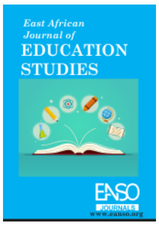


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*Original Article*

# Noticing Students' Geometry Learning Using Van Hiele's Geometry Thinking Model at the Senior High School level in Builsa South District of Upper East Region

*Enoch Kabinaa Suglo[1*], Dacosta Aboagye[1], Isaac Aligi[2], Ebenezer Agudey Akuteye[1], Sarah Akanbang[3] & Cletus Angnonobaala Dery[3]*

[1] Regentropfen University College, Bolgatanga, Ghana.
[2] Anh Duong Language Center.
[3] University for Development Studies, Ghana.
[*] Author for Correspondence ORCID ID: https://orcid.org/0009-0009-1396-454X; Email: enochsuglo85@gmail.com

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## ABSTRACT

This study focused on assessing students' geometry learning using Van Hiele's Geometry Thinking Model at the Senior High School level in the Builsa South District of the Upper East Region, Ghana. Employing a one-group quasi-experimental design, data were collected from a population of 360 students, with a sample size of 186 selected via simple random sampling. The study utilized questionnaire surveys and a Geometry Achievement Test (comprising pretest, posttest, and retention test) for data collection. Analysis, conducted using SPSS's paired samples test procedures and simple linear regression model, revealed several key findings. Firstly, a predictability relationship was observed between Van Hiele's geometry thinking model and students' academic performance in geometry ($p = 0.019$). Secondly, a significant difference existed between pretest and post-test scores among eleventh-grade students $p < 0.005$). Lastly, learning retention substantially impacted students' geometry learning and performance ($p = 0.005$). Based on these findings, the study recommends teachers adopt Van Hiele's Geometry Thinking Model to enhance students' geometry learning skills and academic performance. This research sheds light on effective pedagogical approaches to improve geometry education in the selected school context, contributing to the broader discourse on mathematics education enhancement in Ghana.

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## INTRODUCTION

Van Hiele's model for learning geometry stands as a cornerstone in geometry education, renowned for its effectiveness and widespread adoption among educators and researchers alike (Mostafa et al., 2017). Its significance lies in its structured approach, which guides students through distinct levels of geometric thinking, starting from visual recognition and progressing towards abstract reasoning and formal deduction. By emphasizing the development of students' geometric understanding through sequential stages, Van Hiele's model provides a framework that aligns with how learners naturally progress in their geometric comprehension (Howse, & Howse 2015). This model not only fosters deeper conceptual understanding but also encourages critical thinking and problem-solving skills essential for success in geometry. Its enduring popularity among geometry researchers underscores its efficacy and utility in facilitating meaningful geometry instruction, making it a favored methodology for educators seeking to enhance students' geometric learning experiences (Alex, & Mammen, 2016). Theoretically, children can learn geometry at five different hierarchical levels: visualizing, analyzing, ordering, deducing, and rigor (Van Hiele, 1986). However, research by (Alex, & Mammen, 2016; Howse, & Howse, 2015) emphasized the inclusion of level 0 in levels 1–5, with the sixth level 0 being referred to as the pre-recognition level to support learners who have difficulties in achieving Van Hiele's level 1. Students in the pre-cognitive stage may recognize forms like squares by their four-sided properties, including having the same length and four corners when one side is horizontal in the student's viewpoint. Vojkuvkova suggested that students categorize numbers merely by appearance and "compare the figures with things they see every day" (Vojkuvkova, 2012).

In Malaysia, the National Council of Teachers of Mathematics (NCTM, 2000) pointed out that Geometry as a branch of mathematics has a vital role and is a basic mathematical skill in the learning of other aspects of mathematics. In the views of Hong (2005), geometry skills are crucial and applicable in learning other branches of mathematics and subject areas such as engineering drawing, geometry drawing and so on hence students need to study and do well in geometry. NCTM (1976) as cited in (Abdul Halim Abdullah, & Effandi Zakaria, 2013) highlighted two objectives of geometry learning include helping students to develop logical thinking skills and also helping students to develop spatial intuitions that refer to how one views space and area in the real world. Abdullah & Zakaria (2013) asserted that students' difficulties associated with geometry learning have been rectified in some Western countries and African nations where Van Hiele's Model of geometry thing was used to improve students' performance. Van Hiele's Model proposes various levels that students must follow sequentially to build a concrete understanding of the relationships between geometric ideas. According to Vojkuvkova (2012), the Van Hieles initially numbered them from 0 to 4, but later, the USA introduced numbering from 1 to 5. The Van Hiele geometry thinking model is believed to help improve the academic performance of students for instance, Erdogan et al. (2009) conducted a study and found that the Van Hiele model improved the academic performance or scores among 55 6th-grade learners in Bolu, Turkey. This study intended to explore teachers' noticing of students' circle geometry learning and performance using Van Hiele's geometry thinking model at the Senior High School level in Builsa South of Ghana's Upper East Region.

