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Proposed Project-Based To Enhance Students' Performance in Contextualized Geometry Test

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ABSTRACT: This study explored the relationship between Van Hiele levels and students' performance in a contextualized geometry test of 72 grade 9 junior high school students at Sinalhan Integrated High School, during the School Year 2024-2025, 32 male and 40 female. The Van Hiele model was adopted in this study to determine the geometric thinking skills of the respondents. Two instruments were used in this study. The Van Hiele Geometry Test was used to determine the Van Hiele level, while the Contextualized Geometry test was used to determine the geometric performance. A quantitative correlational research design, employing a descriptive method, was utilized to evaluate the relationship between Van Hiele levels and students' performance on the Contextualized Geometry Test. The statistical analysis revealed that the Van Hiele level of the respondents was positively correlated to their geometric performance, having an r-value of 0.27. The relationship between Van Hiele level and the students' performance in the contextualized geometry test was also found to be significant using Spearman Correlation Rank (Spearman's Rho), with a p-value of 0.022 at the 0.5 significance level. This suggests that the higher the students' Van Hiele levels, the better their performance in the Contextualized Geometry Test. The study also found that the majority of the respondents were at lower levels of Van Hiele geometric reasoning, mainly Visualization (51.4%) and Analysis levels (29.2%), and only a few of them had attained the higher levels of Van Hiele geometric reasoning, Informal Deduction (5.6%), Formal Deduction (4.2%), and Rigor levels (9.7%). Meanwhile, their performance level through the contextualized geometry test revealed that they primarily scored at Analysis (44.4%) and Informal Deduction levels (43.1%) of Van Hiele. And the rest had attained a higher level of Van Hiele, the Formal Deduction level (12.5%). Additionally, the students' overall performance in the contextualized geometry test was interpreted as below average, with a mean score of 10.38 and a standard deviation of 3.902. This study highlights the importance of enhancing students' geometric reasoning skills to improve their performance in contextualized geometry tasks.

I. INTRODUCTION

Mathematics is essential to our daily existence, encompassing academic disciplines and all aspects of life. We need it for everything from the simplest to the most challenging tasks. It is also an essential element of the curriculum because it not only focuses on problem-solving but also improves our knowledge and mathematical ability as individuals. Of its high boughs, geometry is emblazed- its forms and figures, its lines and problems, its proportion and order. As students develop knowledge of geometry, the Van Hiele model can be used to describe the development of their cognitive level. The stages in this hierarchical framework—visualization, analysis, informal deduction, formal deduction, and rigor—reflect the many ways in which students understand geometric ideas and connections. Geometry is about more than solving spatial puzzles—it provides the critical thinking that students need to thrive in life.

However, despite being explained more about mathematics and the critical proof, some students preferred something else to this subject. Research surveys said that 77% of the students responded that they knew mathematics, but it was not their most preferred subject (Aguilar, 2021). While it is true that mathematics serves as an essential tool in our lives, it is unfortunate to observe that students find it difficult to learn mathematics and dislike it. According to the article "Why so many students hate math (And how to fix it)," some students despise math because they find it boring. They exhibited less enthusiasm for statistics and formulae than history, physics, languages, and other areas with which they may resonate more emotionally. They regarded mathematics as abstract and irrelevant figures that were difficult to comprehend. They believe that mathematics is a tedious topic that requires complex formulas to learn. They might frequently be asked, "Why should we learn mathematics? Knowing the four major operations is sufficient, and the others are no longer required." Because of their perspective, they did not see or value the fundamental substance of Mathematics, particularly when learning Geometry.

In the Philippines, Lumbre et al. (2023) cited Capate and Lapinid's (2015) study, which revealed that students a year after the launch of K to 12 Mathematics implementation had limited geometry achievement and critical problem-solving skills due to incorrect application of formulas and properties. Furthermore, during the Philippines' second participation in the Organization for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA) in 2022, Filipino students remained among the world's lowest in math, reading, and science, with the most recent test scores showing no significant improvement over the country's performance in 2018. The Philippines increased its mathematics score from 353 in 2018 to 355 in 2022, according to the PISA 2022 highlight, a two-point gain. Filipino students attained at least the basic or baseline level of proficiency in mathematics, labeled in the report as level 1 proficiency (Chi, 2023). According to PISA, level 1 in the six competence levels occurs when students can answer questions about basic ideas, solve routine problems, and complete basic operations. This level is much below what is expected of them, which is level 3, according to OECD average scores. At Level 3, students may use basic problem-solving abilities and procedures, understand representations, and reason directly (skills learned if just geometry ideas are mastered).

Geometry is a mathematical subject that analyzes forms, figures, and spatial relationships. It studies the radii of lines, segments, triangles, angles, and circles. Geometry may help young people thrive in school by improving their problem-solving abilities, deductive and inductive reasoning, and logical thinking. Geometry is widely considered an essential component of mathematics that students must learn to acquire spatial thinking and problem-solving skills. Despite its importance, many students require assistance with geometric ideas, which can have a detrimental influence on their overall mathematical performance. Math educators have also sought to identify the major challenges in secondary school math. Despite these significant efforts, the problem of inadequate mathematics achievement persists. The poor performance of students in geometry, in particular, is a big concern for mathematics educators. To address these issues, educators and scholars have investigated a variety of theoretical frameworks, one of which is the Van Hiele model of geometric reasoning.

Table 1. Van Hiele Model of Geometric Reasoning

Level	Description	Ability of Student
0	Visualization	Describes shapes on the basis of their appearance
1	Analysis	Describes shapes on the basis of their properties
2	Informal Deduction	Recognizes the importance of properties and the relationships among them, which assist students in logically ordering the properties of the shapes
3	Formal Deduction	Attains logical reasoning ability and proves theorems deductively
4	Rigor	Establishes and analyzes theorems in different postulation systems

Dina van Hiele-Geldof and Pierre van Hiele, Dutch educators, devised the Van Hiele model, a hierarchical method for geometry knowledge. It was divided into five levels: visualization, analysis, informal deduction, deduction, and rigor. Students at Level 0 know shapes based on their appearance, while those at Level 1 understand attributes and descriptions. At Level 2, students understand the relationships between characteristics and shapes. Next is level 3, where students know how to follow logical arguments and the significance of definitions and theorems. Lastly, at level 4, they may work with a variety of geometric systems and understand the core concepts.

