Mathematical Software Utilization: Effect on Students' Achievement in Algebra

Jose Sherwin O. Seville

Abstract— **The main problem of this study was to determine the effect of using Mathematical Software in students' achievement in Algebra of the Engineering and Information Technology students of the Palompon Institute of Technology during the S.Y. 2013-2014. This study used the counterbalanced experimental research design, an experimental design in which all the research subjects receive all strategies or treatment conditions. Based on the analysis and interpretation of the data gathered, it was found out that the overall performance of the mathematical software group was the same as the traditional method group during the pretest. Also, the pretest showed that the performance of the students in Linear Equations topic was higher than that of Quadratic Equations topic, thus, the Quadratic Equations topics were more difficult than the Linear Equation topics. Posttest results showed that the mathematical software group performed better than the traditional method group in Linear Equations, while the traditional method group performed better than the mathematics software group in Quadratic Equations. We can therefore say that the mathematical software was more effective in Linear Equations and the traditional method was more effective in Quadratic Equations. After the strategies were applied, the levels of achievement of the subjects in Linear Equations and in Quadratic Equations topics were the same. Thus, we can say that both strategies were effective as far as the topics are concerned. Also, as far as the strategies were concerned, it was shown that both mathematics software instruction and the traditional method of instruction were equally effective in increasing the performance of the students. Thus, Mathematical software instruction was as effective as the traditional method. Implication to this study is the use of Mathematical software to enhance the effectiveness of the traditional method.**

Keywords— **Achievement, counterbalance experimental design, effectiveness, mathematical software, PIT**

I. Introduction

The uses of computer technology nowadays have become surprisingly important in teaching and learning mathematics in the tertiary level [1]. A common help in a classroom situation of mathematical software is that it will increase the student achievement by acquiring knowledge and skills that will enable them to "figure out" math related problems, and interest that will relate real situations at home and in future work situations [9]. Mathematical software features are especially suited to learning and teaching technical subjects in universities, colleges, vocational education and even in high schools.

J. S. O. Seville is a holder of BS in Industrial Education major in Mathematics and obtained a degree of Master of Arts in Teaching (MAT) major in Mathematics at Palompon Institute of Technology Philippines. A part-time faculty of the graduate studies and taught subjects in advanced mathematics and statistics.

One of the tools of Computer-Based Education (CBE) that can enhance learning in mathematics is by utilizing mathematical software. Mathematical software is also a central tool in mathematical application and research. The study of Senoc (2007) showing poor performance of Filipino students in mathematics in the national achievement tests for both public elementary and secondary school children is evident of the slow advancement of Philippine technology compared to other countries [11]. Moreover, policies regarding Information and Communication Technology (ICT) in mathematics education is already implemented by the Commission of Higher Education (CHEd) in the Philippines, but not all Higher Education Institutions (HEI's) in the Philippines integrate ICT to Mathematics [7]. The researcher chose to study the effects of common and familiar software – MathCAD [6]. Thus, he wanted to know if this software would be the more effective to use in teaching Algebra than the traditional method. The researcher will be comparing the effects of a mathematical software package mentioned earlier and the traditional chalk-talk method. Hence, this study.

II. Theoretical /Conceptual Framework

The teacher roles in students' achievement are to provide meaningful learning experience and to develop new tools and teaching methods to determine students' needs in order to guide their learning [12]. This role gives the researcher collected information of theories that can support the study. Computer-supported collaborative learning (CSCL) is the main theory in which this study is anchored. It is a pedagogical approach wherein learning takes place via social interaction using a computer or through the Internet [2]. This kind of learning is characterized by the sharing and construction of knowledge among participants using technology as their primary means of communication or as a common resource. CSCL can be implemented in classroom or online learning environments and can take place synchronously or asynchronously. The researcher believes that when computer software are used in teaching mathematics, it provides opportunity for hands-on activities, supports collaborative learning and provides active or constructive learning experiences to the students. Much more, peer interaction is also expected. Corollary to the CSCL is the sensory stimulation theory which premised that effective learning occurs when the senses are stimulated [5]. Laird added that by stimulating the senses, especially the visual sense, learning can be enhanced. Computer software provides this because the students' visual senses will be more focused on the computer and thus the lesson. One of the best teaching approaches to improve students' achievement in algebra is by using the computer

