understand that any number replace by 2 and 3 in the linear function $y = 2x + 3$ will always result in a straight line.

Observing: Student at this level is able to reflect and question how previous activities or statements are coordinated and then look for proper pattern or approach to describe the concepts as a theorem. ***Structuring***: This level occurs when a student tries to think about previous observation as a theory and obtain sequential argument as evidence or a proof.

Inventising: Pirie and Kieren (1994) assert that this is a level where student obtains complete conceptual understanding and continue to pose questions which may generate into a fully new concept.

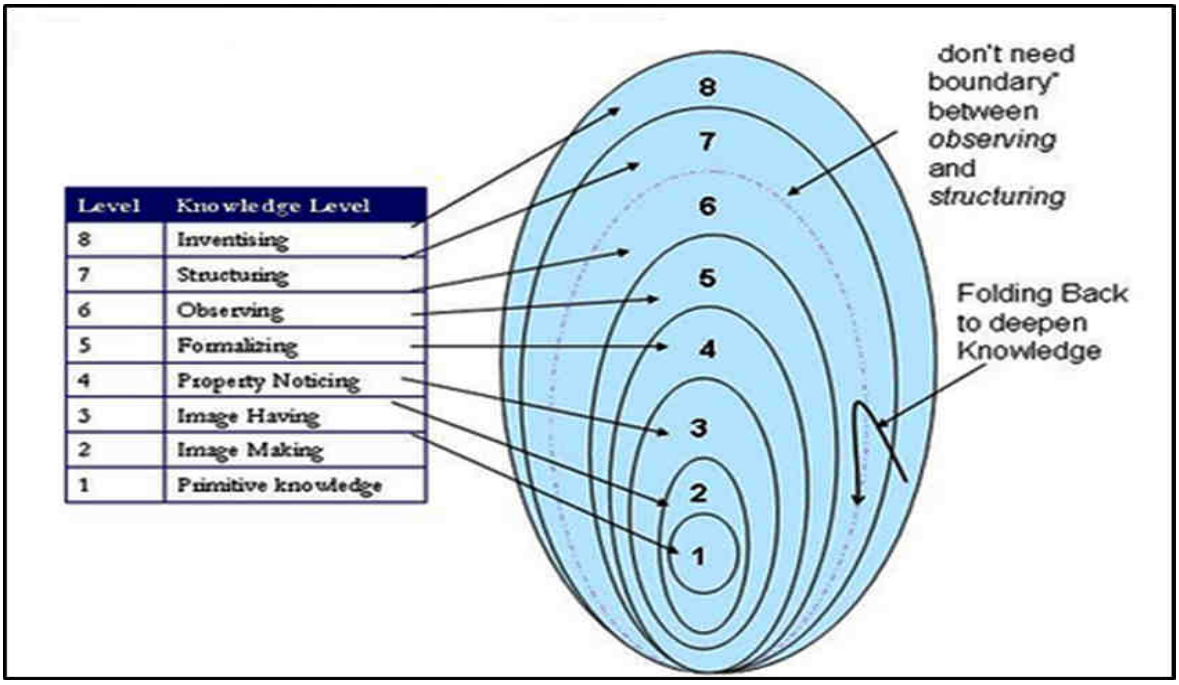

Figure 1: Pirie and Kieren model of the growth of mathematics understanding
Source: Pirie & Kieren (1989)

2.2 Constructivist theory

In current educational research on teaching and learning of mathematics, the focus has been on constructivist viewpoint rather than objectivism. The objectivists believe that knowledge must be transferred to students by the instruction of teachers (Hargis, 2001). In contrast, constructivists believe in active engagement of students in activities to generate their personal knowledge but not transfer from the teacher. Multiple intelligences, development of a child, learning by discovery, scaffolding social cognitive and activism are the backbone of constructivist theory (Roblyer & Doering, 2013). The theory suggests that learning takes place when students are able to construct new understanding as a result of active participation with their old and new experience (Koonce, 2015). This is attained through students' engagement in series of activities including the outcome and the reflection of those activities which lead to better understanding of concepts (Board, 2013).

According to Hiltz (1994), in the constructive classroom, students are the active participants with the strong academic strength which results in retention of knowledge. He stresses that philosophy of teaching in this classroom is students-centred, in which teachers are not perceived as detail explainers but rather facilitators who organise activities that engage students' interest to assist them in developing new knowledge that is connected to the existing ones.