Van Hiele's levels of geometric cognition provided a framework for examining how students learn geometry. These levels represented a transition from fundamental visualizing to advanced logical thinking.Contextualized Geometry Tests, on the other hand, use real-world events and geometry applications in everyday life. Math teachers employed contextualization, which focuses on students' experiences and local resources, to deliver lessons more effectively, resulting in a deeper understanding of themes and allowing students to build their meaning and understanding. (Reyes et al., 2019).Van Hiele (1959) highlighted the critical issue in traditional mathematics education. According to him, the learners learned mathematical relations by rote without understanding their origins. As a result, the relational system was a separate construction that had no bearing on the child's previous experiences. This indicated that the student only understands what has been taught to him and what can be extrapolated from it. He has not learned how to link the system and the sensory world. He will not know how to apply his learning in a new setting.

This issue motivated the researcher to conduct a study about the relationship between Van Hiele Levels and students' performance in Contextualized Geometry Test, aimed to enhance educational outcomes, identify learning gaps, improve teacher training, promote equity, and contribute to educational theory that can helped the researcher and educators to have significant perspectives that mold efficient pedagogical approaches and bolster students' achievement in geometry.

Theoretical Framework: This research study was anchored to Pierre and Dina van Hiele's model, the Van Hiele Theory of Geometric Thought. This theory described how students understood and learned geometry through five hierarchical levels of thinking: Visualization, Analysis, Informal Deduction, Formal Deduction, and Rigor. The Van Hiele model was established by Dutch educators Dina van Hiele-Geldof and Pierre van Hiele. The Van Hiele levels theory describes how students hierarchically understand geometry. There are five levels, each representing a different way of thinking about geometric concepts:

Level 0: Visualization: First, the learners identify shapes and things by their look rather than their attributes. For instance, they can identify a square because it looks like a square, not because of its defining properties.

Level 1: Analysis: Second, the students start to recognize the properties of shapes and can describe them. They understand that a square has four equal sides and four right angles but do not yet understand the relationships between different properties.

Level 2: Informal Deduction: Students can learn about the relationships between qualities and shapes. They can follow logical arguments and understand definitions and theorems. For example, children can see why all squares are rectangles and not all rectangles are squares.

Level 3: Deduction: Students can then develop formal proofs and grasp the structure of a mathematical system. They can deal more abstractly with axioms, definitions, and theorems.

Level 4: Rigor: At this level, students may work with various geometric systems and comprehend the effects of shifting axioms. They can also understand the fundamental ideas of geometry and compare and contrast various systems.

The main characteristics of these levels were their sequential and hierarchical nature, which means that they were learned in a specific order during the learning process. The researcher believed that for the learner to perform well in geometry, they should undergo these levels until they master geometry. It was also anchored on constructivist learning theory, which stated that learners construct new knowledge by building upon their existing understanding. This theory proved that learning was an active process where students make sense of information based on their experiences. In the context of geometry, students build their understanding through active engagement with geometric concepts and problems. The researcher also believed that to master geometry, the learners must construct their knowledge of geometry through experiences and instructions.

Conceptual Framework: The conceptual framework of the study was the IV-DV Framework as shown on the next page. This framework was based on the Van Hiele Theory of Geometric Thought. The theory stated that the students must pass through each level sequentially to have a thorough understanding of geometry.

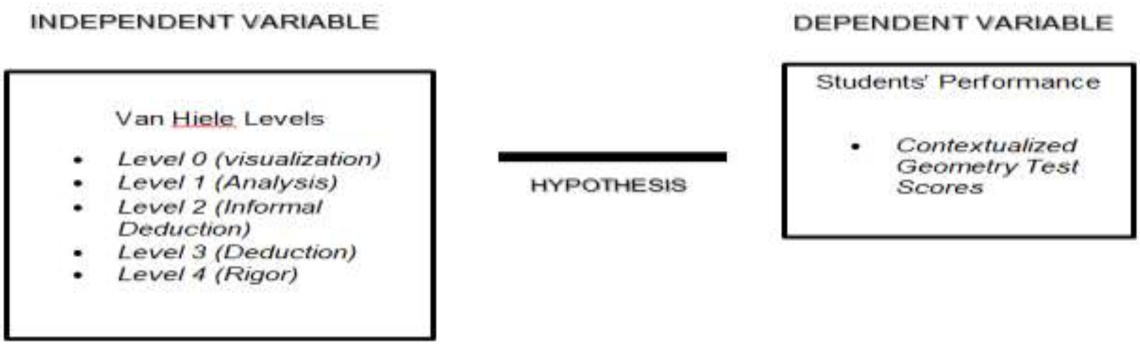

Figure 1. Research Paradigm

The first frame enumerated the independent variable. The independent variable in this study was the Van Hiele Levels of geometric understanding. It outlined the five levels as follows: Level 0 (visualization), Level 1 (Analysis), Level 2 (Informal Deduction), Level 3 (Deduction), and Level 4 (Rigor).The box at the right was the dependent variable. It represented the students' performance based on their scores in the Contextualized Geometry Test. The arrow from the independent variable box to the dependent variable box was the hypothesis. It indicated the hypothesis had a positive relationship, suggesting that having a higher Van Hiele level means the students performed better in the Contextualized Geometry Test.

Research Questions : The study aimed to determine the relationship between Van Hiele levels and students' performance in the Contextualized Geometry Test, particularly for grade 9 students at Sinalhan Integrated High School in Santa Rosa City.

Specifically, it sought to answer the following questions:

1. What is the Van Hiele level of performance among student respondents?
2. What is the level of geometric performance of the students as revealed by their Contextualized Geometry Test during their third quarter?
3. Is there a significant relationship between students' Van Hiele levels of performance and their performance in the Contextualized Geometry Test?
4. Based on the results of the study, what output can be proposed?

Hypothesis of the Study

The null hypothesis (H0) was tested in this study.

(H0). There was no significant relationship between students' Van Hiele levels and their performance in the Contextualized Geometry Test.