multimedia technology in mathematics with the use of mathematical software. The use of multimedia technology in the classroom has been shown to be an extremely effective tool in addressing the learning needs of children [8]. Thus, the purpose of this study was to compare the effectiveness of mathematical software for instruction and the traditional method, on students' achievement in Algebra of Engineering and Information Technology students at Palompon Institute of Technology. The study was to gain better understanding on how important the use of mathematical software in modern mathematics is to provide the best information for any attempt at curriculum reform or improvements. To facilitate mathematics and mathematical thinking, the objectives were to: (a) describe the appropriate selection and use of mathematical software in algebra; (b) describe specific purpose and events for which computer technology is used for mathematical pursuits; (c) increase the knowledge base and awareness of the mathematics education community to facilitate optimizing the use of technology; and (d) describe students' achievement, attitude and beliefs about the use of technology. Figure 1 shows the schematic diagram of the study. There are two independent variables. These are the strategies and the topics. Two strategies - Mathematical Software and the traditional method were compared against the dependent variable – Students' achievement in Algebra. Similarly, the two topics - Linear Equations and Quadratic Equations are compared against the students' achievement. In the schema throughput, the strategies and topics are measured using the achievement score of the students. Then the achievement score is interpreted and analyzed to generate an improved mathematics instruction in the schema output.

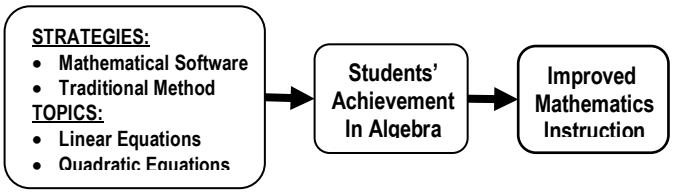

Fig.1 Schematic Diagram of the Study

III. Statement of the Problem

The main problem of this study is to determine the effect of using a Mathematical Software in students' achievement in Algebra of the Engineering and Information Technology students of the Palompon Institute of Technology for the S.Y. 2013-2014. Specifically, this study considered the following questions:

1. What are the pretest and posttest mean scores in each topic in algebra of students exposed to (a) Mathematical Software & (b) Traditional Method?
2. What is the achievement in each topic in Algebra of the two (2) groups of students (a) Mathematical Software & (b) Traditional Method?
3. Is there a significant difference between the pretest mean scores of the two (2) groups in each topic in Algebra?
4. Is there a significant difference between the mean gains of the two (2) groups in each topic in Algebra?
5. Is there a significant difference between the over-all achievements in Algebra of the students who underwent Mathematical Software and Traditional Method?

IV. Methodology

A. Research Design

This study used the *counterbalanced experimental research design* (Figure 2), an experimental design in which all the research subjects received all strategies or treatment conditions. Counterbalancing is the control technique that can be used to control for order effects and carry-over effects. It is carried out by administering each treatment condition to all groups of participants, but it is done in different order for different groups of people [4].

	Time 1	Time 2
Group 1	O_1 x O_2	O_3 y O_4
Group 2	O_1 y O_2	O_3 x O_4

Fig. 2. Counterbalanced Experimental Design

Counterbalancing is illustrated by Figure 2 above (based on the illustrations of David M. Lane and Graphpad [3]-[4]. x represents the first treatment condition while y represents the second treatment condition. These two treatment conditions were administered to both groups in different order indicated by Time 1 and Time 2. O_1 and O_3 represent the dependent variables measured before the treatment or the pretest, while O_2 and O_4 represent the dependent variables tested after each treatment or the posttest.

