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EFFECTIVENESS OF VAN HIELE-BASED LAMPUNG ETHNOMATHEMATICS MOBILE LEARNING ON GEOMETRY UNDERSTANDING

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ABSTRACT

Understanding geometric concepts is often a major challenge for junior high school students due to the abstract nature of the material. This study examines the effectiveness of a mobile learning application based on the ethnomathematics of Lampung culture developed using Van Hiele's theoretical framework in improving students' understanding of geometric concepts. The study employed a quasi-experimental design with a pretest–posttest control group. Using a purposive sampling technique , the research involved ninth-grade students divided into an experimental class (N=31) and a control class (N=33). Data collection techniques consisted of a pretest and posttest , which were administered using a research instrument in the form of an essay test designed based on Van Hiele's comprehension indicators. Results from SPSS version 32 analysis indicated a significant difference between the two groups. The Independent Sample T-Test revealed that the experimental class outperformed the control class, with a posttest mean of 74.96 compared to 43.27 ($p < 0.001$). Additionally, the N-Gain results indicated a higher level of understanding in the experimental class with a score of 0.667 (moderate high category), far surpassing the control class's score of 0.245 (low category). These findings confirm that integrating local culture into digital learning effectively accelerates students' cognitive development in understanding geometric concepts. This approach is recommended as a more contextual and meaningful innovation in mathematics education.

Keywords: conceptual understanding; ethnomathematics; geometry; mobile learning; Van Hiele theory.

ABSTRAK

Pemahaman konsep geometri kerap menjadi tantangan utama bagi siswa SMP karena sifat materinya yang abstrak. Penelitian ini menguji efektivitas aplikasi mobile learning berbasis etnomatematika budaya Lampung yang dikembangkan dengan landasan teori Van Hiele terhadap peningkatan pemahaman konsep geometri siswa. Penelitian menggunakan desain quasi-eksperimen dengan pretest–posttest control group. Dengan menggunakan teknik purposive sampling, penelitian ini melibatkan siswa kelas IX yang terbagi menjadi kelas eksperimen (N=31) dan kelas kontrol (N=33). Teknik pengumpulan data terdiri dari tahap pretest dan posttest , yang dilakukan menggunakan instrumen penelitian berupa tes esai yang dirancang berdasarkan indikator pemahaman pada setiap

level teori Van Hiele. Hasil analisis SPSS versi 32 menunjukkan adanya perbedaan signifikan antara kedua kelompok. Uji Independent Sample T-Test memperlihatkan kelas eksperimen unggul dengan rata-rata posttest 74,96, dibandingkan kelas kontrol sebesar 43,27 (p < 0,001). Selain itu, hasil N-Gain menunjukkan peningkatan pemahaman yang lebih tinggi pada kelas eksperimen dengan skor 0,667 (kategori sedang–tinggi), jauh melampaui kelas kontrol yang hanya 0,245 (kategori rendah). Temuan ini menegaskan bahwa integrasi budaya lokal dalam pembelajaran digital efektif mempercepat perkembangan kognitif siswa dalam memahami konsep geometri. Pendekatan ini direkomendasikan sebagai inovasi pembelajaran matematika yang lebih kontekstual dan bermakna.
Kata kunci*: etnomatematika; geometri; mobile learning; pemahaman konsep; teori Van Hiele.*

Introduction

Mathematics plays a crucial role in developing students' logical thinking skills, yet it is still often viewed as an abstract subject with little relevance to daily life. This issue is particularly evident in geometry, which requires students to understand and visualize spatial relationships. Spatial visualization the key to grasping spatial concepts remains challenging for adolescents without the support of appropriate learning materials or tools (Hamdani et al., 2024). To address these specific spatial challenges, this study utilizes the Van Hiele theory. Unlike general cognitive developmental frameworks (such as Piaget's) or broad constructivist models that do not isolate geometric reasoning, the Van Hiele theory is uniquely suitable because it offers a specialized, sequential taxonomy detailing exactly how students progress from basic visual recognition to complex spatial analysis (Hamdani et al., 2024). This domain-specific structure provides a much more precise mechanism for scaffolding geometry instruction than other general learning frameworks. Furthermore, Cesaria et al. (2021) explain that conventional learning focused on memorizing formulas without relating them to real-world contexts can hinder the development of students' spatial understanding. Therefore, an update to mathematics learning strategies is needed one that not only leverages this specialized geometric cognitive progression but is also relevant to students' real lives.