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**Statement of the Problem**

There are poor geometry learning skills among most senior high school students in the selected school of study. As a result, students go through stages of poor geometry learning and low academic performance relating to geometry problems or questions. The practical nature of geometry in the senior high school core mathematics requires that every student be actively involved in the teaching and learning process to enhance understanding and learning outcomes. Teachers are therefore expected to always pay attention to every student's learning habits and respond to students' individual needs in the geometry classroom and use teaching and learning models that put every student at the core of the lesson. One highly rated model that various researchers have highlighted is the Van Hiele's Geometry Thinking Model. For instance, Oladosu (2014) supported the view that students demonstrated a better conceptual understanding when they underwent lessons which were carried out using the Van Hiele instructional model. In the framework of Van Hiele's Level 4 of geometric thinking, Knight (2006) expressed the idea that when tackling geometry problems, students should be able to create and provide proofs from a variety of premises or circumstances.

Knight had explained that students can differentiate that it was adequate for a particular shape had four sides being a quadrilateral and it was required to have the sides being congruent if the shape was a square or a rhombus where the requirement could be that all angles have to be right angles to name it as a square. Students can create proofs and drive proofs on their own since they can comprehend the implications of induction at this level (Alex, & Mammen, 2016). The Van Hiele's geometry thinking model has been highly recommended for teachers to employ in the teaching and learning of geometry to help improve students' geometry thinking and academic performance (Howse, & Howse 2015; Alex, & Mammen 2016). Van P. (2008) discovered that the majority of pre-service teachers received geometry instruction through route learning and textbooks for proofs and theorems; as a result, the majority of these pre-service teachers were unable to recall geometric concepts, much less apply these concepts logically to solving similar problems. This was why the current study decided to launch an investigation into teaching and learning geometry through Van Hiele's proposed Model to ascertain its impact on students' geometry performance.

**Objectives of the Study**

The main objective of this study is to examine teacher noticing of students' geometry learning and performance using Van Hiele's geometry thinking model. Other objectives of the study included;

- To ascertain whether there is a predictability relationship between Van Hiele's geometry thinking model and students' academic performance in geometry.
- To find out whether there is a significant difference between the pretest and posttest scores of the students in geometry after an instructional intervention.
- To explore the impact of learning retention and its long-term effect on geometry learning and performance among Senior High School students in Builsa south district.

**Research Hypotheses**

- There is no predictability relationship between Van Hiele's geometry thinking model and students' academic performance in geometry.
- There is no significant difference between the pretest and posttest scores of students before and after the intervention.
- There is no significant difference between posttest scores and delayed retention test scores of form three Senior High School students' in geometry in the Builsa South district.

**Significance of the Study**

The significance of this study extends across multiple educational stakeholders, offering invaluable insights that can inform critical decision-making processes and educational practices. Firstly, educational stakeholders, including policymakers and administrators, stand to benefit from the findings as they can utilize them to optimize the allocation of educational resources. By understanding the effectiveness of employing Van Hiele's Geometry

 

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Thinking Model in improving students' geometry learning and performance, stakeholders can prioritize investments in pedagogical approaches that yield the highest educational outcomes. Secondly, students themselves will benefit directly from the study's findings, as it offers them the opportunity to enhance their geometry learning and academic performance. Armed with a deeper understanding of geometric concepts and improved problem-solving skills, students can navigate their academic journey with greater confidence and proficiency. Additionally, parents will find reassurance in knowing that investments in their children's education are worthwhile, as improved geometry learning outcomes increase the likelihood of successful academic progression and future educational achievements.

Moreover, teachers stand to gain valuable insights from the study, as it provides evidence-based strategies for maximizing academic performance and supporting students in their geometry learning journey. By incorporating effective pedagogical approaches informed by the study's findings, teachers can create enriching learning experiences that cater to students' diverse learning needs and promote academic excellence. Finally, scholars and researchers in the field of mathematics education will find the study beneficial, as it contributes to the existing body of knowledge on students' learning and academic performance in various mathematical concepts. By shedding light on the efficacy of Van Hiele's Geometry Thinking Model, the study provides a valuable foundation for future research endeavors aimed at further understanding and improving mathematics education practices. Overall, the significance of this study lies in its potential to drive positive educational outcomes and advance scholarly discourse in the realm of mathematics education.

## LITERATURE REVIEW

### Van Hiele's Geometry Thinking Model and Students' Academic Performance

Yalley et al. (2021) conducted a study at Daffiama Senior High School in the Daffiama-Bussie-Issa District of the Upper West Region, focusing on the impact of the Van Hiele instructional approach on students' achievement in Circle Geometry. In their research, the authors employed a quasi-experimental research design, where they divided participants into two groups: a control group receiving traditional instruction and an experimental group receiving instruction based on the Van Hiele model. The sample comprised 75 participants, selected using a combination of simple random sampling procedures and purposive sampling strategies. Before the intervention, data analysis revealed that participants were at the precognition level in terms of geometric thinking. However, following the implementation of the Van Hiele instructional approach, participants demonstrated advancement to level 2 in geometric thinking. This shift suggests that the Van Hiele model effectively supported students' learning and facilitated progression in their geometric understanding. Based on these findings, the authors recommended that teachers assess students' geometric thinking levels before instruction, enabling them to tailor their teaching approaches to better meet the individual needs of students and promote deeper understanding and learning outcomes in geometry.

