GEN TEFL Journal Special Issue 2, Vol. 10 30 July 2025 E- ISSN 2520 209X and P-ISSN 2520 6648

Enhancing Grade Ten Students' Mathematical Proficiency in Circle Theorems and Coordinate Geometry through Geogebra Application

Johnny S. Landerio[1], Allan Jay S. Cajandig[2,*]

[1]*Teacher, Salabaca National High School, Philippines*
[2]*Sultan Kudarat State University, Philippines*

*johnny.landerio@deped.gov.ph

Abstract

Understanding mathematical concepts, particularly in circle theorems and coordinate geometry, poses a challenge for students, requiring innovative instructional approaches. However, students struggle to develop mathematical proficiency and prioritize rote memorization. This study aimed to examine the effect of integrating GeoGebra on enhancing Grade 10 students' mathematical proficiency in circle theorems and coordinate geometry, focusing on improving their conceptual understanding, adaptive reasoning, and strategic competence at Salabaca National High School for the school year 2024-2025. Utilizing a true experimental research design, the study employed a pretest-posttest controlled group design to measure learning gains, with GeoGebra as the primary instructional tool. Data were gathered using a researcher-made test and an adopted survey questionnaire, which was analyzed through appropriate statistical methods to determine the intervention's effect and the students' views on using GeoGebra. Findings revealed that both groups significantly improved the mean gain of students' mathematical proficiency p-value =0.032, specifically in their strategic competence p-value= 0.006, as they used GeoGebra. Regarding their view of GeoGebra, the respondents found it highly acceptable as a learning tool. The study concludes that integrating visualization tools in mathematics instruction effectively enhances students' learning experiences (M=4.24). It supports existing theories on technology-assisted learning and reinforces the importance of incorporating digital tools in education.

Keywords**:** Circle Theorems; Coordinate Geometry; GeoGebra; Mathematical Proficiency

I. Introduction

Various international assessments reflect the decline in students' mathematical proficiency, which has become a global concern. This issue is particularly evident in the Philippine education system, where students have consistently struggled with mathematical aptitude. In recent evaluations, Filipino students demonstrated significantly lower performance than international benchmarks, highlighting the urgent need for interventions to enhance mathematical proficiency and learning outcomes.

This challenge transcends educational levels in the Philippines. According to a 2019 study by the Department of Education, merely 30% of Grade 10 students passed the National Achievement Test in Mathematics. The country's Science and Math education quality also received a concerning ranking in the 2016-2017 Global Competitiveness Report, with the Philippines placing 79th out of 138 participating nations (Etcuban et al., 2019), as cited by Peteros (2020). It is consistent with the Department of Education's report on the National Achievement Test (NAT) for Grade 10 learners, where the Mean Percentage Score fell short of the department's 50% requirement (DepEd, 2019).

Based on the Department of Education's study of the PISA 2022 data, Filipino students' average mathematical literacy score was 355 points, much lower than the 472-point average for the OECD. Filipino students lagged compared to other ASEAN countries, with the closest performance level to Indonesian students trailing by 26 points. Regarding student ability in mathematics, the Philippines placed 76th out of 81 countries in PISA 2022, with only 19.7% of learners achieving the minimal proficiency level (Level 2) in mathematical literacy. (Department of Education, 2019). As of the 2023-2024 school year, Salabaca National High School reported a mean percentage score (MPS) of 40% among Grade 10 learners in their summative test on circles and circle theorems.

Integrating technology tools such as GeoGebra software into teaching presents a promising solution to this problem. This study explores the application of GeoGebra software in teaching circle theorems and its potential impact on students' proficiency in this mathematical domain. The key variables under consideration are utilizing GeoGebra software and students' proficiency in circle theorems. GeoGebra is a dynamic mathematics software that integrates geometry, algebra, statistics, and calculus, offering a versatile platform for teaching and learning mathematics. As a free tool available in multiple languages, it facilitates both online and offline learning experiences for students across various educational levels (Nzaramyimana, 2021; Narh-Kert & Sabtiwu, 2022). The software's main strength lies in its ability to create interactive and visually engaging mathematical models, aiding in the comprehension of complex mathematical concepts.

One contributing factor to declining mathematical proficiency among learners is the reliance on traditional teaching methods prevalent in Philippine schools. Mathematical proficiency is a critical component of secondary education, serving as a foundation for students' future academic and career opportunities. It encompasses a range of skills that enable students to understand and apply mathematical concepts effectively, which is essential in an increasingly data-driven world. A pivotal aspect of enhancing mathematical proficiency relates to the integration of critical thinking into mathematics education. Developing critical thinking skills is crucial and can be cultivated through appropriate pedagogical strategies in mathematics education (Aizikovitsh-Udi & Cheng, 2015).

The key strands of mathematical proficiency include conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. These strands collectively contribute to students' ability to engage with mathematical ideas and solve problems effectively. While each strand plays a unique role, they are interconnected and essential for fostering a comprehensive understanding of mathematics (Juandi et al., 2021). GeoGebra has emerged as a powerful tool for enhancing mathematical learning, particularly in circle theorems and coordinate geometry. This dynamic mathematics software allows students to visualize and manipulate mathematical concepts, deepening their understanding and engagement. Research indicates that integrating GeoGebra in mathematics instruction can improve student performance and create a more enjoyable learning experience (Jelatu et al., 2018). By leveraging GeoGebra's interactive capabilities, educators can create a more engaging and effective learning environment that supports the development of mathematical proficiency.

Many mathematics educators prioritize rote memorization of formulas and procedures over fostering critical thinking and problem-solving skills, making mathematics tedious and challenging for students (Prendergast et al., 2018). To address this research gap, the researcher advocates integrating technology, specifically GeoGebra software, into Filipino classrooms. GeoGebra improves students' higher-order cognitive skills (Misrom et al., 2020). Several research investigations have suggested that technological interventions present novel opportunities for learners to engage in higher-order thinking and improves educational outcomes in mathematics (Popova et al.,2022).

GeoGebra has emerged as a significant educational tool in mathematics, particularly noted for its effectiveness in enhancing students' mathematical understanding and engagement. Numerous studies have demonstrated that integrating GeoGebra into mathematics instruction improves learning outcomes. For instance, Anzani and Juandi (2022) conducted a meta-analysis that revealed the positive impact of problem-based learning assisted by GeoGebra on students' mathematical abilities. They indicated that students who engaged with GeoGebra showed a more significant improvement in their understanding than those who did not use the software.