To address the need for adaptation to these cognitive stages, Van Hiele's theory can serve as a foundation for designing ideal geometry instruction. This theory explains that understanding of geometry develops through five sequential levels: visualization (level 0), analysis (level 1), informal deduction (level 2), formal deduction (level 3), and rigor (level 4) (Hartono et al., 2025). Each level must be passed through sequentially to build systematic understanding. In line with this, Rahayu and Jupri (2021) state that learning that supports students' transition from the visualization stage to the analysis stage plays a crucial role in reducing misconceptions regarding the properties of plane and solid figures. For students to successfully navigate these cognitive stages, the learning process must be facilitated through an approach that is relatable and easily recognized by students in their daily lives. Theoretically, this necessity creates a powerful synthesis between Van Hiele's framework, ethnomathematics, and mobile learning. Ethnomathematics provides the concrete, culturally familiar artifacts such as traditional motifs and local architecture that serve as the ideal starting points for Van Hiele's visualization stage (Level 0). Meanwhile, mobile learning provides the interactive technological

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medium required to actively manipulate these cultural objects. By utilizing digital features such as 3D manipulation, rotating, and immediate feedback, mobile platforms transform passive cultural observation into active geometric analysis (Level 1). Together, ethnomathematics supplies the relatable context, mobile learning provides the dynamic interaction, and Van Hiele's theory offers the structured cognitive pathway, comprehensively complementing one another to systematically scaffold students' geometric understanding.

As a complement to these cognitive guidelines, the ethnomathematics approach aims to connect mathematical concepts with the local culture familiar to students. Gunawan et al. (2025) state that introducing geometric concepts through traditional architecture can help students understand that mathematics is not separate from their environment. The use of local cultural elements can make abstract mathematical concepts more concrete and easier to understand, as students can directly observe them and relate them to the values around them (Bimantara, 2024). Thus, a more meaningful and relevant learning experience for students will be created by integrating ethnomathematics into the Van Hiele stages.

One rich yet underutilized source of ethnomathematics in education is the culture of Lampung Province. Various cultural artifacts of Lampung, such as Siger motifs, Tapis cloth, and the traditional Nuwo Sesat architecture, clearly demonstrate mathematical concepts such as number patterns, symmetry, and geometric transformations (Linuhung et al., 2025). Research on Lampung Batik and Siger motifs also proves that this cultural heritage is not merely of aesthetic and philosophical value but contains geometric concepts that are highly suitable as a source of contextual learning (Fadila, 2017; Marian & Saputra, 2023). Integrating elements of Lampung culture into education not only brings the subject matter closer to students' experiences but also serves as a means of preserving local culture.

To effectively convey this locally-based geometry material to today's students, supporting media that adapts to advancements in digital technology is required. Students today tend to prefer visual and interactive learning styles, making mobile learning a highly relevant alternative capable of presenting abstract concepts as more concrete and engaging visual representations (Fitri et al., 2024). Previous studies have initiated efforts to combine Van Hiele's theory with digital learning, demonstrating that interactive technology can facilitate complex spatial material while increasing student engagement (Hartono et al., 2025; Lubis et al., 2023). Similarly, recent research has explored Lampung ethnomathematics such as Tapis fabric and traditional architecture proving its potential as a highly contextual learning source (Hamid et al., 2023; Pratama et al., 2025b). However, a significant shortcoming in the existing literature is that most Van Hiele-based digital interventions still rely on culturally neutral, conventional geometric figures that are disconnected from students' daily environments. Conversely, research on Lampung ethnomathematics has predominantly focused on descriptive exploration or static teaching materials, lacking interactive mobile integration that systematically guides students through cognitive stages. Therefore, the novelty of this research lies in synergizing these previously isolated domains: developing a dynamic mobile learning application that systematically structures the rich ethnomathematics of Lampung culture according to Van Hiele's cognitive stages. This innovation not only

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gives students the flexibility to explore geometry without being bound by classroom limitations but also grounds abstract concepts deeply within their local cultural identity.

