VAN Hiele Model And Student Achievement In Mathematics: QUASI-EXPERIMENTAL

Rodel James M. Nasis[1], Lolly Jean C. Simbulas, PhD[2]

[1]University of the Immaculate Conception, Davao City
rnasis_230000000085@uic.edu.ph

[2]University of the Immaculate Conception, Davao City
lsimbulas@uic.edu.ph

ABSTRACT

This quantitative research, specifically a quasi-experimental study utilizing a pre-test-post-test design, aimed to determine the mathematics achievement of Grade 7 junior high school students in Makilala, North Cotabato, using a Van Hiele model to solve geometry problems, specifically polygons. This study used a validated 30-item test questionnaire to determine the level of mathematics achievement in geometry among Grade 7 junior high school students. The study had a total of 74 respondents, with 37 students in the experimental group and 37 in the control group. Mean, standard deviation, t-tests, and Cohen's d were used to analyze the data. The results showed a significant difference between the pre-test and post-test mean scores of students in both groups—control (conventional) and experimental (Van Hiele) groups. Further, the mean gain score of the experimental group (Van Hiele) is higher than the control group (conventional). Lastly, the results indicated that the Van Hiele model method of teaching, utilizing the five phases of teaching, has a positive impact, leading to a large effect on the students' achievement in mathematics, specifically in terms of learning polygons (Cohen's d = 2.94).

KEYWORDS: *Education, Van Hiele, Conventional quasi-experimental, Philippines.*

INTRODUCTION

Globally, mathematics continues to be plagued by poor academic performance specifically on geometry and a general apathy or disengagement among students, and this poor geometric achievement is a significant concern for numerous countries around the world (Chand et al., 2021; Sharma et al., 2018). Geometry is an integrated part of mathematics and a basic mathematical skill (Odoh & Ikyereve, 2016). The importance of geometry as a subject in secondary education in the Philippines is reflected in the K–12 curriculum, which begins in Grade 3 and progresses upward in a spiral development (Adarlo

& Jackson, 2017; Orbe et al., 2018). Unfortunately, despite the significance of geometry and its relevance to human development, students continue to achieve subpar results in this area (Khansila, 2022). In addition, it has been indicated that students fear and hate mathematics, which has resulted in a lack of interest and poor achievement in mathematics, particularly in geometry and measurement (Achor et al., 2017). Students do not understand polygons well (Sulistiowati et al., 2019).

Several research studies conducted in different countries, including Turkey (Yilmaz et al., 2015), the Czech Republic (Haviger et al., 2015), South Africa (Alex et al., 2016), Ghana (Armah et al., 2019) and Malaysia (Hassan et al., 2020), persistently reveal below-average achievement performance of the students in geometry. For instance, Prayito et al. (2019) highlighted the challenges experienced by Indonesian students while learning geometry, similar to those faced by students globally. Moreover, in Slovakia, studies by Pavlovičová et al. (2021) and Gunčaga et al. (2019) have found that students struggle with geometry; specifically, these learners are struggling with their capacity to solve geometric problems, which leads to having a low-achieving geometric performance.

In the Philippines, research conducted by Lumbre et al. (2023) revealed that Filipino students perform worst in mathematics in the field of geometry. Their performance in this field is below the average scale score, making it the only area where they struggled compared to the other fields of mathematics, such as algebra and trigonometry. Likewise, the results of the Programme for International Student Assessment (PISA, 2022), managed by the Organization for Economic Cooperation and Development (OECD), revealed a concerning trend in Filipino students' mathematical achievement, particularly in geometry. Out of 62 countries, the Philippines scored low-average, which is considered a low-performing country in the field of mathematics, specifically in the areas of geometry (Earp, 2023). Additionally, only a few students achieved the mastery level in geometry, specifically polygons, as revealed by Suleiman et al. (2017) in their study on students' geometric achievement, which was also similar to the results of the 2019 National Achievement Test (DepEd, 2019), where students had difficulties in grasping geometric concepts like polygons.