Scope and Limitations of the Study : This study explored the Relationship Between Van Hiele Levels and Students' Performance in Contextualized Geometry Tests. The respondents were grade 9 students currently enrolled in the 2024 - 2025 school year, and the study was conducted at Sinalhan Integrated High School in Santa Rosa City, Laguna. This study was conducted during the third quarter of the school year 2024 – 2025. The Van Hiele levels were assessed using the Van Hiele geometry test designed by Usiskin (1982), and their performance in geometry was measured through a contextualized test that reflects the real-world applications of geometric concepts. The Contextualized Geometry Test was aligned to the third quarter topics based on the Most Essential Learning Competencies (MELCS) for Grade 9 Math. The Grade 9 Math for the third quarter focuses on quadrilaterals and triangles, and these topics were also subtopics of Geometry. A documentary analysis was utilized to gather the data needed. The results of the Van Hieles levels of the geometric test and Contextualized Geometry Test were used as data sources.

Significance of the Study : This study would benefit mathematics teachers, students, school administrators, curriculum planners, and future researchers.

Teachers. The findings in this study could help them develop more effective teaching techniques or strategies appropriate for their students' geometric thinking levels. They might also provide suggestions on addressing the problems they faced in mathematics education in junior high school.

Students. They were the end-beneficiaries of this research. Based on its findings, implementing appropriate teaching styles would significantly affect their geometry comprehension and performance.

School Administrators. This study might enlighten them on ways to help their mathematics teachers use successful geometry teaching techniques and provide professional development for mathematics educators. They might also use this research to create intervention programs to bridge students' learning gaps in geometry if deemed necessary.

Curriculum Planner. Through this study, they might get information to build geometry curricula that better support the students' progression through the Van Hiele levels. They might serve as the basis for drafting the next curriculum for the Philippine educational system.

Future Researcher. They might use this study as a source of both conceptual and research literature when they conduct their studies related to the topic. This could also serve as a platform for the efficacy of various instructional techniques in geometry.

Definition of Terms : The following concepts were described conceptually and operationally to help with clarification and comprehension of the terminologies used in this study:

Contextualized. This refers to the educational approach connecting the academic content to real-world situations, scenarios, and experiences.

Contextualized Geometry Test. This test was designed to measure the students' understanding of geometry within a real-world or meaningful context. It evaluated how well students could apply geometric concepts to solve practical problems.

Correlation. This referred to the relationship between students' performance in the Contextualized Geometry Test and their Van Hiele levels.

Students' Performance. This referred to the output or results of respondents' scores in their contextualized geometry test.

Van Hiele Levels. This referred to the theory developed by Pierre Van Hiele and Dina Van Hiele-Geldof, describing the five levels of geometric thinking. Each level represented a different way of understanding and reasoning about geometric concepts.

Van Hiele Levels Geometry Test. This standardized test was designed to measure the Van Hiele levels of the respondents. This test was originally from Zalman Usiskin.

II. REVIEW OF LITERATURE AND STUDIES

This chapter focuses on the literature surrounding the relationship between Van Hiele levels and students' performance in geometry. It explores various studies that have investigated geometric thinking and understanding as described by Van Hiele, as well as the methodologies and findings of these studies, which provide a foundation for understanding how these levels of geometric thought impact students' ability to perform in contextualized tests.

Conceptual Literature

Van Hiele Model of Geometric Thought. The van Hiele model was a widely used starting point for developing geometry curricula (Pavlovičová & Bočková, 2021). This model consisted of hierarchical levels of geometric understanding (Usiskin, 1982) as mentioned by Lumbre et al. (2023): Visualization, Analysis, Informal and Formal Deductions, and Rigor. Level 0 (Visualization) students discerned geometric shapes using complex visual awareness, with shape orientation being the most critical component. Level 1 (Analysis) taught students about the characteristics of geometric shapes, but not how they relate to one another. Level 2 (Informal Deduction) taught students about the links and organization of geometric shape features. Level 3 (Formal Deduction) taught students the necessity of a logical geometric system, deduction principles, position and postulate tasks, sentences, and definitions. Level 4 (Rigor) taught students how to compare axiomatic systems and explain how adding or removing postulates changes the system. Students could employ a range of proofs and comprehend the standard components of deduction. Research indicated that students' geometric thinking abilities could be assessed and improved using this paradigm (Moyer, 2021).

Contextualized Learning in Geometry. Contextualized learning, which incorporates real-world applications into the learning process, was a very effective way of teaching geometry. Contextualized learning helped students appreciate the significance of geometry by presenting problems in real-world contexts, improving motivation and engagement. This method made geometry more understandable and encouraged students to apply their geometric reasoning skills to real-world problems, reinforcing their learning and reducing the gap between academic principles and practical application (Lumbre et al., 2023). Furthermore, Wang et al. (2017) as cited by Lorbis (2019) defined contextualization as a training technique that links basic skills to academic or vocational issues. This method involved embedding basic skills education into subject matter courses, offering companion courses that contextualize basic skills courses, or teaching knowledge and skills through real-world applications.

Research Literature

Van Hiele Model in Geometry Education. Research showed that the Van Hiele model effectively taught geometry, especially for students with different learning needs (Santos et al., 2022). Thus, instruction utilizing the Van Hiele model was a successful technique for teaching Geometry and a viable alternative to the traditional approach. As a result of the existence of numerous geometric experiences, this method was appropriate for teaching Geometry, particularly to children with diverse learning requirements. Moreover, this instructional model improved students' achievement in geometry compared to traditional teaching methods (Yalley et al., 2021). It indicated that using the Van Hiele model in teaching can identify the student's progress from lower to higher levels of geometric understanding. Therefore, their study recommended that teachers assess students' geometric thinking skills before instruction; the Van Hiele learning and instructional model could be used to build curricula and teach geometry and other areas of mathematics.

Several studies also showed that the Van Hiele approach improved students' grasp of geometry. According to Hassan et al. (2020), geometric thinking (GT) skills were critical to the mathematics curriculum. Their study emphasized that using technology-based methods combined with Van Hiele phases significantly impacts developing geometric thinking skills, specifically on Sketchpads. Moyer (2021) also supported technology-based instruction by integrating Desmos activities in college students, which enhanced the students' performance and increased their Van Hiele levels, particularly at the visualization and analysis levels. While Mathematics teachers grasped van Hiele Levels 1 and 2, they needed ways to help students enhance geometric thinking at Levels 3 and 4 (Armah & Kissi, 2019). Thus, Lumbre et al. (2023) urged that mathematics teachers focus on increasing their geometric thinking skills to function at levels 4 or 5, as is expected of high school mathematics teachers. This could be accomplished by participating in capacity-building seminars, taking geometry classes, or pursuing graduate studies in mathematics. Highly qualified teachers, especially in this area, will boost student growth.