Preliminary observations at the research location, SMP Negeri 2 Merbau Mataram, revealed several specific problems that prompted this study. Students exhibited significant difficulties in spatial visualization, often relying on rote memorization of geometric formulas without grasping the underlying spatial relationships. Furthermore, the existing instructional materials lack interactive digital elements and remain largely disconnected from the students' daily lives and cultural environment, leading to low student engagement and motivation. Given these localized problems and the broader educational background, the urgency of this research lies in developing a learning ecosystem that integrates Van Hiele's theory, the ethnomathematics of Lampung culture, and mobile learning technology into a single cohesive whole. The integration of these three elements is expected to create a contextual, interactive, and meaningful learning experience. In addition to being effective in addressing students' difficulties in understanding geometric space, this approach holds strategic value in introducing local cultural heritage. This aligns with the findings of Hamid et al. (2023), who noted that the incorporation of local culture through learning media serves as an effective means to strengthen national identity while simultaneously motivating students' active engagement.

Globally, the integration of local wisdom into innovative technological media is fully aligned with current digital education paradigms, such as Education 5.0, which emphasizes a human-centered approach to digital tools such as mobile-based and artificial intelligence (AI)-supported learning (Crompton & Burke, 2020; Fikriyah et al., 2025). Bridging the transition from passive cultural observation to interactive digital exploration, this study specifically focuses on Lampung cultural artifacts namely, Tapis fabric motifs and Lamban Pesagi architecture. These specific artifacts were deliberately chosen over other local elements because their complex physical structures naturally exhibit distinctive geometric properties such as symmetry, transformation, and tessellation, thereby providing an optimal foundation for concrete spatial reasoning. Therefore, this study aims to determine the effectiveness of using Van Hiele theory-based mobile learning in the ethnomathematics of Lampung culture to improve students' understanding of geometric concepts. Theoretically, this study advances mathematics education by establishing a new synthesis: combining the dynamic interactivity of mobile learning with the highly relevant sociocultural context of distinctive Lampung artifacts, all systematically organized through the domain-specific cognitive scaffolding of Van Hiele's theory. Practically, this approach fosters a deep and sustainable understanding of geometry that is both technologically adaptive and culturally rooted. Therefore, the main hypothesis of this study is that students who utilize this integrated ethnomathematics mobile learning will achieve a significantly higher level of conceptual understanding of geometry compared to those who receive conventional instruction.

Research Methods

This study employed a quasi-experimental research design using a pretest-posttest control group design. This approach was chosen to evaluate the effect of

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mobile learning incorporating Lampung cultural ethnomathematics based on Van Hiele's theory on students' level of understanding of geometric concepts. According to Tatulus et al. (2021), this design provides an appropriate foundation for measuring the effectiveness of an educational technology intervention. The study population included all ninth-grade students at SMP Negeri 2 Merbau Mataram. Sampling was conducted using purposive sampling, resulting in two equivalent groups: the experimental class (N=31) and the control class (N=33). To minimize confounding variables, both classes were taught by educators with equivalent pedagogical qualifications.

The data collection instrument used consisted of five essay test items with a maximum score of 100. The items were designed based on indicators of conceptual understanding at each level of Van Hiele's theory. Before implementation, the instrument was validated by experts in geometry, ethnomathematics, and educational assessment to ensure content and construct validity. The validation results showed that the questions were deemed valid by all three validators. Data collection was conducted in two stages. The first stage was a pretest to assess students' initial conceptual understanding. The second phase was a posttest administered after the intervention was completed; during this phase, the experimental class learned using the Lampung ethnomathematics mobile learning program over five sessions in accordance with Van Hiele's five stages of thinking, while the control class used conventional textbooks. The learning process in both the experimental and control classes spanned five sessions, ensuring that both groups had an equal duration of instruction.