In addition, Siagan et al. (2019) further observed that high school students, in particular, tend to have difficulties in memorizing geometry content, which is mostly the reason for their low mathematical problem-solving abilities.

Moreover, various studies show that Filipino students perform poorly in mathematics in general and in geometry in particular (Azucena et al., 2022; Pentang et al., 2020; Capuno et al., 2019). This indicates that they need to improve when dealing with polygons, specifically on the sizes, shapes, positions, angles, and dimensions of things, among other things (Capuno et al., 2019). In North Cotabato, teachers have been investigating resources that can enhance and level up students' geometric achievement. Geometric innovative instruments provide a platform for learning by allowing students to work with representations, see the results, and make hypotheses; however, conventional methods are employed, and they are ineffective in helping students think more geometrically (Verzosa et al., 2018).

Researchers are constantly looking for methods to improve students' poor geometric achievement. Some educators view the Van Hiele (VH) geometric model as a factor that helps improve students' geometric achievement (Dimla, 2018). In view of this model, research done by Delos Santos et al. (2022) revealed that this model performed better or has established a significant difference compared with other geometric mathematical models. Similarly, Hamzeh et al. (2017), in their study, recommend using the VH model in teaching mathematics, as it gives a significant role in the geometric thinking styles of students. With these findings, teachers may use the Van Hiele model to create lesson plans that will assist students in doing better in mathematics, particularly in geometry (Delos Santos et al., 2022). Several researchers found that there was a significant difference between the VH model and the conventional strategy. Delos Santos et al. (2022) also reported that students' mathematics achievement in polygons will improve after they are exposed to the VH model. Further, the VH model enhances students' geometric understanding, and it has a significant influence on students' mathematics achievement in geometry compared to the conventional approach (Machisi et al., 2021). It was also revealed in the findings of the study of Suglo et al. (2024) that after using the VH model method, the mathematical achievement of the students in geometry, particularly in learning polygons, improved.

Several research projects have addressed those problems. Many similar studies have been conducted using the VH model paired with other variables such as proof writing and justification (Delos Santos et al., 2022), teachers' instructional methods (Schulman, 2023), application of metacognition (Naufal, 2021), and many other related studies. However, a wide gap between conventional geometric teaching and VH models is still an area in the scope of these variables that needs to be studied (Hamzeh, 2017). This study conducted quasi-experimental research to support the geometric achievement of students utilizing the VH model.

This study predominantly dealt with the effectiveness of the VH model among the junior high school (JHS) students. The data gathered in this research will benefit JHS students, teachers, and decision-makers in both private and public schools. The findings of this study can also help the mathematics teachers, which leads to the improvement of the geometric achievement of the JHS students. In preparing the next generation of JHS students, the researcher strongly believes that improving geometric mathematical achievement using the VH model is important for learning any geometric thinking model. Besides, it has some connections to the United Nations Sustainable Development Goals (SDGs), especially in terms of education quality.

The findings of this study can be disseminated through various networks, such as presentations to school or university research, associations of mathematics teachers, policymakers, participation in educational consultations, and publication in peer-reviewed journals to share the knowledge gained with relevant stakeholders. The results of this study can also be shared with a wider audience over diverse educational establishments, encompassing both public and private institutions, with an emphasis on academic success in geometry. These initiatives strive to promote awareness about the advantages of the VH model in improving geometric achievement

Statement of the Problem

1. What are the pre-test mean scores of the experimental group and control group prior to conducting the experiment?
2. Is there a significant difference in the pre-test mean scores between the experimental and control groups prior to the experiment?
3. What are the post-test mean scores of the experimental group and control group after the experiment?
4. Is there a significant difference in the post-test mean scores between the experimental and the control groups after the experiment?
5. Is there a significant difference between the pre-test and post-test mean scores of the control group?
6. Is there a significant difference between the pre-test and post-test mean scores of the experimental groups?

7. What are the mean gain scores of the experimental group and control group?
8. Is there a significant difference between the mean gain scores of the experimental and control groups?