Demircioglu, & Hatip (2023) conducted a study focusing on the thinking levels, proof writing, and justification abilities of eighth-grade students in Van Hiele geometry. The research involved sixteen eighth-grade students from a private school in Sivas, Turkey, selected through convenient sampling. Data were collected during face-to-face instruction in the fall semester of the 2020/2021 academic year, with students volunteering to participate in the study on the data collection day. The study utilized the Van Hiele geometry test and a geometry proofing test as data collection tools, employing the document analysis method for analysis. The researchers assessed the data using a justification test rubric and evaluation criteria for geometry proof writing. Following data analysis, the study revealed a linear relationship between students' Van Hiele thinking levels and their proof-writing skills. However, it did not find a positive association between students' justification skills and their Van Hiele thinking levels or proof-writing abilities. These findings suggest that while there is a correlation between students' geometric thinking levels and their ability to construct geometric proofs, there may be other

 

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factors influencing their justification skills that warrant further investigation.

The study provides insights into the interplay between geometric thinking levels and proof-writing skills among eighth-grade students, contributing to the understanding of geometry education and instructional practices. Also, Abdullah, & Zakaria's (2013) assessed the degree to which students have learned the various geometry levels as well as the effectiveness of Vanhiele's phases of geometry learning. In their inquiry, two student groups, the treatment group and the control group were involved in two quasi-experiments. Before the start of their study, five students from each group were randomly selected and interviewed to determine their initial levels of geometric thinking. The results showed that the majority of students in both groups completed their basic levels of geometric reasoning at the first Van Hiele levels. But practically all of the students in both groups demonstrated poor level 2 acquisitions and no level 3 acquisitions. During the follow-up interview, the majority of students in the control group demonstrated an increase in geometric reasoning from level 1 to level 2, but none of the students attained level 3. On the other hand, every student in the therapy group demonstrated full mastery of Van Hiele level 1 and nearly every one of them demonstrated full mastery of level 2. Only one student fell short of level 3, while the other students demonstrated a thorough and advanced level of acquisition. As a result, the authors concluded that using exercises based on the Van Hiele phases of geometry instruction helps students acquire higher-order geometric thinking skills.

In order to investigate and explain the Van Hiele levels of geometric thinking of a selected sample of grade 10, 11, and 12 students in South African and Nigerian schools, Atebe (2008) used the Van Hiele theory of geometric thought levels. The study also aimed to provide a comprehensive and detailed account of the methods employed in geometry instruction, which could have influenced the level of geometric conceptualization exhibited by this group of high school students. Six mathematics teachers and 144 math students from South Africa and Nigeria made up the study's author sample, which was chosen using purposive and stratified selection methods. The study used classroom footage, interviews, and questionnaires to gather data. As just 2% and 3% of the students were at Van Hiele levels 3 and 4, respectively, while 47%, 22%, and 24% were at levels 0, 1, and 2, the study's findings showed that the majority of the students were not yet prepared for the rigorous deductive study of school geometry. Van Hiele level 0 was reached by more students from the Nigerian subsample (53%) than by students from the South African subsample (41%). Six percent of the South African learners were at level 4, whereas none of the Nigerian subsample's learners were at Van Hiele level 4. Given that students from the South African subsample achieved noticeably higher mean scores on the Van Hiele Geometry Test (VHGT) and all other tests used in this study, students from the Nigerian subsample generally knew less about school geometry than their counterparts from the latter subsample. The Van Hiele levels of students for each participating school are highly correlated with their success on geometry topic examinations and in mathematics in general.

According to Alex, & Mammen (2016), schooling founded upon the Van Hiele model fosters substantial advancement in geometrical knowledge alongside the cultivation of lifelong learning skills. The Van Hiele model's structured approach to geometry instruction guides students through progressively deeper levels of geometric understanding, from basic recognition to abstract reasoning and formal deduction. By engaging students in active exploration and problem-solving within this framework, educators create an environment conducive to comprehensive comprehension and skill development in geometry. Furthermore, the model emphasizes metacognition and reflection, encouraging students to monitor their learning processes and make meaningful connections between geometric concepts. This fosters not only mastery of geometry but also instils in students the cognitive flexibility, critical thinking abilities, and self-regulated learning habits necessary for continuous learning and adaptation beyond the classroom. Thus, by nurturing both geometric knowledge and broader learning skills, schooling based on the Van Hiele model equips students with the tools they need to thrive in academic pursuits and beyond, enabling them to become lifelong learners

 

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capable of navigating the complexities of an ever-evolving world.

**Comparison of Pre-intervention Test and Post-intervention Test Performance of Students**

To show how sample characteristics affect pretest-posttest correlation coefficients, Cole et al. (2011) conducted their study to investigate the variability in pretest-posttest correlation coefficients of state assessment data for samples of low-performing, average-performing, and proficient students. The authors' report emphasized how correlation coefficients that differ based on sample characteristics can reduce statistical power. The findings supported the hypothesis that lower pretest-posttest correlation coefficients for low-performing samples reduce statistical power in impact studies. In the planning stage of a study, the authors proposed that it could be helpful to evaluate the pretest-posttest correlation coefficients of state assessments for the target population of an intervention.