Quantitative data analysis in this study was conducted using SPSS version 32. The analysis began with parametric statistical prerequisite tests, including the Shapiro-Wilk normality test to assess data distribution and Levene's test of homogeneity of variances to ensure equal variability across groups (Darmayanti et al., 2023). If the data met the assumptions of normal distribution and homogeneity, the analysis proceeded to the main hypothesis testing stage using the Independent Sample T-Test with a significance level of α=0,05. Next, to complement the interpretation of the hypothesis test results, an effect size calculation was performed using Cohen's d. This analysis aimed to determine the extent of the effect of using Van Hiele theory-based mobile learning in Lampung cultural ethnomathematics on students' understanding of geometric concepts. According to Lakens (2013), reporting effect sizes is important because it provides information about the practical significance of a treatment that cannot be explained solely through statistical significance values.

In addition to hypothesis testing, this study also used N-Gain analysis (normalized gain coefficient) to measure improvements in students' understanding before and after the intervention. N-Gain calculations were used to minimize the potential bias arising from differences in students' initial abilities. The results of these calculations were then converted into standard criteria (low, moderate, and high) to evaluate the effectiveness of using ethnomathematics mobile learning media in improving students' understanding of the geometric concepts of similarity and congruence.

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Results and Discussion

Before presenting the results of the data analysis, it is important to provide an overview of the primary intervention instrument used in this study. The implementation of learning in the experimental class was fully facilitated by a mobile learning application based on the ethnomathematics of Lampung culture, which integrates Van Hiele's stages of thinking. The app's interface was designed to be interactive and contextual, ranging from the main menu and the presentation of visual materials featuring local artifacts such as Tapis fabric motifs (Figure 1) to structured assessment features that included a digital pre-test (Figure 2). These visualizations serve as a crucial foundation for understanding how this technology facilitates students' cognitive processes and conceptual understanding of geometry throughout the study.

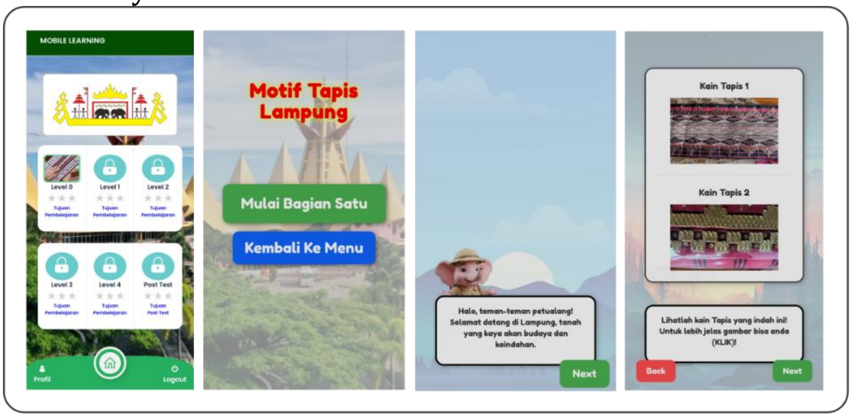

Figure 1. Main Menu of the mobile learning platform and a preview of the course content