On the other hand, the study of Harrison & Bansilal (2019) revealed that learners often operate at lower levels of geometric thinking and have difficulties understanding basic geometric concepts, operating primarily at the visual and analysis levels of the Van Hiele theory. The study suggested that to improve mathematical comprehension, educators should motivate students to alternate between various semiotic representations and bolster their proof and reasoning abilities.

Geometry Education and Students' Performance. Geometry continued to be a complex topic for many students worldwide, including in the Philippines. Lumbre et al. (2023) mentioned Capate and Lapinid's study (2015), who evaluated the mathematics performance of Grade 8 students in the Philippines, discovering that geometry was one of the poorest areas in student assessments. They emphasized that Filipino students frequently struggle applying geometric principles, such as shape characteristics and angle-side relationships. These findings were comparable with broader trends observed in international examinations, such as the Programme for International Student Assessment (PISA) 2022, in which Filipino students performed below the global average in mathematics, particularly in geometry-related activities. In addition, the Philippines ranked last among 58 countries in Grade 4 Math in the 2019 Trends in International Mathematics and Science Study (TIMSS) report (Bernardo & ABS-CBN News, 2020). The report showed that the Philippines scored 297 in Math, and only 1 percent of Filipino students reached the high benchmark. This indicated that Filipino students were still in the early stages of grasping mathematical concepts.

Studies on geometry also identified various elements that impact student success. Lopez & Dela Cruz (2023) argued that the students' success in geometry was significantly influenced by their attitudes towards the subject. Students who have positive attitudes towards the subject will have better academic performance. On the other hand, compared to traditional teaching methods, the use of technology, GeoGebra, enhances students' competency in geometry (Ansong et al., 2021). The research conducted by Pujawan et al. (2020) yielded valuable insights into the correlation between students' overall mathematics performance and their geometric reasoning levels. Their results underscored those students who exhibited higher Van Hiele levels, particularly Informal Deduction (Level 3) and Formal Deduction (Level 4), exhibited substantially superior mathematical proficiency. Furthermore, the investigation underscored the significance of spatial reasoning exercises in enhancing students' comprehension of geometry. The research, which employed a quasi-experimental design with control and experimental groups, demonstrated that targeted spatial thinking interventions resulted in substantial enhancements in students' overall mathematics and geometry performance. Meanwhile, Marpa and Pareno (2019) investigated the challenges Grade 9 students faced when it comes to understanding mathematics. Through focus groups and open-ended surveys, the study discovered that while many students find geometry challenging and abstract, some find it fascinating due to its practical applications and enjoy drawing geometric shapes. The main problems involve reasoning, demonstrating, and recalling postulates and theorems, highlighting shortcomings in logical and critical thinking skills. The study emphasizes the necessity of rewarding students and developing customized learning activities to improve their performance in reasoning and problem-solving tasks.

Role of Contextualized Learning in Geometry Performance. Several teaching approaches helped students improve their mathematical skills, and the methods varied depending on the learner. Some research investigated the effect of contextual learning on geometry proficiency.According to Saputra et al. (2022), contextual teaching and learning improved students' conceptual understanding of geometry better than standard training. This implied that implementing contextual teaching and learning (CTL) in geometry learning effectively promoted students' learning. Relating the lessons to students' daily lives and local materials enhanced the students' understanding and engagement with mathematics, particularly in geometry (Reyes et al., 2019). The math teacher could deliver lessons effectively and efficiently by using available materials and information in the classroom, which created a better understanding of math concepts.

On the other hand, contextualized and tailored math word problems employing modern technologies like Generative Pre-trained Transformers (GPT) and augmented reality (AR) could enhance students' geometry learning performance (Utami et al., 2024). Meanwhile, research by Gamage & Charles-Ogan (2019) indicated that pupils instructed in circle geometry using GeoGebra surpassed those educated via conventional techniques. These findings substantiate that contextual instruction via GeoGebra may enhance students' geometric reasoning and participation in mathematical learning. Some researchers developed a geometry learning module incorporating the principle of contextual teaching and learning to promote contextual learning (Utami et al., 2024b). Moreover, Lumbre et al. (2023) extended the understanding of contextualized learning in the Philippine context. They suggested that contextualized geometry tests allowed educators to assess students' ability to apply geometric concepts in practical situations. Their study showed that students performed better when geometry problems were situated in familiar, real-world contexts, indicating that contextualization helped bridge the gap between academic knowledge and everyday applications. This approach aligned with the Van Hiele levels by enabling students to understand geometry through hands-on, meaningful experiences, particularly for students in the Visualization and Analysis levels.

Synthesis : Many studies determined that the Van Hiele model effectively taught mathematics and geometry to diverse learners. This strategy offered a step-by-step process that enhanced students' geometric understanding and helped students' progress through various stages of geometric thinking, from visualization to more formal reasoning (Santos et al., 2022; Yalley et al., 2021). It also used technology learning tools such as Sketchpads and Geogebra to increase the performance level of the students (Hassan et al., 2020). However, Educators were frequently faced with the challenges of teaching at higher levels, a process in which they should constantly develop their skills to be better equipped for performance (Armah & Kissi, 2019; Lumbre et al., 2023). All these aside, many students continued to lag at basic levels of competencies, and it is suggested that teachers give students work that requires them to move between symbolic representations and improve their ability to show parts of mathematical relationships (Ngirishi & Bansilal, 2019). Contextualized learning and modern technology effectively enhanced understanding and encouraged engagement in geometry, thus promising to resolve such educational problems (Saputra et al., 2022; Utami et al., 2024).

Research Gaps : One of the research gaps for this study lay in limited empirical research, specifically on exploring the relationship between Van Hiele levels and performance on contextualized geometry tests. Most studies explored traditional assessment, which included multiple-choice questions, oral exams, assignments, and seatwork, rather than contextualized ones. There was also a need for more studies investigating the association between Van Hiele levels and students' performance in contextualized geometry tests across the diversity of student demographic profiles, such as age groups, cultural backgrounds, and learning requirements. Longitudinal studies were also required to track the students' progress through Van Hiele levels and their performance on contextualized geometry assessments over time to understand the stability of the two variables.

This could provide better aid in identifying long-term trends and the ongoing influence of contextualized learning.

III. RESEARCH METHODOLOGY

This chapter discussed the structured approach to investigate the relationship between Van Hiele levels and students' performance on the Contextualized Geometry Test. It described the research design, participants, research locale, data collection methodologies, and analysis procedures.

