AN IMPACT ASSESSMENT OF ACADEMIC APP IN MOTIVATING STUDENTS TO ENGAGE IN LEARNING: A CASE STUDY OF GRAPH PLOTTING IN PHYSICS.

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ABSTRACT

When it comes to courses needing high level of motivation to ensure continuous and adequate enrollment by students in Nigerian institutions of learning, Physics or Mathematics will come first. In order to reduce the level of apathy shown by students toward plotting graphs during Physics laboratory exercise, a graphing application (App) called UJ-Math Graphing Tool (UJ-MaGT) was developed. The popularity of the App among the year one students that enrolled for Physics practical courses in the department of Physics, University of Jos necessitated this work which was to evaluate the effect of the App on the students' performance and readiness in graph plotting and to also validate a motivation scale that can be used in academic App designs. The results show great improvement in students' performance. A class mean of 11.4 was achieved with the help of the App as compared to 3.4 when the App is not used. The observed differences are statistically significant ($P<0.01$). Also, the gap between the below average students and the above average students is greatly narrowed. A 59% increase in desire to enroll for graphing course when App is available was achieved. Academic App motivation scale (AAMS) was validated with a five-factor, 21 items model fitting the observed data better. The most pronounced motivation types that were aroused by the app are extrinsic motivation identified regulation (EMID), extrinsic motivation external regulation (EME) and intrinsic motivation towards accomplishment (IMA). Furthermore, results indicate that the three types of motivations have stronger positive correlation with the app's design properties (ease of use, time saving and simplification of concept the app is designed to address). In conclusion, academic apps when designed with the properties of ease of use, time saving and simplification of learning any concept can improve students' performance, close achievement gap and motivate students in a way that leads to internalization and integration of the concept being learned.

Chapter one
Introduction

1.0 Background of the Study

1.0.1 School subject enrollment and Poor performance

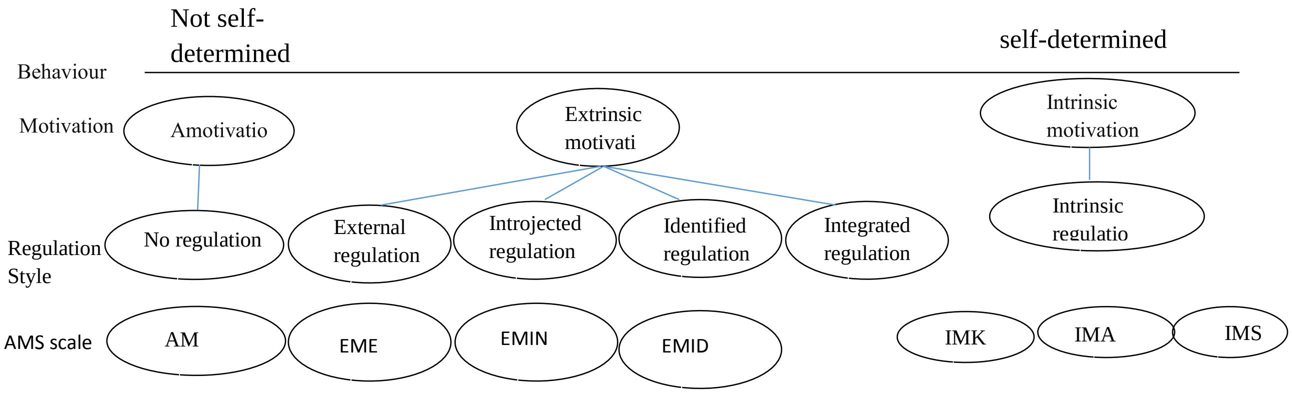
In Nigeria, subjects such as Physics and Mathematics suffer lack of large enrollment rate relative to other subjects except that mathematics is made compulsory at the secondary school level. This challenge which has been considered a global challenge (Marušić, and Sliško, 2012) has become a threat to the future of Science, Technology and Engineering in the country. Poor performance in sciences have been an age long problem and some of the factors responsible include lack of qualified teachers and inadequate teaching/learning resources (Majo, 2000; Ezezobor, 1989; Nwokolo, 1995).

Till date, poor performances are being witnessed in many aspects of science subjects. For example, West African Senior Secondary School Examination results (WASSCE) has over the years shown poor performance in graph plotting (Waeconline.org.ng, 2008 to 2017). Poor performance, perceived difficulty and abstract nature of some science topics are among reasons for lack of interest in these subjects (Erinosho, 2013). All these are perceived causes of law enrollment in sciences in Nigeria (Kola and Akanbi, 2013).

1.0.2 Motivation

Motivation has been shown to be a powerful tool for sustaining students' interest in learning (Hyungshim, 2008). Where low achievement, desertion, and difficulty in the transition between educational levels is observed, the appropriate intervention has always been motivation based (Oliver et al, 2011; Vázquez, 2009). Motivation is approached by self-determination theory (SDT) from the view point of what motivates a person as opposed to a unitary concept view point.

In SDT, distinctions are made between different types of motivation and the consequences of them (Stover et al, 2012; Wikipedia, 2017). Hyungshim, (2008), in a study that seek to find the capacity of two different theoretical models of motivation to explain why an externally provided rationale for doing a particular assignment often helps in a student's motivation, engagement, and learning during relatively uninteresting learning activities, concludes that only SDT based model helped students to engage and learn. STD considers that motivation can be expressed through a



continuum of increasing self-determination with three fundamental positions reflecting the degree of autonomy on which behaviors are based: amotivation, extrinsic and intrinsic motivation. Stover et al, (2012) explains diagrammatically (Figure 1) the self-determination continuum based on Deci and Ryan (1985) and Vallerand et al, (1998).

Figure 1 Self-determination continuum (Stover et al, 2012)

Abbreviations: *AMS, Academic Motivation Scale; IMS, Intrinsic Motivation orientation towards stimulating experiences; IMA, Intrinsic Motivation orientation towards accomplishment; IMK, Intrinsic Motivation orientation towards knowledge; EMID, Extrinsic Motivation identified regulation; EMIN, Extrinsic Motivation introjected regulation; EME, Extrinsic Motivation external regulation; AM, Amotivation*

1.0.3 Academic Apps

Apps is a short form for applications. The term became popular with the advent of mobile technology. With the increasing acceptability of mobile devices, apps development has equally been on the rise. Some common examples of apps are WhatsApp, Facebook, Instagram etc. apps are utilized in almost every expect of human endavour with entertainment and communication dominating (Apps Statistic Report, 2016). Educational Apps are becoming increasingly patronized within the educational cycle (http://www.educationalappstore.com, 2015). In line with this emerging trend of using apps in teaching and learning, a graphing application (App) called Mafuyai Graphing Tool (MaGT) now called UJ-Math Graphing Tool (UJ-MaGT) was developed (Figure 10 and 11 in appendix A).

1.0.4 UJ-Math Graphing Tool (UJ-MaGT)

This is useful in plotting graphs both in Mathematics and Physics. It was developed in response to the poor performance in graphing amongst students as shown by the result of students' yearly performance in WASSCE physics practical (Waeconline.org.ng, 2008 to 2017). The App was introduced to year one students numbering over 2000 from 24 Departments of the 8 Faculties of the University of Jos during the first semesters of the 2014/2015 and 2015/2016 academic years.

The students registered for Physics 104 or 107 which are practical based courses that involve plotting of graphs. The App was installed in the University Library's computers following the approval of the Vice Chancellor of the University of Jos. This was to make it accessible to all the students. To further decongest the long queue which was due to high patronage and few number of computers available in the library, the App was installed on students' personal laptops for those that have one. Furthermore, the App was developed to fit other mobile devices platforms such as android, BlackBerry, iOS and was made available to the year one students during the first semester of 2015/2016 academic session. While it was obvious that the students were pleased and showed great enthusiasm toward the use of the App, this research work seeks to show scientifically whether or not the App improves students' ability to plot graphs correctly and also to determine if the use of the App increases students' motivation to personally plot graphs by themselves. This will help in future design and implementation of educational Apps and will usher in the era of inculcating indigenous technologies meant to address common problems encountered by our students into our educational system.

1.1 Purpose

The purpose of the study was to assess the impact of UJ-MaGT in motivating students to engage in graph plotting activity.

1.2 Objectives of the Study

1. To determine the effect of the app on students' performance and ascertain how user friendly is the UJ-Math Graphing Tool (UJ-MaGT)
2. To determine the willingness of the students to enroll for an Apps-Assisted graphing
3. To determine the type of motivation created by the App
4. To determine factors that make educational app motivational.
5. To validate Kaburuk-Mafuyai Academic Apps Motivation Scale

1.3 Research Hypothesis and Research questions

The hypothesis and questions include:

1.There is no significant effect of using UJ-Math Graphing Tool (UJ-MaGT) on students' performance in graph plotting.
2. To what extent is UJ-MaGT easy to use?
3. To what extent does UJ-MaGT makes graph plotting easier?
4. What aspects of graph plotting are made easier using UJ-MaGT?
5. What percentage of students does UJ-MaGT motivates to plot graphs?
6. To what extend did the students agree that the app can motivate them?
7. What kind of Motivation can educational app (UJ-MaGT) create?
8. What factors are responsible for educational App motivation?

1.4 Problem Statement/Justification

The growing apathy towards the study of Physics and Mathematics is no more disputable. This fact is better understood and appreciated by the admission offices of the tertiary institutions. It is difficult to find students willingly opting to study these courses. One of the major reasons is the perceived uninterestingness and difficulty associated with the assimilation of the concepts being taught in these courses (Erinosho, 2013; Majo, 2000; Kola and Akanbi, 2013; Council of Europe: Parliamentary Assembly, 2006; Marušić, and Sliško, 2012; Spall et al, 2003; Williams, et al, 2003; Tobias, and Birrer, 1999).

Furthermore, statistics from WASSCE shows poor performance in students' graphing ability. The annual mean score and the standard deviation of the students' performances in WAEC Physics practical examinations are as follows (*http://waeconline.org.ng/e-learning/Physics/physmain.html*):

- 2008, MS=25 and SD=10.25
- 2009, MS=26 and SD= 9.00
- 2010, MS=20 and SD=9.43
- 2011, MS=24 and SD=10.58
- 2012, MS=30 and SD=9.95
- 2013, MS=24 and SD=8.89
- 2014, MS=24 and SD=10.00
- 2015, MS=24 and SD=9.59

The result has been characterized by low class mean marks and high standard deviations implying poor performance and a wide achievement gap among the students. This, therefore, calls for research in the area of materials, methods and methodologies that simplify the concepts in order to increase the motivation of the learner in studying these courses (Subramaniam and Riley, 2008; Osborne et al, 2003).