B. Research Subjects

The population for the study consisted of Algebra students from two (2) groups - the Engineering and Information Technology. The Engineering group was composed of twenty-four (24) students while the Information Technology group was also composed of twenty-four (24) students in a section. By the use of counterbalanced experimental research design, each group of respondents was exposed to the two conditions - the mathematical software-assisted instruction and the traditional method of teaching. In gathering the data, the class instruction was conducted during regular class schedules of both sections. Random selection of the order of the treatment was done to identify which group was first exposed to the mathematical software and which one was exposed to the traditional method. Each group used each of the methods randomly from (2) two topics of algebra which were the Linear Equations and Quadratic Equations. Time 1 considered the first topic – Linear Equations and Time 2 considered Quadratic Equations.

C. Research Instruments

Two (2) instructor-made questionnaires were developed and served as the main instruments for evaluating students' achievement. The questionnaires went through standard validation procedures to make it effective as a tool for the study [10]. The instructor-made algebra questionnaire covered the two (2) Algebra topics considered - Linear Equations and Quadratic Equations. These topics were based from the

approved course syllabus of Algebra for Engineering and Information Technology students. A table of specification was formulated and referred to experts for their scrutiny. There were 35 test items prepared by the researcher. The validation of the questionnaire was conducted to the second year Bachelor of Science in Marine Engineering students who had finished Algebra during the First Year, First Semester, SY 2013-2014. Reliability of the items was computed by using split-half method. The final form of the test contained 30 valid items based on the validation that was done. The final form was then administered to the subjects before the start of each treatment as pretest and after as posttest. The pretest was the same as the post test; they only differed in the sequence of the items.

D. Data Gathering Procedure

After the approval of the request for permission to conduct the study and validation of the instructor-made questionnaire, the researcher randomly selected which group was assigned to the mathematical software instruction and which one was assigned to the traditional method of instruction. Random selection, using the fish bowl technique, came up with the Engineering students as the first group to use the Mathematics Software Instruction and the Information Technology Students to use Traditional Method. The researcher then administered the pretest using the validated instructor-made questionnaire of the first topic – Linear Equations to the two groups of research subjects. After the pretest of the first topic was conducted, the topics were then taught using Mathematics Software Instruction to the Engineering Students while the Traditional Method to the Information Technology students. After the first topic on Linear Equations had been covered, the posttest was then administered. After the conduct of the posttest of the first topic, the pretest for the second topic – Quadratic Equations was then administered to both groups of subjects, after which, instruction on the second topic was carried out. This time, switching of the groups was done. That is, the group of engineering students which had Mathematics Software Instruction now utilized the traditional method and the group of Information Technology Students that utilized the traditional method now utilized Mathematics Software Instruction. Again, after the topic had been discussed, posttest for the topic on Quadratic Equations was conducted to both groups. After the conduct of the posttest in the Quadratic Equations topic to each group, the data were stored in a spreadsheet database file in the researcher's personal computer and were utilized in the computations and statistical analysis.

E. Statistical Tools

All data collected from this research were presented in spreadsheet tables designed by the researcher using Microsoft Excel. This database file storing the students' responses was exported to statistical software for query information. In particular, data exported to Microsoft Excel for weighted averaging, comparing the standard deviation and variances, normality tests of the scores and computation of two-way factor analysis of variance (ANOVA). In the analysis using two-way factor ANOVA, the following conditions must be complied with. These conditions are as follows: the samples must be equal, the variance must be approximately equal in each variable, the variable must be independent, and the variable must be normal. Cross-tabulated queries used to examine differences between response variables and two-way factor analyses of variance were performed to determine independence.

V. Results and Discussion

TABLE 1. PRETEST, POSTTEST AND ACHIEVEMENT MEAN SCORES

Strategies	Topics	Pretest	Posttest	Achievement (Mean Gain)
Mathematical Software	Linear Equation	14.67	20.50	5.83
	Quadratic Equation	8.58	10.54	1.96
	Overall	11.63	15.52	3.90
Traditional Method	Linear Equation	11.21	13.42	2.21
	Quadratic Equation	13.25	19.33	6.08
	Overall	12.23	16.37	4.15

As shown in Table 1, the mean scores in the pretest and posttest in the topic Linear Equation of the group exposed to mathematical software were 14.67 and 20.50 respectively. This means that there was an increase in the academic ability of the students in the topic after using mathematical software in teaching because the mean gain score was 5.83. Similarly, in the topic Quadratic Equations, the mean scores in the pretest and posttest of the group exposed to mathematical software were 8.58 and 10.54 respectively. This means that there was an increase in the students' academic ability though not as high compared to their mean gain in Linear Equations because the mean gain was only 1.96 compared to the mean gain of 5.83 in Linear Equations. Considering the overall achievement in both topics – Linear and Quadratic Equations of the subjects belonging to the group who were exposed to mathematical software, improvement is also seen because the overall mean gain was 3.90.