METHODOLOGY

Research Design Procedure. This study used a quantitative approach, specifically a quasi-experimental method, to gather and analyze data. This study utilized a pretest-posttest design, and the dependent variable is assessed both before and after the intervention is employed (Chiang et al., 2015). Consisting of two experiments, both groups are exposed in a conducive environment; the experiment will be conducted on the experimental group employing the VH model while using the traditional method for the control group. The researcher used this research design since he wants to determine whether there is a significant difference in the levels of geometric thinking of both groups after being exposed to different levels of geometric thinking styles in the experimental group and the traditional type of teaching in the control group. There was a pre-test and a post-test. Finally, the intervention was commenced, and it is composed of ten (10) sessions. After the tenth session, the post-test was given. In this study, Van Hiele's model served as the treatment for the experiment.

Respondents. The study involved seventh-grade students attending a private junior high school, precisely those who enrolled in the First Quarter of the S.Y. 2024-2025. The respondents were heterogeneous, divided into two groups: the experimental group, which underwent the VH model, and the control group, implementing the conventional approach. In addition, the respondents of this study were those students who were experiencing difficulties in learning geometry, as shown in the latest math examinations done by the school. In addition, Grade 7 students have been selected as respondents since geometry topics were incorporated primarily based on the learning competencies of the Department of Education.

Research Instruments. The research instrument of this study was a researcher-made test, which is a multiple-choice test, consisting of topics in geometry such as polygons, properties of regular and irregular polygons, measure of each interior angle in a regular polygon, and calculating total interior angles of any polygon, which are lessons taught in the First Quarter of the S.Y. 2024-2025. The research instrument underwent a validation by expert validators in the field, and their suggestions were integrated into the instrument. To secure the validity and reliability of the results, the questionnaire underwent pilot testing. Further, to determine the level of mathematics achievement of students, the mean scores were calculated and aligned with the guidelines outlined in DepEd Order No. 8, s. 2015.

Data Gathering Procedure. In carrying out the study, the researcher sought permission from the University of Immaculate Conception through the Dean's office to conduct the study. Ethical clearance was obtained from the University of the Immaculate Conception Research Ethics Committee (UIC REC) to guarantee adherence to ethical standards throughout the study. Approval and authorization to conduct research involving respondents from the particular school were also obtained from the school administration. This process involved the school principal issuing a resolution, which the institution's executive director authenticated and endorsed.

Following the administration of the pretest, the researcher then started the conduct of intervention. The researcher also prepared lesson plans and a table of specifications based on the syllabus, instructional materials, and other supporting tools. There were a total of ten sessions for the experiment employing the VH method. Each group was taught five days a week, i.e., one period a day, and each period will last for 60 minutes, including the preliminary activities.

After the ten sessions following the pre-test, the researcher gave the same set of test items as the post-test to both groups, which lasted for 60 minutes. This step is to make sure of the validity of the results of the study. Moreover, the researcher personally checked the post-test. The data were gathered, sorted, analyzed, and then interpreted in a confidential manner using statistical methods. The performance of the groups was compared to see how effective the VH method was in improving students' mathematics achievement in learning geometry, specifically in the concept of polygons. Finally, the results were drawn to develop the conclusion and recommendations in preparation for the ultimate presentation

Statistical Analysis. The subsequent statistical methods were used in this Study. **Mean.** This method was used to determine the mathematics achievement of the Grade 7 JHS students. **Standard Deviation.** This was used to determine how the scores for the mathematics achievement, specifically on polygons, among Grade 7 junior high school students spread out from the average score. **Independent Sample t-test.** This method was used to see if there is a significant difference between two data sets, specifically on the Conventional Strategy and VH model. It helps to determine if the scores of the same group of students improve over time. **Paired Sample t-test.** The paired sample t-test compared two distinct groups. This helped the researcher determine whether the conventional teaching strategy and VH model positively affect students' mathematics achievement before and after the intervention. **Cohen's d Effect Size.** A large effect size indicates that a research finding has real-world importance, while a small effect size suggests it has limited practical use. It determines the difference between the means of two groups divided by the weighted pooled standard deviations of the VH Model and the conventional strategy.