Chapter Two
Literature Review

2.0 Graphing in Physics

The importance of graph plotting in Physics practical cannot be overemphasized. Graph helps in visualizing both the physics and the mathematics of any theoretical concept. While graphing soft-wares exist, the concept of plotting graphs using pencil and paper has been emphasized for undergraduate students (Deacon, 1999; "Graphing Techniques", 2017). Despite the need for this technique for graph plotting, there are varied challenges that are usually encountered by students using the paper and pencil technique (Waeconline.org.ng, 2008 to 2017; "Basic Graphing Skills", 2017; "Welcome to e-Learning Online", 2017). These challenges often constitute a barrier to achieving the goal of physics experiments which serve to validate theories. This have cause students to lose interest in physics laboratory exercises. To motivate students, there is the need for methods and materials that can ease the art and science of graph plotting using paper and pencil.

2.1 Educational Benefits of Apps

A study conducted by McGraw-Hill Education and Hanover Research in 2015, found that 81 percent of students use mobile devices (such as smartphones and tablets) to study. The study further states that 77 percent of the students said that the technology has positive impact on their grades, 48 percent said it saves their time, 62 percent said it helps them feel be prepared for classes while 52 said it helps them have better confidence of the course materials. Also, in US, the adoption of 1:1 iPad program has covered 600 school districts (Bonnington, 2012). A study conducted by Apple in conjunction with textbook publishers Houghton Mifflin Harcourt performed a pilot study using an iPad text for Algebra 1 courses and found that 20% more students (78% compared to

59%) scored 'Proficient' or 'Advanced' in subject comprehension when using tablets rather than paper textbook counterparts (Bonnington, 2012).

These technologies are compatible with applications (apps) which are largely classified as entertainment, communication, educational etc. While the entertainment and communications Apps are the most used (Apps Statistic Report, 2016), the educational Apps are becoming increasingly patronized within the educational cycle (http://www.educationalappstore.com, 2015). For instance, the gap between education and applications (Apps) is rapidly closing in the western world. Educational App.com has developed and distributed many educational apps worldwide in different areas of studies such as sciences, mathematics, humanities etc. In mathematics, Apps such as “mental Abacus”, “show me the money Part1”, “Math Racer 3.0” etc. have been in use by students and over 2000 teachers in about 1000 schools in UK (http://www.educationalappstore.com, 2015). Recently, the use of mobile app technology to help understand concepts in sciences have received a boost (Zydney, and Warner, 2016).

2.2 Assessment of the Educational Benefits, Selection rubrics and Design properties of educational apps

This sudden increase in the use of educational Apps as teaching aids as a result of the availability of mobile devices has started attracting the attention of researchers around the world. For example, a research paper by Kamlesh and Akash (2013) which is based on the study carried out in Barbarian Institute of Technology on 10 selected students to evaluate the efficacy of Mobiles-Assisted Language Learning (MALL) shows that there is positive impact of the technology on the students. Leinonen et al, (2014) studied how the use of apps could support reflection in learning in K-12 education and concluded that there is potential for fostering the practice of reflection in classroom learning through the use of apps for audio-visual recordings. This finding is interesting as reflection plays an important role in collaborative progressive inquiry or project-based learning (Minna, 2008; Rahikainen et al, 2001).

The evaluation for the selection of the most beneficial apps has seen some progress over the years (Lee and Cherner, 2015). However, the area of guidance in design of apps that will increase acceptability by users has only begun. Kathy, et’al (2015) proposed a set of principles that can guide researchers, educators and apps designers in evidence-based app development. They hope to evolve a new means of choosing and evaluating an educational app. However, their work was abstracted and did not measure motivation.

Motivation is one of the early rubrics for evaluation of educational apps proposed by Reeves and Harmon (Lee and Cherner, 2015). Though this is considered as weakness by Lee and Cherner, (2015) due to its difficulty of measurement, yet the role of source of motivation in design of educational apps cannot be compromised.

2.3 Role of motivation in learning

Motivation is considered the compelling force that brings out behaviours appropriate for achieving a set goal (Ofoke et al, 2015). Motivation can either be intrinsic, extrinsic or amotivation according to self-determination theory (STD) (Stover et al, 2012). When motive for engaging in an act is driven by pleasure and satisfaction derived from the act or is considered necessary for personal development, the motivation is considered intrinsic motivation while extrinsic motivation on the other hand is a reward driven motivation (Nnachi, 2003; Ryan et al, 1997; Luc et al, 1995). Academic motivation has been on the front burner of research topics in educational psychology because of it links either directly or indirectly with learning processes (Côté and Levine, 2000; Miñano, 2012; Murphy and Alexander, 2000; Pintrich and De Groot, 1990). Effort in information processing, use of self-regulated cognitive and metacognitive strategies are believed to be related to motivation and it is also believed to have close relationship with self-efficacy, perception, goal establishment and generation of achievement expectation (Pintrich, 2000; Gil, et al, 2009; Torrano, et al, 2004). Stover et al, (2012) noted that many studies have indicated the pertinence of using external reward in increasing the value of an assigned task. Where low achievement, desertion, and difficulty in the transition between educational levels is observed, the appropriate intervention has always been motivation based (Oliver et al, 2011; Vázquez, 2009). The findings of the study by Hyungshim, (2008) show the role that externally provided rationales can play in helping students generate the motivation they need to engage in and learn from uninteresting, but personally important material.

Despite all the documented benefits of educational apps and the role of motivation in learning, motivation studies that investigate motivation types in relation to the design properties of an educational apps are scarce. Knowing whether the motivation is extrinsic, intrinsic or amotivation (Stover et al, 2012; Luc and Stéphanie, 2007) and the app design properties that are responsible for each type can be helpful in both design and selection of app that can illicit the appropriate motivation.

Chapter Three
Materials and Method

3.0 Material Used and Description

3.0.1 Materials

The material used include: UJ-Math Graphing Tool (UJ-MaGT) (Appendix A), Graph papers, rulers, pencil, Test Questions (Appendix B2), Survey questionnaire (Appendix B1), IBM SPSS Statistics 25.0 and Excel.

3.0.2 Description

During the 2014/2015 academic session, only the computer version of the app was available. The UJ-Math Graphing Tool was installed on the university's library computers and students' personal computers. However, in 2015/2016 session, the mobile app was developed. the App was developed to fit other mobile devices platforms such as android, BlackBerry, IOS and was made available to the year one students during the first semester of 2015/2016 academic session. The app helps students find suitable scales for any given data-set and paper size, convert coordinates into the equivalent of the millimeter squares of the graph paper for ease of locating the coordinate on the paper and helps in reading the intercepts and the coordinates of the right-angle triangle when determining slope by converting the millimeter squares back to the equivalent numbers.

3.1 Method

3.1.1 Selection and Grouping of Students

. In 2014/2015 academic session, only survey data was collected. There was no experimental data collection due to lack of enough computers that can allow for the administering of achievement test. This is because only the computer version was available during this academic session. Hence, no categorization of students was done.

In 2015/2016 academic session however, both the experimental and survey data were collected since it was easy to administer achievement test due to the availability of the mobile version of the app and many students have a mobile device. The selection was not random, it was based on possession of a mobile and willingness participate in the study as member of treatment group. The students were categorized into treatment group and control group. Those that had a mobile device and were willing to use the app form the treatment group while those that did not have or were not willing to use the app form the control group. To ensure the effect of this selection method does impact the conclusion of this study, a pre-treatment test was administered to both group to ascertain any difference in performance between two group so as to account for any statistically significant when discussing the impact of the app on students' performance.

3.1.2 Treatment

The groups had same lectures about physics practical and reporting in the same hall during the research period. The students had two or one practical weekly depending on their course of study. No extra training was given to the treatment group except that they learned how the apply the app in plotting their graphs through a tutorial video that is in the app itself.

At the end of the semester, a post-treatment test on graph plotting was administered and the treatment group were allowed to use the app in the test.

3.1.3 Data Collection

In 2014/2015 academic session due to the shortage of the available computers in the Library, at the end of the semester only the survey data was collected from these set of population. A total of 1500 questionnaires were distributed to the students, 1250 were completed and returned. This gives an 83.3% return rate which is good (Draugalis et al, 2008). However, in 2015/2016 academic session, both the experimental and survey data were collected since it was easy to administer achievement test due to the availability of the mobile version of the app and many students have a mobile device. In this academic session, a total of 1125 (Treatment Group) students made use of the app and hence, were eligible to complete the survey questionnaire. However, only 1000 questionnaires were distributed and 805 were completed and returned; giving a return rate of 80% which is good (Draugalis et al, 2008).

a. Experimental Data

The students' graphs were graded in accordance to the West African Examination Council (WAEC) practical grading standard. Each graph was awarded a total score of 15 marks. The marks were distributed to the seven technical aspects of graph plotting as follows: 1 mark for axis correctly distinguished (A), 2 marks for suitable scales (SC), 5 marks for correctly matched points (PT), 5 marks for slope determination (SL), $^1/_2$marks for a correct line of best fit (L), $^1/_2$marks for a suitable Right-angle Triangle (RT) and 1 mark for intercept (I).

The graded scripts were then vetted by an expert with over ten years of experience in grading Physics practical for WAEC. The purpose was to ensure that scripts were graded uniformly and in accordance to the standard rules and to reduce biasness to the barest minimum. The scores for various aspect that constitute the technicalities of graph plotting were recorded and tabulated and the mean score and standard deviation were then determined (Table 1).

Students were told that the test will form part of their continuous assessment. This was to ensure that the students put in their possible best in attempting the test question.

b. Survey Data

A total number of 2,500 survey questionnaires were also administered to the students at the end of data collection. A total of 1250 was returned during the 2014/2015 academic session while 805 were returned during the 2015/2016 academic session. The questionnaire contained in addition to other questions, a question with items (question 9) that measure academic app motivation. The Academic Motivation Scale by Vallerand et al. (1992) with well-established psychometric properties was adapted and modified to suit the purpose of this study. Students were asked to be candid in their opinions as the purpose of the research was to improve the app and equally make available knowledge on how to design students' friendly and problem solvingcentered educational apps. The total returned questionnaires at the end of the data collection were 2055 i.e. a return rate of about 82% which is good (Draugalis et al, 2008). The questionnaires were coded and made suitable for analysis.