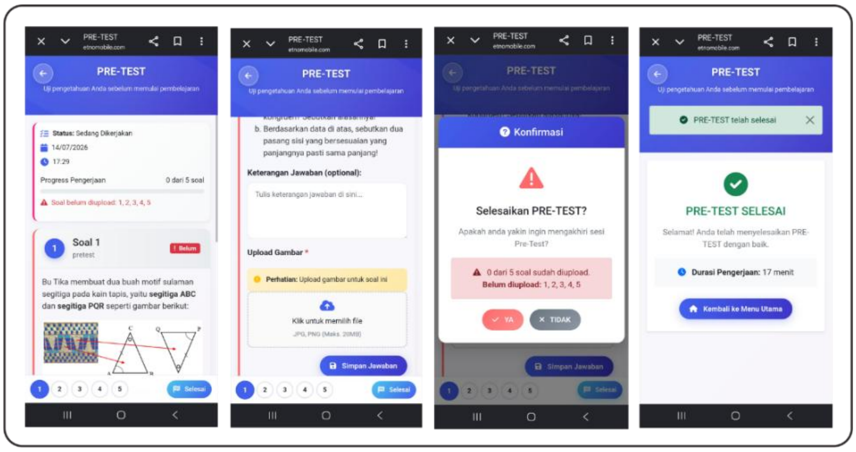

Figure 2. The pretest page in mobile learning

The presentation of these research results begins with the compilation, tabulation, and descriptive analysis of pretest and posttest data from the experimental class which utilized a mobile learning medium for Lampung cultural ethnomathematics based on Van Hiele's theory and the control class. Descriptive analysis was conducted to identify data trends, value distributions, and changes in learning outcomes prior to inferential analysis (Sari and Sulisworo, 2023). Additionally, descriptive statistics assist researchers in reviewing learning achievement trends both visually and quantitatively (Pahmi et al., 2024). A summary of the statistical results for both groups is presented in Table 1.

Table 1. Descriptive statistics on understanding of geometric concepts

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Group	Test Phase	N	Minimum	Maximum	Average	Standard Deviation
Experiment	Pretest	31	5,00	41,25	24,71	10,45
	Posttest	31	45,00	97,50	74,96	11,23
Control	Pretest	33	5,00	62,50	24,78	15,68
	Posttest	33	12,50	95,00	43,27	19,85

Prior to evaluating the statistical assumptions and hypothesis testing, the decision criteria for all subsequent inferential analyses were established at a significance level of $\alpha = 0{,}05$. Based on Table 1, the initial abilities of the students in both groups were relatively similar and statistically equivalent. This is evident from the average pretest scores of 24,71 for the experimental class and 24,78 for the control class. These scores indicate that the students' initial understanding of geometric concepts was still relatively low. This finding aligns with the results reported by Waliyuddin and Sulisworo (2021), who noted that many students struggle with solving abstract geometric problems. According to Daimah and Suparni (2023), low initial test scores may be caused by conventional instruction that has not yet been able to optimally develop students' ability to visualize geometry. Therefore, these equivalent and low initial conditions provided an appropriate baseline for assessing the intervention. The success of the subsequent intervention in producing better learning outcomes can be attributed to its direct approach to addressing this visualization deficit. By integrating familiar Lampung cultural artifacts within an interactive mobile platform, the intervention transformed abstract geometric properties into tangible objects. This contextual scaffolding successfully guided students from basic visual recognition to deeper spatial analysis a cognitive progression within the Van Hiele framework that conventional teaching methods often fail to facilitate.

After the intervention, there was a significant difference in the results of the conceptual understanding test between the experimental class, which used mobile learning, and the control class, which did not use mobile learning. The average posttest score for the experimental class increased to 74,96, while the control class achieved an average of only 43,27. This difference indicates that learning using ethnomathematics-based mobile learning yields better results than the learning implemented in the control class. This finding aligns with research Julianingsih and Widayanti (2023) showing that the integration of technology and cultural context in learning can enhance students' mathematical understanding. Furthermore, Sugiarto et al. (2023) state that significant improvements in learning outcomes in mathematics indicate that the use of technology not only serves as a learning medium but can also support students' thinking processes and conceptual understanding more effectively.

Before conducting a parametric hypothesis test to compare the results of the two groups, a normality test was first performed using SPSS version 32. The normality test aims to ensure that the data obtained are normally distributed, thereby meeting the requirements for the use of parametric tests. In this study, data normality was tested using the Shapiro–Wilk method because the sample size in each group was less than 50 participants. This step is crucial to ensure the accuracy of the analysis and the validity of the research findings. Darmayanti et al. (2023)

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state that the normality test is a procedure that must be performed before parametric analysis because it can affect the accuracy of the research conclusions. Additionally, the use of the Shapiro–Wilk test for small samples is also recommended in multimedia learning evaluation studies (Ninghardjanti and Dirgatama, 2021). The detailed results of the normality test are presented in Table 2.

