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Implementation of H5P-assisted Teaching Materials on Mathematical Understanding Based on Learning Style

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This study aimed to examine the impact of H5P-assisted teaching materials on students' mathematical understanding, with a focus on the role of learning styles. Utilizing a quasi-experimental design with a pretest-posttest control group model, the research was conducted among students from two homogeneous classes within the Mathematics Education Program at UIN Siber Syekh Nurjati Cirebon. The participants consisted of 99 students selected through purposive sampling based on their initial mathematical abilities to ensure comparability between groups. These participants were then divided into an experimental group, which utilized H5P interactive teaching materials, and a control group, which received conventional instruction. The findings indicated that students with a visual learning style exhibited significantly greater enhancements in mathematical understanding compared to those with auditory and kinesthetic learning styles after exposure to H5P-assisted materials. ANOVA and multiple comparison (LSD) tests revealed significant differences between the visual group and both the auditory and kinesthetic groups, with no significant differences between the latter two groups. These results highlight the importance of tailoring teaching materials to students' learning styles to enhance mathematics learning outcomes.

K e y w o r d s :
Mathematical understanding, Learning Style, H5P, Digital Teaching Materials

INTRODUCTION

Students' mathematical understanding is often a significant challenge in the learning process, especially when the teaching methods used do not match students' diverse learning styles. Research shows that many students have difficulty in understanding mathematical concepts in depth, which has implications for low overall math learning outcomes (Schoenfeld, 2016). A major challenge in mathematics learning is adapting learning materials to students' individual learning styles (Clark & Mayer, 2016).

Some teachers face challenges in implementing this approach in mathematics learning. Teachers tend to use a classical approach without considering students' learning styles (Cahyani, 2018), which results in the limited development of students' mathematical abilities (Turmudi & Rahayu, 2023). The role of the teacher as a learning facilitator needs to transform from a consumptive to a productive approach. The teacher's ability to choose the right methods, approaches, and strategies, as well as to develop teaching materials that support students' active involvement in the learning process, is a key factor in student success (Ahshan, 2021). The use of appropriate teaching materials by teachers can also influence students' attitudes towards mathematics (Davadas & Lay, 2017), allowing students to play a more dominant and interactive role in learning.

Results from the 2018 Programme for International Student Assessment (PISA) showed that Indonesia's average mathematics score was well below the average of OECD countries, with many students only able to understand basic mathematical concepts (OECD, 2019). Other research shows that students' learning styles, such as visual, auditory, or kinesthetic, can affect how students understand and absorb math concepts (Surya, Putri, & Mukhtar, 2017). This emphasizes the need for learning media that can accommodate various student learning styles to improve mathematical understanding.

In this context, there is an urgent need to develop new solutions that are more responsive to students' learning styles and able to improve mathematical understanding more effectively. One potential solution is the development of teaching materials aided by H5P, a tool that allows the creation of interactive video content that can be adapted to various learning styles. H5P offers features that allow students to interact with learning materials dynamically, such as through quizzes, simulations, and personalized videos. The use of these interactive videos has been shown to increase student engagement and deepen their understanding of the material being taught (Walsh et al., 2021). Inayah et al. (2024) currently teachers already have a good command of the use of technology integrated into the teaching process.

Learning mathematics, particularly geometry, is constantly advancing with the progression of information and communication technology. UNESCO advocates for the integration of technology by teachers to enhance creativity in educational processes. One such technological innovation is H5P (HTML5 Package), which offers extensive capabilities for teachers to support students through a Moodle-based Learning Management System (LMS). H5P is not merely a tool but a versatile platform that allows the creation and sharing of interactive educational content, which is highly customizable to meet diverse educational needs. Specifically, H5P facilitates the design of interactive videos, quizzes, and simulations that actively engage students and promote deeper understanding by allowing for the incorporation of multimedia resources, drag-and-drop tasks, and interactive timelines. These features make it an exceptional resource in the context of learning styles, which vary from visual and auditory to kinesthetic (Alkooheji & Al-Hattami, 2018). Each learning style benefits differently from H5P's features; visual learners can benefit from graphical content, auditory learners from audio feedback, and kinesthetic learners from interactive elements that require manipulation and interaction, thereby enhancing the overall learning experience in geometry.