3.1.4 Data Analysis

Data analysis was statistical. For the experimental data, both descriptive (*M*, SDs) and inferential (paired sample t-test) statistic were carried out while for the survey data, descriptive statistics (*M*, frequency count and percentage) were calculated for question 1 to 8. But for question 9, descriptive statistic (*M*, SDs, skewedness, and kurtosis indexes) were calculated in order to study items distribution at a univariate level. In addition, confirmatory factor analysis was conducted to study the factorial structure of the scale. Furthermore, correlational analysis was carried out between question 9 and the items in question 4 and 5. Analyses were carried out using SPSS.

Chapter Four
Data Presentation and Results

4.0 Experimental Data and results

4.0.1 Descriptive Statistics

Table 1: The mean score and standard deviation of the various technical aspects of graph plotting.

	A		SC		PT		SL		L		RT		I		Total	
	M	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
CG. 1st Test	0.9018	0.2774	0.1114	0.4167	0.6566	1.506	1.3301	1.6072	0.0443	0.254	0.3279	0.2377	0.3969	0.3577	3.8369	3.6808
CG 2nd Test	0.9245	0.2542	0.6802	0.8303	0.1512	0.6568	0.8231	1.3077	0.0098	0.0749	0.4054	0.2752	0.4987	0.273	3.4815	2.0072
TG. 1st Test	0.9122	0.4621	0.1697	0.5174	0.8088	1.6125	1.5902	1.6819	0.0618	0.2163	0.377	0.2512	0.4475	0.4949	4.3662	3.3545
TG 2nd Test	0.9844	0.1155	1.9561	0.3085	4.052	1.5929	2.8926	1.5908	0.2258	0.2581	0.4994	0.2256	0.7821	0.2685	11.381	2.5722

Abbreviations: (A), axis; (SC), scales; (PT), points; (SL), slope; (L), line of best fit; (RT), Right-angle Triangle; (I), intercept; (CG), control group; (TG), treatment group; (M), mean and (SD), standard deviation.

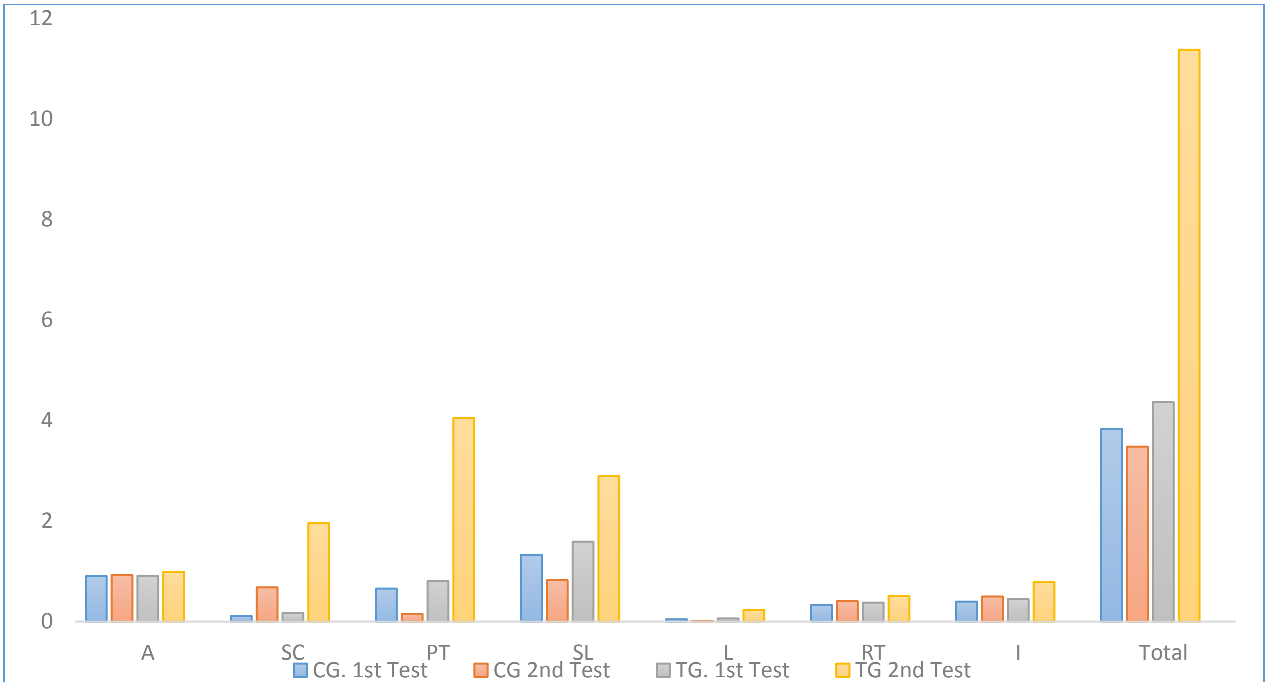


Figure 2: Comparison of the mean scores of the various aspects of the plotted graphs

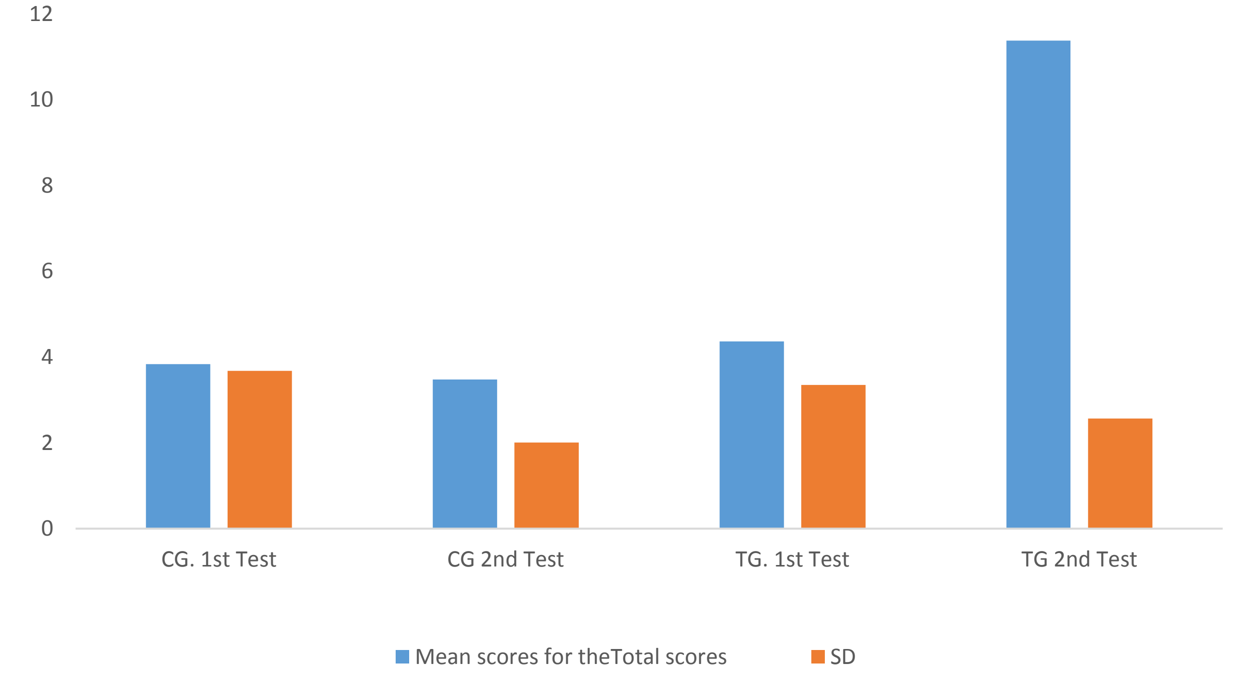


Figure 3: Comparison of the Mean Score (MS) for the Total Scores and their Standard Deviations (SD)

Table 2: The Percentage mean score of the various technical aspects of graph plotting.

	A (%)	SC (%)	PT (%)	SL (%)	L (%)	RT (%)	I (%)	Total (%)
CG. 1st Test	90.18	5.57	13.13	26.6	8.86	65.58	39.69	25.58
CG 2nd Test	92.45	34.01	3.02	16.46	1.96	81.08	49.87	23.21
TG. 1st Test	91.22	8.5	16.18	31.8	12.36	75.4	44.75	29.08
TG 2nd Test	98.44	98.81	81.04	57.85	45.16	99.88	78.21	75.87