In using constructivist theory, most teachers have difficulty on how to introduce concepts particularly in mathematics without detail explanation to students (Richardson, 2005). In addition, implementation of constructivist theory is difficult since teachers cannot arrange an environment that engages students' interest in order to connect what they know and their proceeding knowledge. Also, teachers further questions on how they can generate the interest of their students to construct and explore the concept of mathematics (Ball, 1993).Yet, the constructivist method has been considered appropriate teaching and learning method (Larochelle, Bednarz, and Garrison, 1998) and the best widely accepted theory in education (Elkind, 2004). The Traditional method of teaching approach only focuses on knowledge transfer without any collaboration between the past and new knowledge which enable students to construct their own understanding (Richardson, 1997). Many studies indicate that constructivist learning environment has affected students' performance positively than other used instructional methods (Lizzio, Wilson, & Simons, 2002).

2.3 Technology in mathematics teaching and learning

Technology integration in mathematics teaching and learning in the classroom would become widely used across schools over time (Cuban, Kirkpatrick & Peck, 2001). The impact of using a technology in classroom instruction is still an ongoing debate among educators (Egbert, Paulus & Nakamichi, 2002). Some educators agree that technology use in teaching transform instruction but they see this effort as a failure (Becker, 1994). In support, technology is doubtful to enhance students' academic attainment or any possible educational achievement (Wenglinsky, 1998). In agreement, Hoyles and Noss (2003) confirm that even though most disciplines in education have acknowledged technology, its role in teaching is still uncertain.

In contrast, Dynarski et al. (2007) believe that using educational technology has a major difference in students' achievement than the traditional method. Technology use can enhance mathematics instruction and increase students' achievement in learning (National Council of Teachers of Mathematics, 2000). Also, Clark (1983) compares the use of lecture method and computer instructional delivery of teaching in a study to determine which approach could improve students learning. He concluded that both methods enhance learning outcomes depending on their implementation. Further, technology has impacted and improved teaching strategies and engagement of students in learning environment (Wright, Fugett & Caputa, 2013). In support, Ittigson and Zewe (2003) argue that technology enhances students' knowledge and understanding of basic concepts. The effective implementation of technology can be a tremendous tool that would enable teachers to prepare an interactive and conducive environment for students to explore concepts of mathematics (Huetinck & Munshin, 2008).

2.4 Effect of graphing calculator in mathematics

The important aspect of students understanding of concept does not depend on examining their transcribed effort but requires a cautious analysis of the process of thinking on a given mathematical problem (Pirie and Kieren, 1994). A Graphical calculator is a very significant and effective instructional tool for preparing content and concepts of mathematics for students to assist them to acquire and understand new knowledge (Mcknight, 2016). It is also an acceptable tool for teaching and learning mathematics which enables teachers to represent instruction in multiple ways for students to have knowledge in concepts (Ford, 2008).

Graphing calculator in Microsoft Maths Tool presents the pedagogy of visual and three-dimensional environment to enable students to understand the concepts they learn. In support of this view, Dunham and Dick (1994) stress that graphical calculator enables students to visualise questions in order to ascertain mathematical concepts on their own, check the correctness of their answer and find a different way of getting a solution to the question. Also, Barrett and Goebel (990) confirm that the use of graphing calculators in mathematics classrooms particularly high schools have a substantial influence on the teaching and learning of their school mathematics. In the study of Noraini, Tay, Nilawati, Goh, & Aziah, (2003), they compared how graphical calculator affects students' performance of learning algebraic function. They administered a pre-test to the students and afterwards taught them with graphical software for five weeks. Students were retested (Post-test). It was found in their study that students' performance was significantly higher than their achievement in the traditional way of instructional delivery.

The use of technology in teaching especially computers and graphical calculator inspire students to acquire an intense understanding of concepts. Also, abstract content of mathematics concepts could be easily and better understood by students with the assistance of technology which display visualize or graphical representation of object and their properties (Tarmizi, et. al., 2008)

The following are some of the effects of using a graphical calculator in teaching methods (Ye, 2009).

1. The quality and concept of understanding mathematics in the middle school are achieved with the use of graphing software
2. Mathematics textbook modernization, beneficial information, modification and visualized materials use in teaching can be promoted by the graphical calculator.
3. Graphing calculator brings variations in inactive and past learning methods to encourage students to learn in an interactive environment.
4. The use of graphical calculator in teaching enables teachers to plan appropriate assessment strategies in secondary school.