Similarly, Mensah (2023) found that using GeoGebra in teaching circle theorems significantly enhanced student-teacher performance, reinforcing that technology can facilitate meaningful learning experiences in mathematics. Despite its benefits, integrating GeoGebra into mathematics teaching does present challenges. Teachers may encounter difficulties implementing the software effectively due to a lack of training or familiarity with its features (Garba, 2019)

Furthermore, while GeoGebra can enhance conceptual understanding, educators may need additional time to prepare lessons that effectively incorporate the software into their teaching strategies (Baye et al., 2021) However, the benefits of using GeoGebra, such as its ability to provide dynamic visualizations and foster interactive learning environments, often outweigh these challenges, making it a valuable resource in mathematics education. The impact of GeoGebra on learning outcomes is well-documented in the literature. For example, Kusumah et al. (2020) highlighted that GeoGebra significantly improved students' mathematical communication abilities in three-dimensional geometry, demonstrating its effectiveness in enhancing specific mathematical skills.

Additionally, Muslim (2023) reported that GeoGebra facilitates students' conceptual understanding by allowing them to explore various representations of mathematical concepts, thus promoting deeper learning. GeoGebra helps students improve their problem-solving skills, as Pamungkas and Nugroho (2020) noted. The software's utility extends to solving mathematical problems, deepening conceptual understanding, and real-world application. These findings underscore the potential of GeoGebra as a transformative tool in mathematics education, capable of engaging students and improving their overall mathematical proficiency.

However, limited research has focused on its impact on developing mathematical proficiency, particularly in cultivating problem-solving skills (Philemon et al., 2022).

To address this gap, this study employs well-defined research instruments that assess mathematical proficiency across conceptual understanding, adaptive reasoning, and strategic competence in problem-solving, providing a more comprehensive evaluation. By leveraging GeoGebra's interactive capabilities, this research aims to explore its potential to enhance students' proficiency and problem-solving in mathematics through innovative, real-world applications. It is crucial since producing mathematically proficient and critical problem solvers is the center of the Revised Grade 1-10 Mathematics Curriculum, anchored to the MATATAG Curriculum (DepEd, 2023).

Given this backdrop, a compelling case exists for investigating methods to support Filipino learners, particularly in geometry and circle theorems. This study raises the question of whether integrating GeoGebra into the classroom can ameliorate students' geometric comprehension and application weaknesses. GeoGebra's accessibility, offline functionality, and multi-platform availability, which enable learners to access it conveniently across various devices, are the driving forces behind its selection as a technological intervention. This study uses both the Diffusion of Innovation Model by Rogers (1962) and the Constructivist Learning Theory. The two identified frameworks are inherently interconnected. Given that GeoGebra software represents an innovation for the study's respondents, their perception of the software is paramount. The GeoGebra classroom activities are designed for pairs or trios to facilitate collaborative work among the respondents.

The study focused on two major topics, which are (1) circle theorems and (2) coordinate geometry, which are topics for Grade 10 Mathematics for the second quarter. This study also highlighted the development of students' conceptual understanding, adaptive reasoning, and strategic competence in problem-solving.

Statement of the Problem

This study determined the impact of integrating GeoGebra software into classroom instruction on the mathematical proficiency and learning experience of Grade 10 learners in circle theorems and coordinate geometry at Salabaca National High School. It addressed the following research questions:

1. What is the level of mathematical proficiency in circle theorems and coordinate geometry among students both in control and experimental groups during the pretest in terms of:
   1.1 conceptual understanding;
   1.2 adaptive reasoning, and
   1.3 strategic competence?
2. What is the level of mathematical proficiency in circle theorems and coordinate geometry among students both in control and experimental groups during the post-test in terms of:
   2.1 conceptual understanding;
   2.2 adaptive reasoning, and
   2.3 strategic competence?
3. Is there a significant difference in the level of mathematical proficiency among students of the control and experimental group during the pretest in terms of:
   3.1 conceptual understanding;
   3.2 adaptive reasoning, and
   3.3 strategic competence?
4. Is there a significant difference in the level of mathematical proficiency among students of the control and experimental group during the post-test in terms of:
   4.1 conceptual understanding;
   4.2 adaptive reasoning; and
   4.3 strategic competence?
5. Is there a significant difference in the level of mathematical proficiency based on the mean gain score among students both in control and experimental groups in terms of:
   5.1 conceptual understanding;
   5.2 adaptive reasoning; and
   5.3 strategic competence?
6. What is the experimental group's view on the use of GeoGebra software in terms of:
   6.1 engagement and enjoyment in learning;
   6.2 cognitive skills and critical thinking, and
   6.3 learning outcomes and academic improvement?

II. METHODOLOGY

Research Design

This study follows a true experimental with a pretest and post-test research design. A true experimental pretest and post-test research design is a rigorous methodology used to evaluate the effectiveness of an intervention or treatment by comparing outcomes before and after its implementation. This design typically involves randomly assigning participants to either an experimental group that receives the treatment or a control group that does not. The key characteristic of this design is the use of pretests and posttests to measure the dependent variable, allowing researchers to assess the impact of the independent variable on participants' performance (Novrizal et al., 2021).

A true experimental pretest-posttest design is widely regarded as the benchmark in research methodology due to its ability to generate strong evidence of causal relationships between variables. By systematically measuring changes in the dependent variable, researchers can draw meaningful conclusions about the effectiveness of educational interventions and inform best practices in teaching and learning.

The implementation of this design unfolds in four phases: first, two groups were assigned as control and experimental groups, respectively; second, both groups undergone pretesting; third, the intervention strategies were introduced to the experimental group; and finally, a post-test is administered to both groups, facilitating a comprehensive assessment of the study's outcomes.

Locale of the Study

The study was conducted at Salabaca National High School in Salabaca, Esperanza, Sultan Kudarat, one of the four public secondary schools in Esperanza. The school's accessibility and familiarity with the researcher justified the selection of this locale, which facilitated the efficient implementation and monitoring of the study while minimizing disruptions to regular instruction.

Respondents of the Study

The study's respondents are the Grade 10 students currently enrolled at Salabaca National High School for the School Year 2024-2025. The two groups were comprised of 15 randomly selected respondents, totalling 30 respondents. The respondents were chosen because they are the ones who have the topics of circle theorem and coordinate geometry in their curriculum, which is best taught with GeoGebra.