Table 2. Results of the Shapiro-Wilk normality test

Data Variables	Group	Statistic (W)	df	Sig. (p-value)	Distribution Information
Pretest	Experiment	0,965	31	0,450	Normal
	Control	0,940	33	0,100	Normal
Posttest	Experiment	0,930	31	0,060	Normal
	Control	0,950	33	0,200	Normal

As detailed in Table 2, shows that all p-values (significance) for both pre-test and post-test data across the experimental and control groups exceed the threshold of 0,05. Consequently, the null hypothesis is accepted, confirming that the dataset derives from a normally distributed population (Julianingsih & Widayanti, 2023). Meeting this normality assumption reflects that the sample effectively represents the target population, justifying the application of parametric statistical procedures Sugiarto et al. (2023).

Following the verification of normality, a variance homogeneity test was executed using Levene's Test of Equality of Variances. This procedure evaluates whether the variance between the experimental and control groups is equivalent, thereby ensuring a reliable comparison of group means (Fikriyah et al., 2025). In line with Fitri et al. (2024), satisfying the homogeneity assumption is essential prior to running an Independent Sample t-Test. The outcome of this variance homogeneity assessment is outlined in Table 3.

Table 3. Results of Levene's test for homogeneity

Variable	Levene's Statistic (F)	df1	df2	Sig. (p-value)	Test Results
Posttest Score	1.205	1	62	0276	Homogeneous (Equal Variance)

The results Table 3. of Levene's Test showed an F-value of 1.205 with a p-value of 0.276. Since the p-value is greater than 0,05, it can be concluded that the variances of the data in the experimental and control groups are homogeneous or not significantly different (Ninghardjanti & Dirgatama, 2021). According to Fikriyah et al. (2025), the fulfillment of the assumption of homogeneity of variance allows for the use of parametric mean difference tests, such as the Independent Sample t-Test, without adjustments to the degrees of freedom. Thus, the analysis can be conducted in accordance with applicable statistical procedures.

Once all parametric assumptions were verified, hypothesis testing was executed via an independent samples t-test using SPSS version 32. This two-tailed test aimed to determine whether there was a significant difference between the group that received the treatment a mobile learning application for Lampung

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cultural ethnomathematics based on Van Hiele's theory and the group that did not receive the treatment. According to Khasanah et al. (2025), the mean difference test is an appropriate method for assessing the effectiveness of an intervention in educational research. The results of the Independent Sample T-Test are presented in Table 4.

Table 4. Results of the independent samples T-Test (posttest scores)

Criteria for the T-Test	t_{count}	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Diff**	**95% CI Lower**	**95% CI Upper**
Equal variances assumed	7,954	62	< 0,001	31,69	3,98	23,73	39,65

Based on the results in Table 4, the independent samples t-test yielded a t-value of 7,954 with a significance level (Sig., two-tailed) of < 0.001. Since the significance level is less than 0.05, the null hypothesis (H_0) is rejected. These results indicate that the use of ethnomathematics media based on Lampung culture and Van Hiele's theory has a significant effect on students' geometric concept comprehension compared to learning using conventional textbooks. This finding is supported by a mean difference of 31,69 points and a 95% confidence interval ranging from 23,73 to 39,65 that does not include zero, thus indicating a significant difference between the two groups (Lubis et al., 2023).

Table 5. Effect size calculation results

Mean Posttest Experiment	**Mean Posttest Control**	**SD Pooled**	**Cohen's d**	**Interpretation**
74,96	43,27	16,26	1,95	Very Large

Based on Table 5, a Cohen's d value of 1.95 was obtained. This value is well above the 0.80 threshold, thus falling into the "very large effect" category according to Cohen (1977). These findings demonstrate that integrating Lampung cultural ethnomathematics into Van Hiele based mobile learning yields statistically significant improvements and exerts a substantial effect on enhancing students' comprehension of geometric concepts relative to conventional instruction.