Shivaraju et al. (2017) employed a questionnaire-based pre-test and post-test evaluation approach to gauge the students' understanding of didactic lectures. To assess the students' receptiveness, pre- and post-lecture knowledge and teaching efficacy, the study's selected students were required to complete a pretest comprised of ten questions. Additionally, a post-test questionnaire including the same ten questions was given at the end of the lecture. The results showed that the recipient's knowledge had significantly improved after the post-lecture evaluation when compared to the pretest. The student's cognitive organization has improved, according to the post-test results.

Schalich (2015) investigated students' pre- and post-test performance in an elementary school learning center model. To find out if small group instruction tailored to each student's reading level improved their reading comprehension test scores, the researcher brought the students into a different classroom and implemented three different reading comprehension programs. Students' learning success appeared to have improved in the post-test as compared to the pretest, according to an analysis of the study's pre- and post-test performance data. This implied that giving students the chance to participate in one-on-one, small-group training inside a Learning Center Model will improve their performance.

Khashi'ie et al., (2017) compared the results of a pre- and post-mathematics competency test taken by students. Their study considered 176 first-year students in the Mechanical Engineering Technology Department who were chosen to take a Mathematics Competency Test. While the pre-test was administered during the first week of the semester, the post-test was administered during the second semester. The results showed that the students' post-test performance was higher than their pre-test performance.

**Learning Retention and its Long-term Effects on Learning and Performance**

Khasawneh et al. (2024) carried out a study to look at how gamifying the classroom might help students retain and apply what they have learned in the Jordan educational system. During the year-long research, 500 participants from a wide range of educational attainment levels served as participants. Immediately after participation in gamified courses, participants retain a significant proportion of their newly acquired skills over a long period, demonstrating a notable improvement in retention.

Eyenaka et al. (2023) carried out their study to appraise the impact of ICT-based teaching methodologies on academic performance and retention of secondary school students. The study was conducted in Cross River State, Nigeria. The authors used a quasi-experimental non-randomised pre-test and post-test control group design. The sample for their study consisted of 176 SS2 students drawn from four intact classes of four secondary schools within the study area. The Physics Achievement Test (PAT) with a reliability coefficient of 0.85 was used for data collection. The authors' study showed that there was a significant difference in the academic performance and retention of students taught using video-taped instructions and those taught using PowerPoint presentations. The findings of the study showed that students taught using video-taped instructions had higher academic performance and retention than those taught using PowerPoint presentations.

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## METHODS AND DESIGN

### Study Design

The study implemented a one-group pretest-posttest quasi-experimental design. The rationale for implementing this design was that the study aimed to establish a cause-and-effect relationship between the independent and dependent variables. The study implemented the pretest followed by instructional intervention activities, and the posttest was implemented to determine whether there was any change in the performance of the students after the intervention. Various research studies have used and highlighted that using the one-group pretest-posttest quasi-experimental design provides researchers with the opportunity to establish any cause-and-effect relationship between dependent and independent variables, which this current study sought to do. For instance, McCaleb et al. (2015) investigated pre-service teachers' perceptions of school violence using a one-group pretest-posttest experimental design. Their findings indicated that respondents' perceptions changed about school violence after completing the treatment. Additionally, Kongkaew et al. (2020) conducted a study using fourth-year undergraduate students in which a one-group pre-test/post-test experimental study was implemented. The authors found that students' knowledge was based on their post-test performance.

**Figure 1: Showing One-group Pretest-posttest Quasi-experimental Design**

| Measurement: Dependent variable | | Treatment: Quasi-independent variables | | Measurement: Dependent variable |
|---|---|---|---|---|
| Assess students' geometry performance using achievement test | → | Students receive 4 weeks of teaching using van Hiele's model | → | Assess students' geometry performance using achievement test |

**Source:** Adapted from McCaleb, Andersen, and Hueston, (2015)

### Population

The form three students who were the interest group were categorized into 13 classrooms based on their programme electives. These classes included: 3A1-to-3A2; 3B1-to-3B5; 3C1-to-3C3; 3D1-to-3D2 and 3F1. Each class contained a minimum of 35 and a maximum of 55 student's study. The total accessible population at the time of data collection was 360. This was after the study removed students who were qualified but could not participate in the study. These included chronically absent students, sick students, and students who were on exeat. Therefore, the accessible population for the study was 360 students. Shukla (2020) described a research population as a collection of all the units that share the variable characteristic under investigation and for whom the findings of the study can be extensively generalized.

### Sample and Sampling Technique

The study sample size of 186 students was determined using the table for determining sample size from a given population developed by Krejcie, & Morgan (1970). With a population size of 360 students, Krejcie and Morgan's table indicated that a sample size of 186 would be sufficient for the study's purposes. To select the sample members, a simple random sampling technique was employed. This involved assigning numbers to the 13 classes, representing the entire population. Using a random number generator, three classes were then selected from the pool of 13. The students from these three selected classes were combined to form the final sample of 186 students. This sampling method ensures that each student in the population had an equal chance of being selected for the study, thereby increasing the generalizability of the findings to the broader population of 360 students.