Sampling Technique

The samples were selected from the population using a cluster sampling method. Salabaca National High School's Grade 10 students were organized into three sections, each already randomized due to the school's use of a lottery method for classroom assignments. This approach ensured classroom heterogeneity, aligning with the Department of Education's policy on inclusive education (DepEd, 2019)

Two sections were selected as the study respondents out of the three sections. One served as the control group, which received the lecture method, and the other served as the experimental group, which underwent integration of the GeoGebra application. Fifteen (15) students were randomly selected from each group through a lottery method.

To avoid bias in determining the respondents, the Mean Percentage Scores (MPS) of the three sections in the first quarter mathematics quarterly grades were used as proof that the three sections have the same academic standing. They have MPS of 82.15, 82.54, and 82.73, respectively.

Research Instruments

The researcher employed two primary research instruments for this study. The first was a 28-item teacher-made test, divided into three parts to assess the strands of mathematical proficiency. Part 1, a 20-item multiple-choice test, measured respondents' conceptual understanding. Part 2, consisting of five open-ended questions, evaluated adaptive reasoning, while Part 3, with three problem-solving questions, assessed strategic competence. A holistic rubric was used to assess responses in parts 2 and 3. To ensure validity, experienced teachers and five mathematics education experts reviewed and validated the instrument, resulting in a high content validity mean of 4.80. The 20-item multiple-choice test was pilot-tested, yielding 24 acceptable items with a Cronbach's alpha value of 0.81, indicating acceptable reliability. To determine the level of mathematical proficiency of the students, the Rating Scale and Transmutation Table that is enclosed from DepEd Order No. 8 series of 2018, were utilized.

The second instrument was a 14-item Likert-scale survey adapted from Bayaga et al. (2020), focusing on respondents' experiences with GeoGebra software in teaching circle theorems. This instrument was used solely for the experimental group receiving the intervention. Its content validity was also high, with a mean of 4.87. The survey was designed to gather insights into the effectiveness and reception of GeoGebra software, providing further data on the impact of the intervention on students' learning experiences. To determine and interpret experimental groups' view on the use of GeoGebra, the rating scale of Pimentel (2019) shown in table 1.

Table 1
Students' View on the Use of GeoGebra

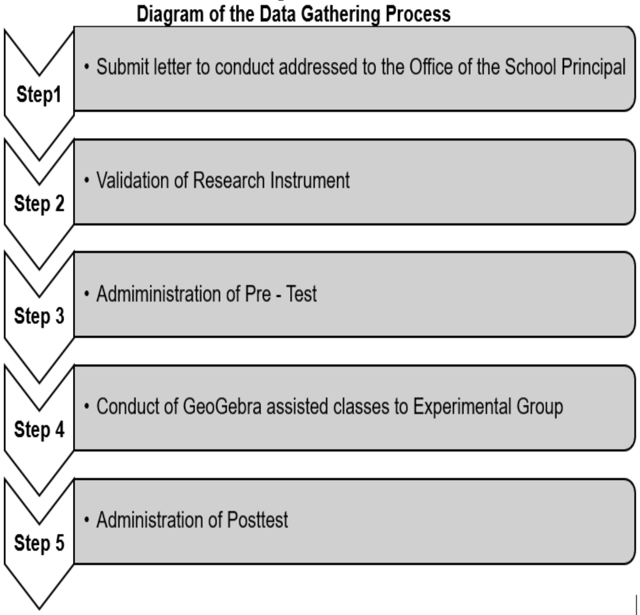
Rating	Mean Interval	Description	Interpretation
5	4.21- 5.00	Strongly Agree	Highly Acceptable
4	3.41- 4.20	Moderately Agree	Moderately Acceptable
3	2.61- 3.40	Neutral	Neutral
2	1.81- 2.60	Slightly Disagree	Slightly Acceptable
1	1.00- 1.80	Disagree	Not Acceptable

Data Gathering Procedure

The following procedures were used to gather the data from the respondents. A letter was sent to the Office of the Principal of Salabaca National High School asking permission to utilize the Grade 10 learners.

After getting all the necessary permits, the researcher distributes consent forms to the study respondents. Then, the validated research instrument was distributed for the pretest. The experimental group received the intervention, while the control group was exposed to the typical chalkboard discussion. After the 40 sessions for both groups, they were given the post-test evaluation to determine mastery in the circle theorem and coordinate geometry. The whole data gathering process is shown in figure 1.

Figure 1
Diagram of the Data Gathering Process



Statistical Treatment

This study used descriptive statistics to determine the groups' level of mathematics performance in circle theorem and coordinate geometry, using the mean and standard deviation of the respondents' pre-test and post-test scores.

An independent sample t-test was used to identify if there was a statistically significant difference between the control and experimental groups for the pretest and post-test across all indicators.

An independent sample t-test was employed as an appropriate statistical instrument to determine whether there is a statistically significant difference in the students' mathematical proficiency mean gain score as influenced by the lecture method and the integration of the GeoGebra application. All test statistics are tested at a 95% level of significance.

The researcher used descriptive statistics, specifically the weighted mean and standard deviation, to determine the experimental group's opinion of using GeoGebra software.

III. Results and Discussion

Table 2
Students' Level of Mathematical Proficiency in the Pretest

Indicators	Group	Mean	SD	Interpretation
Conceptual Understanding	Control	67.07	2.46	Did not meet expectations
	Experimental	67.27	2.22	Did not meet expectations
Adaptive Reasoning	Control	62.13	1.85	Did not meet expectations
	Experimental	61.00	2.22	Did not meet expectations
Strategic Competence	Control	60.13	0.35	Did not meet expectations
	Experimental	60.07	0.26	Did not meet expectations

Table 2 presents the mathematical proficiency of the two groups across three indicators: conceptual understanding, adaptive reasoning, and strategic competence. The table indicates that both groups did not meet expectations in all strands, suggesting that they had the same level of mathematical proficiency before the intervention was given to them.

The control group's conceptual understanding scored 67.07, with a standard deviation of 2.46. In contrast, the experimental group scored 67.27, with a slightly higher mean score and a standard deviation of 2.22. These results suggest that both groups demonstrated a similar conceptual understanding of mathematical concepts related to circle theorems and coordinate geometry.

For adaptive reasoning, the control group's mean score was 62.13 (SD=1.85), whereas the experimental group got a slightly lower mean score of 61.00 (SD=0.35). These scores suggest that the students in both groups struggled with logical reasoning and explaining mathematical concepts in coming up with a solution. In strategic competence, the control group got a mean score of 60.13 (SD=0.35), while the experimental group had a mean score of 61.00 (SD=0.26). The low scores in this strand indicate that students faced challenges in applying appropriate strategies in mathematical problem-solving.