Table 1 also shows that the mean scores in the pretest and posttest in linear equation of the group utilizing the traditional method was 11.21 and 13.42 respectively. This means that there was an increase in academic ability of the students in the topic after using traditional method of teaching because the mean gain score was 2.21. Also the same in the topic-Quadratic Equations, the mean scores in the pretest and posttest of the students exposed to traditional method were 13.25 and 19.33 respectively. This again means that there was an increase in academic ability because the mean gain was 6.08. Further, the overall academic ability of the group exposed to traditional method improved because the overall mean gain was 4.15.

Also, Table 1 shows the achievement mean scores in Linear and Quadratic Equations topics of the group exposed to Mathematical Software Instruction. These were 5.83 and 1.96 respectively. This means that the academic ability of the students was better in Linear Equations compared to Quadratic Equations. For the group using the traditional method, the result was opposite. The achievement mean score in Linear and Quadratic equations of the group exposed to traditional method were 2.21 and 6.08 respectively. This means that there was a higher increase in academic ability of the students in Quadratic Equations compared to increase in their academic ability in Linear Equations. The results, thus show, that academic ability of the students in Linear Equations was improved more when

using mathematical software and that the academic ability of the students in Quadratic Equations was increased more when using the traditional method. Also based in the overall achievement, both methods have increased the academic ability of the students in both topics; the mathematical software group having a mean gain of 3.90 and the traditional method group having a mean gain score of 4.15. This means that both methods were effective in improving the academic ability of both groups in the two topics considered in the study.

TABLE 2. PRETEST MEAN SCORE

Strategies	Topics		Overall
	Linear Equation	Quadratic Equation	
Mathematical Software	14.67	8.58	11.63
Traditional Method	11.21	13.25	12.23
Overall	12.94	10.92	11.93

Table 2 shows the pretest mean scores of the mathematical software and traditional methods in linear equation and quadratic equation topics. The table 2 shows that the mathematical software group performed better in linear equations while the traditional group performed better in quadratic equations.

TABLE 3. TWO-WAY ANOVA RESULT OF THE PRETEST SCORE BETWEEN TREATMENTS, TOPICS AND IN BETWEEN TREATMENTS AND TOPICS

Source Between	Probability F-Value	Interpretation
Treatments (MathCad and Traditional)	**.531**	No significant difference
Topics (Linear and Quadratic Equation)	**.038***	Significant difference
Treatments * Topics	**.000***	Significant difference

Note: * -significant difference below 0.05 level.

To determine whether there was a significant difference in the performance of the two groups of students in College Algebra in the pretest, the researcher used the two-way analysis of variance, the results of which are shown in Table 3. Before the analysis of variance was administered, the researcher saw to it that the requirements in testing the analysis of variance were suitable in the problem. The requirements are as follows: the samples must be equal, the variance must be approximately equal in each variable, the variable must be independent, and the variable must be normal. Using the following requirements the number of sample in each group was equal, the variance in each variable was approximately the same, the variable in each group was independent, and the test of normality shows that all the scores are normal because the skewness lies within the range -3 to 3.