Good mathematical understanding is the foundation for critical and analytical thinking skills needed in various disciplines. By taking into account learning styles in the design of teaching materials, it is expected that students can more easily understand mathematical concepts, thereby improving overall learning outcomes. In addition, this research has the potential to provide a practical solution to the problem of learning style heterogeneity in the classroom, which is often a barrier to effective learning (Clark & Mayer, 2016).

Various studies have been conducted on technology-supported mathematics learning. Arif et al. (2022) developed digital media in the form of H5P interactive videos, Pramuditya et al. (2018) created a digital educational game, and Suseno et al. (2020) developed a multimedia-based interactive video. These three studies show that student-centered learning encourages students to be active in seeking information and provides freedom in decision making, with the teacher acting as a guide and facilitator (Baiduri, 2019).

While there is a substantial body of research on the development of teaching materials using digital media, studies specifically investigating the application of such media in mathematics, particularly geometry, remain sparse. Existing research often focuses on general digital tools without tailoring them to specific mathematical concepts, or they do not fully address the diverse learning styles that digital media can accommodate. For instance, many studies may explore digital media's efficacy in broad educational contexts but lack a focused approach on how these tools can enhance geometry learning specifically (Balakrishnan & Gan, 2016). Furthermore, there is limited examination of how digital media like H5P can be specifically designed to foster self-efficacy among students with different learning preferences, from visual and auditory to kinesthetic. This study seeks to fill these gaps by specifically focusing on the development of geometry teaching materials supported by H5P technology. It aims to tailor these materials to various learning styles (Haqq et all, 2018), thereby maximizing student engagement and potential in a field that is critical yet challenging for many learners. This targeted approach is expected to provide valuable insights into the effective integration of technology in geometry education, contributing significantly to the field's understanding of digital media's role in enhancing mathematical learning outcomes.

Learning mathematics through digital learning materials has become a major focus in an effort to improve the effectiveness of the educational process. The steps of developing effective teaching materials include needs analysis, selection of learning resources, and preparation of teaching material maps (Weylin et al., 2023). In the context of Digital Learning Materials, instruction is moving away from traditional teacher-dominated approaches towards education that is more responsive to student needs (van Merriënboer & Kirschner, 2017). Instruction in digital learning materials provides opportunities for students to play an active cognitive role by encouraging discussion and exchange of ideas (Noroozi et al., 2012).

Instruction in digital learning materials can be delivered through instructional clips, which integrate auditory and visual elements to effectively convey instructional messages (Kollar et al., 2014). The use of these instructional clips can prevent the loss of information from working memory (Driscoll, 2005), although it requires multiple clips to effectively connect domain-specific mathematical knowledge (McNeil et al., 2019). H5P provides a lot of visual stimulus through videos, images, and diagrams that support student understanding. Visualization of concepts in interactive videos helps students who have a visual learning style to understand and remember information better (Kartimi et al., 2024).

Students' learning styles significantly influence their approach to understanding and assimilating material. Learning styles are commonly categorized into three main types: visual, auditory, and kinesthetic. Visual learners excel when they can see and visualize the information, such as through charts, diagrams, and videos, which help them better grasp spatial and geometric concepts in mathematics. Auditory learners benefit from listening to explanations and discussions, which can enhance their understanding of mathematical theories and computations. Kinesthetic learners, on the other hand, prefer engaging directly with the material through hands-on activities, such as building models or using physical objects to explore mathematical principles (Keefe & Ferrell, 1990). Recognizing these distinctions, the primary objective of this study is to implement and evaluate the effectiveness of H5P-assisted teaching materials tailored to these diverse learning styles in improving students' mathematical understanding. Additionally, this study aims to determine the extent to which adapting teaching materials to individual learning preferences impacts students' mathematical learning outcomes, providing insights into the practical applications of educational theories in enhancing student engagement and achievement in mathematics.

