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Effect Of Using Geoboard In Teaching Plane Geometry On The Performance Of Pre-Service Teachers

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Abstract:
Background: *This study examines the effect of utilizing geoboards as a teaching tool for plane geometry on the academic performance of pre-service teachers at E.P College of Education and St. Francis College of Education.*
Materials and Methods*: Employing a quasi-experimental research design, pretest and posttest scores of level 100 students were collected.*
Results*: The results indicate that integrating geoboards into plane geometry instruction significantly enhances the performance of pre-service teachers. These findings align with existing literature supporting the efficacy of geoboards in geometry education. Moreover, the study establishes empirical evidence for the effectiveness of geoboards as a pedagogical strategy for enhancing pre-service teachers' performance. The research carries crucial implications for mathematics education, emphasizing the value of incorporating manipulatives like geoboards into geometry instruction. However, limitations include the use of a quasi-experimental design. Future investigations should employ a randomized controlled trial design to establish a causal relationship. Furthermore, longitudinal studies are needed to explore the long-term effects of geoboard utilization on learners' performance and problem-solving skills.*
Conclusion**:** *In conclusion, this study lays the groundwork for further research on the effectiveness of geoboards in teaching geometry, highlighting their significance in mathematics education*
Key Words*: Geoboards; Mathematics Education; Geometric Theorems; Pre-service Teachers*

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I. Introduction

Mathematics, as a scientific discipline, explores patterns, shapes, symbols, numbers, and the interconnections among them. Its significance extends beyond mere academic pursuit, as it holds a vital role in the advancement and betterment of human society (Bornaa et al., 2023). Understanding the pivotal role of mathematics in social and economic progress, the Ghanaian government is dedicated to providing high-quality mathematics education. However, despite these efforts, there has been limited improvement in the teaching and learning of mathematics, resulting in persistently low achievement levels among high school students studying the subject (Mullis, Martin, & Foy, 2008; Ottevanger, Van den Akker, & de Feiter, 2007). A prominent approach in mathematics instruction observed in Ghana is the teacher-centered method, commonly known as "chalk and talk." In this approach, the teacher assumes the central role, delivering lectures, explaining concepts, and presenting examples, while students are expected to passively listen, take notes, and absorb the information (Ottevanger et al., 2007). This approach heavily relies on teachers' expertise, leading to limited opportunities for students to actively engage with the material or collaborate with peers in problem-solving and communication (Wu & Huang, 2007). Consequently, students often struggle to think critically about mathematical concepts or apply their knowledge to real-life situations (Baptiste, 2022). An alternative perspective, proposed by Piaget (1948/1973), emphasizes that education should not solely focus on disseminating knowledge but also on fostering individuals' cognitive abilities, promoting autonomy in thinking and decision-making. This involves encouraging independent thought, self-reflection, and considering multiple perspectives (Stephan, 2020). However, teacher-centered teaching, which relies on lectures, repetitive practice, and constructive feedback, has faced criticism for not adequately preparing students for higher levels of mathematical achievement (Ampadu, 2012; Davis et al., 2019; Baafi, 2020; Kaymakamoglu, 2018; Akiba and Liang, 2016). Recognizing these challenges, recent efforts have focused on developing clear and effective mathematics teaching methods that benefit both educators and students alike (Benning & Agyei, 2016). Researchers such as Vidermanova and Vallo (2014) have extensively discussed the impact of various teaching techniques on students' understanding of geometry, highlighting how instructional methods can influence their grasp of mathematical concepts. In light of these issues and the need for improved mathematics education, this research aims to investigate an alternative pedagogical approach, specifically geoboards in enhancing student performance. By exploring innovative methods that align with the principles of autonomy and cognitive development, this study seeks to contribute valuable insights to enhance mathematics education in Ghana.

Statement of the problem

Numerous studies, including Anamuah-Mensah, Mereku, and Asabere-Ameyaw (2006), Anku (2005–2006), Djangmah and Addae-Mensah (2012), and UNESCO (2004), discovered that the majority of Ghanaian students had a general dislike for mathematics, which contributed to their poor performance in both national and international examinations (such as the West African Senior Secondary Examination, or WASSCE). According to Jones (2002), a better understanding of geometry helps students achieve excellent results in mathematics. According to Couto and Vale (2014), the development of geometrical cognition is also a critical tool for assisting learners in overcoming challenges in their daily lives. Notwithstanding the significance of geometry, examiners' reports for colleges of mathematics education expressed worry over pre-service teachers' poor performance in this area (Adolphus, 2014). Little research has been conducted on the effects of incorporating specific instructional tools, such as geoboards, in order to improve pre-service teachers' performance in this area, despite the importance of geometry instruction and the need to prepare pre-service teachers to perform effectively. The study's goal is to find out how pre-service teachers' performance changed as a result of using geoboards to teach plane geometry

Research Objective

This study aimed to examine the effect of using geoboard on the academic performance of level 100 pre-service students of E. P. College of Education and St. Francis College of Education, in plane geometry

***Research Hypothesis*:**

To answer the specific objective of the study, the following research hypothesis was formulated to guide the study and will be tested at 0.05 level of significance:

Null hypothesis (**H_0**): The use of a geoboard in teaching plane geometry has no significant effect on the performance of pre-service teachers.