The standard deviation values in each group indicate minimal variation in scores within each group, suggesting that students generally performed at similar levels of mathematical proficiency. These findings confirmed that both groups across all strands have the same mathematical literacy standing, ensuring a fair basis for evaluating the effectiveness of GeoGebra integration on students. Equal pretests among groups are important to accurately assess fairness in an educational assessment (Henderson et al., 2018).

Table 3
Students' Level of Mathematical Proficiency in the Post-test

Indicators	Group	Mean	SD	Interpretation
Conceptual Understanding	Control	82.00	6.59	Satisfactory
	Experimental	84.67	8.62	Very Satisfactory
Adaptive Reasoning	Control	78.67	11.05	Fairly Satisfactory
	Experimental	81.93	10.99	Satisfactory
Strategic Competence	Control	72.00	5.78	Did Not Meet Expectations
	Experimental	82.00	12.28	Satisfactory

Table 4 presents post-test results for both groups across three indicators of mathematical proficiency. The results reveal an overall improvement in both groups after instruction, with the experimental group consistently achieving higher mean scores across all strands.

Regarding conceptual understanding, the control group obtained a mean score of 82.00 (SD = 6.59), interpreted as satisfactory. In contrast, the experimental group achieved a higher mean of 84.67 (SD = 8.62), interpreted as very satisfactory. This suggests that the integration of GeoGebra into instruction helped deepen students' understanding of mathematical concepts, particularly in circle theorems and coordinate geometry. By providing dynamic visualizations and interactive representations, GeoGebra may have allowed students to make meaningful connections between ideas and retain information more effectively. These results demonstrate the potential of technology to enhance both learning outcomes and long-term retention. The findings support that GeoGebra-enhanced instruction improves students' conceptual understanding (Birgin & Yazıcı, 2021). Similarly, the experimental group in this study showed a higher post-test score than the control group using traditional lectures, highlighting GeoGebra's effectiveness in enhancing learning and retention.

For adaptive reasoning, the control group obtained a mean score of 78.67 (SD=11.05), which was interpreted as fairly satisfactory, whereas the experimental group scored 81.93 (SD=10.99), which was interpreted as satisfactory. Both teaching methods improved students' adaptive reasoning, but the experimental group's higher post-test scores suggest that GeoGebra integration was more effective in developing logical reasoning. Its interactive and visual features helped students explore, justify, and apply concepts more effectively, enhancing their ability to formulate explanations and draw conclusions. These findings align with Bennie et al. (2019), who emphasized the effectiveness of interactive and immersive technologies in enhancing student engagement and understanding of complex concepts.

The most notable difference was observed in strategic competence, where the control group scored 72.00 (SD=5.78), interpreted as not meeting expectations. In contrast, the experimental group significantly outperformed them with a mean score of 82.00 (SD=12.77), interpreted as satisfactory. While traditional instruction led to some improvement, GeoGebra integration proved more effective in enhancing students' strategic thinking and problem-solving skills in circle theorems and coordinate geometry. The use of dynamic visual tools may have allowed learners to better analyze problems and explore multiple solution strategies, which are key components of strategic competence. This suggests that incorporating technology in mathematics instruction can bridge gaps in understanding and encourage deeper engagement with abstract concepts. These findings support Marita and Hord (2016), who highlighted the effectiveness of visual representation in improving students' strategic competence in problem-solving.

Table 4: Summary Table for Pre-test and Post-test for Level of Mathematical Proficiency

Mathematical Proficiency	Group	Mean	SD	Interpretation
Pretest	Control	63.47	1.19	Did Not Meet Expectations
	Experimental	63.20	1.15	Did Not Meet Expectations
Post-test	Control	77.07	6.51	Fairly Satisfactory
	Experimental	82.40	9.29	Satisfactory

Table 4 summarizes the students' levels of mathematical proficiency in the pretest and post-test for the control and experimental groups. The data illustrate student performance changes before and after the intervention. In the pretest, both groups demonstrated low mathematical proficiency, with mean scores of 63.47 (SD = 1.19) for the control group and 63.20 (SD = 1.15) for the experimental group. Both groups were interpreted as not meeting expectations.

After the intervention, the post-test results showed notable improvement in both groups. The control group achieved a mean score of 77.07 (SD = 6.51), which is interpreted as fairly satisfactory. This indicates that traditional instruction contributed to some progress. Meanwhile, the experimental group, which was exposed to GeoGebra-integrated learning, obtained a higher mean score of 82.40 (SD = 9.29), reaching a satisfactory level.

These results suggest that while both teaching approaches improved students' mathematical proficiency, using GeoGebra substantially enhanced their understanding and performance in circle theorems and coordinate geometry. A study by Hidayat et al. (2024) supported these findings. In it, teachers who engaged in training to explore GeoGebra's pedagogical applications adopted a student-centered approach, ultimately leading to improved teaching practices and better student outcomes in mathematics.

Table 5: Test of Difference Between Means on the Level of Mathematical Proficiency of the Control and Experimental Groups in the Pretest

Strands	Group	Mean	SD	p-value	Interpretation
Conceptual Understanding	Control	67.07	2.46	0.817	Not significant
	Experimental	67.27	2.22		
Adaptive Reasoning	Control	62.13	1.85	0.108	Not significant
	Experimental	61.00	2.22		
Strategic Competence	Control	60.13	0.35	0.559	Not significant
	Experimental	60.07	0.26		

Table 5 presents the test of the difference between the pretest mean scores of the control and experimental groups across three strands of mathematical proficiency, including conceptual understanding, adaptive reasoning, and strategic competence. The result indicates that the control and experimental groups had no significant difference in their means before the intervention in all strands, since all the p-values were greater than 0.05.

For conceptual understanding, the control group has a mean score of 67.07 (SD=2.46), and the experimental group has a mean score of 67.27 (SD=2.22) with a p-value of 0.817, indicating that the difference between the two groups was negligible. Similarly, in adaptive reasoning, the control group has a mean of 62.13 (SD=1.85), and the experimental group has a mean of 61.00 (SD=2.22) with a p-value of 0.108, which suggests that both groups had a comparable level of reasoning skills before the instructional intervention. Lastly, in strategic competence, the control group has a mean of 60.13 (SD=0.35), and the experimental group has a mean of 60.07 (SD=0.26) with a p-value of 0.559, further confirming the absence of a significant difference.

