MATHEMATICAL MODELLING INTEGRATED WITH DYNAMIC *GEOGEBRA* APPLICATIONS AND STUDENTS' PERFORMANCE IN MATHEMATICS

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ABSTRACT: *This study determined the effectiveness of Mathematical Modelling integrated with Dynamic GeoGebra Application on students' performance in mathematics. The participants of this study were the two (2) intact grade 8 class of Casisang National High School during the school year 2019-2020. Results of the analysis revealed the level of students' performance in mathematics improved and increased when taught using Mathematical Modelling integrated with Dynamic GeoGebra application. Since it was found out that there was a significant difference in the performance between the experimental and the control group, then mathematical modelling integrated with dynamic GeoGebra software could be used to enhanced student's capabilities and interest in understanding mathematics. It was recommended that mathematics teachers are encouraged to use mathematical modelling integrated with dynamic GeoGebra software in the teaching and learning process to enhance student's performance in mathematics and become more effective in their lesson presentation. Furthermore, institutional training on the use of mathematical modelling integrated with dynamic GeoGebra software could be provided to all mathematics teachers in the school so they could incorporate it in their lessons and increase the interest of students in learning mathematics.*

Keywords: mathematical modelling, GeoGebra application, mathematics performance

1. INTRODUCTION

Mathematics is an essential discipline students' need to learn in order to live in this complex changing world. In the field of science, engineering and technology, students need to have a solid foundation in mathematics to help them possess strong analytical skills and become excellent problem-solvers which is essential to live in this generation. The use of effective and efficient approach is imperative in the context of teaching and learning mathematics. This pose a great challenge to mathematics teachers to make use of varied and innovative approaches to help students become independent and strategic learners. Hence, choosing an innovative teaching approach to foster learning in mathematics need to be given utmost importance.

Modelling in mathematics have shown great impact and become an interest for most researchers in the teaching and learning of mathematics. Mathematical modelling is an approach to mathematics that seeks to understand and make decision about real-world problem. It is also a process that uses mathematics to represent, analyze, make predictions or otherwise provide insight into actual phenomena. It can be used to motivate curricular requirements and can highlight the importance and relevance of mathematics in answering important questions. It can also help students gain transferable skills, such as habits of mind that are pervasive across subject matter [1]. Mathematical modeling is an essential component in high school curriculum which students use mathematics to explain or interpret physical, social or scientific phenomena [2]. Also, [1] came together to produce GAIMME- Guidelines for Assessment and Instruction in Mathematics Modeling Education. The major reason for the creation was the fact that, despite the usefulness and value in demonstrating how mathematics can help analyze and guide decision making for real world messy problems, many people have limited experience with math modeling.

The study of Erbas which focuses on mathematical modelling in mathematics education found out that few studies have been conducted in Turkey on using modeling in mathematics education [3]. Furthermore there are insufficient resources (e.g., modeling tasks) for teachers who want to integrate modeling into their teaching. Thus, there is a need for more research on using modeling for different levels of education. Accordingly, this can enable the production of resources that can be used in pre-service and in-service teacher education programs. Sources including good examples of modeling tasks are needed for teachers. From this, it is evident that mathematical modeling as an approach, is widely used in the field of education yet many step has been taken to meet the demand of the curricular requirements and to adapt in this changing world especially in the light of technological advancements.

In the complex changing environment, teaching should also be parallel to the rapid technological evolutions. Technology aided instruction have shown great advantage for students to learn mathematical concepts effectively. According to [4], technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. GeoGebra, a Dynamic Mathematics Software (DMS), is an interactive tool which can be used by mathematics teachers making mathematics learning meaningful and students' can appreciate the way mathematics are taught to them inclined to the way their generation best and effectively learns. It allows its user to work interactively with a wide range of mathematical concepts. DGS provide an environment in which to create and then manipulate geometric construction thereby providing learners with opportunities to interact with geometrical theorems and see the results [5].

This interest the researcher to study the effectiveness of integrating GeoGebra in Mathematical Modelling in teaching mathematics which might be instrumental in improving the mathematics performance of the students especially in the National Achievement Test in the future. Specifically, the researcher will investigate the effect of mathematical modelling with GeoGebra application on students' performance in mathematics.

2. THEORETICAL FRAMEWORK

This study is anchored on the notion that integrating GeoGebra in Mathematical Modelling to teaching and learning may affect the performance of students in mathematics. This is aligned with the extended Mathematical Modelling Cycle of Greefrath [6]. This concept is also supported by [7] who stressed that adaptation of innovative technologies and methodologies in education and in classrooms ensures interactive, effective and efficient learning, and it also lends a helping hand to students to develop an understanding in a practical and profound way. Technology use makes learning ubiquitous, situated, collaborative, and authentic. This means learning could happen anywhere and at any time using real life situations making it more relevant and meaningful [8].