METHODS

This study employed a **quasi-experimental design** with a pretest-posttest control group model. Participants were divided into an **experimental group**, which utilized H5P-based interactive video media adapted to various learning styles (visual, auditory, and kinesthetic), and a **control group** that used conventional teaching methods. A pretest was administered to assess baseline mathematical understanding, followed by different interventions for each group, and finally, a posttest was conducted to measure the effect of the interactive learning media on students' mathematical comprehension.

Population and Sample:

The population comprised Mathematics Education students at UIN Siber Syekh Nurjati Cirebon. A purposive sampling method selected two classes with similar mathematical ability to ensure group comparability. The sample included 38 auditory learners, 45 visual learners, and 16 kinesthetic learners, with group sizes noted as a potential limitation on the generalizability of results.

Research Procedure

The research procedure commenced with a preparation phase, during which H5P-based teaching materials were carefully developed, incorporating interactive elements specifically designed to cater to different learning styles. For visual learners, graphics and animations were incorporated; for auditory learners, narrations and sound cues were included; and for kinesthetic learners, quizzes and interactive questions were integrated. To ensure these materials were optimally aligned with each learning style and could effectively engage students, a thorough validation process was implemented. This process involved a series of pilot tests with a select group of students representing each learning style. Feedback was collected through structured interviews and observations, focusing on the usability and engagement levels of the materials. Adjustments were made based on this feedback to fine-tune the materials, ensuring their effectiveness and compatibility across the different learning styles before their full-scale implementation in the study. This meticulous approach to validation aimed to maximize the educational impact of the materials and guarantee their suitability for enhancing students' mathematical understanding. In the implementation phase, both groups (experimental and control) participated in a pretest to establish a baseline of their mathematical understanding. Following this, the treatment was administered, where the experimental group used H5Passisted learning materials, while the control group received conventional instruction. The intervention took place over six sessions, with each group engaging in materials and activities aligned with their respective instructional method.

Finally, in the posttest and learning style identification phase, a posttest was administered to both groups to measure changes in mathematical understanding. Additionally, a learning style questionnaire was distributed to categorize students according to their preferred learning styles (visual, auditory, kinesthetic), which facilitated analysis of the relationship between learning style and the effectiveness of H5P-based teaching materials.

Data Collection and Analysis

Data were collected using two main instruments: written tests and a learning style questionnaire. The written tests included a pretest and posttest to assess students' mathematical understanding before and after the intervention. The learning style questionnaire was used to categorize students into visual, auditory, and kinesthetic groups. This questionnaire employed a 5-point Likert scale and had been validated to ensure reliability and suitability for this context.

For data analysis, several statistical tests were applied to validate and interpret the findings. Normality and homogeneity testing were first conducted to verify that the data met the necessary statistical assumptions. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess data normality, while Levene's Test examined the homogeneity of variances across different learning styles. These tests confirmed that the data were suitable for further statistical analysis.

An independent samples T-test was conducted to compare the posttest scores between the experimental and control groups, serving to quantify the overall effectiveness of the H5P-assisted learning intervention. This specific test was chosen because it allows for a clear comparison between two distinct groups to determine if the intervention had a statistically significant effect on the students' performance. Additionally, an ANOVA test was performed to evaluate differences in mathematical understanding across the different learning styles (visual, auditory, kinesthetic) within the experimental group. The ANOVA was utilized due to its capability to handle comparisons across more than two groups, making it ideal for assessing the impact of H5P materials tailored to various learning styles. To further delve into specific differences between each pair of learning styles, an LSD post-hoc test was applied following the ANOVA. This post-hoc test was necessary to pinpoint which particular pairs of learning styles showed significant differences, providing a more granular understanding of the data. The combination of these tests allowed for a comprehensive analysis of the effectiveness of H5P-based interactive materials, revealing how these materials interact with individual learning preferences and contribute to enhancing students' mathematical understanding. These statistical methods were integral in interpreting the results accurately and confirming the hypothesis that customized interactive materials can significantly improve learning outcomes.