These findings suggest that both groups had a similar level of mathematical proficiency at the beginning of the study, ensuring that any improvements observed in the post-test could be attributed to the intervention given rather than pre-existing differences in their ability. This was further supported by a study by Halder et al. (2024), where equal pretest scores among groups are necessary to establish a fair comparison.

Table 6: Test of Difference Between Means on the Level of Mathematical Proficiency of the Control and Experimental Groups in their Post-tests

Strands	Group	Mean	SD	p-value	Interpretation
Conceptual Understanding	Control	82.00	6.59	0.349	Not significant
	Experimental	84.67	8.26		
Adaptive Reasoning	Control	78.67	11.05	0.424	Not significant
	Experimental	81.93	10.99		
Strategic Competence	Control	72.00	5.72	0.008	Significant
	Experimental	82.00	12.28		

Table 6 presents the statistical comparison between the control and experimental groups regarding the post-test scores across three strands of mathematical proficiency: conceptual understanding, adaptive reasoning, and strategic competence. The results indicate no significant difference between the two groups in conceptual understanding (p-value of 0.349) and adaptive reasoning (p-value of 0.424), suggesting that both teaching approaches had a similar impact on students' proficiency in these areas.

However, a significant difference was found in strategic competence, with a p-value of 0.008, indicating that the experimental group outperformed the control group in this strand. This result suggests that integrating GeoGebra was particularly effective in enhancing students' ability to develop and apply problem-solving strategies, reinforcing the benefits of technology-based instruction in mathematics learning.

Table 7: Test of Difference in Mean Gain Scores of the Control and Experimental Group

Strands	Group	Mean	SD	p-value	Interpretation
Conceptual Understanding	Control	8.20	2.37	0.386	Not significant
	Experimental	9.13	3.36		
Adaptive Reasoning	Control	7.60	3.76	0.162	Not significant
	Experimental	9.44	3.36		
Strategic Competence	Control	6.87	2.92	0.006	Significant
	Experimental	10.2	3.26		
Overall Mathematical Proficiency	Control	22.67	7.04	0.032	Significant
	Experimental	28.80	7.85		

Table 7 compares the mean gain scores of the control and experimental groups across different strands of mathematical proficiency. For conceptual understanding, the control group had a mean gain of 8.20 (SD = 2.37), while the experimental group had 9.13 (SD = 3.36), p = 0.386, indicating no significant difference. Similarly, for adaptive reasoning, the control group had a mean gain of 7.60 (SD = 3.76), while the experimental group had 9.44 (SD = 3.36), p = 0.162, also showing no significant difference.

However, a significant difference was observed in strategic competence, where the control group had a mean gain of 6.87 (SD = 2.92), while the experimental group had 10.20 (SD = 3.26) with a p-value of 0.006. Additionally, the overall mathematical proficiency gain was significantly higher for the experimental group (M = 28.80, SD = 7.85) than for the control group (M = 22.67, SD = 7.04), with a p value= 0.032. These findings suggest that the GeoGebra-integrated approach substantially improved students' strategic competence and overall mathematical proficiency compared to traditional instruction.

Table 8: Experimental Group's View of GeoGebra in Terms of Engagement and Enjoyment

Statements	Mean	SD	Interpretation
1. I am excited to use GeoGebra in circle geometry.	4.47	0.64	Highly Acceptable
2. I like studying lessons on circle theorems with GeoGebra.	4.47	0.74	Highly Acceptable
3. I feel confident using GeoGebra while learning circle geometry.	4.33	0.72	Highly Acceptable
4. I can actively engage in the learning process when using GeoGebra.	4.13	0.83	Moderately Acceptable
5. GeoGebra enhances the interactions between the teachers and the students.	4.73	0.46	Highly Acceptable
Section Mean	**4.43**	**0.47**	**Highly Acceptable**

Table 8 shows the experimental group's perception of GeoGebra regarding engagement and enjoyment. Among the statements, the highest rate was attributed to the fact that GeoGebra enhances teacher-student interaction with a mean of 4.73 (SD=0.46), which is interpreted as highly acceptable. This suggests that students promote communication and collaboration in learning the circle theorem and coordinate geometry.

In addition, students showed excitement and interest in studying while using GeoGebra, which both got a mean of 4.47 (SD=0.64 and SD=0.74); both were interpreted as highly acceptable. Students also showed confidence in learning circle theory using GeoGebra with a mean of 4.33 (SD=0.72), which was interpreted as highly acceptable. The lowest rated statement was on the active engagement of learners in the learning process, with a mean of 4.13 (SD=0.83), yet it is interpreted as moderately acceptable. Generally, the experimental group's view of GeoGebra as their engagement and enjoyment has a section mean of 4.43 (SD=0.47), which is interpreted as highly acceptable.

This result was supported by Mensah's study (2023), which confirmed GeoGebra's effectiveness in enhancing student engagement and understanding. Similarly, students performed better and had more enjoyable learning experiences using GeoGebra (Awaji, 2022).

Table 9: Experimental Group's View of GeoGebra in terms of Cognitive Skills and Critical Thinking

Statements	Mean	SD	Interpretation
1. I can apply my visualization skills during lessons using GeoGebra.	4.80	0.41	Highly Acceptable
2. I can think creatively and critically in the discussion using GeoGebra.	4.53	0.52	Highly Acceptable
3. I make logical assumptions to come up with bright ideas.	4.53	0.64	Highly Acceptable
4. I make connections between new and previous lessons while using GeoGebra.	4.53	0.72	Highly Acceptable
5. I believe that integrating GeoGebra into the discussion of circle geometry develops strong reasoning skills.	4.47	0.74	Highly Acceptable
Section Mean	**4.53**	**0.38**	**Highly Acceptable**

Table 9 shows the experimental group’s perception of GeoGebra in terms of cognitive skills and critical thinking. Among the statements, the highest rate was attributed to the fact that the students can apply visualization skills through GeoGebra with a mean of 4.80 (SD=0.41), which is interpreted as highly acceptable. This means that the students believed that GeoGebra was helping them to visualize mathematical concepts better.

In addition, students considered GeoGebra a tool to help them connect new and previous lessons, think creatively and critically, and make logical assumptions with a mean of 4.53 (SD=0.52), which was interpreted as highly acceptable. The lowest-rated statement was about students’ believing that GeoGebra integration helped them develop their reasoning skills, with a mean of 4.47 (SD=0.74), yet it was still interpreted as highly acceptable. Generally, the experimental group's view of GeoGebra as to how it develops their cognitive skills and critical thinking has a section mean of 4.53 (SD=0.38), interpreted as highly acceptable.

