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RESEARCH ARTICLE

GEOGEBRA INTERVENTION: HOW HAVE STUDENTS' PERFORMANCE AND CONFIDENCE IN ALGEBRA ADVANCED?

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Abstract

The study's goal was to provide an educational intervention in Algebra through GeoGebra that would boost students' confidence, improve their learning, and correct their most minor mastered skills, allowing them to improve their Algebra performance. The research design was quasi-experimental, with 40 nonrandomly chosen participants comprising the GeoGebra and control groups. Mean and standard deviation was employed to describe the algebra performance and confidence of the respondents. At the same time, independent and dependent t-tests were used to determine the students' significant difference in algebra performance and confidence in the pre-and post-test between the control and GeoGebra groups. GeoGebra effectively improved algebra confidence, enhanced learning, and remedied the students' least mastered skills. GeoGebra is recommended as an instructional material in teaching and learning Algebra and can be extended to other mathematics content areas.

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INTRODUCTION

Technology is an essential tool in facilitating teaching-learning. Utilizing it properly in a classroom will benefit the teachers and the students' learning (De Souza et al., 2021; Saha et al., 2010; Tanas et al., 2017; Uwurukundo et al., 2022). Technologies are helpful in mathematics learning because they provide dynamic opportunities for instruction, enhance the learning process, and make concepts come to life (Hilkemeijer, 2022; Mariano-Dolesh et al., 2022; Pentang, 2021; Putri & Wardika, 2020; Tabuena & Pentang, 2021). One of the technologies that are useful in learning mathematics is graphing applications, such as GeoGebra. Mathematics software aids teachers in efficiently supporting learning and assisting students in grasping mathematics concepts like GeoGebra Software (Udofia & Uko, 2018; Velichova, 2011). Free of charge for non-commercial users, including teachers and students (GeoGebra, 2022), GeoGebra can help teachers and students with teaching and learning, not just in algebra but also in geometry, statistics, graphing, and calculus (Bedada & Machaba, 2022; Hohenwarter & Preiner, 2007).

GeoGebra Software

GeoGebra software is a great motivational tool as students' confidence increases with its use to enhance student learning (Saha et al., 2010; Shadaan & Leong, 2013). Besides, Bakar et al. (2015), Ocal (2017), Saputra and Fahrizal (2019), Uwurukundo et al. (2022), and Velichova (2011) found several benefits achieved using GeoGebra, including being independently easy to use by students, being equipped with attractive animations and images, and providing a simple experiment. GeoGebra in learning mathematics has several positive impacts. Geogebra is a great tool to improve the quality of learning, particularly in exploring, visualizing, and constructing mathematical concepts, enhancing students' mathematical abilities (Azizah et al., 2021; Shadaan & Leong, 2013; Tamam & Dasari, 2021). Consistent with the University of Wisconsin System (n.d.), GeoGebra's different features are approved for use within the digital learning environment. It allows users to quickly solve math problems, graph functions, and equations, do statistics and calculus, combine with interactive geometry, and save and share results (Dahal et al., 2019; Hamzah & Hidayat, 2022). The algebra view of GeoGebra allows the user to enter algebraic input or commands and will be graphed if it is possible to graph. With the different extensions, GeoGebra has, the researchers aim to find out if GeoGebra can be an intervention in teaching algebra, particularly in solving problems involving systems of linear inequalities in two variables, and if it can affect the confidence level of the students in learning Algebra.

The use of GeoGebra in learning has received a positive response from most teachers at any educational level, an innovative way of teaching mathematics supported by technology (Em & Roman; 2020; Zakaria & Lee, 2012). Different features of GeoGebra can help mathematics teachers diversify their teaching methods to facilitate students' understanding of mathematics concepts through effective teaching and learning. Technology in mathematics exposes students to education without boundaries and promotes student-centered learning where the teacher acts as a facilitator of learning (Mariano-Dolesh et al., 2022; Pentang, 2021; Zakaria et al., 2022). GeoGebra is a mathematics software that combines geometry, algebra, spreadsheets, graphing, statistics, and calculus into a user-friendly application. GeoGebra is used by a growing community of millions worldwide (Tanas et al., 2017).