Alternative hypothesis (**H_a**): The use of a geoboard in teaching plane geometry has a significant effect on the performance of pre-service teachers.

Literature Review

Several studies have investigated the effect of using geoboards on the learning of geometry. Mudaly and Sibiya (2018) found that students who used geoboards to learn geometric theorems showed a significant improvement in their understanding of the material compared to those who did not use geoboards. Participants in the geoboard group also reported feeling more engaged and motivated in their learning, and were able to apply the concepts they learned to real-world problems more effectively. Deborah et al. (2020) established from their findings that Geoboard technique revealed effectiveness of Geoboard in providing adequate structure for in-depth learning of authentic tasks leading to meaningful understanding and hence enhance better performance of Geometry which was perceived as difficult by senior secondary school students. It also demonstrated that Geoboard is a very effective technique for enhancing students' performance in geometry and understanding geometric concepts (Scandrett, n.d.). Scandrett (n.d.) further highlighted that geoboards have the potential to develop students' understanding of measurement, space, and geometry. A study by Sibiya (2020) found that geoboards give learners the freedom to learn on their own and in small groups, while the teacher provides guidance. Sibiya (2019) found that geoboards can be used to construct geometric theorem shapes and explore their relationships. Undoubtedly, geometry is a curious branch of mathematics linked to the real world, as claimed by Bayuningsih et al. (2018). This supports the widely accepted idea that geometric aspects (such as symmetry, perspective, and orientation) are essential to our perception of beauty in art, architecture, and design and are present in much of our cultural life. Knight (2006) asserted that geometry has numerous uses in science and technology, including the building sector, design, and architecture. In addition to giving mathematics a rich background, geometry promotes spiritual and cultural development. Every society's socioeconomic progress, it is argued, depends on geometry. Consequently, the geometrical information and abilities that students acquire are crucial in many fields of development. The development of students' spatial visualization and reasoning depends on their geometry. Spatial visualization involves the formation of semiotic representations and a complete understanding of any relations through training to manage both the full configuration of relations and the figure as a geometric object, according to Kalogirou et al. (2013).

In line with this idea, Ozerem (2012) contended that learning geometry helps students develop a deeper grasp of reality because it strengthens their ability to reason and connects to other areas of mathematics. According to Sollervall (2012), geometrical diagrams are the most effective tools for effective, critical, and creative thinking, whether they are presented with or without accompanying words. This is because they not only help students understand geometrical concepts more quickly, but also make generalizations easier than when using numerical examples. Therefore, according to the theories advanced by these academics, students truly need to strengthen their visual and reasoning abilities, especially in analyzing geometrical diagrams, to comprehend and accurately interpret information conveyed through diagrams. The continued use of teacher-centered methodologies in the instruction of Euclidean geometry in secondary schools is seen as a factor in learning difficulties. More specifically, the employment of conventional teacher-centered methods blames the problems that students face when learning numerous geometrical topics, such as geometric proofs. The use of educator-centered methods in this section of geometry and other concepts has been marked by a number of difficulties because these methods place students in situations where they are seen as rote memorization receptors of mathematical facts, formulas, principles, and theorems (Armah et al., 2018).

II. Material And Methods

The present study aimed to investigate the effect of using a geoboard in teaching plane geometry on the performance of pre-service teachers. A quantitative research strategy was adopted, utilizing a quasi-experimental design –with a combination of designs specifically pre-test and post-test non-equivalent control groups.

Participants: The study population consisted of pre-service teachers enrolled in E. P. College of Education, Amedzofe, and St. Francis College of Education, Hohoe. The total population of pre-service teachers in these colleges was approximately 2800 students. From this population, a purposive sampling technique was employed to select 58 participants (29 in each group) for the study. The selection criteria ensured the representation of pre-service teachers from diverse backgrounds while also considering commonalities within the population.