Table 2 has shown that the mathematical software group had an overall pretest mean score of 11.63 while the traditional method group had an overall pretest mean score of 12.23. Also, Table 3 shows that the probability F value of the pretest between treatments was 0.531. This is greater than the significant value at $\alpha = 0.05$. This means that there is no significant difference between the pretest scores of the students exposed to the mathematical software and traditional method of instruction. This outcome led the researcher to conclude that during the pretest, the mathematical software group performed as well as the traditional method group. From Table 2, the overall pretest mean score shows that the subjects' performance in Linear Equation topic (12.94) was greater than that in the Quadratic Equation topic (10.92) before the treatment was applied in each topic. Table 3 also shows that the probability F value of the pretest between topics was 0.038. This is lower than the significant value at $\alpha = 0.05$. This means that there is significant difference in the pretest score between topics. Thus, this outcome led the researcher to conclude that the performance of the students in Linear Equations topic was higher than that in Quadratic Equations topic. Further, this implies that the Quadratic Equations topics were more difficult than the Linear Equation topics. Based on Table 2, the pretest mean scores in each topic show that the academic abilities of each group before the treatment were varied. In Linear Equations, the mathematical software group performed better (14.7) than the traditional method group (11.21). On the other hand, in Quadratic Equations, the traditional group performed better (13.25) than the mathematical software group (8.58). Table 3 also shows that the source in between treatments and topics, the probability F value was 0.000 or almost zero. This is lower than the significant value at $\alpha = 0.05$. This means that there is significant difference in between treatments and topics in the pretest scores. Thus, this outcome led the researcher to conclude that during the pretest, the mathematical software group performed better than the traditional method group in Linear Equations. And, the traditional method group performed better than the mathematical software group in Quadratic Equations.

Table 4 shows that the overall mean gain in Linear Equations was 4.02 which is equal to the mean gain in Quadratic Equations. This gain is due to the treatments.

TABLE 4. ACHIEVEMENT MEAN SCORE

Strategies	Topics		Overall
	Linear Equation	Quadratic Equation	
Mathematical Software	5.83	1.96	3.90
Traditional Method	2.21	6.08	4.15
Overall	4.02	4.02	4.02

Table 5 also shows that the probability F value of the mean gain score of the topics was 1.0. This is greater than the significant value at $\alpha = 0.05$, which means that there is no significant difference between the mean gain scores of the students in the two topics considered. This outcome led the researcher to conclude after the treatment was applied the level of achievement of the subjects in Linear Equations and in Quadratic Equations topics were the same. Thus, we can say that both treatments were effective as far as the topics are concerned.

TABLE 5. TWO-WAY ANOVA RESULT OF THE MEAN GAIN SCORE BETWEEN TREATMENTS, TOPICS AND IN BETWEEN TREATMENTS AND TOPICS

Source Between	Probability F-Value	Interpretation
Treatments (MathCad and Traditional)	**.795**	No significant difference
Topics (Linear and Quadratic Equation)	**1.000**	No significant difference
Treatments * Topics	**.000***	Significant difference

Note: * -significant difference below 0.05 level.

From Table 4, it was also shown that the mean gain of the mathematical software group was 3.90 while that of the traditional method group was 4.15. Based on this result, we can deduce that the treatments were effective because of the positive mean gain score and this is due to the respective treatments applied on each group. Table 5 above also shows that the probability F value of the mean gain score of the treatments was 0.795. This is greater than the significant value at $\alpha = 0.05$. This means that there is no significant difference in the mean gain score of both groups. Thus, this outcome led the researcher to conclude that after using the treatments, the mathematical software instruction was as effective as the traditional method of teaching. Table 5 also shows that the source in between treatments and topics the probability F value was 0.000 or almost zero. This is the same as the result shown in Table 3 which again is lower than the significant value at $\alpha = 0.05$. This shows that there is significant difference in between treatments and topics in the mean gain score. Thus, this outcome led the researcher to conclude that the treatments were not equally effective with respect to the topics involved. The students that underwent mathematical software gained more in Linear Equations while the traditional method group gained more in Quadratic Equations. Thus, the researcher concludes that the mathematical software is more effective in Linear Equations and Traditional Method is more effective in Quadratic Equations.