2.5 Concepts of linear function

The concept of a function is the most vital and fundamental knowledge in the current study of mathematics and science education (Kline, 1990). Many educators have advocated for a great emphasis on functions in the school curriculum (Oehrtman, Carlson & Thompson, 2008). Yet, this significant concept of learning functions has not been effective, some students find it difficult to understand and apply it in other related topics (Janvier, 1998). In mathematics, the linear function could be written in the form $y = mx + c$ where m and c are real coefficients where x is the horizontal axis, y is the vertical axis, m is the gradient, and c is the y-intercept. The slope is another name for gradient which is given as rising to up or down of the y-axis over run to left or right of the *x-axis*. For example, $y = 2x +1$ is a linear function since it has x with an exponent of 1 but $y = 3x^2$ cannot be a linear function since the exponent of the variable x is 2. Functional notation such as f (x) is mostly used instead of y . For instance, if $f(x) = x + 1$, where $x = 3$ means that $f(3) = 3 + 1 = 4$. The outcome of drawing any graph of the linear function gives a straight line. This straight line always intercepts at c of the linear function. For example, the straight line would intercept at 2 when the graph of the function $y = 3x + 2$ is drawn. Also, $x = 0$

and *y* = *0* are the linear functions of the line *y-axis* and *x-axis* respect.

2.6 The effect of *m* and *c* of the linear function

2.6.1 The effects of m in linear graph

As stated earlier, the value of *m* is the gradient of the graph of the linear function which indicates the steepness of the graph. If *m* of this linear function, *y = mx* changes, the results are shown in figure 2. When the x values are higher than the *y* values, then *m* is negative and when values of *y* are higher than *x*, then *m* is positive.

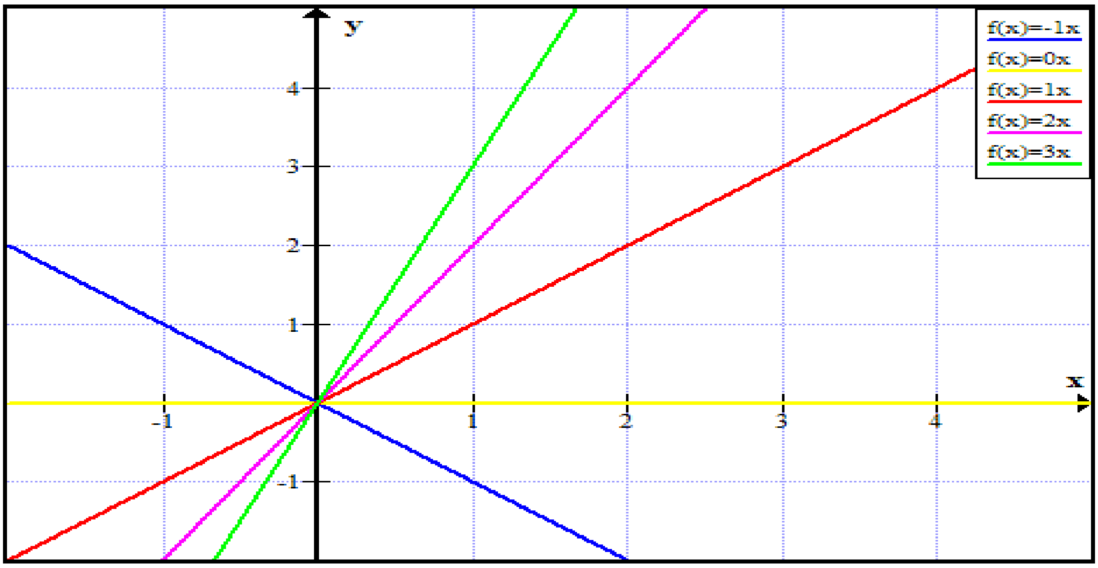

Figure 2: $f(x) = mx, m = -1, 0, 1, 2, 3$

2.6.2 Effects of c on linear graph

The value c as presented earlier is the y intercept where the linear graph intercepts the y axis. For example, given linear functions *f(x) = x -1* and *f(x) = 2x + 1*, the linear graphs of these functions would intercept at -1 and 1 respectively on the *y-axis*. This can be seen in figure 3.