The ability to export creations as interactive web pages is a crucial feature of GeoGebra (Velichova, 2011). GeoGebra is not required to be installed on the computers of the users. A web browser is required to access it. On Android phones, it can also be downloaded from the Google Play store. GeoGebra is a powerful mathematics tool that helps students visualize and control data (Korkmaz, 2021; Ziatdinov et al., 2022). It is a free software program with a large development community and an award-winning educational program that has a global impact and is accessible to all learners using any computer—a call to action to revitalize mathematics education and a method to improve any mathematical education (GeoGebra, 2022). GeoGebra empowers teachers and learners of mathematics.

Furthermore, GeoGebra is one of the software programs that can help students study mathematics using cognitivist learning techniques (Choi, 2010; Khobo, 2015; Nzaramyimana et al., 2021; Ogbonnaya & Mushipe, 2020). The development of a person's thought processes is the subject of cognitive theory. It can be described as the act or process of knowing broadly. Learning occurs when knowledge from the environment is translated into and stored in the mind of a human. Knowledge is acquired through experience or the change of previously acquired knowledge to adapt to changing circumstances. Furthermore, this theory focuses on the mind and demonstrates that knowledge is typically acquired, digested, stored, and recalled. Learning can be achieved by listening, observing, feeling, researching, and then processing and remembering the knowledge (Dahal et al., 2019).

Research Questions

With the modular teaching-learning challenges posed by the COVID-19 pandemic (Agayon et al., 2022; Bacomo et al., 2022; Caasi & Pentang, 2022; Hamora et al., 2022), and online learning is more feasible (Bacsal et al., 2022; Mariano-Dolesh et al., 2022; Zakaria et al., 2022), GeoGebra has been adopted to further mathematics instruction. This study answered how GeoGebra software could enhance students' algebra performance and confidence. Specifically, it answered the following questions:

1. Do statistical differences exist in the algebra performance of the students between the control group and the GeoGebra group in the pre-and post-test?
2. Do statistical differences exist in the algebra performance of the students between the pre-and post-test of the control and GeoGebra group?
3. Do statistical differences exist in the algebra confidence of the GeoGebra group before and after the intervention?

METHODOLOGY

Research Design and Participants

Interventions have been considered to improve mathematical performance and confidence among learners (Pentang, 2021). This study was introduced as an intervention to demonstrate that the GeoGebra software is applicable and valuable as mathematics instructional material. The study employed a quasi-experimental research design considering two independent groups (control and GeoGebra). Both groups have undergone pre-and post-assessments in algebra. The algebra confidence of the GeoGebra group before and after the lecture was also determined. Besides, a quasi-experimental research design was used since nonprobability sampling due to limitations in considering larger random samples.

The study involved 40 Grade 8 STE students in a selected school in Puerto Princesa City, Philippines, who were nonrandomly chosen using the purposive sampling technique. The research participants were the control (Section Ilang-Ilang) and GeoGebra (Section Sampaguita) groups, with 20 student participants. Before, during, and after the study, ethical measures were considered to ensure that the participants were safe from harm. No personal details were collected, conforming to data privacy, and data gathered regarding their performance and confidence were treated with the utmost confidentiality.

Data Gathering Procedures and Tools

For the first phase, approved request letters signed by the principal and class advisers were obtained. The pre-test for algebra performance and confidence through Google Forms was sent to the class group chat. Throughout this week, lessons for online classes were also prepared to focus on linear inequalities (based on the MELCS). During the second phase, a video lesson was provided for the control group. The discussion is about solving problems involving systems of linear inequalities in two variables. The GeoGebra group was provided with a video about the benefits and procedures of using GeoGebra software and a video lesson on the same topic but with the use of GeoGebra software. For the third and final phase, the post-test concerning the algebra performance and confidence of the two groups were ascertained. For the students not to get pressured, the pre-and post-test results were not included as part of their class standing.

This study employed the pre-test and post-test for algebra performance and the algebra confidence scale developed and pilot-tested by the researchers. The instrument passed the validation of three experts (mathematics teacher-researcher, ICT coordinator, and language editor) and reliability tests (internal consistency greater than 90). The data were gathered online with the supervision of two class advisers, as it is most convenient for the participant's schedules and to ensure their safety against COVID-19.