Research Design : The researcher employed a quantitative correlational research design (Mekonnen, 2020) to investigate the relationship between Van Hiele levels and students' performance in Contextualized Geometry Tests. A descriptive method of research was used to utilize the study's development to attain the desired evaluation of the relationship between Van Hiele levels and students' performance in the Contextualized Geometry Test.The descriptive method was considered appropriate for the study because the problems call for the collection of data necessary to describe how the Van Hiele levels affect the students' performance in the Contextualized Geometry Test.

Research Locale : This study was conducted at Sinalhan Integrated High School, known as SIHS, located at Purok 3, Barangay Sinalhan, City of Santa Rosa, Province of Laguna. This study was focused on The Relationship Between Van Hiele Levels and Students' Performance in Contextualized Geometry Tests on Grade 9 Junior High School Students. Thus, the research locale of this study took place at Sinalhan Integrated High School. The researcher believed that Sinalhan Integrated High School was the right school to gather data for this study because of its accessibility for the researcher. The researcher also has a friend who is a faculty member of this institution, who can help the researcher in conducting this study.

Respondents/Participants of the Study : The respondents of this study were the Grade 9 students who enrolled in Sinalhan Integrated High School during the school year 2024-2025.There were 280 total population of grade 9 junior high school students from different sections as follows:

Table 2. Total number of population

SECTIONS	MALE		FEMALE		TOTAL	
	N	%	N	%	N	%
A	20	13	20	15	40	14
B	24	16	18	14	42	15
C	18	12	19	15	37	13
D	18	12	22	17	40	14
E	25	17	15	11	40	14
F	22	15	17	13	39	14
G	22	15	20	15	42	15
Total	149	100	131	100	280	100

There were seventy-two out of 280 students who participated in this study.

Sampling Design : The study used a convenience sample strategy to pick respondents owing to the researcher's restricted access to the teaching profession. Convenience sampling was considered suitable since it guaranteed practical feasibility during the researcher's visit to the school. The selection method emphasized class availability, making it efficient and time-critical. The researcher collaborated with the Grade 9 Mathematics teacher to achieve a balanced representation, who selected two sections from the seven available. The Grade 9 teacher verified that these sessions were not organized by ranking levels, hence promoting diversity among students. From these selected sections, 72 students participated as respondents, representing a subset of the 280 Grade 9 students in the total population. This variety enabled the researcher to include a broader spectrum of opinions and competencies among the sampled group. Despite convenience sampling, measures were implemented to mitigate selection bias, including relying on the teacher's judgment and ensuring that the selected portions reflected a typical classroom's composition. This method enhanced the sample's representativeness while maintaining the practical advantages of convenience sampling.

Instrumentation (Validation and Scoring of Instruments for Quantitative Research) : The researcher used a test questionnaire design, the Van Hiele Levels Geometry Test (VHLGT*) (see Appendix C)*, a test developed by Zalman Usiskin to assess students' geometric reasoning levels based on the Van Hiele levels: Visualization, Analysis, Abstraction, Deduction, and Rigor. The test questionnaire consisted of 25 multiple-choice questions with five questions per level to determine the geometric level to which the respondents belong. This instrument was a standardized questionnaire that the researcher adopted from Zalman Usiskin. Therefore, there was no need to go through content validation. The scoring system was also adopted to determine their Van Hiele levels. Please see Appendix C for the scoring rubric.

A self-made test questionnaire, the Contextualized Geometry Test, was used to evaluate the students' performance or ability to apply geometric concepts to real-world problems. The test was made after getting the result from the standard test, the Van Hiele Geometry Test. It also consisted of 25 multiple-choice questions and was aligned with the Van Hiele model. The self-made test was aligned with Grade 9 Mathematics Most Essential Learning Competencies (MELCs). For validation purposes, copies of the test questionnaire were given to the right personnel, such as Master Teachers or Head Teachers majoring in Mathematics. After the validation, the researcher collected the validation form from the validators to find out their assessments of the questionnaire. The researcher accepted any suggestions or corrections from the validators to improve the self-made questionnaire. To ensure the consistency and reliability of the test, pilot testing was conducted using Kr-20, resulting in a 0.76 value. *(see Appendix C)* Then, the researcher produced copies and distributed them to the respondents with the help of their mathematics teacher. The researcher also applied for ethics clearance for protocol review by the Research Ethics Review Committee before administering the instruments to the respondents.

Data Gathering Procedure : After validating the questionnaire, the researcher multiplied it by the number of copies sufficient to accommodate all the respondents. At the same time, the researcher made a request letter to the division office and the school principal to allow the researcher to conduct the study at the school concerned. After the requested permit to conduct the study was granted by the Division office and the school principal, the researcher sought the cooperation of the respondents' mathematics teacher in distributing and retrieving the questionnaire. The respondents were administered the research instruments after the request letter was granted. However, the test questionnaire was administered to respondents on separate days and weeks. The Van Hiele Geometry Test was administered first and retrieved. The Contextualized Geometry Test was made after getting the Van Hiele Geometry Test results. Then, it was administered several weeks after getting the VHGT result with their mathematics teacher's help. On the same day, the contextualized geometry test was also collected.The questionnaire was retrieved after the respondents completed it and tabulated to ensure the 100% retrieval of the copies from the respondents. The data results were carefully analyzed and interpreted using appropriate statistical procedures.

Treatment of Data / Thematic Process : To determine the relationship between Van Hiele Levels and students' performance in the Contextualized Geometry Test, the following statistical tools were used to analyze and interpret the data results of the study:

Frequency and Simple Percentage. This was used to determine and analyze the simple percentage distribution in each Van Hiele level based on the Van Hiele Geometry Test results. It was also used to determine the geometric level performance of the students aligned with the Van Hiele model based on the results of their Contextualized Geometry Test.

Spearman Rank Correlation (Spearman's Rho). This was used to measure the strength and direction of the correlation between students' Van Hiele levels and their performance in their contextualized geometry test. This aligns perfectly with the goal of understanding how students' Van Hiele levels relate to their contextualized geometry test. It was also used to evaluate statistical significance, typically using a p-value to determine whether the observed correlation is meaningful. The relationship is deemed statistically significant if the p-value falls below a predetermined threshold (often 0.05).