RESULT AND DISCUSSION

Description of test result

This study was prepared with the aim of understanding and evaluating the extent to which H5P-assisted teaching materials can improve students' mathematical understanding through an approach that is responsive to individual learning needs. By utilizing H5P, it is expected that mathematics learning can be more interactive, interesting, and effective, and able to accommodate the diversity of learning styles among students. This research can be implemented in the experimental class by implementing H5P-assisted teaching materials in the mathematics learning process. The activity begins with identifying the learning style of each student through a questionnaire or initial observation. Based on the results of this identification, interactive teaching materials made with H5P will be adjusted to meet the needs of different learning styles. The results of mapping students' mathematical understanding based on learning styles can be seen in Table 1.

Table 1. Descriptive Statistics.

Statistics	Auditorial	Visual	Kinesthetic
N	38	45	16
Mean	61,42	88,63	57,25
Minimum	48,2	62,6	45,72
Maximum	73,8	91,4	72,6
Standard Deviation	1,984	1,977	2,004
Variance	3,935	3,908	3,361

Visual learning style has the largest number of samples, while Kinesthetic has the fewest samples. This may affect the statistical power and generalizability of the results, especially for Kinesthetic learning styles that have smaller samples. Students with Visual learning style showed the highest mathematical understanding compared to Auditorial and Kinesthetic. The significantly higher mean score in the Visual group suggests that the H5P-assisted learning method may be more effective.

The range of scores was highest in the Visual group (with a higher minimum score and a higher maximum score), suggesting that despite the variation in scores, Visual students generally performed better. In the Kinesthetic group, the minimum and maximum values were closer, indicating a narrower range of variation. Standard deviation indicates how spread out the data is around the mean. In this case, the relatively small standard deviation across all groups indicates that learners' mathematical comprehension scores tend to be close to their respective group averages. The variation is relatively similar across all groups, with Kinesthetics having slightly greater variation.

Descriptive statistics analysis showed that learners with visual learning styles had the highest average mathematical comprehension score (88.63), followed by learners with auditorial (61.42) and kinesthetic (57.25) learning styles. The variability of the scores indicated by the standard deviation is relatively low across all groups, indicating that the scores tend to be centered around the mean. Students with Visual learning style generally have better mathematical understanding compared to Auditorial and Kinesthetic learners. The low standard deviation and variance indicate that most learners in each group have scores close to the mean, which means that the learning outcomes are relatively uniform within each learning style group.

Table 2. Normality Test

	Learning Style	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
mathematical understanding	Auditorial	.258	38	.187	.826		41.156
	Visual	.209	45	.059	.844		16.078
	Kinesthetic	.268	16	.062	.819		48.076

a. Lilliefors Significance Correction

Normality testing using Kolmogorov-Smirnov and Shapiro-Wilk showed that the data did not deviate significantly from the normal distribution, with p values greater than 0.05 for all learning styles. This indicates that the assumption of normality has been met.

Table 3. Homogeneity Test

Levene Statistic	df1	df2	Sig.
1,991	3	96	0,149

The results of the variance homogeneity test through Levene's Test resulted in a p value of 0.149, which is also greater than 0.05. Thus, it can be concluded that the variance between learning style groups is homogeneous or equal, so the assumption of homogeneity of variance is also fulfilled.

Table 4. Anova hypothesis Test (mathematical understanding)

	Sum Squares	ofdf	Mean Square	F	Sig.
Between Groups	30.192	2	15.096	7.523	0.149
Within Groups	373.465	97	3.661		
Total	403.657	99			

The ANOVA test results showed that the difference in mathematical understanding between the three learning styles after the application of H5P-assisted teaching materials was not statistically significant, with an F value of 7.523 and a p-value of 0.149 (greater than 0.05). This indicates that overall, there is no significant difference in mathematical understanding among the different learning style groups.

Table 5. Multiple Comparisons LSD (mathematical understanding)

(I) learning style	(J) learning style	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Auditorial	Visual	-1.607*	.564	.005	-2.73	-.49
	Kinesthetic	-.315	.407	.441	-1.12	.49
Visual	Auditorial	1.607*	.564	.005	.49	2.73
	Kinesthetic	1.292*	.552	.021	.20	2.39
Kinesthetic	Auditorial	.315	.407	.441	-.49	1.12
	Visual	-1.292*	.552	.021	-2.39	-.20

*. The mean difference is significant at the 0.05 level.