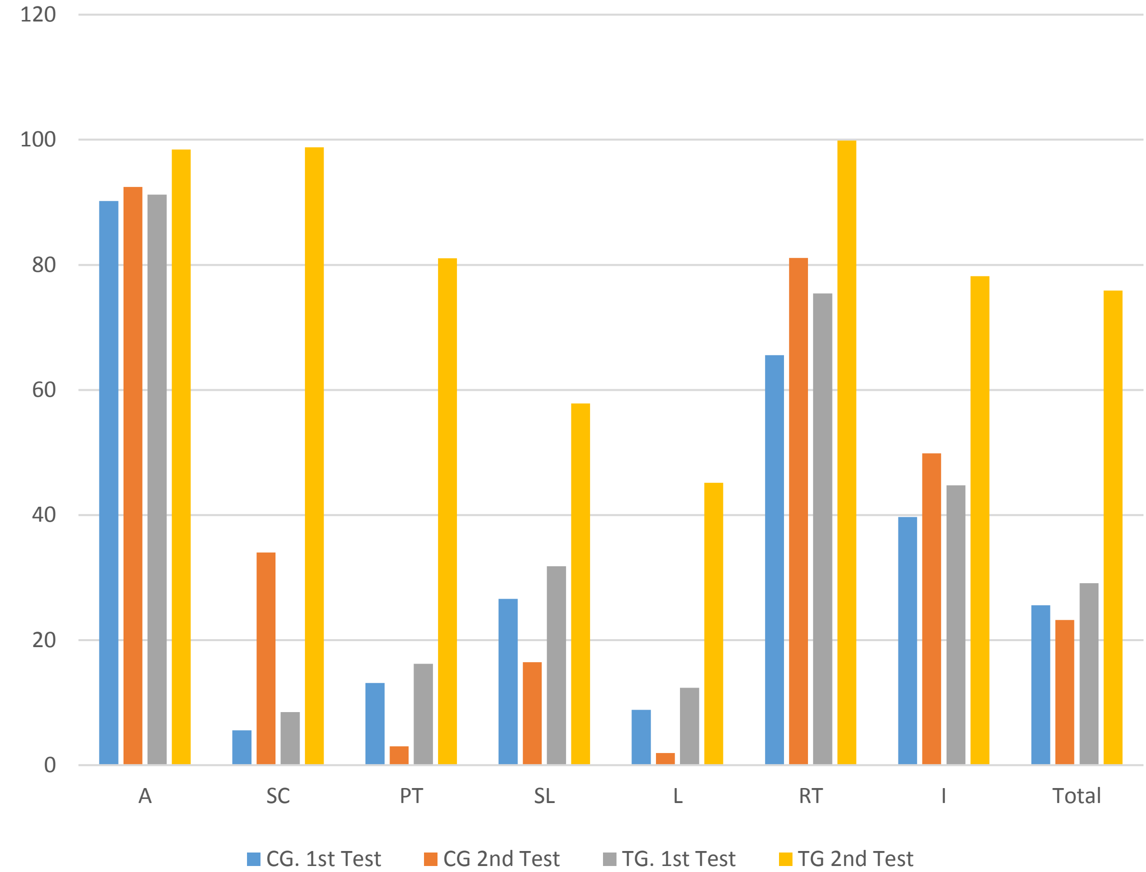


Figure 4: Bar Chart Comparing the Percentages of the Mean scores of the Various Techical Aspects of a Plotted Graph

4.0.2 Inferential Statistics

Out of the students who took the achievement test, only 616 met the inclusion criteria for the analysis which was set as; only scores of students that have both pre and post treatment test score were to be included. A paired-samples t-test was carried out to test the null hypothesis and the results were:

Comparing the pre-treatment test scores between the two groups: The control group (CG) had mean and standard deviation; M=3.8 and SD=3.7 and treatment group (TG) had mean and standard deviation; M=3.5 and SD=2.0 with t-value of 2.34 at degree of freedom of 616 and $p > 0.01$.

Comparing the pre-treatment and post-treatment test scores of the control group (CG): The pre-test scores for control group (CG) had mean and standard deviation; M=3.8 and SD=3.7 and post-test scores for control group (CG) had mean and standard deviation; M=4.6 and SD=3.5 with t-value of 3.69 at degree of freedom of 616 and $p<0.01$.

Comparing the pre-treatment and post-treatment test scores of the treatment group (TG): The pre-test scores for treatment group (TG) had mean and standard deviation; M=3.5 and SD=2.0 and post-test scores for treatment group (TG) had mean and standard deviation; M=11.5 and SD=2.5 with t-value of 50.12 at degree of freedom of 616 and $p<0.01$.

Comparing the pre-treatment test scores between the two groups: The post-test scores for the control group (CG) had mean and standard deviation; M=4.4 and SD=3.3 and post-test scores for the treatment group (TG) had mean and standard deviation; M=11.4 and SD=2.6 with t-value of 50.12 at degree of freedom of 616 and $p<0.01$.

4.1 Survey Data and results

4.1.1 Descriptive Statistics (*M*, frequency count and percentage)

Questions 1,2 and 3

A total of 2000 out of 2055 students made the inclusion criteria for this analysis. The criterion was that only returned questionnaires without missing data were to be included for analysis.

The students’ ages range between 15 years to 40 years with mean age of 20 and standard deviation of 8. Of the 2055 students, 54% were males while 46% were females. 73% completed their high schools from private secondary schools, 12% from state government secondary schools while 15% completed from federal government secondary schools.

Question 4

Table 3: Average Likert scale and percentages of degree of agreement with item in question 4

		Percentages			
	Average Likert Scale	Strongly Agree	Agree	Disagree	Silent
Easy to use	2.5	50%	43%	1%	6%
Saves time	2.6	56%	34%	3%	7%
Makes graph plotting easier	2.7	71%	25%	1%	3%

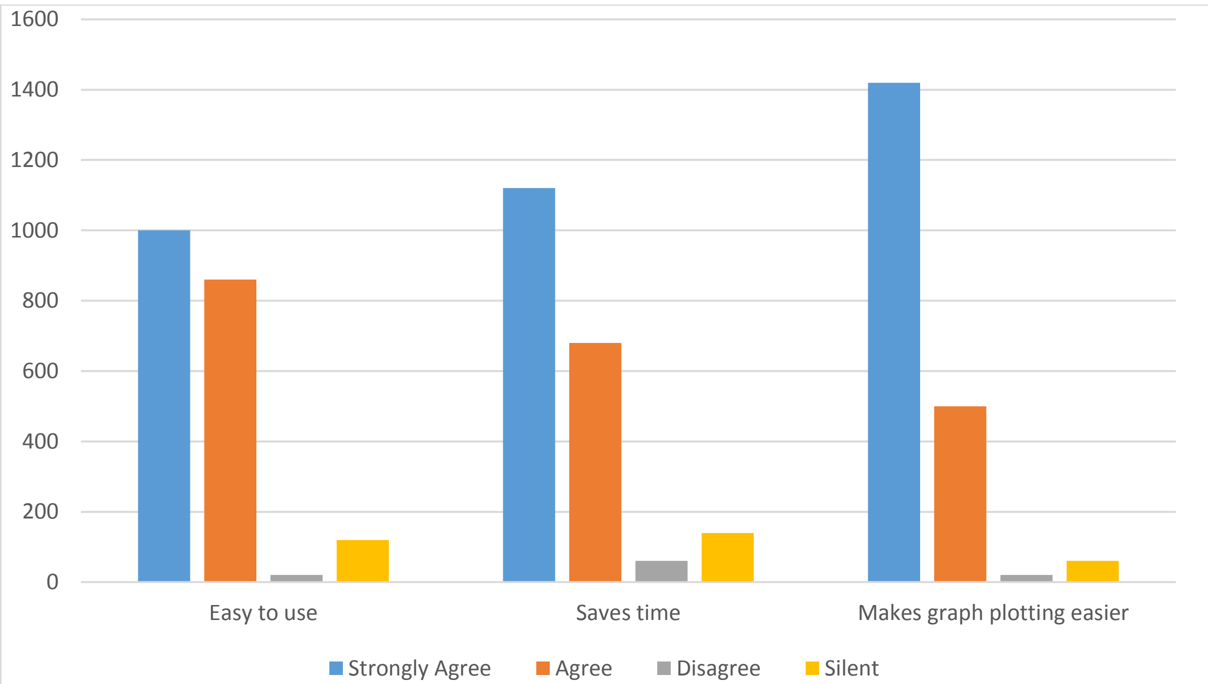


Figure 5: Frequency Distribution of Responses to question 4

Question 5

Table 4: Average Likert scale and percentages of degree of agreement with items in question 5

		Percentages			
	Average Likert Scale	Very easy	Easy	Not easy	Silent
Finding Scale	2.8	74.62%	23.23%	0.61%	1.53%

Points Plotting	2.6	60%	36%	3%	1%
Determining Y1,Y2,X1 and X2	2.5	50%	44%	5%	1%
Determination of Intercept	2.6	64%	32%	3%	1%

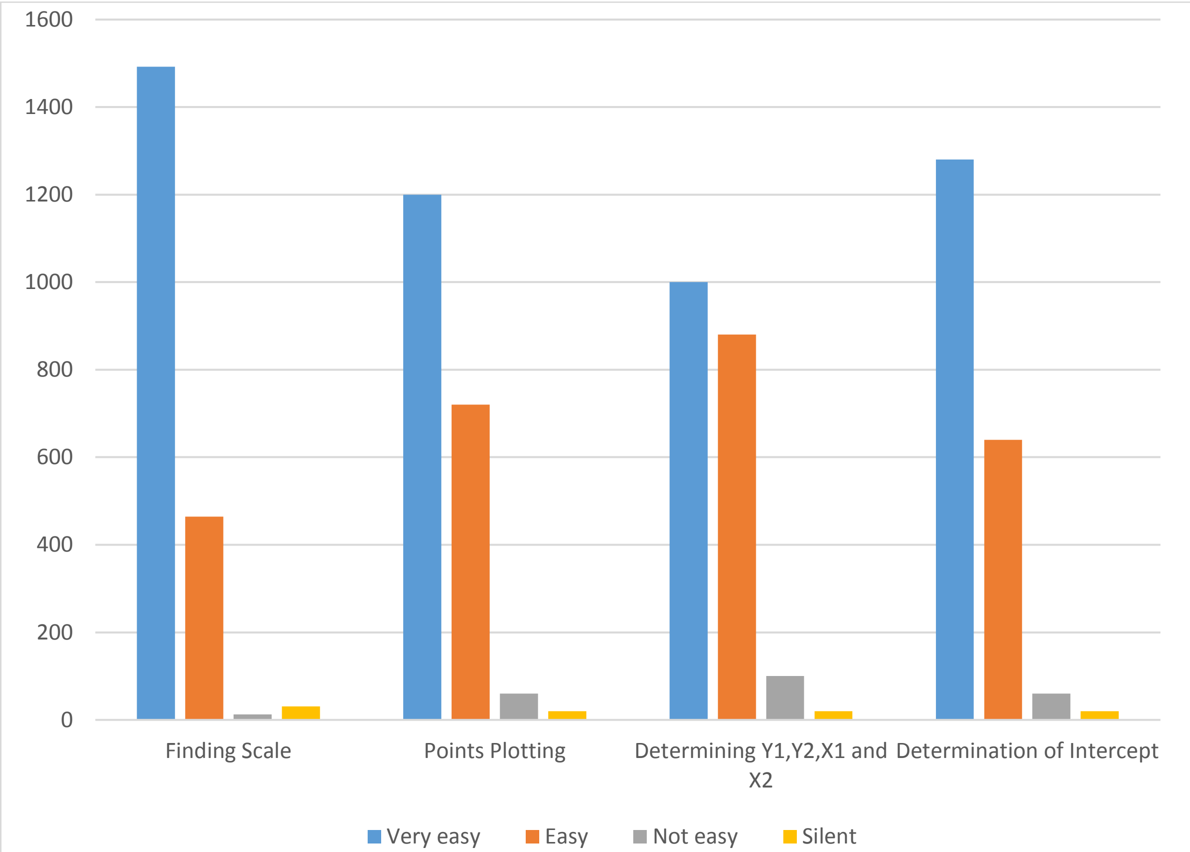


Figure 6: Frequency Distribution of Responses to question 5

Question 6.