Design and Group Allocation: Due to practical constraints and the inability to perform a true experimental design, a quasi-experimental design was deemed appropriate (Price et al., 2015). Two groups were formed: the experimental group and the control group. The control group consisted of pre-service teachers who did not receive the intervention (i.e., did not use the geoboard), while the experimental group received instruction using the geoboard as a teaching tool. To ensure minimal disruption to contact hours, the selection of participants was based on intact classes, rather than individual student randomization (Thomas, 2022)

Data Collection Procedure: The study involved a pre-test and post-test assessment to measure the performance of pre-service teachers. Prior to the intervention, all participants (both control and experimental groups) were administered a pre-test to establish their baseline level of knowledge and skills in plane geometry. The pre-test assessed various aspects of plane geometry that aligned with the curriculum. Following the pre-test, the experimental group received instruction using the geoboard as a teaching aid, whereas the control group received traditional instruction without the geoboard. Both groups received an equal amount of instructional time. After the intervention period, a post-test was administered to assess the performance of both groups. The post-test measured the same aspects of plane geometry as the pre-test, allowing for a comparison of performance between the control and experimental groups.

Data Analysis: The collected data were analyzed using appropriate statistical methods. A comparative analysis was conducted to examine the performance differences between the control and experimental groups. This analysis include statistical tests such as ANOVA to determine the significance of any observed differences.

Ethical Considerations: Ethical guidelines were followed throughout the study. Informed consent was obtained from all participants, and their privacy and confidentiality were ensured. The study was conducted in accordance with the ethical standards and regulations governing research involving human subjects

III. Result

An intact class of 29 level 100 students who constituted the control group were taught using the conventional method of teaching after the pretest. The geoboard intervention was introduced for the experimental group after the pretest. Test scores for both sessions were recorded for analysis. Below are the results from the pretest and posttest exercises. A summary of the result is presented in Table 1.

Table 1: Pretest and Posttest Scores of level 100 Students

Group	Pretest	Posttest	Difference
Control	40	63	23
Control	43	67	23
Control	37	60	23
Control	47	70	23
Control	43	50	7
Control	40	40	0
Control	40	47	7
Control	33	37	3
Control	77	57	-20
Control	43	57	13

Control	50	40	-10
Control	60	70	10
Control	60	70	10
Control	57	70	13
Control	43	47	3
Control	43	50	7
Control	40	50	10
Control	50	53	3
Control	73	73	0
Control	37	93	57
Control	57	83	27
Control	67	80	13
Control	67	77	10
Control	40	60	20
Control	33	63	30
Control	30	57	27
Control	63	70	7
Control	40	60	20
Control	73	73	0
Treatment	33	63	30
Treatment	47	73	27
Treatment	50	83	33
Treatment	20	63	43
Treatment	37	73	37
Treatment	57	77	20
Treatment	53	83	30
Treatment	67	100	33
Treatment	47	80	33
Treatment	83	63	-20
Treatment	47	83	37
Treatment	57	93	37
Treatment	50	67	17
Treatment	47	100	53
Treatment	40	87	47
Treatment	37	100	63
Treatment	33	100	67
Treatment	33	97	63
Treatment	37	100	63
Treatment	47	83	37
Treatment	53	93	40
Treatment	67	97	30
Treatment	47	80	33
Treatment	47	57	10
Treatment	43	60	17
Treatment	57	73	17
Treatment	57	63	7
Treatment	57	90	33
Treatment	47	53	7

Analysis of Variance (ANOVA) report for student performance to compare the effectiveness of the two groups. Results are displayed in table two (2) below.

Table 2: Anova: Single Factor analysis summary

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
Control	29	360	12.41379	203.0925
Treatment	29	943.3333	32.52874	373.5359
Table 3: Anova Single Factor analysis				
ANOVA				
Source of Variation	*SS*	*Df*	*MS*	*F*
Between Groups	5866.858	1	5866.858	20.34884
Within Groups	16145.59	56	288.3142	

Total	22012.45	57		

It is evident from the ANOVA analysis table that the mean posttest score for the treatment group (M = 32.52874) was significantly higher compared to the mean posttest score for the control group (M = 12.41379). This finding suggests a notable disparity in the performance outcomes between the two groups. The statistical significance of this difference was assessed through a p-value of 3.35104E-05 (0.0000335104), which is well below the predetermined significance level of 0.05. The p-value represents the probability of observing such a substantial difference in scores by mere chance. In this case, the obtained p-value indicates that there is less than a 0.5% chance that the observed difference in scores is attributable to random variation. Consequently, the results provide robust evidence to reject the null hypothesis and support the presence of a significant relationship between the treatment and the posttest scores. The statistically significant difference in means indicates that the treatment, likely involving a specific intervention or instructional approach, had a substantial impact on the posttest scores compared to the control condition.

It is important to note that these findings imply a strong association between the treatment and the observed outcomes, suggesting that the treatment group demonstrated significantly higher posttest scores than the control group. These results have important implications for understanding the effectiveness of the treatment in influencing the measured variable.