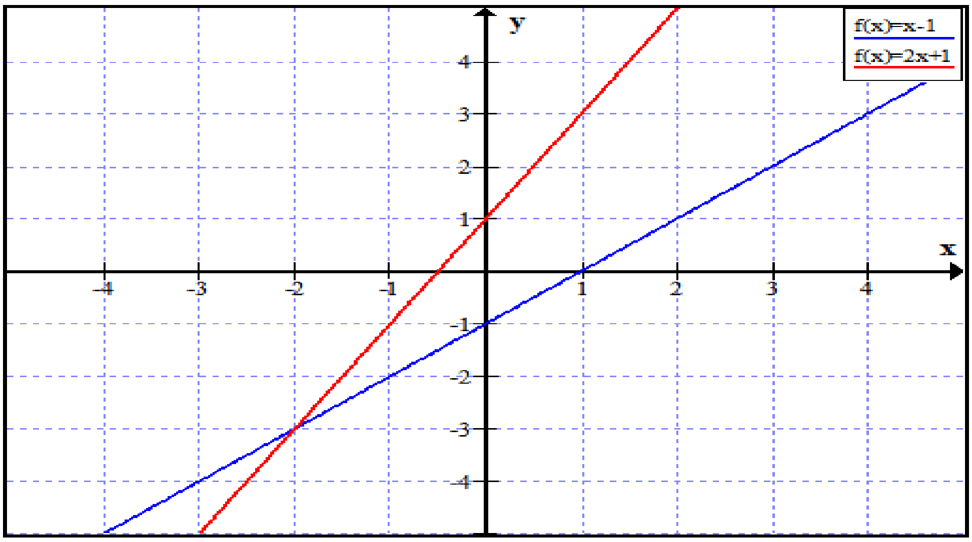

Figure 3: Graph showing effect of c functions $f(x) = x - 1$ and $f(x) = 2x + 1$

2.7 How linear function is taught in the traditional classroom

In many traditional classrooms, the teacher introduces the topic by writing the linear function on the board and explains the various components. Afterwards, students are asked to complete a table with given x-values to draw the linear function. Below is a topical example

Question

ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.7, No.21, 2016

Complete the table below with the function $y = x + 1$

x	-4	-3	-2	-1	0	1	2	3	4
y	-3	-2	-1	0	1	2	3	4	5

After the calculations, the teacher then asks students to draw the graph locating all the points on the graph sheet as shown in figure 3