In expressing their willingness to enroll for a graph plotting course, 88% said they will enroll if app is available while 12% said they will not enroll if app is available. And 29% said they will enroll if app is not available while 71% said they will not enroll if app is not available.

Question 7

Table 5: Average Likert scale and percentages of degree of agreement with question 7

		Percentages			
	Average Likert Scales	Strongly Agree	Agree	Disagree	Silent
Apps can increase students' desire to learn an otherwise difficult subject	2.4	45%	49%	3.2%	2.8%

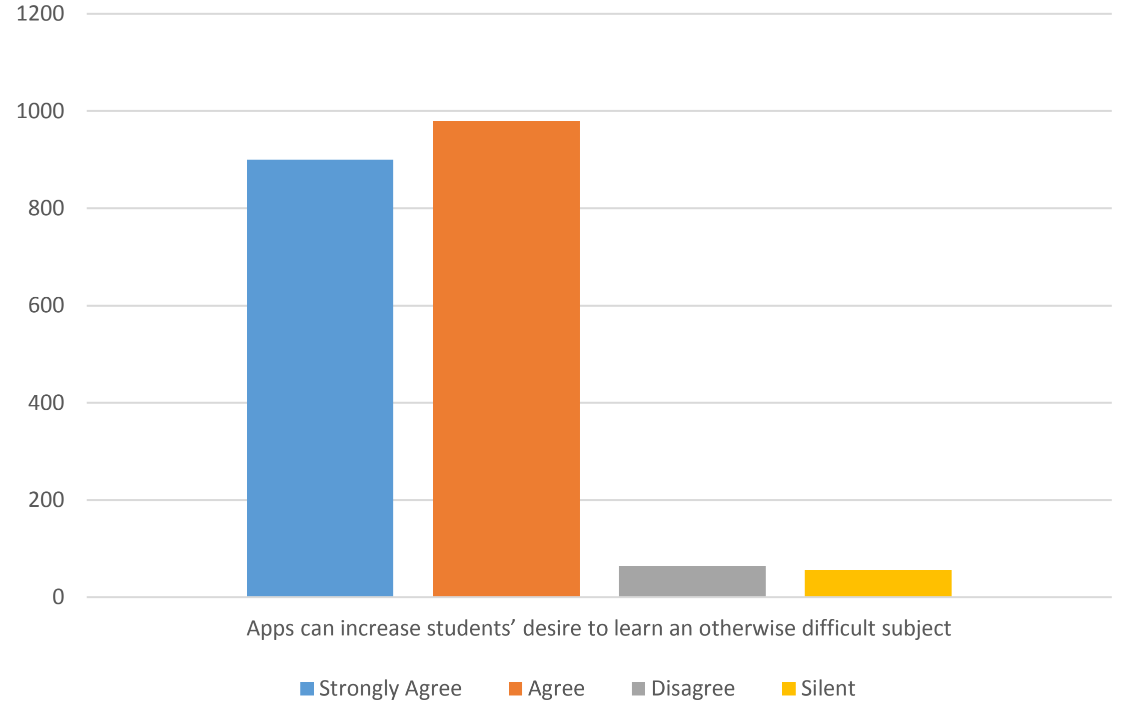


Figure 7: Frequency Distribution of Responses to question 7

Question 8

Participants were asked to indicate, out of six listed factors, the ones that influenced their desire to use the app. 92% indicated 'it makes graph plotting easier', 83% indicated 'it saves time', 82% indicated that 'it is easy to use', 45% indicated 'it is developed in the University', 23% indicated 'it looks like other apps you are used to' while 15% indicated 'every student is using it'.

Note: the total percentage is greater than 100 because respondents were free to choose as many factors as possible.

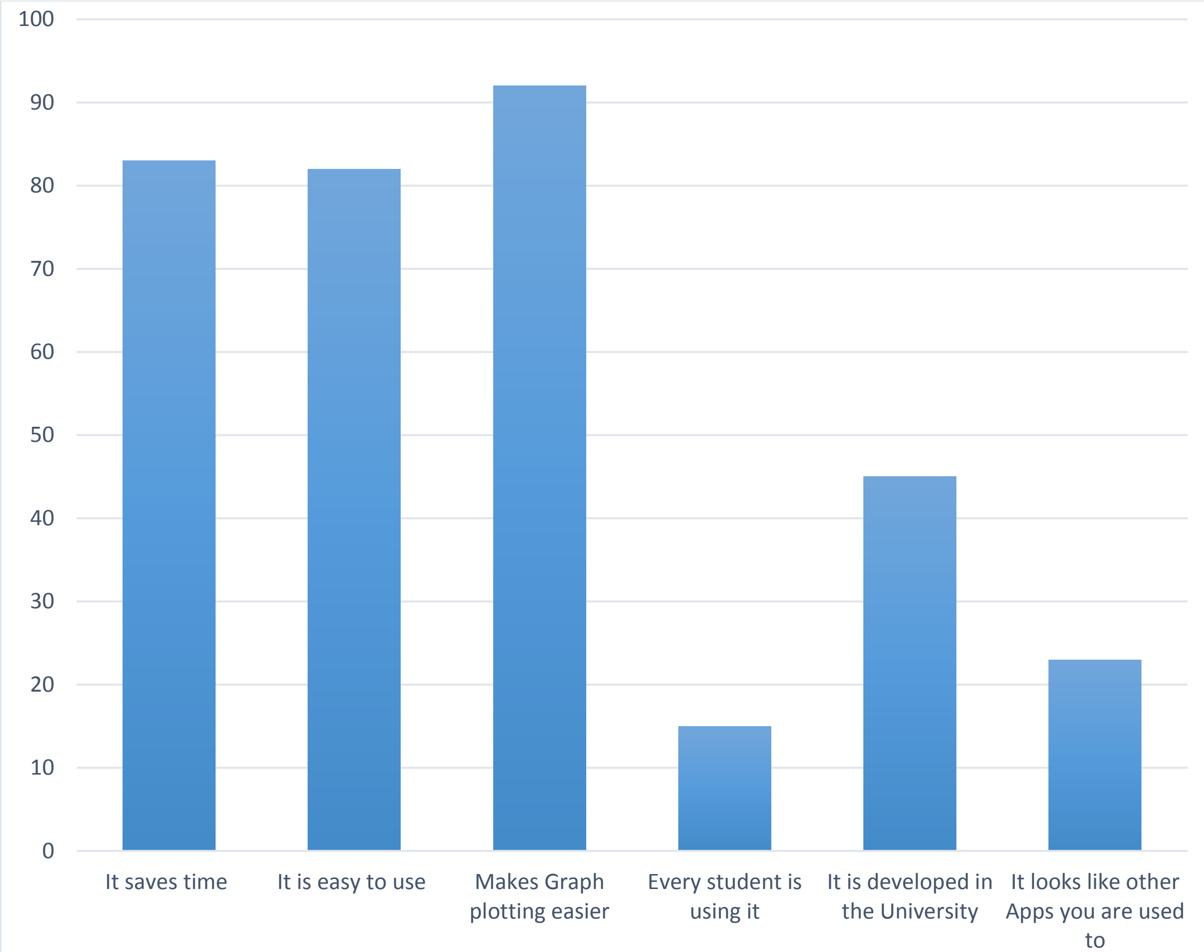


Figure 8: Percentage Indication of Factors that influenced desire to use the app

Question 9

4.1.2 Descriptive statistic (*M*, SDs, skewedness, and kurtosis indexes)

Out of the 2000 questionnaires that met the analysis inclusion criteria for the survey data, only a representative sample of 1500 was used for the validation of Academic App Motivation Scale (AAMS)

Table 6. Measurement Instrument, Academic App motivation scale (AAMS) Mean Score, Standard Deviation, Skewness, and Kurtosis (N=1500, 21 items).

S/N	Items	M	SD	Skewness	Kurtosis
1	Because I experience pleasure and satisfaction while learning new things IMK1	3.96	1.095	-1.234**	1.039**
2	For the pleasure I experience when I discover things never seen before IMK2	3.85	1.083	-.925**	.268*
3	For the pleasure that I experience in broadening my knowledge about (App) which appeal to me IMK3	3.92	1.032	-1.093**	.966**
4	Because my studies (Physics) allow me to continue to learn about many things that interest me IMK4	3.76	1.090	-.852**	.205*
5	For the pleasure I experience while doing greater than I thought I could do in my studies (Physics) IMA1	4.03	1.027	-1.232**	1.330**
6	For the pleasure that I experience while I am doing better myself in one of my personal accomplishments (Studies) IMA2	4.05	1.010	-1.281**	1.493**
7	For the satisfaction I feel when I am in the process of accomplishing difficult academic activities IMA3	4.12	1.022	-1.403**	1.733**

8	Because academic Apps allow me to experience a personal satisfaction in my quest for excellence in my studies (Physics) IMA4	4.05	1.042	-1.230**	1.159**
9	For the pleasure that I experience when I feel completely absorbed by new technological innovations IMS3	3.71	1.068	-.720**	.032
10	For the ‘‘high’’ feeling that I experience while reading about various simplified interesting subjects (Physics) IMS4	3.68	1.037	-.629**	-.066
11	Because I think that App (Physics) will help me better understand the art of graph plotting EMID1	4.24	1.042	-1.626**	2.214**
12	Because I believe that a few additional use of MaGT App will improve my competence as a student of Physics EMID2	4.19	1.036	-1.470**	1.821**
13	To prove to myself that I am capable of using new inventions EMIN1	3.80	1.254	-.908**	-.208*
14	Because of the fact that when I succeed in school (Physics) I feel important EMIN2	3.78	1.168	-.898**	.041
15	Because I want to show myself that I can succeed in my studies (Physics) EMIN4	3.75	1.179	-.818**	-.182*