VI. Conclusions

The researcher made the following conclusions based on the findings of the study:

1. At the start of the study, the pretest showed that the overall performance of both the mathematical software group and the traditional method group were the same – thus they had the same ability prior to the study.
2. The pretest showed that the performance of the students in Linear Equations topic was higher than that in Quadratic Equations topic, thus, the Quadratic Equations topics were more difficult than the Linear Equation topics.
3. The mathematical software group performed better than the traditional method group in Linear Equations and the traditional method group performed better than the mathematical software group in Quadratic Equations. We can therefore say that the mathematical software was more effective in Linear Equations and the traditional method was more effective in Quadratic Equations.
4. After the strategies were applied, the overall levels of achievement were the same for both Linear and Quadratic Equation topics. Thus, we can say that both strategies were as effective as far as the topics were concerned.
5. As far as the strategies were concerned, it was shown that the achievement levels of both mathematical software instruction and the traditional method of instruction were significantly the same. Thus, Mathematical software instruction was as effective as the traditional method.

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References

[1] A. Ayub, T. Sembok, and W. Luan. *Teaching and Learning Calculus using Computer*. 2003. Website: http://www.educ.upm.edu.my/teachingandlearningcalculususingcomputer.html

[2] *Computer Supported Collaborative Learning* (CSCL). Website: http://encyclopedia.thefreedictionary.com/Computer-supported+collaborative+learning.

[3] D. M. Lane, *Online Hyperstat Counterbalancing*, Website: http://davidmlane.com/hyperstat/A90779.html

[4] *Graphpad Software Inc.*, 1995-2015. website: http://graphpad.com/guides/prism/6/statistics/index.htm/stat_experimental_design_tab_2way.htm

[5] D. Laird, *Approaches to Training and Development*. Reading, Massachusetts: Addison Wesley, 1985.

[6] *MathCAD*. Website: http://www.ptc.com/product/mathcad/about/

[7] S. Ocampo, Information and Communication Technology (ICT) in the Philippines Higher Education and Training. *Empowering Mathematics and Science Education: ICT + UbD. 2011 National Conference on Mathematics and Science Education*. Hotel Indah, Manila. January 26-28, 2011. Website: http://www.internetworldstats.com/asia.htm

[8] W. R. Penuel, B. Means, & M. B. Simkins, *The multimedia challenge. Educational Leadership*, 58, 34-38. 2000. Website: http://ctl.sri.com/people/displayPerson.jsp%3FNick%3Dbpenuel

[9] J. Quinlan, *Profiles of Software Utilization by University Mathematics Faculty*. 2001. Website: http://etd.ohiolink.edu/send-pdf.cgi/QuinlanJames.pdf/osu1180441531

[10] M. B. Ruiz, *Evaluation and Measurement for Philippine Schools*. Quezon City, Phils. Rex Book Store Publishing. 1994.

[11] G. Senoc, *The Effectiveness of Three Methods of Instruction in Statistics*, MPSC, Cagayan de Oro City, Philippines. 2007

[12] P. Wolfe and R. Brandt, *Integrating Technology Into Brain-Based Lesson Plans, Educational Leadership*. 1998. Website: www.editlib.org/d/9845/proceeding_9845.pdf

Jose Sherwin O. Seville. The author is born in Muntinlupa City, Metro Manila, Philippines on August 16, 1980. He graduated his Bachelor of Science in Industrial Education-Mathematics in Palompon Institute of Technology (PIT), Palompon, Leyte, Philippines on March 2001 and graduated his Master of Arts in Teaching-Mathematics (MAT-Math) in the same school on March 2013.

He is working as a teacher in PIT as Assistant Professor II in the Math & Science Department under College of Arts & Sciences. He is teaching Advanced Statistics & Mathematics subjects in College and in Graduate Studies. He is also designated as Department Research Coordinator and Institute Statistician. He is also a thesis adviser and panelist member in graduate school & college research thesis. He is an oral presenter in International Conference on Science Technology and Management in Singapore, National Conference in Methodological Advances in Research in Tacloban City, Philippines, poster presenter in National Conference in Health Research in Ormoc City, and oral & poster presenter in several local R & D conferences.

Assistant Professor Seville won as Best in Oral Presenter, Best in PowerPoint Presentation and Best in Poster Presentation in local R&D Conferences, and 2nd placer in Poster Presentation in National Conference in Health Research in Ormoc City. He is also published in several international and national research journals.