### Data Collection Instrument

The study utilized two instruments for data collection: a questionnaire developed using Google Forms and a Geometry Achievement Test (GAT) consisting of pretest, posttest, and retention-test

 

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components. The questionnaire aimed to gauge students' perceptions and experiences related to lessons taught using the Van Hiele's geometry thinking model. It comprised statements aligned with the concepts covered in these lessons, and students were prompted to respond by selecting from options ranging from "strongly disagree" to "strongly agree." This allowed researchers to gather qualitative insights into students' attitudes and understanding of geometry concepts taught within the framework of the Van Hiele model.

On the other hand, the GAT was designed to assess students' proficiency in geometry before, immediately after, and sometimes following the intervention phase. It consisted of 25 multiple-choice questions drawn from past West African Senior School Certificate Examination (WASSCE) papers, ensuring alignment with the curriculum and standards. This test served as an objective measure of students' geometry knowledge and problem-solving abilities, enabling researchers to quantify the impact of the Van Hiele model on students' academic performance in geometry.

During data collection, both the questionnaire and the GAT were administered to students. Students completed the questionnaire, responding to the statements based on their experiences with Van Hiele's geometry instruction. Simultaneously, students were instructed to write the GAT before and after the intervention phase. After each test administration, scripts were collected, marked, and scores were recorded for subsequent analysis. This comprehensive approach to data collection allowed researchers to triangulate findings from qualitative responses to the questionnaire with quantitative data from the GAT, providing a well-rounded understanding of the effectiveness of the Van Hiele model in enhancing students' geometry learning and performance.

**Data Collection Procedures**

The study adhered to ethical guidelines by seeking permission from the management of the participants' school before commencing data collection. This step ensured transparency and respect for the institution's protocols, aligning with professional standards outlined by researchers (e.g Denzin, & Lincoln 2005). With permission granted, students were provided with an orientation about the purpose and goals of the study. This served to inform participants about the studys' objectives, procedures, and potential impacts, fostering a sense of understanding and cooperation among them. Following the necessary permissions and orientation, the data collection phase commenced. The study employed a structured timeline, beginning with the administration of the pretest to assess students' baseline geometry knowledge. Subsequently, the intervention phase, lasting four weeks, was implemented.

During this phase, students received instruction using the Van Hiele model, aiming to enhance their geometry learning and performance. After the intervention phase, the posttest was administered to evaluate the immediate effects of the intervention on students' geometry proficiency. Following this, a delayed retention test was conducted three weeks after the post-test to assess the sustainability of learning outcomes over time. This comprehensive approach allowed researchers to gauge the efficacy of the Van Hiele model in facilitating long-term retention of geometric concepts. Finally, the survey questionnaire was administered to gather students' perspectives on the effectiveness of the model during the intervention lessons. This qualitative component provided valuable insights into students' experiences, attitudes, and perceptions regarding the instructional approach employed.

**Data Analysis Instruments**

In this study, two statistical analysis methods were employed to analyze the data collected from the respondents: the paired samples t-test and a simple linear regression model. Paired Samples t-test: This statistical test was utilized to measure the difference between the pretest and post-test scores, as well as the retention test scores. The paired samples t-test is suitable for comparing the means of two related groups, such as the scores of the same group of students before and after an intervention. Simple Linear Regression Model: The simple linear regression model was employed to analyze data collected from both the questionnaire and the Geometry Achievement Test (GAT). Simple Linear Regression analysis allowed the researcher to explore the relationship between students' responses

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to the questionnaire (independent variable) and their performance on the GAT (dependent variable).

## RESULTS AND DISCUSSION

### Data Analysis

The data for the study were analyzed with respect to the hypothesis of the study. The study determined the influence of the independent variables on the academic performance of students. All the study results are represented in statistical tables as shown below.

#### *There is no Predictability Relationship between Van Hiele's Geometry Thinking Model and Students' Academic Performance in Geometry*

This hypothesis intended to determine whether lessons taught using Van Hiele's geometry thinking model had enhanced students' geometry learning and academic performance. Refer to Table 1 for the output of the analysis.

**Table 1: Showing Simple Linear Regression Analysis Results on Students' Views about Lessons Taught using Van Hiele's Model and its Impact on their Geometry Learning and Performance**

| Model Summary | | | | | | |
|---|---|---|---|---|---|---|
| **R** | **$R^2$** | **Std. Error** | **F** | **df1** | **df2** | **Sig. value** |
| .335[a] | .112 | 4.283 | 2.215 | 10 | 175 | .019 |

a. Predictors: (Constant), Statement 10, Statement 3, Statement 7, Statement 8, Statement 9, Statement 1, Statement 6, Statement 2, Statement 4, Statement 5
b. Dependent Variable: Geometry achievement test scores