16	Because Apps are very common and easy to use EME1	4.12	1.088	-1.355**	1.323**
17	Because Apps can be installed on other portable devices such as phones etc EME2	4.14	1.057	-1.369**	1.467**
18	Honestly, I don't know; I really feel that I am wasting my time in using the MaGT App AM1	1.56	1.001	2.139**	4.129**
19	I once had good reasons for using the MaGT App; however, now I wonder whether I should continue AM2	1.96	1.165	1.233**	.612**
20	I can't see why I should use the MaGT App and frankly, I couldn't care less AM3	1.69	1.057	1.739**	2.387**
21	I don't know; I can't understand why I am using the MaGT App AM4	1.63	1.023	1.964**	3.378**
	Subscales of AAMS				
1	IMK_Knowledge	15.4893	3.50587	-1.201**	1.481**
2	IMA (Accomplishment)	16.2477	3.41826	-1.524**	2.632**
3	IMS (Stimulation)	7.3838	1.85517	-.680**	.212*
		8.4221			

4	EMID (Identified)		1.91514	-1.565**	2.236**
		11.3214			
5	EMIN (Introjected)		2.94469	-.859**	.184

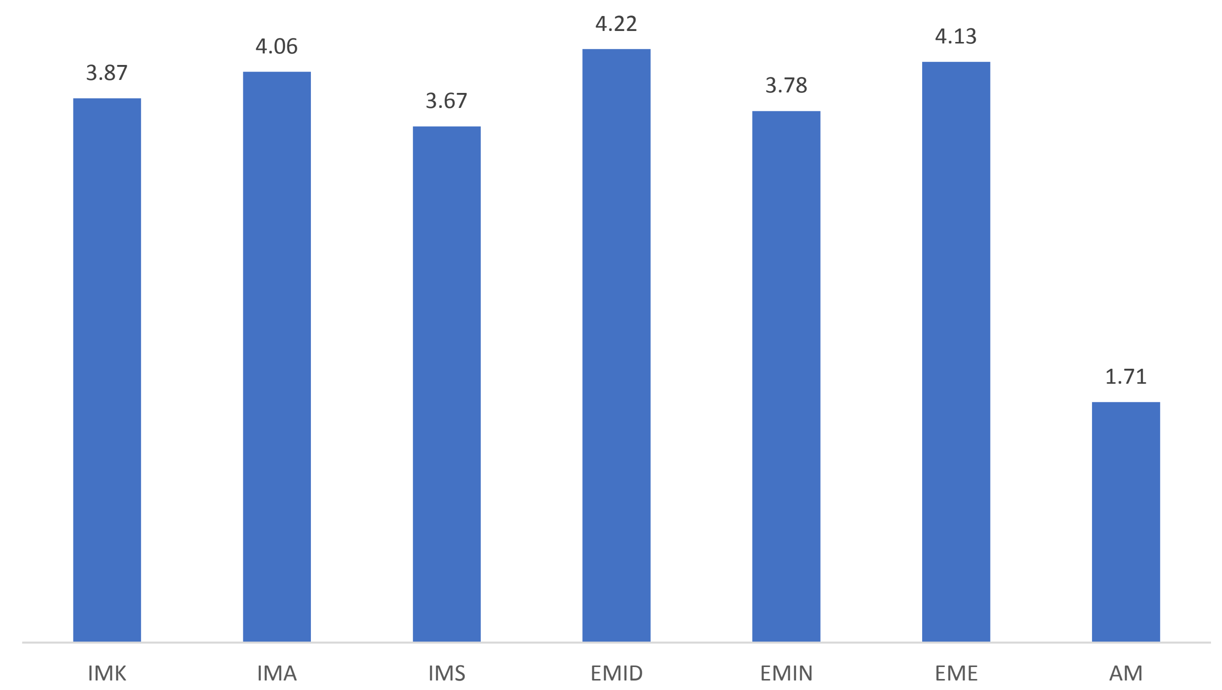


Figure 9. Average Mean Score of each Subscale

4.1.3 Confirmatory factor analysis (CFA)

a. The original 7-factor model

The 7-factor model (Model 1) was tested first. Covariance among subscales was desirable, given previous findings that different types of motivation are correlated (e.g., Brown, 2006). The CFA revealed significant t values for all factor loadings ($p < .01$), ranging between .31–.89.

Tabachnick and Fidell (2001) considered loadings ≥ 0.55 to be good, which was the case for 23 of the 26 items. Three loading might be considered as poor ($\lambda = .31$ for item EMS1, .36 for

EME3, .49 for EME4). Ideally, the standardized factor loadings should be at least .70 (Hair et al, 2010), as was the case for 18 of the 26 items.

Together with the factor loadings, the square of a standardized factor loading (R2) was used to assess the degree to which an item was a good measure of the factor and represented how much variation in an item was explained by the latent factor (Brown, 2006; Hair et al., 2010). In our study, *R2* values ranged between .20 and .82. Kline (2011) has suggested that shared variance with a factor should be greater than .50, which three of the 26 items in Model 1 also did not fulfill. Factor loadings, *t* values, and *R2* are presented in Table 2.

b. Dimensionality in Models 1 and 2

The original 7-factor, 28-item measurement model of the AMS (i.e., Model 1) was tested by means of CFA, which showed significant estimates ($p < .01$). Model 1 also demonstrated a modest fit with observed data: $\chi2$ = 976.44, p = .001, df = 329, $\chi2$/df = 2.97, RMSEA = .70, SRMR = .068, NFI = .95, NNFI = .96, CFI = .96 (Table 4). Since previous studies have indicated that the three intrinsic motivation factors have acted as a single construct of intrinsic motivation (e.g., Alivernini and Lucidi, 2008; Grouzet et al., 2006), a 5-factor solution of the AMS was tested and used to frame Model 2. Consequently, Model 2 comprised one factor measuring intrinsic motivation, the three original types of extrinsic motivation, and amotivation; it ultimately revealed a slightly worse fit, as Table 4 shows ($\chi2$ = 1,089.85, p = .001, df = 340, $\chi2$/df = 3.21, RMSEA = .074, SRMR = .075, NFI = .94, NNFI = .95, CFI = .96). The chi-difference test showed that Model 1 was significantly better than Model 2 ($\chi2$diff (-11) = -113.41 (976.44–1,089.85, 329–340); for the model to be significantly better, the change in $\chi2$ value had to exceed the critical value of the difference in degrees of freedom at the 5% level. Accordingly, the 7-factor structure was superior to the 5-factor model, which supported the original dimensionality of the AMS that comprised seven dimensions.

MODEL 1 (26-ITEM)

Notes for Group (Group number 1)

<u>The model is recursive.</u>

Sample size = 1500

Notes for Model (Default model)

Computation of degrees of freedom (Default model)

Number of distinct sample moments: 351

Number of distinct parameters to be estimated: 73

Degrees of freedom (351 - 73): 278

Result (Default model)

Minimum was achieved

Chi-square = 1286.936

Degrees of freedom = 278

Probability level = .000

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	73	1286.936	278	.000	4.629
Saturated model	351	.000	0		
Independence model	26	13379.320	325	.000	41.167

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.085	.899	.873	.712
Saturated model	.000	1.000		

Model	RMR	GFI	AGFI	PGFI
Independence model	.422	.229	.167	.212

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.904	.888	.923	.910	.923
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.855	.773	.789
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	1008.936	901.195	1124.190
Saturated model	.000	.000	.000
Independence model	13054.320	12679.293	13435.677

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	1.319	1.034	.923	1.152
Saturated model	.000	.000	.000	.000
Independence model	13.708	13.375	12.991	13.766

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.061	.058	.064	.000
Independence model	.203	.200	.206	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	1432.936	1437.090	1789.504	1862.504
Saturated model	702.000	721.973	2416.455	2767.455
Independence model	13431.320	13432.800	13558.317	13584.317

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	1.468	1.358	1.586	1.472
Saturated model	.719	.719	.719	.740
Independence model	13.762	13.377	14.152	13.763

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	242	255
Independence model	27	29

Minimization: .198

Miscellaneous: 3.627

Bootstrap: .000

Total: 3.825

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
IMK4	<---	IMK	.655
IMK3	<---	IMK	.778
IMK2	<---	IMK	.792
IMK1	<---	IMK	.762
IMA4	<---	IMA	.728
IMA3	<---	IMA	.787
IMA2	<---	IMA	.810
IMA1	<---	IMA	.761
IMS4	<---	IMS	.715
IMS3	<---	IMS	.769

			Estimate
IMS2	<---	IMS	.640
IMS1	<---	IMS	.305
EMID2	<---	EMID	.806
EMID1	<---	EMID	.826
EMIN4	<---	EMIN	.805
EMIN3	<---	EMIN	.729
EMIN2	<---	EMIN	.718
EMIN1	<---	EMIN	.659
EME4	<---	EME	.489
EME3	<---	EME	.383
EME2	<---	EME	.845
EME1	<---	EME	.885
AM4	<---	AM	.866
AM3	<---	AM	.829
AM2	<---	AM	.674
AM1	<---	AM	.761

Correlations: (Group number 1 - Default model)

			Estimate
IMK	<-->	IMA	.795
IMK	<-->	IMS	.715
IMK	<-->	EMID	.688
IMK	<-->	EMIN	.610
IMK	<-->	EME	.655
IMK	<-->	AM	-.346
IMA	<-->	IMS	.704
IMA	<-->	EMID	.824
IMA	<-->	EMIN	.575
IMA	<-->	EME	.714
IMA	<-->	AM	-.480
IMS	<-->	EMID	.624
IMS	<-->	EMIN	.754
IMS	<-->	EME	.623
IMS	<-->	AM	-.211
EMID	<-->	EMIN	.618
EMID	<-->	EME	.721
EMID	<-->	AM	-.450
EMIN	<-->	EME	.730

	Estimate
EMIN <--> AM	-.202
EME <--> AM	-.452

MODEL 2 (21 ITEM)

Notes for Group (Group number 1)

The model is recursive.