IV. Findings and Discussion

Quantitative data was collected, and Microsoft Excel and also ANOVA: Single factor was used to analyze results. The results of the study showed that the mean score of the treatment group (32.52874) was significantly higher than the mean score of the control group (12.41379). The ANOVA test revealed a significant difference between the two groups, with a p-value of 3.35104E-05. Therefore, the null hypothesis was rejected, and the alternative hypothesis was accepted. The use of a geoboard in teaching plane geometry significantly improves the performance of pre-service teachers. Existing literature supports the findings of the study that the use of a geoboard in teaching geometry improves the performance of learners. A study by Sibiya (2020) investigated the effect of using Geoboards in teaching Euclidean geometry in Grade 11 mathematics learners. The findings revealed that the Geoboard gives learners the freedom to learn on their own and in small groups while the teacher acts as a facilitator. Another study by Mudaly and Sibiya (2018) examined the effects of the geoboard on learner understanding of geometry theorems. The results revealed that Geoboards improved learners' understanding of geometric theorems. Moreover, a study by Kaur, B. (2010) discussed the use of geoboards in primary mathematics. The study found that geoboards were effective in teaching primary geometry and helped learners to develop spatial reasoning skills. Another study by McAuliffe, S. M. (1999) examined the impact of a geometry course on pre-service teachers' understanding of geometry. The study found that the use of manipulatives, such as geoboards, helped pre-service teachers to develop a deeper understanding of geometry concepts. Therefore, the findings of the study that the use of a geoboard in teaching plane geometry significantly improves the performance of pre-service teachers are consistent with existing literature.

Recommendations

Based on the findings of the current study, several recommendations can be made to further enhance our understanding of the impact of geoboards on geometry instruction. Firstly, it is advisable to replicate the study with a larger sample size. By increasing the number of participants, the generalizability of the findings can be improved, allowing for more robust conclusions to be drawn. A larger sample size would also provide a more diverse representation of the population, ensuring that the results can be applied to a broader range of learners.

To gain a comprehensive understanding of the effectiveness of geoboards in teaching geometry, it is recommended to extend the study to other levels of education. This would involve investigating the impact of geoboard-based instruction across learners of different ages, ranging from primary school to higher education. By including participants from various educational stages, valuable insights can be gained into the applicability and effectiveness of geoboards as an instructional tool across a wider spectrum of learners.

In addition to examining the immediate effects, it is crucial to investigate the long-term impact of using geoboards in teaching geometry on learners' performance. Future research should focus on conducting longitudinal studies to assess the enduring effects of geoboard usage. By conducting follow-up assessments over an extended period, researchers can determine whether the benefits observed during the intervention are sustained or diminish over time. Such investigations would provide valuable insights into the long-term sustainability and effectiveness of geoboard-based instruction.

Lastly, it is recommended to investigate the effects of using geoboards on learners' spatial reasoning skills. Spatial reasoning plays a crucial role in geometry comprehension and problem-solving. By extending the study to examine the impact of geoboard usage on learners' spatial reasoning abilities, researchers can gain insights into how this instructional tool enhances learners' spatial thinking and geometric visualization skills. This investigation would further contribute to the overall understanding of the benefits of geoboard-based instruction.

Limitations

It is important to note that this study has some limitations. One limitation is that it used a quasi-experimental design. This means that the researchers did not randomly assign participants to the treatment and control groups. As a result, it is possible that some other factor, such as the students' prior knowledge of plane geometry, may have influenced the results. Another limitation of this study is that it was conducted with a relatively small sample size. This means that the results may not be generalizable to a larger population of pre-service teachers.

Despite these limitations, the findings of this study suggest that the use of a geoboard may be an effective way to improve the performance of pre-service teachers in plane geometry. Further research is needed to confirm these findings and to investigate the mechanisms by which geoboards may improve learning

V. Conclusion

In conclusion, the study investigated the effect of using a geoboard in teaching plane geometry on the performance of pre-service teachers at the E.P College of Education and St. Francis College of Education. The study used a quasi-experimental research design with pretest and posttest scores from level 100 students. The results of the study showed that the use of a geoboard in teaching plane geometry significantly improves the performance of pre-service teachers. The findings of the study are consistent with existing literature that supports the effectiveness of using geoboards in teaching geometry. The study provides evidence that the use of a geoboard in teaching plane geometry is an effective teaching strategy that can be used to improve the performance of pre-service teachers. The study has important implications for mathematics education and highlights the importance of using manipulatives, such as geoboards, in teaching geometry. However, the study has limitations, including the quasi-experimental design. Future research should use a randomized controlled trial design to establish a causal relationship between the use of a geoboard and improved performance. Additionally, future research should investigate the long-term effects of using geoboards in teaching geometry on learners' performance and problem-solving skills. Overall, the study provides a foundation for future research on the effectiveness of using geoboards in teaching geometry

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