**Source:** Primary data, 2024

The results presented in Table 1 indicate a significant relationship between students' perceptions of Van Hiele's geometry thinking model and their academic performance in geometry. The coefficient of determination, R^2, which measures the proportion of the variance in the dependent variable (academic performance in geometry) explained by the independent variable (students' views about the Van Hiele model), was found to be 0.112. This suggests that approximately 11.2% of the variation in students' geometry performance can be attributed to their perceptions of the Van Hiele model. Furthermore, the F-statistic F(186) = 2.215) and its associated p-value (p = 0.019) indicate that the relationship between students' views about the Van Hiele model and their academic performance in geometry is statistically significant. The p-value of 0.019 is less than the conventional alpha level of 0.05, indicating that there is sufficient evidence to reject the null hypothesis. Therefore, the study failed to accept the null hypothesis, which posited that there was no predictability relationship between Van Hiele's geometry thinking model and students' academic performance in geometry. Additionally, the standard error of the estimate, with a value of 4.283, indicates the average deviation of students' test scores from the regression model based on their perceptions of the Van Hiele model. This value suggests that, on average, students' test scores were approximately 4.283 points away from the predicted scores based on their views about the Van Hiele model.

The results provide compelling evidence that utilizing Van Hiele's geometry thinking model to implement geometry-related lessons can significantly enhance students' performance in geometry. This underscores the importance of considering students' perceptions and attitudes towards instructional models in shaping their academic outcomes and highlights the effectiveness of the Van Hiele model in improving geometry learning outcomes.

#### *There is no Significant Difference between the Pretest and posttest Scores of Form Three Students in Geometry*

The intention for this particular hypothesis was to ascertain whether there was a significant difference between the pretest and posttest scores of form three students' after an instruction intervention. A paired samples t-test method was used to compare the means of the pretest and post-test scores. Table 2 displays the results for the paired sample analysis in respective to the hypothesis.

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**Table 2: Paired Samples t-test showing *Significant Difference between the Pretest and posttest Scores of Form Three Students in Geometry***

| Paired Differences | | | | | |
|---|---|---|---|---|---|
| **Pretest scores - Posttest scores** | **df** | **Std. Deviation** | **Std. Error Mean** | **t** | **Sig. (2-tailed)** |
| | 185 | 3.335 | .245 | -15.302 | <.005 |

**Source:** Primary data, 2024

The study's results revealed a paired sample correlation value of 0.695, which indicates a strong and significant relationship between the pretest and posttest scores. This correlation value suggests that as students' scores on the pretest increase, their scores on the posttest also tend to increase, and vice versa. Additionally, the statistical analysis yielded a t-value of -15.302, with a p-value of less than 0.005, indicating a highly significant difference between the pretest and posttest scores of form 3 students at Fumbisi Senior High School.

The decision to reject the null hypothesis, which posited that there is no significant difference between the pretest and posttest scores, was based on the highly significant t-value and the associated p-value. The negative t-value of -15.302 indicates that the mean score on the pretest was significantly lower than the mean score on the posttest. This suggests that the intervention, which involved implementing geometry lessons using the Van Hiele model, had a positive impact on students' geometry learning outcomes. The significant improvement in posttest scores compared to pretest scores provides evidence that the intervention was effective in enhancing students' understanding and proficiency in geometry.

The findings from Table 2 support the conclusion that the intervention utilizing the Van Hiele model led to a statistically significant improvement in Form 3 students' geometry performance at Fumbisi Senior High School. This underscores the effectiveness of the Van Hiele model in promoting meaningful learning outcomes and highlights its potential to positively impact students' academic achievement in geometry.

**Table 3: Showing Paired Samples Statistics Results**

| | | **Mean** | **N** | **Std. Deviation** | **Std. Error Mean** |
|---|---|---|---|---|---|
| Pair 1 | Pretest scores | 15.56 | 186 | 4.074 | .299 |
| | Posttest scores | 19.30 | 186 | 4.422 | .324 |

**Source:** Primary data, 2024.

The output in Table 3 presents the descriptive statistics for the pretest and posttest scores, indicating a pretest mean of M (15.56) and a posttest mean of M (19.30). The average difference between the paired pretest and posttest scores is calculated as -3.74. The paired sample t-test yielded a p-value of less than .005, indicating statistical significance. Consequently, the study rejected the null hypothesis, as the results provided strong evidence that the average paired difference between the pretest and posttest scores is not zero. Moreover, the post-test mean exceeding the pretest mean further supports the conclusion that post-test scores are significantly better than pretest scores. This finding aligns with the study of Schalich (2015), who observed improved learning success in the post-test compared to the pretest in an elementary school learning center model. Similarly, Khashi'ie et al. (2017) reported higher post-test performance compared to pre-test performance in a study examining students' mathematics competency.

***There is no Significant Difference between Post-test and Delayed Retention Test Scores of the Sampled Students at the Senior High School Level in Builsa South***

Referring to Table 4 for the paired sample results of the pretest and posttest scores, the study aimed to investigate whether learning retention had occurred among students. The hypothesis underlying this investigation was rooted in the belief that learning retention plays a crucial role in enhancing students' academic performance by reinforcing the application of knowledge and skills over time.