Sample size = 1500

Notes for Model (Default model)

Computation of degrees of freedom (Default model)

Number of distinct sample moments:	231
Number of distinct parameters to be estimated:	63
Degrees of freedom (231 - 63):	168

Result (Default model)

Minimum was achieved

Chi-square = 421.534

Degrees of freedom = 168

Probability level = .000

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	63	421.534	168	.000	2.509
Saturated model	231	.000	0		
Independence model	21	11190.284	210	.000	53.287

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.033	.961	.946	.699
Saturated model	.000	1.000		
Independence model	.439	.236	.159	.214

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.962	.953	.977	.971	.977
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.800	.770	.782
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	253.534	196.898	317.857
Saturated model	.000	.000	.000
Independence model	10980.284	10637.088	11329.797

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	.432	.260	.202	.326
Saturated model	.000	.000	.000	.000
Independence model	11.465	11.250	10.899	11.608

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.039	.035	.044	1.000
Independence model	.231	.228	.235	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	547.534	550.440	855.257	918.257
Saturated model	462.000	472.654	1590.316	1821.316
Independence model	11232.284	11233.253	11334.858	11355.858

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	.561	.503	.627	.564
Saturated model	.473	.473	.473	.484
Independence model	11.508	11.157	11.867	11.509

HOELTER

Model	HOELTER .05	HOELTER .01
Default model	462	495
Independence model	22	23

Minimization: .013

Miscellaneous: 2.176

Bootstrap: .000

Total: 2.189

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
IMK4	<---	IMK	.656
IMK3	<---	IMK	.780
IMK2	<---	IMK	.791
IMK1	<---	IMK	.761

			Estimate
IMA4	<---	IMA	.728
IMA3	<---	IMA	.786
IMA2	<---	IMA	.810
IMA1	<---	IMA	.763
IMS4	<---	IMS	.757
IMS3	<---	IMS	.732
EMID2	<---	EMID	.806
EMID1	<---	EMID	.827
EMIN4	<---	EMIN	.764
EMIN2	<---	EMIN	.714
EMIN1	<---	EMIN	.648
EME2	<---	EME	.859
EME1	<---	EME	.906
AM4	<---	AM	.866
AM3	<---	AM	.829
AM2	<---	AM	.674
AM1	<---	AM	.761

Correlations: (Group number 1 - Default model)

			Estimate
IMK	<-->	IMA	.796
IMK	<-->	IMS	.749
IMK	<-->	EMID	.688
IMK	<-->	EMIN	.668
IMK	<-->	EME	.609
IMK	<-->	AM	-.346
IMA	<-->	IMS	.764
IMA	<-->	EMID	.824
IMA	<-->	EMIN	.641
IMA	<-->	EME	.673
IMA	<-->	AM	-.480
IMS	<-->	EMID	.684
IMS	<-->	EMIN	.765
IMS	<-->	EME	.606
IMS	<-->	AM	-.276
EMID	<-->	EMIN	.680
EMID	<-->	EME	.689
EMID	<-->	AM	-.450
EMIN	<-->	EME	.760

	Estimate
EMIN <--> AM	-.253
EME <--> AM	-.449

4.1.4 Correlational analysis

Table 7. Correlation between the factors of AAMS and the items in question 4

	Easy to use	Saves time	Makes graph plotting easier
Intrinsic motivation knowledge	.146**	.103**	.077*
Intrinsic motivation accomplishment	.133**	.150**	.144**
Intrinsic motivation stimulation	.174**	.126**	.096**
extrinsic motivation identified	.130**	.179**	.161**
extrinsic motivation introjected	.120**	.114**	.085**
extrinsic motivation extrinsic	.062**	.078*	.050*
Amotivation	-.066*	-.106**	-.111**

** Correlation is significant at 0.01 level (2 tailed); * Correlation is significant at 0.05 level (2 tailed)

Table 8. Correlation between the factors of AAMS and the items in question 5

	Finding scale	Point plotting	Determining Y1, Y2, X1, and X2	Determination of intercept
Intrinsic motivation knowledge	.107**	.143**	.097**	.107**
Intrinsic motivation accomplishment	.126**	.150**	.091**	.101**
Intrinsic motivation stimulation	.110**	.157**	.121**	.125**
extrinsic motivation identified	.160**	.160**	.086**	.131**
extrinsic motivation introjected	.048	.118**	.079*	.090**
extrinsic motivation extrinsic	.090**	.128**	.058**	.068*
Amotivation	-.155**	-.141**	-.084**	-.109**

** Correlation is significant at 0.01 level (2 tailed); * Correlation is significant at 0.05 level (2 tailed)

Chapter Five
Result Discussion

5.0 Research hypothesis answered.

5.0.1 There is no significant effect of using UJ-Math Graphing Tool (UJ-MaGT) on students' performance in graph plotting

A total of 2,055 students completed the survey questionnaire. The students' ages range between 15 years to 40 years with mean age of 20 and standard deviation of 8. Of the 2,055 students, 54% were males while 46% were females. 73% completed their high schools from private secondary schools, 12% from state government secondary schools while 15% completed from federal government secondary schools.

From Figure 2, Figure 3 and the result of the inferential statistics that compares the pre-treatments scores of the two groups, it is clear, the selection method does not impact the outcome of the treatment since there was no significant difference ($P > 0.01$) in the performance of the groups. Furthermore, the both the inferential and descriptive statistics show that the observed difference between the pre and post treatment test scores of the control group (CG) is significant ($P < 0.01$). this proves that usual teaching and coaching the students receive in the university do improve their performance in graphing. However, the improvement is small as shown in Figure 3.

In the same vein, the results show that the app can improve students' performance when it comes to graph plotting. The mean scores of the post treatment test for the treatment group (TG) is far greater than that of the pre-treatment test which was done without the use of the app. This difference is significant ($P < 0.01$).

To compare the impact of the app to the usual teaching and coaching intervention by the university, the post treatment scores were compared. It is also obvious from the graph (Figure 3) that the mean score of the post treatment test for the treatment group (TG) is greater than mean score for the control group (CG). This difference is also statistically significant ($P < 0.01$). this implies that the use of the app can be a better intervention compare to the usual teaching when graphing.

In Figure 3, the difference between the mean score and the standard deviation of the treatment group (TG) post treatment test is high. First, the mean of over 11 is close to the total mark of 15 that any candidate could score and the standard deviation of less 3 implies that the distribution of scores around the mean score is clustered closely. That is, the range between the lowest score and the highest score is small. This suggest that the use of the app has the advantage of closing the gap between the 'below average' students and the 'above average' students in the class. This is interesting because one of the greatest challenges a teacher faces in a class is that of carrying all students on board during a lesson. The use of the app also has the advantage of improving the students' performance (mean of over 11) as seen from Figure 2 and 3.

5.1 Research Questions Answered

5.1.1 What aspects of graph plotting are made easier using UJ-MaGT?

To understand in detail how the app impacts the students' performance, a percentage mean scores were calculated (Table 2). This was to allow for an analysis into which technical aspect(s) of the graph plotting is(are) impacted more. From Figure 4, finding a suitable scale, plotting points, determination of slope, fitting of best line and determination of intercepts are the most impacted aspects in that order. Furthermore, this result is supported by frequency of response to survey question 8 (Figure 6). It is worthy of note that these very aspects are the most challenging aspects to students as reported by WAEC chief examiner's annual report.

5.1.2. To what extent is UJ-MaGT easy to use? And To what extent does UJ-MaGT makes graph plotting easier?

The degree of students' agreement to item in question 4 were averaged while the percentage of responses were calculated and given in Table 3 (Warmbrod, 2014; Alexandrov, 2010; Sullivan, and Artino, 2013). It is clear from the Table 3 and Figure 5 that the students strongly agreed that the app makes graph plotting easier, saves time and is easy to use. This further supports the result of the experimental data as presented in Table 1 and Figures 2 and 3. Closer look at Figure 5 shows that more students strongly agreed that the app makes graph plotting easier followed by time saving and the ease of use. Furthermore, Table 4 and Figure 6 corroborated the result in Figure 4, further confirming that the app impacts more on the scale finding, points plotting, slope determination and intercept determination aspects of graph plotting.

5.1.3 What percentage of students does UJ-MaGT motivates to plot graphs? And To what extend did the students agree that the app can motivate them?

This question was answered through survey questions 6 and 7. Question 6: "Would you like to enroll for a course that has graph plotting if: (a) app is available? (b) app is not available? This question was framed in this manner to help know the exact number of students that given their choice, they would go for courses with graph plotting components only if the app was to be available. This is found by finding the difference between those that said yes in part (a) of the question and those that said yes in part (b) of the question

In expressing their willingness to enroll for a graph plotting course, 88% said they will enroll if app is available while 12% said they will not enroll if app is available. And 29% said they will enroll if app is not available while 71% said they will not enroll if app is not available. Looking at 88% and 29%, it clear that the presence of app could increase enrollment rate by 59%. From Table 5 and Figure 7, 45% and 49% of the students strongly agreed and agreed respectively that app can increase their desire to learn an otherwise difficult concept. These are interesting findings to educationists and stake holders. The findings support earlier studies by Bonnington, (2012), Leinonen et al, (2014) and Kamlesh and Akash (2013).

5.1.4 What kind of Motivation can educational app (UJ-MaGT) create?

To answer this question, academic app motivation scale (AAMS) was first validated.

Confirmatory Factor Analysis (CFA) – The original 7-factor model

The 7-factor model (Model 1) was tested first. Covariance among subscales was desirable, given previous findings that different types of motivation are correlated (e.g., Brown, 2006). The CFA revealed significant t values for all factor loadings ($p < .01$), ranging between 0.31 and 0.89.

Tabachnick and Fidell (2001) considered loadings ≥0.55 to be good, which was the case for 23 of the 26 items. Three loading might be considered as poor (λ = 0.31 for item EMS1, 0.36 for EME3, 0.49 for EME4). Ideally, the standardised factor loadings should be at least 0.70 (Hair et al, 2010), as was the case for 18 of the 26 items.

Together with the factor loadings, the square of a standardised factor loading (R2) was used to assess the degree to which an item was a good measure of the factor and represented how much variation in an item was explained by the latent factor (Brown, 2006; Hair et al., 2010).

Dimensionality in Models 1 and 2

The original 7-factor, 26-item measurement model of the AMS (i.e., Model 1) was tested by means of CFA, which showed significant estimates ($p <.01$). Model 1 also demonstrated a modest fit with observed data: $\chi 2$ (CMIN)= 1286.94, p = .001, df = 278, $\chi 2$/df (CMIN/DF= 4.629, RMSEA = 0.70, SRMR = 0.061, NFI = 0.904, PNFI = 0.773, CFI = 0.923, GFI = 0.899.