Data Analysis

Appropriate statistical tools were utilized to ensure the accuracy and reliability of the examination and interpretation of the data collected based on Magulod et al. (2021) and Pentang (2021). Mean with standard deviation was used to determine the level of algebra performance and confidence of the two groups of students. On the other hand, a dependent (paired) t-test was performed to determine the significant difference between pre-and post-test performance and confidence, while an independent t-test was for the differences between groups.

RESULTS AND DISCUSSION

Pre-test Algebra Performance between the Control Group and GeoGebra Group

No statistical differences were found in the pre-test performance of the two groups (Table 1), similar to the studies of Em and Roman (2020) and Shadaan and Leong (2013), but as opposed to Ocal (2017). It shows that before the intervention, both the control (7.50∓3.58) and the GeoGebra (8.85∓2.01) group had statistically the same algebra performance, $t_{(38)} = -1.47$, $p > .05$. These groups qualified to take part in the quasi-experimental study.

Notably, the student's performance is far behind the expected excellent performance ranging from 16 to 20 points, affirming the results of Pentang et al. (2020). The student's unsatisfactory performance may be associated negative impact of modular learning (Agayon et al., 2022; Bacomo et al., 2022; Hamora et al., 2022). The dismal performance clearly shows the need for intervention to improve the student's competencies in

mathematics, particularly Algebra. The GeoGebra software was used in mathematics instruction to support the students' online learning amid the pandemic.

Table 1: Pre-test Algebra Performance of the Control Group and GeoGebra Group

Pre-test	Mean	SD	t-value	p-value	Interpretation
Control Group	7.50	3.58	-1.47	.149	No Significant Difference
GeoGebra Group	8.85	2.01			

Post-test Algebra Performance between the Control Group and GeoGebra Group

Results showed that GeoGebra software had improved the performance of both groups (Table 2), $t_{(38)} = -6.27$, $p < .01$, which is parallel to Choi (2010), Khobo (2015), and Nzaramyimana et al. (2021). However, it is more notable that the GeoGebra group (17.00∓2.43) performed more than the control group (10.20∓4.20), agreeing with the results of Bakar et al. (2015), Ocal (2017), Ogbonnaya and Mushipe (2020), Putri and Wardika (2020), Saha et al. (2010), and Shadaan and Leong (2013).

The findings show that GeoGebra motivates students to learn and improve their knowledge even for a short period, which may be due to the convenience provided by the software in doing mathematics. Interventions are indeed helpful when helping students to cope with math, both conceptual understanding and their dispositions (Bacsal et al., 2022; Ibañez & Pentang, 2021; Mariano-Dolesh et al., 2022; Pentang, 2021). Since the students still struggle with their algebra competencies, further innovations can aid them in attaining outstanding performance. The teacher may give the students more time with the GeoGebra software and allow them to explore it on their own to discover additional features that may be informative.

Table 2: Post-test Algebra Performance of the Control Group and GeoGebra Group

Post-test	Mean	SD	t-value	p-value	Interpretation
Control Group	10.20	4.20	-6.27	.001	Significant Difference Exist
GeoGebra Group	17.00	2.43			

Pre-test and Post-test Algebra Performance of the Control Group

A significant difference exists between the pre-test (7.50∓3.58) and post-test (10.20∓4.20) algebra performance of the control group, $t_{(19)} = -4.69$, $p < .01$ (Table 3). The data suggests that even without using GeoGebra, the students can still perform better in Algebra, but their performance is not as high as the other group who used GeoGebra. The result supports the findings of Udofia and Uko (2018). The control group's improved performance can also be attributed to the usefulness of video lessons even without using GeoGebra. Still, these achievements are far behind those exposed to the software. More so, this agrees with Pentang (2021) that any method can be done to aid students in learning mathematics. Teachers must do their best, whether or not technology is available.