Moreover, [9] theory of connectivism also supports the present study. Connectivism is a learning theory that explains how Internet technologies have created new opportunities for people to learn and share information across the World Wide Web and among themselves. Connectivism holds that the process and goals of learning in a highly networked and connected world is different than learning in the predigital world, because learners are now persistently connected to information sources and other resources through their electronic devices, such as smartphones or laptops. From the connectivist perspective, learning need not be isolated to the mind, but becoming a learned and capable citizen in a digital society requires learners to become connected with one another in such a way that they can make use of the network as an extension of their own mind and body. In this study, the integration of technology in mathematical modelling is a connectivist activity because students are given the opportunity to experience the use of GeoGebra which is technology aided in nature thus providing a chance for students' to be connected with other learners in the technology world.

3. METHODS

The study utilized quasi-experimental control pretest-posttest group design to investigate the effects of integrating GeoGebra in mathematical modelling in teaching mathematics on the performance of Grade 8 mathematics students at Casisang National High School. The objects of this study were students' performance in mathematics.

The researcher constructed a forty (40) item mathematics questionnaire to measure students' performance. The test follow a Table of Specifications (TOS) to guarantee the inclusion of all topics discussed in the class. Test contents together with the TOS were validated by the mathematics faculty of Casisang National High School comprising three mathematics teachers and the head of the mathematics department. After the revisions and finalization of the material, it was pilot tested to students of different level in the same school during the first quarter. The test was analyzed and obtained a reliability coefficient of 0.853. However, there were five items with negative correlation in the reliability test. The final form of the performance test was reduce to thirty-five (35) item.

In order to determine the level of students' performance in mathematics, descriptive statistics using mean and standard deviation were used. Moreover, to determine the significant differences of students' performance in mathematics for both experimental and control groups, analysis of covariance (ANCOVA) was employed.

4. RESULTS AND FINDINGS

The mean scores from the pretest and posttest result of the groups, the experimental and control group, were analyzed and presented in Table 1.

Table 1: Mean and Standard Deviation of the Students' Performance Scores in Mathematics

Groups	N	Pretest			Posttest		
		Mean	SD	Descriptive Level	Mean	SD	Descriptive Level
Control	40	11.78	3.521	Beginning	19.40	6.267	Beginning
Experimental	40	13.60	3.704	Beginning	25.78	5.834	Approaching Proficiency

Perfect Score: 35	Mean Score	Descriptive Level	
Advanced	31 – 35	Proficient	28 – 30
Approaching Proficiency	25 – 27	Developing	23 – 24
Beginning	0 – 22		

During the pre-test both groups were still at the beginning level of proficiency and the pretest mean score difference was only 1.82. This indicates that the levels of student's abilities in Grade 8 mathematics from both groups were very close and therefore comparable prior to the conduct of this study. This might be due to the fact that they were enrolled in the same school and their background and experience in the previous mathematics were similar. Moreover, the standard deviations of experimental group was lower compared to the control group. This indicates a wider dispersion in the scores of the students in the control group and the scores of the experimental group were closer to the mean. The standard deviation of the control group signifies that some students got high and low scores in the pretest while the experimental had almost similar scores in the pretest.

During the posttest, it can be observed that the control group who were taught using the conventional method with the aid of GeoGebra still remained at the beginning level of proficiency whereas the experimental group improved to the approaching proficiency level. This indicates that the performance scores of the students in the control group improved but did not reached the expected level. This shows that they were starting to cope up and develop knowledge while the prerequisite and fundamental skills have not yet been fully acquired to aid their understanding of the concepts. On the other hand, the experimental group obtained an approaching level of proficiency which means that the students have developed the fundamental knowledge and skills, core understanding with minimum guidance from the teacher using mathematical modelling integrated with GeoGebra. Although the performance of the students in both groups improved during the posttest, but an observable difference in their mean scores wherein the experimental group scored higher than the students in the control group by a margin of 6.38. This means that those students exposed in mathematical modelling with GeoGebra integration improved their mathematical abilities as well as their analytical skills in solving real-world problems in mathematics. The use of GeoGebra application was also instrumental in enhancing students' performance in dealing mathematical problems when used side by side with mathematical modelling.

The standard deviation of the posttest scores for both groups indicates that their responses were varied. Considering the standard deviations of the scores of the students in the control group, it was smaller compared to the standard deviation of the scores of students in the experimental group. The lower value in the standard deviations for the control group shows that their scores were closer to the mean compared to the experimental group. It further employs that the distribution of the scores of the students in the control group were less dispersed than those in the experimental group. This also means that the students from control group were to some extent homogeneous in performance scores compared to the experimental group. Likewise, the higher value of the standard deviations of the experimental group implies that some students obtained very high or low scores compared to the students in the control group. Moreover, wider dispersion of the scores in the experimental group indicates that some students had become more confident in using mathematical modelling integrated with dynamic GeoGebra because it helped them to process and progressed their learning and increased their score in the performance test.