Ethical Consideration : The researcher applied the ethics in research writings discussed by Padama (2023) on his YouTube channel, and in compliance with the University Ethics Protocol. Concerning participation in this study, there was no risk of harm to the respondents. Before the study, full consent of respondents and whoever else was obtained. In addition, the researcher ensured that the privacy of the respondents was protected. The voluntary participation of the respondents in the research was essential. Moreover, they had the right to withdraw or refuse from the study at any stage if they wished to do so. In managing the data, confidentiality was maintained under the Data Privacy Act of 2012 (Republic Act No. 10173). This included implementing appropriate security measures to protect personal data from unauthorized access, alteration, and destruction. Any misleading information and biased representations of data findings were avoided. However, maintaining the highest level of objectivity in debates and analyses throughout the research was considered. Finally, every communication in this study was honest and transparent.

IV. RESULTS AND DISCUSSION

This chapter analyzes and interprets data gathered to answer the research questions stated in Chapter I. The data and statistical findings are presented with implications to concretize the concepts.

Van Hiele Levels Among Student Respondents: Table 3 presents the frequency and percentage of Van Hiele Levels among the respondents based on the results of the Van Hiele Geometry Test.

Table 3: Van Hiele levels among student respondents

Van Hiele Level	Frequency	Percentage
Visualization	37	51.4%
Analysis	21	29.2%
Informal Deduction	4	5.6%
Formal Deduction	3	4.2%
Rigor	7	9.7%
Overall	72	100%

The table revealed that of seventy-two respondents, thirty-seven, or 51.4%, fell under the Visualization. Around twenty-one students or 29.2%, were at the Analysis level. Small parts of the respondents, with four students, or 5.6%, were under the Informal Deduction, and only three, or 4.2% of respondents, fell under Formal Deduction. Lastly, Rigor, the last level, consisted of seven students, or 9.7% of the total respondents. of the respondents were at the Visualization level, indicating that they primarily rely on recognizing figures through visual cues without a deep understanding of geometric properties. This result highlighted the need to provide teaching strategies that enhance the growth of learners at various levels of Van Hiele. Given that most learners were still in the Visualization and Analysis phases, this raised issues concerning possible instructional approaches targeting higher-order geometric reasoning. This calls for including logic-based exercises, hands-on investigations, and scaffolded learning activities with opportunities to generate formal proofs. Furthermore, underlined in the results was the need for early integration of abstract thinking and axiomatic techniques into curriculum designs to support a more seamless transition to advanced degrees like Formal Deduction and Rigor. By filling these gaps, students would be more geometrically competent and in line with world norms and have critical thinking abilities that are relevant outside of mathematics.

The summary of Van Hiele levels in the data reflected the findings of Filipino researchers who have studied geometric reasoning among students. According to Pujawan et al. (2020), involvement in spatial activities significantly increased their reasoning power, notably in assisting students in navigating the Van Hiele phases. This was consistent with the present statistics, which revealed that most Visualization level students need more dynamic and spatially engaging learning methodologies. Similarly, Lumbre et al. (2023) underlined the need for teachers' Van Hiele degrees in deciding geometric student achievement. Their findings, which emphasized the importance of teacher training in improving geometric thinking, revealed that students whose teachers function at higher Van Hiele levels tend to perform better. According to Parreño and Marpa (2019), Filipino students struggle with basic skills such as proving and reasoning, which are necessary for higher Van Hiele levels. Their findings suggested that children can advance beyond basic levels with concentrated interventions emphasizing logical and critical thinking. The study also confirmed Usiskin's (1982) findings that many secondary school learners are at the visual or analysis levels of Van Hiele's.

Level of Geometric Performance of the Students as Revealed by their Contextualized Geometry Test: Table 4 on the next page shows the frequency and percentage distribution of the students' geometric performance levels as revealed by their contextualized geometry test aligned with Van Hiele levels.

Table 4: Level of geometric performance of the students as revealed by their Contextualized Geometry Test

Geometric Performance *(Van Hiele Level)*	Frequency	Percentage	Contextualized Geometry Test Performance		
			Mean (score)	Standard Deviation	Verbal Interpretation
Analysis	32	44.4%	10.38	3.902	Below Average Performance
Informal Deduction	31	43.1%			
Formal Deduction	9	12.5%			
Overall	72	100%			

Verbal Interpretation Scale Range: 7 to 10 (Above Average Performance), 4 to 6.9 (Average Performance), 0 to 3.9 (Below Average Performance)

As presented in Table 4, data revealed that the geometric performance levels of seventy-two students were evaluated utilizing the Van Hiele methodology based on a contextualized geometry test. Most students exhibited lower comprehension levels, with 44.4% or thirty-two students achieving the Analysis level. Correspondingly, 43.1% of the students, or thirty-one students, were categorized as being at the Informal Deduction Level. In contrast, 12.5% or nine students have attained the Formal Deduction level. This distribution emphasized the need for targeted interventions to help more students attain higher levels of geometric proficiency.

Based on the data, most students fall under the Analysis and Informal Deduction level. Therefore, they can be considered progressing learners developing their intermediate geometric reasoning skills. Since the contextualized geometry test was given on the spot without intervention, but aligned with their school curriculum, it reflects their natural performance based on their prior knowledge and the curriculum standards they have been exposed to. Overall, with a mean score of 10.38 and a standard deviation of 3.902, their Contextualized geometry performance showed they have a verbal interpretation of below-average performance. Saputra et al. (2022) asserted that contextual teaching and learning enhance students' conceptual comprehension of geometry more effectively than conventional instruction. This indicated contextual teaching and learning (CTL) in geometry education helped enhance student learning. Connecting lessons to students' everyday experiences and utilizing local materials improved their comprehension and involvement in mathematics, especially geometry (Reyes et al., 2019). The mathematics teacher could impart courses effectively and efficiently by utilizing accessible resources and information in the classroom, enhancing comprehension of mathematical ideas.

These results suggested that geometry education and curriculum should be redesigned to raise student learning standards. Most students fall within the intermediate Van Hiele geometric thinking levels; they have basic skills but require customized help to develop. Contextual teaching and learning (CTL) approaches, according to Saputra et al. (2022), can help conceptual understanding by combining courses with real-life situations. Including hands-on activities and locally relevant resources in the curriculum can help teachers generate significant learning opportunities to fill in knowledge and reasoning gaps. According to performance studies, combining instructional tactics with children's developmental phases will help them progress to higher geometric competency, thereby improving cognitive engagement and academic success.