RESULTS AND DISCUSSION

Pre-test Mean Scores of the Experimental and Control Groups

Conferred in Table 1 are the pre-test mean scores of the experimental and control groups. Both the control and experimental groups have a very low level of achievement. The pre-test mean score of the control group was obtained as 9.67, or 32.25 percent of correct answers, with a standard deviation of 2.48, while the experimental group got 9.35, or 31.17 percent of correct answers, with a standard deviation of 3.51. Both groups were described as very low and did not meet expectations. The result implies that the academic achievement of students in learning polygons did not meet expectations.

This demonstrates that students at this level have established a very low level of achievement in understanding geometric concepts, specifically polygons, where they lack a basic conceptual understanding of the fundamental properties and definitions of polygons in general. In addition, the standard deviation of the control and experimental groups is 2.48 and 3.51, respectively, indicating that the control group has more clustered responses than the experimental group.

Table 1

Pre-test Mean Scores of the Experimental and Control Groups

Groups	Mean	Percent of correct answers	SD	Description
Control (ConventionalStrategy)	9.67	32.25	2.48	Very Low
Experimental (Van Hiele Method)	9.35	31.17	3.51	Very Low

The pre-test results coincide with the study of Simbulas et al. (2023), which revealed that students' mathematics achievement in geometry is low. This means that students possessed minimum knowledge and skills and core understanding of geometric concepts. Similarly, Chaudhary (2015) also reported in his study that there was insufficient understanding of preliminary tests in geometry, specifically regarding polygon concepts and shapes. Students at this level are lacking understanding on the topic.

Significance of the Difference in the Pre-test of Experimental and Control Groups

The difference between the pre-test mean scores of the experimental (VH method) and control group (conventional method) was tested at an alpha level of 0.05. Presented in table 2, the p-value is 0.616, which is greater than 0.05 with a t-value of -0.505. This indicates that the experimental and control groups had similar levels of understanding about geometry, particularly polygons, before the study started. Further, this demonstrates that the conventional method group and the VH model group have comparable levels of knowledge and understanding in the topics of polygons before the conduct of the study. The findings are parallel with the result of Usman et al.'s (2020) study, which investigated the mathematics achievement of the students in geometry, specifically on polygons, using the VH method. They found that the pre-test achievement of students in both the conventional and VH models showed no significant difference.

Table 2

Significance of the Difference in the Pretest of Experimental and Control Groups

Groups	t	p-value	Remarks
Control (Conventional method) Experimental (Van Hiele method)	-0.505	0.616	Not Significant

Post-test Mean Scores of the Experimental and Control Groups

Table 3 illustrates the mean scores of the experimental and control groups after the experimental model method and conventional method were implemented. It is apparent that the control group has an average score of 15.05, or 43.01 percent correct answers, which is labeled as very low, implying that the students' academic achievement in solving polygons did not meet expectations. It shows that the respondents at this level have established basic abilities and core concepts in polygons and can evaluate and interpret the properties of polygons. In addition, the standard deviation is 3.09, leading to quite dispersed responses.

The results were affirmed by the study of Doorman (2022), which pointed out that the conventional method of teaching assists students in understanding concepts of polygons and even the most difficult mathematical procedures through board works, seat works, teamwork, and inquiry, which improves their academic achievement in solving polygon problems. In addition, San et al. (2018) support this finding by claiming that a conventional teaching strategy is an effective method to enhance success in mathematics education. Furthermore, this finding is confirmed by Nwoke (2015), which stated that the conventional teaching approach acknowledges effective learning experience through a series of activities like seat work and inquiry-based activities.

Similarly, Table 3 shows that the experimental group scored an average of 23.65, which translates to 67.57% correct answers. This score is considered low and indicates that the students have achieved a fairly satisfactory level of understanding in learning polygons. It proposes that the students in this group have developed a profound understanding of the properties of polygons, along with strong skills and knowledge. In addition, the standard deviation is 3.82, showing quite dispersed responses.