The analysis of post-test results should be supplemented by a measurement of students' improvement in ability using the N-Gain index. This index is used to determine the level of improvement in the understanding of geometric concepts after the intervention was administered, taking into account each student's initial ability. According to Gunawan et al. (2025), the use of N-Gain helps mitigate the influence of initial ability differences, thereby allowing the evaluation to focus more on the improvement in learning outcomes achieved. N-Gain analysis not only serves as an evaluation tool but can also be used as a reference for optimizing learning media, creating a more effective learning environment, and improving the overall quality of education (Trianto, 2010). Therefore, N-Gain analysis is recommended as one of the indicators in reporting educational research results. The results of the N-Gain index calculations are presented in Table 6.

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Table 6. Results of the N-Gain index calculation

Group	Average Pretest Score	Posttest Average	N-Gain Index Score	Classification Criteria
Experiment	24,71	74,96	0,667	Medium (Almost Tall)
Control	24,78	43,27	0,245	Low

As detailed in Table 6, the experimental group recorded an N-Gain score of 0.667 placing it in the moderate range and approaching the high threshold whereas the control group only attained 0.245, classifying it in the low category. This numerical divergence reveals a more substantial progress in students' geometry proficiency within the experimental cohort compared to the control group. In line with Gunawan et al. (2025), such findings imply that integrating technology and cultural elements into learning media offers a more effective framework for advancing students' geometric understanding.

The success of this study is supported by the digital application's ability to facilitate the development of geometric understanding in accordance with the stages of Van Hiele's theory. In the early stages, the application presents two-dimensional cultural objects that help students recognize various visually similar two-dimensional shapes. This feature supports learning at the visualization level (Level 0), where students recognize shapes based on their overall form without focusing on their specific properties. According to Cesaria et al. (2021), progression toward the analysis level (Level 1) can be enhanced through direct interaction with objects, such as rotating, zooming in, and observing shapes from various angles. These features are available in the app via touchscreen on mobile devices.

The mobile learning app consists of several features designed to support the development of conceptual understanding. The main menu contains three key features: the pretest, learning materials, and learning outcomes. The pretest is the first feature students must complete before beginning their studies. The pretest includes a conceptual understanding assessment used to measure students' initial proficiency before they proceed to the learning materials. Only after completing the pretest can students access the learning materials menu. The learning materials feature contains content organized according to the five stages of Van Hiele's geometric thinking and concludes with a posttest. These menus are structured in a sequential manner; students cannot access the next level until they have completed the previous one. After the five stages of Van Hiele's geometric thinking have been completed or studied, students will take the posttest. Students can view their scores or results in the "Student Results" menu located on the main menu page. The content and questions in the app are integrated with Lampung culture, featuring tapis fabric motifs and Lamban Pesagi ornaments.

The integration of authentic values from the architecture of the Lamban Pesagi (a traditional house native to West Lampung) into the application interface serves as a highly effective cultural catalyst in reconstructing students' understanding of two-dimensional shapes. This technology-based visual approach aligns with findings that visualizing the physical structure of traditional houses bridges abstract geometric concepts into more concrete spatial representations for

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students (Pratama et al., 2025b). According to Hamid et al. (2023), the use of this traditional house normalizes the complexity of geometry into something very familiar, so that when students are asked to calculate volume or surface area, they feel as though they are designing or restoring a heritage legacy from their ancestors, rather than merely memorizing lifeless formulas. Through this introduction to the context of ethnomathematics, the process of mathematical internalization becomes far more meaningful because students not only sharpen their cognitive intelligence but also cultivate a deep sense of ownership and appreciation for the values of their own local culture (Pratama et al., 2025a).

In addition, this application utilizes mathematical elements found in Lampung cultural artifacts such as Tapis cloth, traditional houses, and traditional tools as a context for learning geometry. The patterns on Tapis cloth and the shapes of the ornamental surfaces on traditional houses and tools help students understand the concepts of similarity and congruence. Through these activities, students are encouraged to connect various properties and relationships between geometric figures, thereby supporting the development of understanding at the informal deduction level (Van Hiele Level 2). According to Pratama et al. (2025b), integrating cultural elements into mathematics learning can help students understand concepts more meaningfully because the material is linked to objects familiar to their daily lives.