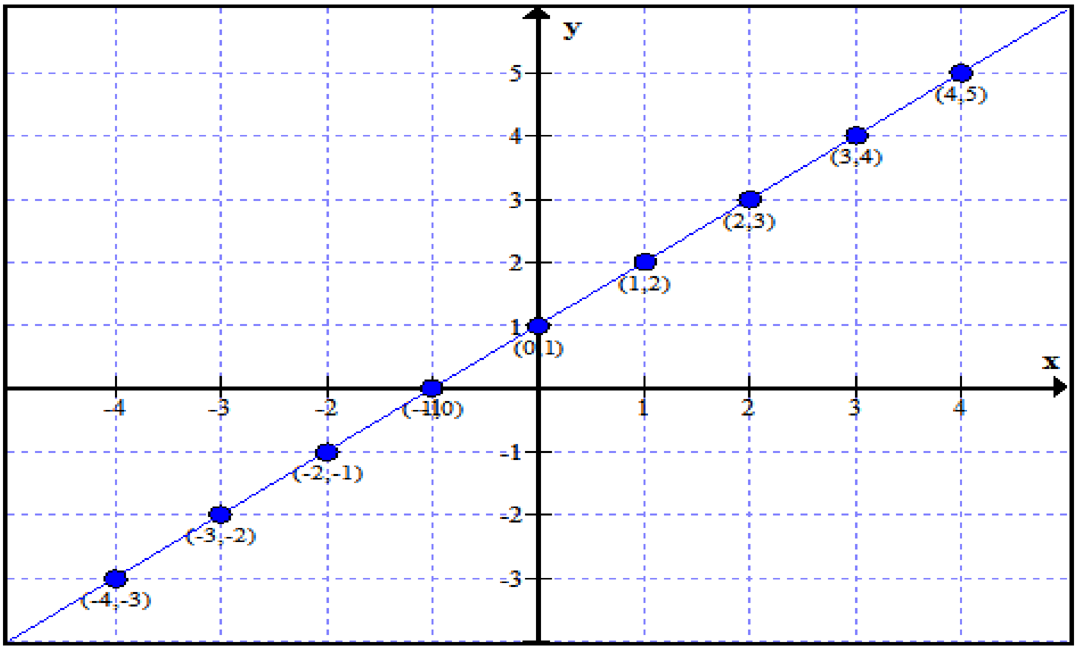

Figure 4: Draw graph of $y = x + 1$ in traditional classroom

3. Methodology

The study employed the quasi-experimental research design. This is because quasi-experimental design is used to assess the benefits of specific interventions (Harris, el at., 2006; Campbell & Stanley, 2015). The main aim of the study was to investigate the effects of Microsoft Math Tool (graphical calculator) on students' performance in linear functions. Quantitative data was collected through Pre-test and Post-test instruments for the study. Ninety-eight (98) students were selected for the study from two different Senior High Schools (SHS) in Accra, Ghana. The two schools were categorized as School A (Control group) of forty-eight (48) students and School B (Experimental group) of fifty (50) students. Convenient sampling technique was used to select the schools. Pre-test assessments were done in the two schools to select equivalent classes of School A and School B for the study. The experimental group received teaching instruction using graphical calculator while traditional lecture method was used to teach the control group by the same instructor by the same instructor.

The Post-test instrument administered after the two groups had already been thought. The test consisted twenty-five (25) multiple choice tests items on the linear function. The questions were based on linear functions selected from West Africa Senior Secondary School Certificate Examination (WASSCE) which assess the proficiency level of SHS final year students' mathematics content. The internal consistency and validity of the tests were high since the questions were set by knowledgeable mathematics examiners, pre-tested and approved by the West Africa Examination Council. The total marks for the Post-test assessment questions were twenty-five (25), one mark for each question. The SPSS software version 23.0 was used to analyse the data. Independent t-test with equal variance assumed was used to test whether or not a significant difference exists between the control and experimental groups. Table 1 shows a brief description of the lesson

Table 1: Brief Description of Lesson Template

Unit	**Specific Objectives**	**Content**	**Teaching and learning Activities**
Linear function	The student will be able to: 1. Draw graph of linear function 2. Identify and describe the gradient (c) and y-intercept of linear graph	Linear graph Gradient and y-intercept	Guide students to familiarizing the with the Microsoft Math Tool (graphing calculator) interface as indicate in figure 3. Assist students to use the graphical calculator to draw a graph of the linear function as shown in figure 3. Guide the students to draw the same graph using graph sheet, pencil and eraser Assist students to identify and describe the point of y - intercept and the gradient as in figure 3.