Table 3

Post-test Mean Scores of the Experimental and Control Groups

Groups	Percentage	Percentage	SD	Description
Control (Conventional method)	15.05	43.01	3.09	Very Low
Experimental (Van Hiele method)	23.65	67.57	3.82	Low

The finding concurs with the study of Naufal et al. (2021), which stated that using the VH method in teaching geometry, specifically on polygons, can result in a better understanding of various geometric concepts and can elevate students' mathematics achievement levels by enhancing geometric thought and geometric thinking. Also, the findings are in accordance with the study of Delos Santos et al. (2022), which asserted that students can better understand polygons and other geometric mathematical relationships when they are presented with Van Hiele's phases of teaching.

Significance of the Difference between the Post-test Mean Scores of the Experimental and Control Groups

Presented in Table 4 are the mean scores on the post-test for both the group that learned with the VH model and the group that learned with the conventional method. The difference in post-test scores between the experimental and control groups was tested for significance at a level of 0.05. The t-test result was 10.91, which means the experimental group significantly outperformed the control group. The p-value was less than 0.001, which is smaller than the significance level of 0.05. This means that the difference in post-test scores between the two groups was statistically significant. In simple terms, the group that was taught using the VH model did much better on the post-test compared to the group that was taught using the conventional method. This suggests that the VH model had a positive effect on learning geometry, leading to the highest test scores.

Table 4

Significance of the Difference between the Post-test Mean Scores of the Experimental and Control Groups

Groups	t	p-value	Remarks
Control (Conventional Strategy) Experimental (Van Hiele method)	10.9	<.001	Significant

The results are congruent with the study of Alex (2016), which revealed a great difference between the mean achievement of the students in learning polygons using the conventional and VH models. He pointed out that using the VH method for instruction has a positive influence on improving students' thinking levels associated with the conventional teaching methods. He also emphasized that the application of the model in teaching to student learning demonstrates that the VH model improves students' understanding, comprehension, and critical thinking skills to solve geometric problems, particularly on polygons. They conclude that using five phases of teaching students were actively engaged.

Significance of the Difference between the Pre-test and Post-test Mean Scores of the Control Group

The analysis revealed a t-value of -10.23, indicating that students' post-test scores were significantly higher than their pre-test scores, and it is very large, showing the difference between the groups, which is much greater than what would be expected by chance. This result demonstrates a substantial improvement within the control group throughout the study. The analysis revealed a p-value that is smaller than 0.001, which is far below the standard cutoff of 0.05. This indicates a statistically significant difference between the control group's scores before and after the intervention. This suggests that the intervention had a noticeable impact on the control group. Specifically, the control group students showed a significant improvement in their geometry scores, particularly in their understanding of polygons, between the pre-test and post-test. This implies that using the conventional strategy helped them better understand and perform better in a polygon.

Table 5

Significance of the Difference between the Pre-test and Post-test Mean Scores of the Control Group

Control Group	t	p-value	Remarks
Pre-Test Post-Test	-10.23	<.001	Significant

The outcome confirms the study of Delos Santos et al. (2022), which revealed a significant difference in the pretest and posttest scores of the control group when exposed to the conventional strategy. It was also reported that students' mathematics achievement in polygons will improve after being exposed to the conventional strategy.

Moreover, the results coincide with the study of Doorman (2022), which introduced the effects of the conventional strategy. It was found that the pretest and post-test scores of the students vary significantly after the intervention of the conventional strategy. In addition, the outcome suggests that the conventional strategy improves the academic achievement of the students and enhances their success in mathematics education.

Significance of the Difference between the Pre-test and Post-test Mean Scores of the Experimental Group

Table 6 highlights the change in average scores for students in the experimental group who used the VH model. Table 6 results revealed that the t value is equivalent to -19.31, indicating that the scores of the students in the pre-test are lower than the post-test scores. It denotes a substantial improvement in the scores of the experimental group from the beginning to the end of the study. Additionally, the experimental group showed a statistically significant improvement from pre-test to post-test.