Significant Relationship Between Students' Van Hiele Levels and Their Performance in the Contextualized Geometry Test

Table 5 on the next page presents the relationship between students' Van Hiele levels and their performance in the Contextualized Geometry Test.

Table 5: **Significant Relationship between students' Van Hiele levels and their performance in the Contextualized Geometry Test**

Variables	r-values	Interpretation	p-value	Decision	Interpretation
Van Hiele and Contextualized Geometry Test	0.27	Moderate Positive Relationship	0.022*	Reject Ho	Significant

*Highly significant at 0.05,
Spearman's Rho (ρ): +1.0 (Perfect relationship), +.76 to .99 (Very Strong relationship), +.51 to .75 (Strong relationship), +.26-.50 (Moderate Relationship), +.11 to .25 (Weak relationship), +.01 to .10 (Very weak relationship), .00 (No relationship)

Correlation between Van Hiele levels with their performance in the contextualized geometry test. Table 5 shows two variables, the Van Hiele and Contextualized Geometry Test. The r-value was 0.27, indicating a moderate positive relationship. Table 5 below interprets Spearman's Rho, which clearly explains the correlation between the two variables: A value of +1.0 indicates a perfect relationship, or a direct and complete correlation. Values ranging from +0.76 to +0.99 indicate a very strong relationship, while values between +0.51 and +0.75 indicate a significant and strong relationship. A moderate relationship is observed when the value falls between +0.26 and +0.50, and values between +0.11 and +0.25 indicate a weak relationship. For very weak relationships, the coefficient lies within the range of +0.01 to +0.10, whereas a value of 0.00 shows no relationship. The r-value was 0.27 and lay between +0.26 and +0.50 values. It means the data indicated a moderate positive relationship. This suggests that the higher the students' Van Hiele levels, the better their performance in the Contextualized Geometry Test. The data table also illustrates a moderate positive correlation between students' Van Hiele levels and their performance on the Contextualized Geometry Test, as evidenced by an r-value of 0.27.

These findings were similar to Lumbre et al. (2023), who demonstrated a significant correlation between the Van Hiele levels of mathematics educators and students' performance in geometry, indicating that higher levels of geometric reasoning improve academic achievement. Similarly, Santos et al. (2022) contended that the Van Hiele model provides a comprehensive framework for geometry instruction, particularly in enhancing students' conceptual understanding and application skills, which aligns completely with the results of this study. The findings confirm that students improve in solving contextualized geometry problems as their Van Hiele levels rise. Furthermore, Harrison and Bansilal (2019) explored high school students' understanding of geometric concepts using the Van Hiele model. Their findings emphasized that students with higher Van Hiele levels demonstrated greater proficiency in solving geometry problems, reinforcing the importance of structured instructional strategies to enhance geometric reasoning. Moreover, Pujawan et al. (2020) investigated the correlation between Van Hiele levels of geometric thinking and students' mathematics performance, revealing that higher levels of geometric reasoning are significantly associated with overall academic success in mathematics.This research would impact geometry education. Geometric thinking may improve academic performance since Van Hiele levels are marginally positively correlated with contextualized geometry test performance. Geometric reasoning requires Van Hiele-aligned teaching. The findings suggest that teachers should be trained to apply the Van Hiele framework to assess and assist students' thinking through focused interventions. Schools could also include geometry, conceptual comprehension, and application exercises. Van Hiele levels may improve geometry and math skills, promoting academic success in related subjects. These discoveries enable more personalized and effective teaching techniques that fit individual learning needs, enhancing student achievements in specific and general contexts.

Significant relationship between students' Van Hiele levels and their performance in the contextualized geometry test. Table 5 from the previous page also presents the significant relationship between students' Van Hiele levels and their performance in the Contextualized Geometry Test.

Table 5 focuses only on the variables, p-value, decision, and interpretation. It was shown that the p-value was 0,022 at a 0.05 significance level; it means that the null hypothesis (Ho) was rejected.

Therefore, a significant relationship existed between students' Van Hiele levels and their performance in the Contextualized Geometry Test. It implied that the effect of their performance is directly proportional to their Van Hiele level. The increased level of Van Hiele would also increase the level of performance in the contextualized geometry test. For instance, the findings of Yalley et al. (2021) closely corresponded with the data in Table 5, highlighting the substantial impact of the Van Hiele model on improving students' performance in geometry. Their research demonstrated that advancement through the Van Hiele levels enhanced comprehension and academic achievement in geometric concepts. This study confirmed the observed correlation in the Van Hiele level and performance on the contextualized geometry test, demonstrating that higher Van Hiele levels were associated with enhanced performance in geometry evaluations. Yalley et al. (2021) also underscored the necessity of utilizing instructional strategies aligned with the Van Hiele model to improve students' geometric reasoning for success in contextualized geometry assessments.

Likewise, Moyer. (2018) provided significant insights by examining the influence of students' geometric reasoning, as classified by Van Hiele's theory, on their academic achievement. Their findings indicated that students at elevated Van Hiele levels demonstrate enhanced reasoning abilities and a more profound comprehension of geometric concepts, which correlates directly with superior exam results. This research indicates a significant association between performance on contextualized geometry tests and Van Hiele levels. This research showed evidence that Van Hiele levels predict and enhance geometry performance and understanding, confirming the rejection of the null hypothesis in these studies. The findings suggest that students' Van Hiele levels significantly impact their performance in contextualized geometry tests, implying that aligning teaching strategies with the students' Van Hiele levels helps them perform well academically. By advancing through the Van Hiele levels, students can improve their comprehension and academic achievement in geometric concepts, leading to better performance in geometry evaluations.

Moreover, educators must use instructional techniques that promote the development of geometric thinking, providing students with opportunities to engage with and apply their understanding in meaningful contexts. This technique may boost students' performance in geometry and equip them with critical thinking and problem-solving abilities vital for wider mathematics and STEM-related pursuits. By fostering elevated Van Hiele levels, educational institutions may enhance comprehension of geometry and its practical applications.

Action Plan: RAISE Geometry - Raising Achievement through Instruction, Support, and Evaluation: Based on the study's results, the researcher developed an action plan to help the Grade 9 students perform better in geometry.