 

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**Table 4:** ***Paired Samples t-test showing Significant Difference between the Post-test and Delayed Retention Test Scores of the Students***

| | Std. Deviation | Std. Error Mean | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|
| Posttest-Retention test | 4.729 | .347 | 2.000 | 185 | .047 |

**Source: Primary data, 2024**

The output in Table 4 indicates a marginal significance between the posttest and retention-test scores, with a t-value of 2.000 and a p-value of 0.047 at an alpha level of 0.05. Despite being marginally significant, this result leads to the rejection of the null hypothesis, suggesting that there is indeed a significant difference between the posttest and retention-test scores of the students. This implies that the retention-test scores were significantly better than the posttest scores, indicating that learning retention had occurred among the students. The finding of marginal significance aligns with the study conducted by Eyenaka et al.(2023), who investigated the impact of ICT-based teaching methodologies on the academic performance and retention of secondary school students. Their results similarly showed a significant difference in retention and academic performance among the students who participated in their study. This suggests that interventions aimed at reinforcing learning over time, such as ICT-based teaching methodologies or other retention strategies, can lead to improved academic performance and retention of knowledge among students.

## CONCLUSIONS

The study's evidence strongly supports the conclusion that implementing Van Hiele's geometry thinking model in geometry instruction enhances students' geometry learning skills and academic performance. This conclusion is based on several key findings:

The existence of a predictability relationship between Van Hiele's geometry thinking model and students' academic performance in geometry indicates that the instructional approach significantly influences students' learning outcomes. The study's analysis revealed a statistically significant relationship between students' perceptions of the Van Hiele model and their geometry performance, suggesting that the model effectively contributes to improved academic achievement.

The significant difference observed between pretest and posttest scores further underscores the efficacy of the Van Hiele model in enhancing students' geometry learning. The substantial improvement in posttest scores compared to pretest scores indicates that students benefited from the instructional intervention, demonstrating increased mastery of geometry concepts and problem-solving skills.

The significant impact of learning retention on students' geometry learning and performance highlights the importance of reinforcing and retaining learned material over time. The delayed retention-test scores being significantly better than the posttest scores suggested that students retained and applied the knowledge and skills acquired through the Van Hiele model, leading to sustained improvements in geometry performance.

## RECOMMENDATION

The recommendation for teachers to consider using Van Hiele's Geometry Thinking Model to teach geometry lessons is based on the compelling evidence provided by the study, which demonstrates the model's effectiveness in enhancing students' geometry learning skills and academic performance. Several key factors support this recommendation:

Empirical Evidence: The study's findings revealed a significant relationship between the implementation of Van Hiele's model and students' academic performance in geometry. Through statistical analysis, it was demonstrated that students who were taught using the Van Hiele model exhibited improved geometry learning outcomes compared to those who received traditional instruction methods. This empirical evidence provides a strong rationale for adopting the Van Hiele model in geometry teaching practices.

Cognitive Development: Van Hiele's Geometry Thinking Model is grounded in cognitive developmental theory, which posits that student’s progress through distinct levels of geometric understanding as they mature cognitively. By

 

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structuring geometry instruction according to these levels, teachers can scaffold students' learning experiences and facilitate the development of more advanced geometric thinking skills. This approach aligns with the principles of effective pedagogy and can lead to deeper conceptual understanding among students.

Active Engagement: The Van Hiele model emphasizes active engagement and hands-on exploration of geometric concepts, encouraging students to construct their knowledge through inquiry-based learning activities. By actively participating in the learning process, students develop a deeper understanding of geometric principles and are better equipped to apply their knowledge in problem-solving contexts. This active engagement fosters a more dynamic and interactive classroom environment, promoting student motivation and enthusiasm for learning geometry.

Long-Term Retention: The study also highlighted the significant impact of learning retention on students' geometry learning and performance. By utilizing the Van Hiele model, teachers can implement strategies to reinforce and retain learned material over time, ensuring that students retain and apply their geometry knowledge beyond the immediate instructional context. This emphasis on long-term retention contributes to more enduring learning outcomes and prepares students for future academic success.

## REFERENCES

Abdullah, A. H., & Zakaria, E. (2013). The effects of Van Hiele's phases of learning geometry on students' degree of acquisition of Van Hiele levels. *Procedia-Social and Behavioral Sciences*, *102*, 251-266**.**

Abdullah, A. H., & Zakaria, E. (2013). Enhancing students' level of geometric thinking through van Hiele's phase-based learning. *Indian Journal of Science and Technology*, *6*(5), 4432-4446.

Alex, J. K., &Mammen, K. J. (2016). Lessons Learnt from Employing van Hiele Theory Based Instruction in Senior Secondary School Geometry Classrooms. Eurasia Journal of Mathematics, Science & Technology Education, 12(8), 2223– 2236. https://doi.org/10.12973/eurasia.2016.1228a

Atebe, H. U. (2008). Students' Van Hiele Levels of Geometric thought and Conception in Plane Geometry: A Collective Case Study of Nigeriaand South Africa.