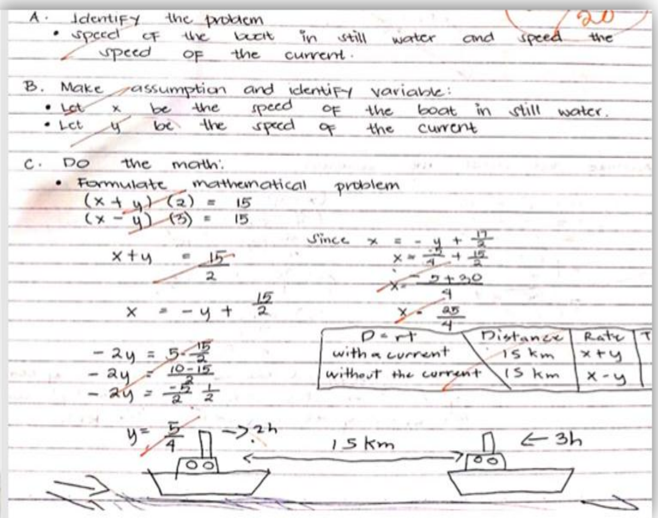

Figure 1. Student Answer in the Distance, Rate, Time Problem Using Mathematical Modelling with GeoGebra Integration.

Figure 1 shows the solution of the student using mathematical modelling with GeoGebra integration on distance, rate, and time problem during the teaching and learning process. It can be observed that the student was able to follow the steps in mathematical modelling. Using the steps, the students was given a clearer path in finding the answer of the given problem. Also, the student was able to create a visual representation of the situation in the problem as can be seen in the above figure. It helped the student to deepen his understanding and eventually led him to create an equation which serves as the models of the problem. It was manifested that student using mathematical modelling with GeoGebra Integration promotes learning in such a way that student was given a chance to process his thoughts with the steps provided in mathematical modelling and GeoGebra software to reinforced understanding to further the learning.

In addition, the standard deviations would tell us that there were students in the experimental group obtained advanced level of proficiency which indicates that they had exceeded the core requirements in terms of knowledge, skills and understanding in solving mathematical problem. It also further indicates that there were also students in the experimental group that obtained beginning and developing level of proficiency which means that student at this level possesses the minimum knowledge, skills and core understandings of the mathematics lesson but needs help throughout the performance of authentic task. Moreover, it can be deduced that the use of mathematical modelling integrated with dynamic GeoGebra had helped students in the experimental group to obtained higher level of proficiency compared to the students in the control group. Furthermore, the use of GeoGebra application software had a positive effects on the students' performance when integrated to mathematical modelling because it improves students' quality of learning towards mathematics and had caused a 12.8 marked of change as can be observed in the mean difference of the experimental group.

In order to test the significant difference in the posttest performance between the students from experimental group and those from the control group, the data gathered were subjected to One-way Analysis of Covariance (ANCOVA).

Table 2: One-Way ANCOVA Summary of the Students' Mathematics Performance

Source	Df	Adj SS	Adj MS	F-Value	p-Value
Treatment Within	1	238.900	238.900	41.443	0.000*
Error	77	443.865	5.764		
Total	80	44483.000			

*significant at p<0.05 alpha level

The data in Table 2 shows that there was a significant difference in the posttest scores in the performance between the students in the experimental group and the students in the control group. The null hypothesis which states that there is no significant difference in the performance of Grade 8 students when taught with mathematical modelling with the integration of GeoGebra and those taught using conventional methods of teaching with the aid of GeoGebra was tested at 0.05 level of significance. The result shown in Table 2 indicated that the treatment within obtained a p-value of 0.000 .Since the p-value was lower than the significant level of 0.05, the null hypothesis was *rejected*. Based on the results, mathematical modelling integrated with GeoGebra had helped students' obtain high scores and improved their performance. The activities with mathematical modelling integrated with GeoGebra had enabled the students to broaden and deepen their understanding about their lessons through discovering the necessary concepts and relationships among models in the topic. Mathematical modelling provided the students an avenue to explore, develop, understand and make decisions in solving real world problems. With the aid of GeoGebra software, the students were provided an interactive and friendly environment as manifested in their active participation in the cooperative and collaborative learning process during the conduct of the study. This further shows that students taught with mathematical modelling integrated with GeoGebra performed better compared to the students taught using the conventional method with the aid of GeoGebra because it provided them a room to understand the problem better and develop strategies to solve mathematical problem.

5. CONCLUSIONS AND RECOMMENDATIONS

It can be inferred from the findings of the study that mathematical modelling integrated with dynamic GeoGebra software can improve and increase student's level of proficiency in mathematics. Since there was a significant difference in the performance between students taught with mathematical modelling integrated with dynamic GeoGebra software (Experimental Group) and students taught using the conventional method with the aid of GeoGebra (Control Group) favoring the experimental group, then mathematical modelling integrated with dynamic GeoGebra software could be used to enhanced student's capabilities, and interest in understanding mathematics.

It is recommended that mathematics teachers are encouraged to use mathematical modelling integrated with dynamic GeoGebra software in the teaching and learning process to enhance student's performance in mathematics and become more effective in their lesson presentation. Furthermore, institutional training on the use of mathematical modelling integrated with dynamic GeoGebra software could be provided to all mathematics teachers in the school so they could incorporate it in their lessons and increase the interest of students in learning mathematics

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