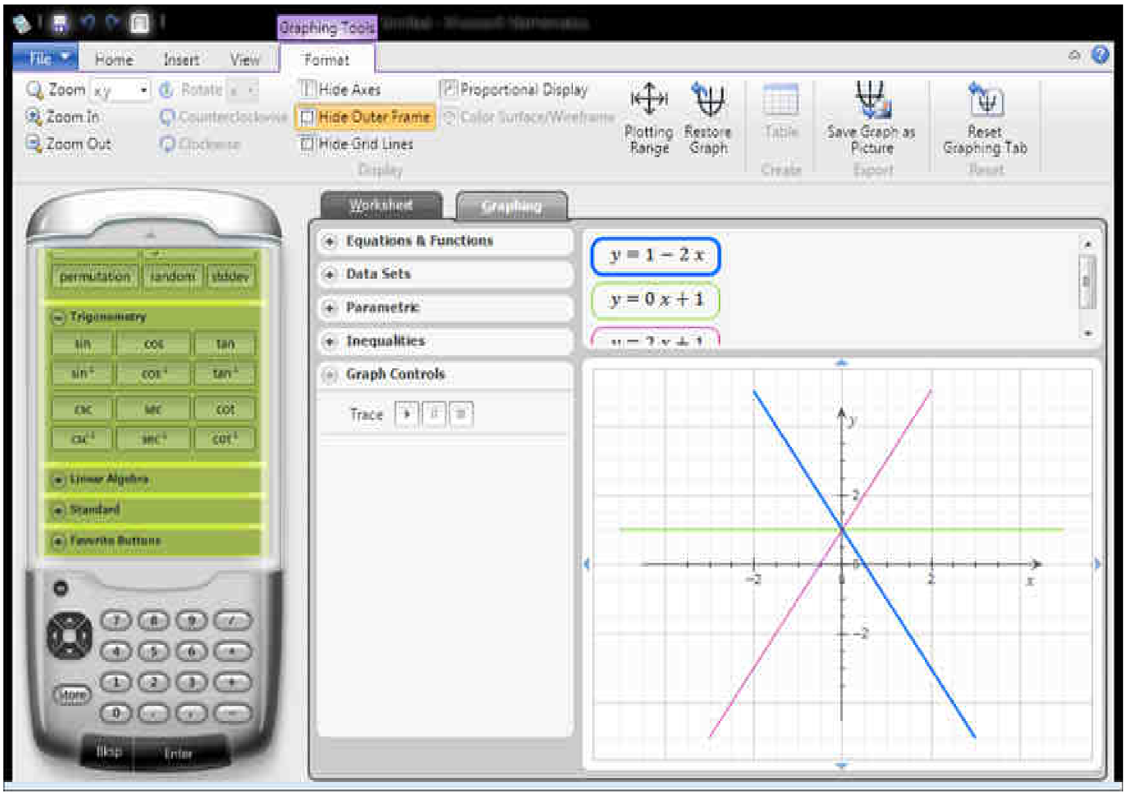

Figure 3: Screen shoot showing interface and effect of m and y-intercept of linear graph
Source: Microsoft Math Tool interface of graphical calculator

4. Results, Discussion, and Conclusion

Testing for homogeneity of the control and experimental groups

Table 2: Independent T-test with Equal Variances not assumed

Groups	**Test**	**Mean**	***SD***	**df**	***t* - value**	***p* – value**
Control group	Pre-test	4.40	2.181	95.72	-4.41	0.660
Experimental Group	Pre-test	4.60	2.339			

Table 2 and appendix A indicated the Pre-test mean scores of the control group and the experimental group as 4.40 (*SD* = 2.181) and 4.60 (*SD* = 2.339) respectively. Also, there is no significant different, t (95.720) = -4.41, p = 0.660, p > 0.05 between the performance of the two groups. This showed that the performance of the two groups was homogenous or equivalent.

4.2 Final findings after the lesson

Testing of Hypothesis Question of the study

To determine whether there is difference in linear function performance of students between the control and experimental groups, it was hypothesized that:

> There is no difference in linear function performance of students between the control and experimental groups after the post-test.

Table 3: Independent T-test with Equal Variances not assumed

Groups	Test	Mean	*SD*	df	*t* - value	*p* – value
Control group	Post-test	12.88	3.443	96	-6.984	0.000
Experimental Group	Post-test	17.74	3.451			

Independent T-test with equal variance assumed analysis showed that there was a significant difference, t (96) = -6.984, p = 0.00, $p < 0.05$ in linear function performance of students between the control and the experimental groups. Therefore, the stated hypothesis was rejected. Again, Post-test mean scores were 12.88 (*SD* = 3.442) for control group and experimental group 17.74 (*SD* = 3.451) as indicated in Table 3 and appendix B. Hence, there was a significant difference in achievement between students exposed to the use of graphical calculator instructional approach and those exposed to the traditional instructional approach of teaching linear function. This signifies that the students exposed to the graphical calculator instructional model had a better understanding of the concept of linear compare frequent use of lecture method.

In support, many educators have recommended computer-assisted instruction as the best replacement of classroom teaching to the traditional approach (Schmidt et al., 1990) and enhance students understanding in the process of learning (Bingimlas, 2009). in agreement, Maloy, Verock-O'Loughlin, Edwards, & Woolf, (2013), affirm that technology use in teaching is a powerful tool to engage and motivate students.

5. Conclusion

The graphical calculator has proven to be a useful technological tool to enhance teaching and learning and as a result, improve students mathematical understanding particularly linear function. It is therefore important that institutions especially High school educators should use this tool in their teaching curriculum.

Reference

Ball, D. L. (1993). With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. *The elementary school journal*, 373-397.

Barrett, G., & Goebel, J. (1990). The impact of graphing calculators on the teaching and learning of mathematics. In T. J. Cooney & C. R. Hirsch (Eds.), *Teaching and learning mathematics in the 1900s, National Council of Teachers of Mathematics (NCTM) 1990 year book* (pp.205-211). Reston, VA: NCTM.

Becker, H. J. (1994). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. *Journal of Research on Computing in Education*, 26, 291-320.

Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science & Technology Education*, *5*(3), 235-245.