Table 3: Pre-and Post-test Algebra Performance of the Control Group

Control Group	Mean	SD	t-value	p-value	Interpretation
Pre-Test	7.50	3.58	-4.69	.001	Significant Difference Exist
Post-Test	10.20	4.20			

Pre-test and Post-test Algebra Performance of the GeoGebra Group

The pre-test (8.85∓2.01) and post-test (17.00∓2.43) algebra performance of the GeoGebra

group is statistically different favoring the latter, $t_{(19)} = -13.50$, $p < .01$ (Table 4). The result indicates that teaching algebra through GeoGebra significantly impacted the learner's achievement, which is related to Azizah et al. (2021), Bedada and Machaba (2022), Dahal et al. (2019), Ocal (2017), Uwurukundo et al. (2022), and Ziatdinov et al. (2022). The study even supports Mariano-Dolesh et al. (2022) and Zakaria et al. (2022), where ICT integration in mathematics instruction, both in online and hybrid learning, can boost students' understanding of mathematics.

Since cooperative online learning is effective in mathematics instruction (Bacsal et al., 2022; Ibañez & Pentang, 2021), collaborative use of GeoGebra software may be instrumental in achieving better results performance for the students. Thus, teachers may plan to incorporate group or peer activities in their instructional design.

Table 4: Pre-and Post-test Algebra Performance of the GeoGebra Group

GeoGebra Group	Mean	SD	t-value	p-value	Interpretation
Pre-Test	8.85	2.01	-13.50	.001	Significant Difference Exist
Post-Test	17.00	2.43			

Algebra Confidence of the GeoGebra Group

The algebra confidence of the GeoGebra group significantly improved after the intervention, $t_{(19)} = -16.10$, $p < .01$ (Table 5). The level of Algebra confidence of the group became positive after the intervention (3.17∓.11) compared to before the GeoGebra intervention (2.30∓.16). The result supports Hamzah and Hidayat (2022), Korkmaz (2021), Saha et al. (2010), Saputra and Fahrizal (2019), Shadaan and Leong (2013), and Uwurukundo et al. (2022). They found that technology such as GeoGebra software is a great motivational tool as students' confidence, interest, and learning independence increase when GeoGebra is used to enhance student learning. The level of confidence of the GeoGebra group became positive after the intervention. Using GeoGebra as an intervention, the study revealed that it could enhance students' perception in terms of motivation and confidence in learning algebra. With this in mind, the software can be adapted specifically for courses that require it.

Table 5: Algebra Confidence of the GeoGebra Group

Confidence Level	Mean	SD	t-value	p-value	Interpretation
Before Intervention	2.30	.16	-16.10	.001	Significant Difference Exist
After Intervention	3.17	.11			

CONCLUSION

This research looked into the potential use of GeoGebra in teaching algebra, specifically in solving problems involving systems of linear inequalities in two variables. GeoGebra effectively enhances the students' algebraic performance and confidence. In terms of algebra performance, the group that received the intervention outperformed the control group. The study's findings revealed a significant difference in the students' post-test scores in favor of the GeoGebra group. Following the results, the intervention is more effective than the usual video lesson. The findings revealed that mathematical learning software positively impacted students cognitively and 'affectively'. It demonstrates the instructional effectiveness of GeoGebra as compared to simple video lessons.

GeoGebra software intends to assist educators in varying teaching methods to improve students' understanding of and confidence in mathematical concepts through effective teaching and learning. GeoGebra is an excellent resource for enhancing the quality of student learning and experience by allowing them to discover, visualize, and create mathematical concepts. The efficient use of GeoGebra maximizes student potential in mathematics teaching and learning amid the COVID-19 pandemic.

RECOMMENDATIONS

Teachers must ensure they have the functional abilities to use the program effectively. Learners must regularly practice using the GeoGebra software to enhance their talents and lessen misunderstandings. Mathematics teachers and students may explore the different extensions of GeoGebra as it can help to effectively attain the learning objectives in various topics in mathematics, not just in algebra, statistics, geometry, and calculus but also in physics and economics.

School officials can use the findings to support teacher training on using GeoGebra in teaching and learning mathematics. Math teachers may find this study helpful as a reference for their action research, and they need to constantly explore new ways to teach mathematics with the advancement of information technology. This study may inspire future researchers to study the other extensions of GeoGebra and their utility in teaching and learning mathematics topics.

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