Table 6: RAISE Geometry - Raising Achievement through Instruction, Support, and Evaluation

Objectives	Raise Van Hiele Levels, Assessment Strategies, Instructional Improvement, Student-Centric Programs, Empowered Teachers				
Program	**Key Activity**	**Timeline**	**Persons Involved**	**Resources Needed**	**Success Indicator**
Students Support Program	Develop enrichment activities (puzzles, games, group tasks).	Monthly	Teachers, Mathematics Coordinators	Materials for activities, worksheets	90% of students are involved in class discussions
	Provide targeted interventions for transitioning Van Hiele levels.	Twice a month	Teachers, Guidance Counselors	Diagnostic tests, learning kits	At least 75% of students.
Teacher Training	Conduct seminars on Van Hiele and teaching techniques.	Quarterly	Trainers, Master Teachers	Training modules, venue, and budget	At least three math teachers can attend and apply Van Hiele levels in their lessons.
	Provide professional development workshops.	Semi-annually	Trainers, Department Heads	Development funds, speakers	
Assessment and Feedback	Implement Van Hiele-based assessments.	Twice a month	Teachers	Assessment tools, scoring rubrics	At least 75% showing improvement
	Deliver feedback to students and teachers.	During scheduled sessions	Teachers, Supervisors	Feedback forms, communication channels	At least a 20% increase in their performance.

Progression Modules	Design structured instructional modules.	Monthly	Curriculum Developers, Teachers	Module templates, real-life examples	At least 75% can complete the exercises
	Use organized exercises and problem-solving tasks.	Weekly	Teachers, Class Supervisors	Exercise sets, geometry guides	
Engaging Real World Scenarios	Relate geometric concepts to real-life scenarios.	During Lessons	Teachers	Example scenarios,	100% of the students have a practical understanding of geometry concepts and have a deeper understanding and application of geometry.
	Encourage practical application.	During Lessons	Teachers, Students	Activity kits, field projects	

Table 6 presents the action plan outlined for the Raised Geometry project, which aims to enhance students' achievement and raise their Van Hiele Levels in geometry through instruction, support, and evaluation. The researcher also believes that this action plan can help teachers enhance their teaching strategies through seminars and workshops. As Lumbre et al. (2023) recommended, mathematics educators must improve geometric reasoning skills to meet high school standards, potentially through seminars, geometry courses, or graduate studies, thereby enhancing student success. Meanwhile, to support the students, Moyer (2021) proved that to increase the Van Hiele levels of the students, mathematics educators must involve the application of technology in the lesson, such as the CanFigureIt website, a Desmos activity, the Geometer's Sketchpad, and WebSketchpad. Moreover, Ngirishi & Bansilal (2019) advised instructors to provide their students problems demanding mobility across semiotic representations and concentrate on enhancing their proof abilities. This method seeks to improve students' capacity to grasp and apply geometric ideas so they may move to higher Van Hiele levels of geometric thinking. Additionally, according to Reyes et al (2019), applying real-world scenarios in teaching can leverage students' knowledge by incorporating their life contexts into the classroom. This approach helps students relate their lives to the topics discussed, creating a sense of belonging and engagement in school work. Math teachers often use local materials or information to deliver new lessons effectively and efficiently. This approach helps students better understand math concepts by connecting prior knowledge with new concepts. Teachers can use pictures, local games, or materials from the community to represent math concepts.

V. SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

This chapter presents a summary of findings found in the previous chapter, conclusions drawn, and recommendations formulated based on the findings.

Summary of Findings

From the systematic analysis of data gathered in the preceding chapter, the following significant findings are hereby presented:

1. **On the distribution of Van Hiele levels among student respondents.** The study's results showed that most students had reached the Visualization level (51.4%), followed by the Analysis level (29.2%). Very few progressed to the Informal Deduction (5.6%), Formal Deduction (4.2%), and Rigor levels (9.7%). That means most students are functioning at the lower levels of geometric reasoning.

2. **On the level of geometric performance of the students as revealed by their Contextualized Geometry Test.** This was evaluated via a contextualized geometry test. It was revealed that most students performed at the Analysis level (44.4%) and Informal Deduction level (43.1%), demonstrating intermediate reasoning skills. Only a small portion attained the Formal Deduction level (12.5%). The students' performance was

below average, with a mean score of 10.38 and a standard deviation of 3.902.

3. **On the correlation between Van Hiele levels with their performance in the Contextualized Geometry Test.** The study revealed a moderate positive relationship between Van Hiele levels and performance in the Contextualized Geometry Test, with an r-value of 0.27, indicating that higher reasoning levels positively impact test outcomes.

   The study revealed a significant relationship between students' Van Hiele levels and their performance in the Contextualized Geometry Test, with a p-value of 0.022 at a 0.05 significance level; thus, the null hypothesis (Ho) was rejected.

Conclusions

Based on the findings of the study, the following conclusions are drawn:

1. The study showed that most students are at lower levels of Van Hiele geometric reasoning, mainly Visualization and Analysis; likewise, only a few have attained the higher levels.

2. On the Contextualized Geometry Test, the students primarily scored at Van Hiele's analysis and informal deduction levels, indicating they are still in the transitional stages of geometric reasoning. The overall performance falls below average, as reflected by the mean score and standard deviation.

3. The study found a moderate positive correlation between students' Van Hiele levels and their performance on the Contextualized Geometry Test; thus, if the students’ Van Hiele level goes up, their performance on the Contextualized Test also tends to increase.

   Statistical analysis also revealed a significant relationship between Van Hiele levels and geometric performance; therefore, the students’ Van Hiele level is directly proportional to their performance on the Contextualized Geometry Test.

Recommendations

Based on the results and conclusions of the study, the following recommendations are offered.

1. The principal, in coordination with the mathematics teachers, shall design contextualized programs and activities like Desmos, GeoGebra, logic puzzles, and strategy board games to help students develop their geometric thinking skills, particularly at the higher level of geometric thinking skills.

2. Teachers shall utilize contextualized and relevant pedagogical methods that connect geometric principles to real-world scenarios. This may assist students in comprehending and navigating the Van Hiele stages more effectively.

3. Teachers should attend seminars and workshops on Mathematics, particularly about understanding and applying the Van Hiele model to improve and enhance their teaching skills to improve students' geometric reasoning skills.

4. Curriculum Developers, in coordination with teachers, must continuously revise and modify the modules or multiple preferences they use to suit the students' learning styles and abilities.

5. Academic institutions shall implement periodic assessments based on the Van Hiele model to track their improvement over time.

6. Future researchers shall explore the expanded methodologies and technologies that enhance geometric thinking development and instructional effectiveness.

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