The findings have significant implications for educational practices, particularly in enhancing students' engagement with complex mathematical concepts. The ability to link prior knowledge with new learning through dynamic mathematical tools like GeoGebra can foster deeper understanding and retention. Furthermore, the tool’s capacity to support critical thinking and creative problem-solving could translate into greater success in tackling abstract mathematical problems. This result was supported by the study of Misrom et al. (2020), which stated that GeoGebra improves higher-order cognitive skills. In addition, several research studies suggest that technology allows learners to engage in higher-order thinking, leading to practical mathematical reasoning (Stacey, 2019).

Table 10: Experimental Group's View of GeoGebra in Terms of Learning Outcomes and Academic Improvement

Statements	Mean	SD	Interpretation
1. I improve my understanding of circle geometry using GeoGebra.	4.47	0.74	Highly Acceptable
2. My performance in Euclidean Geometry tests and examinations improved after I learned to use GeoGebra.	4.33	0.72	Highly Acceptable
3. Euclidean Geometry improves my performance in Mathematics.	4.20	0.68	Highly Acceptable
4. I believe that only brilliant learners can understand circle geometry without GeoGebra.	2.00	1.00	Slightly Acceptable
Section Mean	**3.75**	**0.54**	**Moderately Acceptable**

Table 10 shows the experimental group's perception of GeoGebra regarding learning outcomes and academic improvement. Among the statements, the highest rate was attributed to the fact that the students improved their understanding of circle geometry using GeoGebra, with a mean of 4.47 (SD=0.74) interpreted as highly acceptable. This means the students believed that GeoGebra helped them understand mathematical concepts effectively.

In addition, students believed that their improvement in the test was attributed to the use of GeoGebra with a mean of 4.33 (SD=0.72), interpreted as highly acceptable. On the other hand, students do not fully believe that only brilliant learners can understand without GeoGebra, having a mean of 2.00 (SD=1.0), which is interpreted as slightly acceptable. Although they think that GeoGebra contributed to their learning outcomes, they believe that regular students can also understand learning circle geometry even without GeoGebra. Generally, the experimental group's view on how GeoGebra contributed to their learning outcomes and academic improvement has a mean of 3.75 (SD=0.58), interpreted as moderately acceptable. This implies that while the students appreciated GeoGebra’s role in enhancing visualization and comprehension, they did not perceive it as the sole reason for success.

This finding aligns with existing literature, as several studies have investigated GeoGebra's influence on mathematics education, revealing numerous benefits. Notably, Arbain and Shukor

(2015) demonstrated that the use of GeoGebra significantly improves students' academic performance, positively impacting learning outcomes and overall achievement in mathematics.

Table 11
Overall Experimental Group's View of GeoGebra

Indicators	Mean	SD	Interpretation
1. Engagement and Enjoyment	4.43	0.47	Highly Acceptable
2. Cognitive Skills and Critical Thinking	4.53	0.38	Highly Acceptable
3. Learning Outcome and Improvement	3.75	0.54	Moderately Acceptable
Overall Mean	**4.24**	**0.58**	**Highly Acceptable**

Table 11 presents the experimental group's overall perception of GeoGebra as it was used in circle theorems and coordinate Geometry. Among the three indicators, cognitive skills and critical thinking got the highest mean of 4.53 (SD=0.38), interpreted as highly acceptable. This shows that students recognized the role of GeoGebra in developing their reasoning and problem-solving skills. Similarly, engagement and enjoyment also received a high rating with a mean of 4.43 (SD=0.47), which was interpreted as highly acceptable. This shows that students found GeoGebra engaging and interactive. This suggests that students found GeoGebra not only useful for learning complex mathematical concepts but also engaging and interactive. The positive feedback on this indicator emphasizes the tool's capacity to create an enjoyable learning experience, which could potentially increase motivation and active participation in mathematical tasks.

However, learning outcomes and improvement received a slightly lower rating, with a mean of 3.75 (SD=0.54), interpreted as moderately acceptable. This means that while students believe that GeoGebra is helpful software, their perception of its impact on their academic performance may vary depending on their learning preferences and prior mathematical proficiency.

The overall mean score of 4.24, with a standard deviation of 0.58, indicates that the experimental group found GeoGebra highly acceptable as a learning tool. This suggests that students perceived GeoGebra as an effective platform that enhances engagement, critical thinking, and the overall learning experience in mathematics. The relatively high rating reflects the tool's potential to not only support understanding of mathematical concepts but also to foster an interactive and engaging environment that encourages deeper cognitive engagement.

This result aligns with findings from Uwurukundo et al. (2022), who emphasized that GeoGebra's interactive and dynamic features significantly promote student engagement and motivation in learning mathematics. Additionally, Kusumah et al. (2020) and Pamungkas and Nugroho (2020) highlighted that the software supports the development of critical thinking and problem-solving skills through its visual and hands-on learning environment, reinforcing students' positive perception of GeoGebra as a highly effective educational tool.

IV. CONCLUSIONS

Summary of Findings

For the mathematical proficiency of the control and experimental groups based on their pretest scores, the control group's conceptual understanding scored 67.07, with a standard deviation of 2.46 while the experimental group got a slightly higher mean score of 67.27, with a standard deviation of 2.22. For adaptive reasoning, the control group's mean score was 62.13 (SD=1.85), whereas the experimental group got a slightly lower mean score of 61.00 (SD=0.35). In strategic competence, the control group scored 60.13 (SD=0.35), which is interpreted as not meeting expectations. In contrast, the experimental group scored 61.00 (SD=0.26), which is also interpreted as not meeting expectations.

For the mathematical proficiency of the control and experimental groups based on their post-test scores, the control group's conceptual understanding during post-tests had a mean of 82.00 (SD=6.59), which is interpreted as satisfactory. In contrast, the experimental group had a higher mean of 84.67 (SD=8.62), which is interpreted as very satisfactory. For adaptive reasoning, the control group obtained a mean score of 78.67 (SD=11.05), which was interpreted as fairly satisfactory, whereas the experimental group scored 81.93 (SD=10.99), which was interpreted as satisfactory. A notable difference was observed in strategic competence. The control group scored 72.00 (SD=5.78), which was interpreted as not meeting expectations, while the experimental group significantly outperformed them with a mean score of 82.00 (SD=12.77), which was interpreted as satisfactory.