Birgin, O. (2012). Investigation of eighth-grade students' understanding of the slope of the linear function. *Bolema: Boletim de Educação Matemática*, *26*(42A), 139-162.

Board, J. (2013). *Learning Theory-Constructivist Approach*. Retrieved on 7th May 2014 from http://education.stateuniversity.com/pages/2174/Learning-Theory-CONSTRUCTIVIST-APPROACH.html

Bouman, K., & Meiners, J. (2012). Retention of Learning: Student-led Classrooms or Traditional Classrooms. Southwest Minnesota State University.

Campbell, D. T., & Stanley, J. C. (2015). *Experimental and quasi-experimental designs for research*. Ravenio

Books.
Cathy, F. (2016). *Deep comprehension of mathematical ideas*. DreamBox Learning. Bellevue. Retrieve on 7th April, 2016 from http://www.dreambox.com/conceptual-understanding.
Clark, R. E. (1983). Reconsidering research on learning from media. *Review of educational research*, *53*(4), 445-459.
Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American educational research journal*, *38*(4), 813-834.
Deslaturiers, L. Scheley, E., & Wieman, C. (2011). Improved learning in a large-enrollment physics class. *Science Education*, 332, 862-864.
Dunham, P. H., & Dick, T. P. (1994). Research on graphing calculators. *The Mathematics teacher*, 87(6), 440-445.
Dynarski, M., Agodini, R., Heaviside, S., Novak, T., Carey, N., Campuzano, L., Means, B., Murphy, R., Penuel, W., Javitz, H., Emery, D., & Sussex, W. (2007). *Effectiveness of reading and mathematics software products: Findings from the first student cohort.* Washington, DC: Institute of Education Sciences.
Egbert, J., Paulus, T. M., & Nakamichi, Y. (2002). The impact of CALL instruction on classroom computer use: A foundation for rethinking technology in teacher education. *Language Learning & Technology*, *6*(3), 108-126.
Elliott, S., Hudson, B., & O'Reilly, D. (2000). Visualisation and the influence of technology in 'A'level mathematics: A classroom investigation. *Research in Mathematics Education*, *2*(1), 151-168.
Elkind, D. (2004). The problem with constructivism. *The educational forum*. 64(4): 306-12. Taylor & Francis Group.
Ford, S. J. (2008). *The Effect of Graphing Calculators and a Three-core Representation Curriculum on College Students' Learning of Exponential and Logarithmic Functions*. ProQuest.
Goldenberg, P. (2000). *Finding some "common notions" about technology in mathematics learning.* Unpublished paper presented at the 9th International Congress on Mathematics Education, Makuhari, Japan.
Hargis, J. (2001). Can students learn science using the Internet?. *Journal of Research on Computing in Education*, *33*(4), 475-487.
Harris, A. D., McGregor, J. C., Perencevich, E. N., Furuno, J. P., Zhu, J., Peterson, D. E., & Finkelstein, J. (2006). The use and interpretation of quasi-experimental studies in medical informatics. *Journal of the American Medical Informatics Association*, *13*(1), 16-23.
Hiltz, S. R (1994). The Virtual Classroom: Learning Without Limits via Computer Networks. *Human-Computer Interaction Series* 36 (2) 95-104
Hoyles, C., & Noss, R. (2003). What can digital technologies take from and bring to research in mathematics education?. In *Second international handbook of mathematics education* (pp. 323-349). Springer Netherlands.
Huetinck, L. & Munshin, S. N. (2008). *Teaching mathematics for the 21st century* (3th ed.) *Methods and activities for grades 6-12.* Columbus, OH: Merrill.
Ittigson, R.J. & Zewe, J.G. (2003). Technology in the mathematics classroom. In Tomei, L.A. (Ed.). *Challenges of Teaching with Technology Across the Curriculum: Issues and Solutions* (pp. 114-133). Hershey: Information Science Publishing.
Janvier, C. (1998). The notion of chronical as an epistemological obstacle to the concept of function. *Journal of Mathematical Behavior*, 17(1), 79-103.
Kline, M. (1990). *Mathematical thought from ancient to modern times* (Vol. 3). Oxford University Press.
Koonce, L. G. (2015). *Taking Sides: Clashing Views on Educational Issues (8th ed.)* United States: McGraw Hill.
Larochelle, M., Bednarz, N., & Garrison, J. W. (1998). *Constructivism and education*. Cambridge University Press.
Lizzio, A., Wilson, K., & Simons, R. (2002). University students' perceptions of the learning environment and academic outcomes: implications for theory and practice. *Studies in Higher education*, 27(1), 27-52.
Maloy, R. W., Verock-O'Loughlin, R. E., Edwards, S. A., & Woolf, B. P. (2013). *Transforming learning with new technologies* (pp. 1-356). Allyn & Bacon.
Mcknight, K. (2016). *Use Graphic Organizers for Effective Learning*. Teach HUB.com Retrieved on 5th May, 2016 from http://www.teachhub.com/teaching-graphic-organizers
Ministry of Education, Science and Sports. (2007). *Teaching syllabus for mathematics (Senior High School).* Accra: Curriculum Research and Development Division (CRDD).
Mousel, A. (2013). Flipping the High School Mathematics Classroom. *Studies in Teaching 2013 Research Digest*, 61-66.
National Council of Teachers of Mathematics (2000*). Principles and standards for school mathematics.* Reston, VA: NCTM