Table 6

Significance of the Difference between the Pre-test and Post-test Mean Scores of the Experimental Group

Experimental Group	t	p-value	Remarks
Pre-Test Post-Test	-19.31	<.001	Significant

The p-value was less than 0.001, indicating a very low probability of it happening by chance is less than 0.001, far below the common threshold of 0.05 for significance. This indicates that the treatment had a noticeable effect on the experimental group. Moreover, the data shows that the experimental group students had different scores in geometry, especially in polygon concepts, before and after the study. This suggests that the VH model had a significant impact and helped improve the students' understanding of geometry, particularly in polygons.

The results coincide with the study of Yalley et al. (2021), which showed that the pre-test and post-test scores of the students differed significantly after implementing the VH model in the classroom. The students' mathematics achievement in geometry, specifically on polygon problems, after the intervention lesson utilizing the VH model is higher than before the intervention lesson in terms of knowledge, comprehension, and academic performance.

Additionally, the study showed that the experimental groups' scores improved significantly after using the VH model. This indicates that the model promoted active learning in the classroom and was effective in teaching polygon concepts.

Further, the result concurs with the study of Adeniji et al. (2022), which found that using the VH model significantly improved scores from the pre-test to the post-test. This suggests that the VH model is effective in helping students gain both theoretical and practical knowledge when learning about polygons.

Mean Gain Scores of the Experimental and Control Groups

Table 7 revealed that both the control and experimental groups improved their scores. However, the experimental group, which utilized the VH model, demonstrated a substantially larger mean increase of 14.30 with a standard deviation of 3.72.

Table 7

Mean Gain Scores of the Experimental and Control Groups

Groups	Mean	Standard Deviation
Control (Conventional Strategy)	5.38	2.15
Experimental (Van Hiele Method)	14.30	3.72

In contrast, the control group's mean improvement was only 5.38 with a standard deviation of 2.15. Therefore, the VH model appears to be a beneficial tool for learning about polygons. The mean gain score, which measures the average improvement between the pre-test and post-test, was higher for the experimental group than the control group. Furthermore, the experimental group's scores are more consistent. This suggests that the VH model was more effective in enhancing student learning than the conventional method used with the control group.

The improved scores suggest that the specific teaching methods, techniques, or curriculum implemented with the experimental group led to significant improvements in student learning. The findings are following the study of Delos Santos et al. (2022), which highlighted that the VH model was more effective than the conventional method in enhancing geometric understanding. In addition, the VH model is particularly effective for teaching geometry, especially for students with diverse learning needs, as it offers a range of engaging geometric experiences.

Further, this outcome follows the statement of Ramlan (2018), stressing that one of the most appropriate alternative instructional approaches for assisting students' understanding and solving geometry problems is the Van Hiele model method. It was explained that allowing students to solve geometric problems and understand geometric reasoning concepts based on Van Hiele's levels of teaching approaches gives a higher post-test achievement.

Consequently, the findings validate Van Hiele's (1959) Geometric Thinking Theory since the Van Hiele Model principles are taught using five phases of teaching strategies with tangible, authentic materials in facilitating learning. Van Hiele (1959) believed that students' ideas about geometric thought can be organized into hierarchical levels, which guide them in comprehending geometric thinking and fully equipping them with the necessary geometric skills for learning polygons, including regular and irregular polygons, sides, and angles. It was manifested in this study that the Van Hiele Model was designed to encourage critical thinking skills, problem-solving, and collaboration, where students actively engage from one level to the highest level of geometric thought. With this approach, students' exposure to active exchange of ideas and a supportive environment accelerated their mathematics achievement.

Significance of the Difference between the Mean Gain Scores of the Experimental and Control Groups

Table 8 demonstrates the difference between the mean gain scores of control and experimental groups and shows that the mean gain scores of control and experimental groups have a computed t-value of 13.55. The t-value indicates that the score of the Conventional Strategy group is lower compared to the Van Hiele group and has a substantial difference between the groups. Further, the p-value of <.001, which is still less than the 0.05 level of significance, implies that the difference between the mean gain scores of experimental and control groups is significant. This study demonstrates that the mean gain scores of the experimental group differed significantly from those of the control group before and after the experiment.