Overall mathematical proficiency reported that in the pretest, both groups demonstrated low mathematical proficiency, with mean scores of 63.47 (SD = 1.19) for the control group and 63.20 (SD = 1.15) for the experimental group, both interpreted as not meeting expectations. After the intervention, the post-test results show a notable improvement in both groups. The control group achieved a mean score of 77.07 (SD = 6.51), interpreted as fairly satisfactory, indicating that traditional instruction contributed to some progress. Meanwhile, the experimental group, which was exposed to GeoGebra-integrated learning, obtained a higher mean score of 82.40 (SD = 9.29), reaching a satisfactory level.

For the mathematical proficiency of the control and experimental groups based on their mean gain scores, for conceptual understanding, the control group had a mean score of 67.07 (SD=2.46), and the experimental group had a mean score of 67.27 (SD=2.22), with a p-value of 0.817, indicating that the difference between the two groups was negligible. In adaptive reasoning, the control group has a mean of 62.13 (SD=1.85), and the experimental group has a mean of 61.00 (SD=2.22) with a p-value of 0.108, which suggests that both groups had a comparable level of reasoning skills before the instructional intervention. In strategic competence, the control group has a mean of 60.13 (SD=0.35), and the experimental group has a mean of 60.07 (SD=0.26) with a p-value of 0.559, further confirming the absence of a significant difference. The overall mathematical proficiency gain was significantly higher for the experimental group (M = 28.80, SD = 7.85) than for the control group (M = 22.67, SD = 7.04). The p-value was 0.032, indicating a significant difference between the two groups.

Generally, the experimental group's view of GeoGebra as their engagement and enjoyment has a section mean of 4.43 (SD=0.47), which is interpreted as highly acceptable. GeoGebra enhances teacher-student interaction with a mean of 4.73 (SD=0.46), which is also interpreted as highly acceptable. This suggests students promote communication and collaboration in learning circle theorem and coordinate geometry.

In addition, students showed excitement and interest in studying while using GeoGebra, which both got a mean of 4.47 (SD=0.64 and SD=0.74); both were interpreted as highly acceptable. Students also showed confidence in learning circle theory using GeoGebra with a mean of 4.33 (SD=0.72), which was interpreted as highly acceptable. The lowest rated statement was on the active engagement of learners in the learning process, with a mean of 4.13 (SD=0.83), yet it is interpreted as moderately acceptable.

For cognitive skills and critical thinking, Generally, the experimental group's view of GeoGebra as to how it develops their cognitive skills and critical thinking has a section mean of 4.53 (SD=0.38), interpreted as highly acceptable. Students can apply visualization skills through GeoGebra with a mean of 4.80 (SD=0.41), which is interpreted as highly acceptable.

In addition, students considered GeoGebra a tool to help them make connections between new and previous lessons, think creatively and critically, and make logical assumptions, with a mean of 4.53 (SD=0.52), which was interpreted as highly acceptable. The lowest-rated statement was about students' believing that GeoGebra integration helped them develop their reasoning skills, with a mean of 4.47 (SD=0.74), yet it was still interpreted as highly acceptable.

For learning outcomes and academic improvement, generally, the experimental group's view on how GeoGebra contributed to their learning outcomes and academic improvement has a mean of 3.75 (SD=0.58), which is interpreted as moderately acceptable. Students have an improved understanding of circle geometry using GeoGebra, with a mean of 4.47 (SD=0.74), which is interpreted as highly acceptable. In addition, students believed that their improvement in the test was attributed to the use of GeoGebra, with a mean of 4.33 (SD=0.72), which is interpreted as highly acceptable. On the other hand, students do not fully believe that only brilliant learners can understand without GeoGebra, which has a mean of 2.00 (SD=1.0), which is interpreted as slightly acceptable.

Conclusions

Based on the findings, the following conclusions are hereby formulated:

The pretest mean scores of both the control and experimental groups showed the same level of mathematical proficiency in circle theorems and coordinate geometry across three indicators interpreted as not meeting expectations, suggesting they were at the same level before the intervention.

Both groups improved overall mathematical proficiency in circle theorems and coordinate geometry after the intervention, as reflected in the post-test mean scores. However, the experimental group consistently achieved higher mean scores across all indicators.

The pretest of both groups demonstrated low mathematical proficiency in circle theorems and coordinate geometry compared to the post-test scores of both groups, suggesting notable improvement after the intervention.

The control and experimental groups across all indicators suggest a similar level of mathematical proficiency before the intervention.

Based on the students' post-test mean scores, only the indicator of strategic competence showed a notable improvement in favor of the experimental group. In contrast, conceptual understanding and adaptive reasoning did not show marked improvements between the two groups. The integration of GeoGebra proved to be especially effective in developing students' strategic competence compared to the traditional lecture method.

Based on the students' mean gain scores, only the indicator of strategic competence showed a clear advantage for experimental group over the control group. In contrast, there were no notable differences between the groups in terms of conceptual understanding and adaptive reasoning.

The overall mean gain scores showed a significant difference between the control and experimental groups, indicating that the integration of GeoGebra had a positive effect on students' overall mathematical proficiency in circle theorems and coordinate geometry. The experimental group generally found GeoGebra highly acceptable as a tool in learning circle theorems and coordinate geometry.

Recommendations

Based on the findings and conclusions derived from this study, the following recommendations are presented:

1. For mathematics teachers, incorporate GeoGebra into their instructional methods, especially for topics that require students to visualize and solve problems.
2. Since both traditional and GeoGebra-integrated methods improve student mathematical proficiency, Mathematics teachers may consider using a blended approach in which lecture-based and interactive learning methods complement each other.
3. School administrators can support the continuous implementation of GeoGebra-integrated instruction by ensuring that computers and internet access are readily available in classrooms. This will facilitate the smooth integration of technology-based learning tools like GeoGebra.
4. Given its effectiveness in improving strategic competence, the DepEd may consider integrating GeoGebra into the standard mathematics curriculum to enhance students' problem-solving skills.
5. Students may use GeoGebra's features to explore geometric concepts interactively and improve their problem-solving strategies.
6. Future researchers may focus on how the continued use of GeoGebra affects students' mathematical proficiency over time to assess its sustained benefits.
7. Future researchers may explore GeoGebra's impact on mathematical topics such as Trigonometry, Algebra, and Calculus.

Acknowledgment

The researcher would like to thank all those who have helped and supported in this research, especially the school principal, the validators, and especially the Grade 10 students of Salabaca National High School in Salabaca, Esperanza, Sultan Kudarat.