The results in model 1 demonstrated poor model fit because EME3, EME4, EMS1, EMIN1 and IMS2 loaded weakly at less than 0.77. Also, the result met the criterion for CMIN/DF Which is set at equal or less than 5, it failed to meet the criteria for and RMSEA and SRMR set at equal or less than 0.05. The result also met the criterion for NFI and CFI set at 0.9 and above it failed to meet the required limit for PNFI and GFI set at 0.9 and above.

In our study, *R2* values ranged between 0.20 and 0.82. Kline (2011) has suggested that shared variance with a factor should be greater than 0.50, which three of the 26 items in Model 1 also did not fulfil.

Models 2

Due to the low loadings in model 1 that are below the standard threshold of .70, when these items (λ = 0.31 for item IMS1, 0.36 for EME3, 0.49 for EME4, 0.65 for EMIN1 (this also brought down IMS2 to 0.31 and consequently were statistically deleted in model 2. This made model 2 to have 21-items that are significantly loaded above 0.70 minimum.

Therefore model 2 demonstrated a stronger model fit with observed data: $\chi 2$ (CMIN) = 421.534, p = .001, df = 168, $\chi 2$/df (CMIN/DF= 2.509, RMSEA = 0.039, SRMR = 0.049, NFI = 0.967, PNFI = 0.904, CFI = 0.941, GFI = 0.952.

The results in model 2 demonstrated good model fit because the deleted items resulted into significantly improved item loading at 0.77 and above. Also, the result met the criterion for CMIN/DF Which is set at equal or less than 5 and the criteria for RMSEA and SRMR set at equal or less than 0.05. The results also met the required limit for PNFI, NFI, CFI and GFI set at 0.9 and above.

From the forgoing therefor, the average mean score of every subscale (Figure 9) of the items in model 2 (Table 6) were found. This shows that extrinsic motivation external regulation, extrinsic motivation identified regulation and intrinsic motivation toward accomplishment were the highest aroused type of motivation among the students. Hence the app has capacity to create high quality motivation in students (Britt and Haugan, 2016). This finding is interesting for the reason that the app which is an external source of motivation regulated the students behaviour toward learning by them identifying with the app for the purpose of accomplishing the task they are engaged.

5.1.5 What factors are responsible for educational App motivation?

The correlational study between the subscales and the items in questions 4 (Table 7) reveals a positive correlation between motivation and the items whereas a negative correlation is revealed between amotivation and the items. Furthermore, it shows that the factors; ease of use, saves time and makes graphing easier have stronger correlation with the three most aroused types of motivations which are extrinsic motivation external regulation, extrinsic motivation identified regulation and intrinsic motivation toward accomplishment. This means that when an app is easy to use, saves students' time for accomplishing a task and simplifies the task, students can identify with it and this will regulate them toward accomplishing a task.

Chapter six

Conclusion and Recommendation

6.0 Conclusion

The study reveals that the app (UJ-MaGT) has the potential to improve students' performance in graph plotting, close achievement gap in graph plotting test and stimulate interest. Academic App Motivation Scale (AAMS) was validated with the five-factor model with 21 items demonstrating a strong model fit with observed data. This work further reveals that academic apps can stimulate motivation ranging from controlled motivation to autonomous motivation. The work further shows that academic apps must be design with among other factors, the factor of time saving, ease of use and above all, meet the need for which it is designed and simplified the concepts being learned through it.

Indigenous apps may also motivate indigenous users as shown in Figure 8, hence there is need for local content in app design and development.

6.1 Recommendations

Going by the result of this study, the following recommendations are made:

1. Further verification of the efficacy of this app among secondary school students is recommended
2. Researchers should develop and investigate the efficacy and the motivational effect of academic app using other perceived difficult concepts or subjects.
3. We therefore recommend that (AAMS) should be validated with other academic apps to verify its stability

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Appendix A

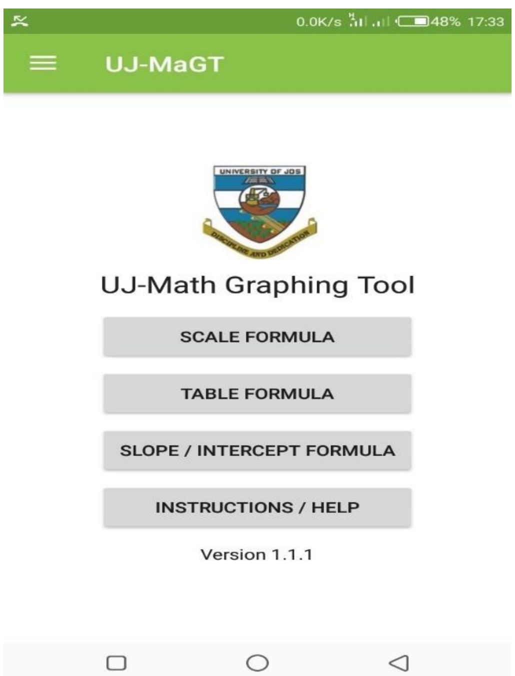

Figure 10. Interface of the UJ-Math Graphing Tool

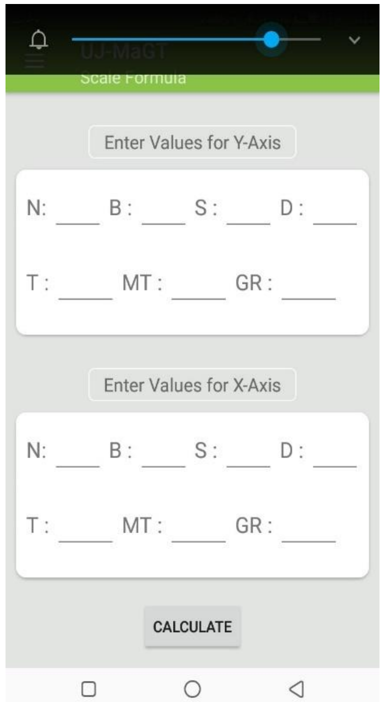

Figure 11. The Interface of the Scale Formula

Appendix B1: Survey Instrument used in collecting the survey data.

Please, this is not examination. Do not COPY anybody's responses.

RESEARCH QUESTIONNAIRE

The growing apathy toward the learning of Physics and Mathematics has become a great concern to educationists and stake holders at all levels of education. As a result, the need for **motivational teaching methods and materials** has become a major area of research. And in line with this, Mafuyai Graphing Tool (MaGT) is invented to assist students in plotting graphs.

The purpose of this questionnaire is to conduct a research that seeks to measure the motivational level and impact of the App on the students' willingness to plot graphs and hence enroll for courses that have graph work. **Therefore, your CANDID opinion will be highly appreciated.**

INSTRUCTION; Fill the questionnaire by only **TICKING** the most appropriate option

(1) Age bracket

15-20yrs	20-25yrs	25-30yrs	30-35yrs	35-40yrs	40-45yrs

(2) Sex:

Male	
Female	

(3) Senior Secondary School attended

Private Secondary School	State Government Secondary School	Federal Government Secondary School

(4). How would you rate the App?

	Strongly Agree	Agree	Disagree
Easy to use			
Saves time			
Makes graph plotting easier			

(5). With the help of the App, how would you rate these areas of graph work?

	Very easy	Easy	Not easy
Finding Scale			
Points Plotting			
Determining Y_1,Y_2,X_1 and X_2			
Determination of Intercept			

(6). Would you like to enroll for a course that has graph plotting if?

a. App is available? Yes ☐ No ☐

b. App is not available? Yes ☐ No ☐

(7). Apps can increase students' desire to learn an otherwise difficult subject;

Strongly Agree	Agree	Disagree

(8). Choose the item(s) that **highly** influenced your desire to use the App. You can choose as many as you wish.

-It saves time	
-It is easy to use	
-Makes Graph plotting easier	
-Every student is using it	
-It is developed in the University	
-It looks like other Apps you are used to	

(9). Using the scale below, please indicate to what extent each of the following items presently corresponds to one of the reasons why you used UJ-MaGT App.

1	2	3	4	5
Strongly Disagree	Disagree	Somewhat Agree	Agree	Strongly Agree

S/n	Items	Response				
		1	2	3	4	5
1	Because I experience pleasure and satisfaction while learning new things					
2	For the pleasure I experience when I discover things never seen before					
3	For the pleasure that I experience in broadening my knowledge about (App) which appeal to me					
4	Because my studies (Physics) allow me to continue to learn about many things that interest me					
5	Because Apps are very common and easy to use					
6	Because Apps can be installed on other portable devices such as phones etc.					
7	For the pleasure I experience while doing greater than I thought I could do in my studies (Physics)					

8	For the pleasure that I experience while I am doing better myself in one of my personal accomplishments(Studies)					
9	For the satisfaction I feel when I am in the process of accomplishing difficult academic activities					
10	Because academic Apps allow me to experience a personal satisfaction in my quest for excellence in my studies (Physics)					
11	I like doing what others are doing					
12	I like being the first to make use of new inventions					
13	For the pleasure that I experience when I feel completely absorbed by new technological innovations					
14	For the ‘‘high’’ feeling that I experience while reading about various simplified interesting subjects (Physics)					
15	Because I think that App (Physics) will help me better understand the art of graph plotting					
16	Because I believe that a few additional use of MaGT App will improve my competence as a student of Physics					
17	To prove to myself that I am capable of using new inventions					
18	Because of the fact that when I succeed in school (Physics) I feel important					
19	To show myself that I am an intelligent person					
20	Because I want to show myself that I can succeed in my studies (Physics)					
21	Because I want to have ‘‘a good class of degree’’ later on					
22	In order to obtain a more prestigious grades later on					
23	Honestly, I don’t know; I really feel that I am wasting my time in using the MaGT App					
24	I once had good reasons for using the MaGT App; however, now I wonder whether I should continue					
25	I can’t see why I should use the MaGT App and frankly, I couldn’t care less					

26	I don’t know; I can’t understand why I am using the MaGT App					

(10). What advice or observation do you have concerning Mafuyai Graphing Tool (MaGT)?

Appendix B2: Sample of test questions used to obtain experimental data.

Time: 25Min.

1. Using the table of values below, plot the graph of K against M.

2. Determine the slope and the intercept on the vertical axis

S/N	1	2	3	4	5
K/cm	5.2865	5.2951	5.2979	5.3014	5.3084
M/cm	1.8542	1.8031	1.7451	1.6782	1.5990