Table 8

Significance of the difference between the Mean Gain Scores of Experimental and Control Groups

Groups	t	p-value	Remarks
Control (Conventional Strategy) Experimental (Van Hiele Method)	13.55	<.001	Significant
Effect Size	2.94		Large Effect

Further, the findings of the study imply the effectiveness of using the VH method as an innovative approach in improving students' mathematics achievement in geometry problems, specifically in polygon problems.

The study's findings were also congruent with the study of Rizo (2016), which found that the experimental group utilizing the VH model performed significantly differently from the control group on the post-test mean gain score. It was asserted that the VH model improved student achievement, reasoning skills, learning strategies, problem-solving strategy recognition, and mindsets toward resolving geometry word problems. It was also emphasized that the VH model enables students to enhance their understanding of various mathematical concepts.

Further, the outcome coincides with the study of Machisi et al. (2021), which claimed that the VH model enhances students' geometric understanding and that it has a significant influence on students' mathematics achievement in geometry compared to the conventional approach. The study revealed that the mean gain scores of the VH model vary significantly from the procedural approach.

Similarly, Armah et al. (2017) investigated the development of contextualizing geometry problems using the Van VH model method in pre-service teachers and discovered that the method was an effective strategy and had a positive impact on the mathematics achievement of the students in geometry compared to the conventional approach. Moreover, the findings concur with the statement of Aliyu et al. (2024) that incorporating the VH model in solving geometry problems, particularly in polygon problems, improves students' mathematics achievement and is significantly better than the conventional or traditional approach of teaching.

Moreover, the effect size (Cohen's d) is calculated as the difference of the means of two groups divided by the weighted pooled standard deviations of these groups. Table 8 presents the effect size of the control and experimental groups, which is 2.94 and is labeled as a large effect. The large effect size indicates that the experimental group's intervention or treatment had a significant impact on the outcome measure. It means that the VH model made a noticeable and significant difference when compared to the control group, which is the conventional strategy. In addition, this result signifies that the VH model has a significant impact on the mathematics achievement of the students in geometry, particularly in polygon problems.

Consequently, this result affirms the theory of Van Hiele (1959) that effective teaching strategies through the five phases of the VH model, which include inquiry, directed-orientation, explication, free-orientation, and integration phases, could help improve learners' achievement and performance in learning geometry, specifically concerning the concept of polygons. The findings also align with Jean Piaget's constructivist learning theory (1964), which posits that students actively build their knowledge by expanding upon their existing experiences and cognitive structures. Thus, students form thoughts and ideas about the world through their experiences and by reflecting on them with experiential learning in the context of using the VH model to develop students' geometric mathematical achievement. On the other hand, the OECD

(2019) stated that test scores of students' math skills have been declining over time, specifically in geometry. Therefore, effective teaching methods, techniques, and strategies could help students achieve mastery in geometry systematically, supporting their academic excellence (PISA, 2022).

The result shows that the students at this level have developed a basic or limited understanding of polygons, specifically on the properties of a polygon and solving its angle, and were still demonstrating some level of academic achievement that was seen as decent or acceptable in the context of their starting point. Moreover, there is no significant difference in the average scores of the pre-test between the experimental and control groups. This shows that, prior to the study, both the Conventional Strategy group and the VH model group had similar levels of understanding of polygons. This finding concludes that students in both methods have the same learning capabilities, evidently having a minimum level of understanding in learning about polygons. Further, the post-test mean score of the experimental group is low, which means that the students' academic achievement in learning polygons is fairly satisfactory. This result demonstrates that the respondents at this level have improved their understanding of polygons and demonstrated good results after receiving the intervention. Also, the post-test mean score of the control group is very low, which implies that the students' academic achievement in understanding polygons in the control group did not meet expectations. It shows that the respondents on this level did not master the fundamental knowledge and core concepts of polygons, such as the properties of polygons and angles.

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