References

Aizikovitsh-Udi, E. and Cheng, D. (2015). Developing critical thinking skills from dispositions to abilities: mathematics education from early childhood to high school. Creative Education, 06(04), 455-462. https://doi.org/10.4236/ce.2015.64045

Arbain, N. & Shukor, N. (2015). The effects of geogebra on students achievement. *Procedia - Social and Behavioral Sciences, 172*(1), 208-214. https://doi.org/10.1016/j.sbspro.2015.01.356

Baye, M., Ayele, M., & Wondimuneh, T. (2021). Implementing geogebra integrated with multi-teaching approaches guided by the apos theory to enhance students' conceptual understanding of limit in ethiopian universities. Heliyon, 7(5), e07012. https://doi.org/10.1016/j.heliyon.2021.e07012

Department of Education (2015*). Policy Guidelines on Classroom Assessment for K to 12 Basic Education Program*. https://www.deped.gov.ph/wpcontent/uploads/2015/04/DO_s2015_08.pdf.

Department of Education (2019). *PISA 2018 National Report of the Philippines*. https://www.deped.gov.ph/wp-content/uploads/2019/12/PISA-2018-Philippine-National-Report.pdf

Department of Education (2023). Matatag Curriculum for Mathematics Grades 1, 4, and 7. https://www.deped.gov.ph/wp-content/uploads/MATATAG-Mathematics-CG-Grades1-4-and-7.pdf

Garba, A. (2019). Issues and challenges in the use of geogebra in teaching and learning of mathematics in secondary schools in makurdi metropolis. Eph - International Journal of Business & Management Science, 5(4), 26-35. https://doi.org/10.53555/eijbms.v5i4.92

Henderson, R., Miller, P., Stewart, J., Traxler, A., & Lindell, R. (2018). Item-level gender fairness in the force and motion conceptual evaluation and the conceptual survey of electricity and magnetism. Physical Review Physics Education Research, 14(2). https://doi.org/10.1103/physrevphyseducres.14.020103

Hidayat, R., Noor, W., Nasir, N., & Ayub, A. (2024). The role of geogebra software in conceptual understanding and engagement among secondary school student. Infinity Journal, 13(2), 317-332. https://doi.org/10.22460/infinity.v13i2.p317-332

Jelatu S. (2018). Effect of Geogebra-Aided REACT Strategy on Understanding of Concepts *Int. J. Instr. 11* 325-36

Juandi, D., Kusumah, Y. S., Tamur, M., Perbowo, K. S., & Wijaya, T. T. (2021). A meta- of geogebra software decade of assisted mathematics learning: what to learn and where to go?. *Heliyon, 7*(5), e06953. https://doi.org/10.1016/j.heliyon.2021.e06953

Kusumah, Y. S., Kustiawati, D., & Herman, T. (2020). The effect of geogebra in three-dimensional geometry learning on students' mathematical communication ability. *International Journal of Instruction, 13*(2), 895-908. https://doi.org/10.29333/iji.2020.13260a

Marita & Hord. (2016). Review of mathematics interventions for secondary students with learning disabilities. learning disability quarterly, 40(1), 29-40. https://doi.org/10.1177/0731948716657495

Mensah, J. (2023). Effectiveness of using geogebra in teaching and learning circle theorems on student-teachers' performance. European Journal of Education Studies, 10(11). https://doi.org/10.46827/ejes.v10i11.5041

Misrom, N. S., Abdurrahman, M. S., Abdullah, A. H., Osman, S., Hamzah, M. H., & Fauzan, A. (2020). Enhancing students' higher-order thinking skills (HOTS) through an inductive reasoning strategy using geogebra. *International Journal of Emerging Technologies in Learning, 15*(3), 156–179. https://doi.org/10.3991/ijet.v15i03.9839

Muslim, N., Zakaria, M., & Fang, C. (2023). A systematic review of geogebra in mathematics education. International Journal of Academic Research in Progressive Education and Development, 12(3). https://doi.org/10.6007/ijarped/v12-i3/19133

Narh-Kert, M. and Sabtiwu, R. (2022). Use of geogebra to improve performance in geometry. African Journal of Educational Studies in Mathematics and Sciences, 18(1), 29-36. https://doi.org/10.4314/ajesms.v18i1.3

Novrizal, R., Nandiyanto, A., Kurniawan, T., & Bilad, M. (2021). The influence of junior high school students' musical preferences on the learning of basic music theory. Indonesian Journal of Multidiciplinary Research, 2(1), 21-26. https://doi.org/10.17509/ijomr.v2i1.38615

Nzaramyimana, E. (2021). Effectiveness of geogebra towards students' active learning, performance and interest to learn mathematics. International Journal of Mathematics and Computer Research, 09(10). https://doi.org/10.47191/ijmcr/v9i10.05

Pamungkas, M., Rahmawati, F., & Dinara, H. (2020). Integrating GeoGebra into space geometry in college. https://doi.org/10.2991/assehr.k.200129.123

Peteros, E., Gamboa, A., Etcuban, J. O., Dinauanao, A., Sitoy, R., & Arcadio, R. (2020). Factors Affecting Mathematics Performance of Junior High School Students. International Electronic Journal of Mathematics Education, 15(1), em0556. https://doi.org/10.29333/iejme/5938

Philemon, N., Chibisa, A., & Mabusela, M. (2022*).* Acceptance of the GeoGebra application in learning circle theorems. *International Journal of Learning Teaching and Educational Research, 21*(12), 1-20. https://doi.org/10.26803/ijlter.21.12.1

Popova, Y., Abdualiyeva, M., Torebek, Y., Yelshibekov, N., & Omashova, G. (2022). Improving the effectiveness of senior graders' education based on the development of mathematical intuition and logic: kazakhstan's experience. Frontiers in Education, 7. https://doi.org/10.3389/feduc.2022.986093

Prendergast, M., Breen, C., Bray, A., Faulkner, F., Carroll, B., Quinn, D., … & Carr, M. 2018). Investigating secondary students beliefs about mathematical problem-solving. International Journal of Mathematical Education in Science and Technology, 49(8), 1203-1218. https://doi.org/10.1080/0020739x.2018.1440325

Uwurukundo, M. S., Maniraho, J. F., & Tusiime, M. (2022). Enhancing students' attitudes in learning 3-dimension geometry using geogebra. *International Journal of Learning, Teaching and Educational Research, 21*(6), 286-303. https://doi.org/10.26803/ijlter.21.6.17