The interactivity and immediate feedback available in mobile-based learning help students understand geometric concepts more effectively. Errors in identifying similar or congruent geometric shapes can be corrected immediately through the real-time feedback feature, thereby reducing the risk of misconceptions. Additionally, the use of animations and dynamic visualizations makes it easier for students to understand shapes and spatial relationships. According to Fitri et al. (2024), mobile learning media can help reduce students' cognitive load, allowing them to focus more on understanding geometric concepts rather than visualizing abstract objects.

The obtained t-value of 7,954 confirms that mobile learning integrated with Lampung ethnomathematics significantly boosts students' comprehension of geometric concepts, notably within the domain of similarity and congruence. This finding suggests that low mathematics achievement is influenced not only by students' abilities but also by the instructional approach used (Hamdani et al., 2024). The integration of ethnomathematics into mobile learning based on Van Hiele's theory provides a more contextual learning experience by linking geometric concepts to local cultural objects. This approach helps students gradually progress from the visualization level to the analysis level in understanding geometric shapes (Clements & Battista, 1992). Additionally, culture-based learning enhances engagement and conceptual understanding because students learn through familiar contexts (Rahayu & Jupri, 2021).

With an effect size reaching 1,95, the integration of Lampung ethnomathematics into Van Hiele-based mobile learning demonstrates a remarkably powerful influence on advancing students' geometric comprehension. This outcome further substantiates the Independent Samples t-test results, which previously established a statistically significant divergence between the experimental and control cohorts. Thus, the effectiveness of the developed medium

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is demonstrated not only by statistical significance but also by the magnitude of the treatment's effect on learning outcomes. According to Cohen (1977), effect size is a practical measure that describes the strength of an intervention so that research results do not depend solely on significance values. This is important because p-values are influenced by sample size, whereas effect size provides a more objective picture of the actual benefits of a treatment in learning practice.

The substantial effect size recorded in this research demonstrates that combining Van Hiele's theoretical model, an ethnomathematical approach, and mobile learning fosters an instructional environment that highly optimizes students' geometric comprehension. Van Hiele's stages of thinking help students build concepts systematically, while the cultural context of Lampung makes the material more relevant to students' experiences. On the other hand, the interactive visualizations available in the app make it easier for students to connect concrete objects with abstract geometric concepts. The combination of these three aspects provides a more meaningful learning experience, which has a significant impact on improving conceptual understanding.

The results of this study are consistent with Lakens (2013) view, which emphasizes that reporting effect sizes is crucial because it provides information regarding the practical significance of an intervention. Furthermore, Sullivan & Feinn (2012) state that research results are more meaningful when significance levels are reported alongside effect sizes, allowing readers to assess the magnitude of the intervention's benefits. Therefore, a Cohen's d value of 1,95 indicates that Van Hiele theory-based mobile learning in Lampung cultural ethnomathematics is highly effective in improving junior high school students' understanding of geometric concepts.

Consequently, integrating Lampung ethnomathematics into mobile learning successfully enhances students' geometric comprehension by offering interactive visualizations, cultural relevance, and structured cognitive progression aligned with Van Hiele's theory. Furthermore, digital technology enriches instructional resources, making learning more dynamic and allowing learners to grasp mathematical concepts through visual and applied approaches.

Conclusion and Suggestion

The use of mobile learning in Lampung cultural ethnomathematics, based on Van Hiele's theory, has proven effective and significantly improved junior high school students' understanding of geometric concepts, particularly in the areas of similarity and congruence. This cognitive success is evidenced by the posttest scores and N-Gain scores of the experimental class, which far exceeded those of the control class. Therefore, this medium is highly recommended as an innovative approach to mathematics learning that is contextual, interactive, and meaningful.

Given that this intervention has proven successful in the cognitive domain, future research is encouraged to explore its impact on the affective domain. Specifically, future research should examine the effect of this approach on students' self-efficacy in geometry, which could begin with the development and validation of a comprehensive self-efficacy scale.

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