Cole, R., Haimson, J., Perez-Johnson, I., & May, H. (2011). Variability in Pretest-Posttest Correlation Coefficients by Student Achievement Level. NCEE 2011-4033. *National Center for Education Evaluation and Regional Assistance*.

Demircioglu, H., & Hatip, K. (2023). Examining 8th Grade Students' Van Hiele Geometry Thinking Levels, Their Proof Writing and Justification Skills. International Journal of Curriculum and Instruction, 15(1), 294-308.

Erdoğan, T., & Akkaya, S. Ç. (2009). The effect of the Van Hiele model-based instruction on the creative thinking levels of 6th grade primary school students.

Efa, Y., & Frimpong, S. A. (2023). Effect of Gender on Senior High School Students' Performance and Perception of Core Mathematics in the Cape Coast Metropolis of Ghana. *African Journal of Educational Studies in Mathematics and Sciences*, *19*(1), 45-73.

Eyenaka, F. D., Ocheleka, G., & Udo, A. A. (2023). An Appraisal Of Students'academic Performance And Retention In Physics Using Ict-Based Teaching Strategies. *GPH-International Journal of Educational Research*, *6*(05), 41-46.

Hong, L. T. (2005). Van Hiele levels and achievement in writing geometry proofs among form 6 students. Universiti Malaya.

Howse, T. D., &Howse, M. E. (2014). Linking the Van Hiele Theory to Instruction. Teaching children mathematics, 21(5), 305–313

Khasawneh, Y., Khasawneh, N & Khasawneh, M. (2024). Exploring the long-term effects: Retention and transfer of skills in gamified learning environment.*International Journal of Data and Network Science*, 8(1), 195-200.

 

Khashi'ie, N. S., Said, R. M., Zainal, N. A., & Miswan, N. H. (2017). A Comparison Study of Students' Performance in Pre and Post Result of A Mathematics Competency Test. In MATEC Web of Conferences (Vol. 87, p. 04001). EDP Sciences.

Kongkaew, C., Scholfield, C. N., Supapaan, T., Mann, C., Mongkhon, P., & Chanunun, S. (2020). Impact of research-based learning on student knowledge and assessment in Pharmacoepidemiology: a one group pretest-posttest experimental study. *Thai Journal of Pharmaceutical Sciences (TJPS)*, *43*(4).

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30(3), 607-610.

Lau, W. W., & Man, Y. K. (2018). Teacher noticing: Advancing understanding of teaching, learning, policy, and practice in mathematics education. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(11), em1657.

McCaleb, K. N., Andersen, A., & Hueston, H. (2015). An Investigation of School Violence and Pre-Service Teachers. *Current Issues in Education*, *10*. Retrieved from https://cie.asu.edu/ojs/index.php/cieatasu/article/view/1570

Mostafa, M., Javad, L. M., & Reza, O. H. (2017). The Effect of Van Hiele Theory-Based Teaching Educational Package on Achievement Goal Orientation of Student Teachers. Review of European Studies, 9(1), 93–105. https://doi.org/10.5539/res.v9n1p93

National Council of Teachers of Mathematics (2000). Principles and standards for school mathematics. Reston: VA.

Oladosu, L. O. (2014). *Secondary school students' meaning and learning of circle geometry* (Doctoral dissertation, University of Calgary).

P. M. Van Hiele (1986). Structure and Insight: A Theory of Mathematic Education, Academic Press, Orlando, FL, USA.

Schack, E. O., Fisher, M. H., & Wilhelm, J. A. (Eds.). (2017). Teacher Noticing: Bridging and Broadening Perspectives, Contexts, and Frameworks. Springer International Publishing. https://doi.org/ 10.1007/978-3-319-46753-5.

Schalich, M. E. (2015). Analysis of Pre Test and Post Test Performance of Students in a Learning Center Model at the Elementary School Level. Graduate Master's Theses, Capstones, and Culminating Projects: https://doi.org/10.33015/dominican.edu/2015.edu.08.

Shivaraju, P. T., Manu, G., Vinaya, M., & Savkar, M. K. (2017). Evaluating the effectiveness of pre-and post-test model of learning in a medical school. National Journal of Physiology, Pharmacy and Pharmacology, 7(9), 947.

Shukla, S. (2020). Concept of population and sample. How to Write a Research Paper, June, 1-6.

Van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scafolding new teachers' interpretations of classroom interactions. Journal of Technology and Teacher Education, 10(4),571–596.

Van Putten, S. (2008). *Level of thought in geometry of pre-service mathematics educators according to the Van Hiele model* University of Pretoria, South Africa University of Pretoria, South Africa.

Vojkuvkova, I. (2012). The van Hiele Model of Geometric Thinking. WDS'12 Proceedings of Contributed Papers, 1, 72– 75.

Yalley, E., Armah, G., & Ansah, R. K. (2021). Effect of the VAN Hiele Instructional Model on Students' Achievement in Geometry. *Education Research International*, *2021*, 1-10.

Yang, X., Kaiser, G., König, J., & Blömeke, S. (2019). Professional noticing of mathematics teachers: A comparative study between Germany and China. *International Journal of Science and Mathematics Education*, *17*, 943-963.