Noraini, I., Tay, B. L., Nilawati, M., Goh, L. S., & Aziah, A. (2003). Pengajaran & pembelajaran matematik dengan kalkulator grafik TI-83 Plus. *Selangor: PenerbitanBangi*.

Oehrtman, M., Carlson, M., & Thompson, P. W. (2008). Foundational reasoning abilities that promote coherence in students' function understanding. *Making the connection: Research and teaching in undergraduate mathematics education*, 27-41.

Pirie, S., & Kieren, T. (1989). A recursive theory of mathematical understanding. *For the learning of mathematics*, 9(3), 7-11.

Pirie, S., & Kieren, T. (1994). Growth in mathematical understanding: How can we characterise it and how can we represent it?. *Educational studies in Mathematics*, 26(2-3), 165-190.

Richardson, V. (1997). Constructivist teaching and teacher education: Theory and practice. *Constructivist teacher education: Building a world of new understandings*, 3-14.

Richardson, V. (2005). *Constructivist teacher education: Building a world of new understandings*. Routledge.

Roblyer, M. D., & Doering, A. H. (2013). *Integrating Educational Technology into Teaching* (5th ed.). Boston. MA: Pearson Education, Int.

Stošić, L. (2015). The importance of educational technology in teaching. *International Journal of Cognitive Research in Science, Engineering and Education (IJCRSEE)*, *3*(1), 111-114.

Schmidt, S. M., Arndt, M. J., Gaston, S., & Miller, B. J. (1990). The effectiveness of computer-managed instruction versus traditional classroom lecture on achievement outcomes. *Computers in nursing*, *9*(4), 159-163.

Tarmizi, R. A., Ayub, A. F. M., Bakar, K. A., & Yunus, A. S. M. (2008). Learning Mathermatics through Utilization of Technology: Use of Autograph Technology vs Handheld Graphing Calculator. In *Proceedings of the7th WSEAS International Conference on Education and Educational Technology (EDU'08). Venice November* (pp. 21-23).

Wenglinsky, H. (1998). Does it compute? The relationship between educational technology and student achievement in mathematics.

Wright, S., Fugett, A., & Caputa, F. (2013). Using E-readers and Internet Resources to Support Comprehension. *Educational Technology & Society*, 16(1), 367-379.

Ye L., (2009).Integration of graphing calculator in mathematics teaching in china. *Journal of Mathematics Education* 2(2), 134-146

APENDIX A

```
T-TEST GROUPS=Groups(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=Pretest
  /CRITERIA=CI(.95).
```

T-Test

Group Statistics

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Control Group	48	4.40	2.181	.315
	Experimental Group	50	4.60	2.399	.339

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pretest	Equal variances assumed	1.082	.301	-.440	96	.661	-.204	.464	-1.125	.716
	Equal variances not assumed			-.441	95.720	.660	-.204	.463	-1.123	.714

APPENDIX B

```
T-TEST GROUPS=Groups(1 2)
  /MISSING=ANALYSIS
  /VARIABLES=Posttest
  /CRITERIA=CI(.95).
```

T-Test

Group Statistics

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Posttest	Control Group	48	12.88	3.443	.497
	Experimental Group	50	17.74	3.451	.488

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Posttest	Equal variances assumed	.697	.406	-6.984	96	.000	-4.865	.697	-6.248	-3.482
	Equal variances not assumed			-6.984	95.854	.000	-4.865	.697	-6.248	-3.482