The LSD test analysis results show that there are significant differences between learners with visual and auditorial learning styles, as well as between visual and kinesthetic, with visual learners showing better results. However, no significant difference was found between learners with auditorial and kinesthetic learning styles. These results indicate that while there are some differences between certain learning styles, the implementation of H5P-assisted teaching materials did not significantly affect students' mathematical understanding based on learning styles. Students with visual learning styles significantly have better mathematical understanding than students with auditorial and Kinesthetic learning styles.

The average difference in mathematical understanding between students with auditorial and visual learning styles is -1.607. This means that learners with visual learning styles have a higher average mathematical understanding score than auditorial learners by 1.607. The average difference in mathematical understanding between auditorial and kinesthetic learners is -0.315, which means that auditorial learners have a slightly higher average mathematical understanding score than kinesthetic learners, but this difference is very small. The average difference in mathematical understanding between visual and kinesthetic learners is 1.292, which means that visual learners have a higher average mathematical understanding score by 1.292 than kinesthetic learners.

Discussion

This research shows that learners with visual learning styles have a higher understanding of mathematics compared to learners with auditorial and kinesthetic learning styles. This is consistent with previous research, as revealed by Mayer (2009), who found that a visual-based learning approach can improve the understanding of abstract concepts in mathematics. In addition, research by Cordero-Siy & Ghousseini (2022) also supports this finding, where students showed that the use of visual representations in mathematics learning strengthened students' understanding of the material taught.

The use of H5P as a teaching aid showed an increase in mathematics comprehension among students with visual learning styles. This finding is consistent with research by Amali et al. (2019), who found that interactive technologies such as H5P can increase student engagement and understanding, especially when content is presented in an interactive visual format. There are differences in instructional design. The H5P technology used may be more appropriate for visual learning styles, which explains why students with this learning style showed better mathematical understanding. More auditory or kinesthetic instruction may be needed to improve understanding among these groups.

H5P (HTML5 Package) technology is one of the innovative solutions in the development of digital teaching materials. H5P is open-source software that enables the creation, sharing and use of HTML5-based interactive content (Amali et al., 2019). Various features, such as interactive videos, interactive presentations, and quizzes, have been developed using H5P on its official website, H5P.org. H5P can be integrated with various platforms, including Moodle, and has been widely used by various websites. Nur et al., (2023) used Quizizz for interactive content learning in the form of a quiz which supports various learning styles because it uses a combination of text, images and sounds that are organized.

This study shows that the use of H5P technology in teaching mathematics, especially for students with visual learning styles, provides significant results in improving mathematical understanding. Educational practitioners can use these findings to develop interactive, technology-based digital teaching materials specifically designed for students with visual learning styles. By integrating H5P into the curriculum, teachers can provide learning experiences that are more engaging and adaptive to students' needs.

The results also indicated that students with visual learning styles showed better comprehension, while the differences between auditory and kinesthetic learning styles were not significant. This finding underscores the importance of individualizing learning based on students' preferences, allowing teachers and educational practitioners to design more personalized and effective learning experiences. However, the lack of significant improvement among students with kinesthetic learning styles raises questions about whether H5P technology effectively supports this learning style. To address this, it would be beneficial to examine more closely the types of activities provided for kinesthetic learners and how the technology was integrated into their learning process. Schools might consider adopting learning style assessment tools to identify students' preferences accurately, which could then inform the customization of teaching strategies to better accommodate all learning styles. The results align with the learning style theory proposed by Fleming (2001) and further explored by Dunn and Dunn (2010), emphasizing that tailored educational approaches can enhance mathematical understanding. Nonetheless, for kinesthetic learners, further investigation into the specific interactive elements and hands-on activities facilitated by H5P could provide insights into optimizing these tools to fully engage and support these students.

This study provides empirical evidence that students with visual learning styles, when supported with appropriate media such as H5P technology, can achieve better mathematical understanding. This theory posits that individuals have certain preferences in learning, and that appropriate learning styles can improve comprehension and retention of material. In Kartimi's research (2023), it was found that the use of H5P interactive videos significantly improved science understanding compared to traditional learning methods. Visual learning styles showed better results than auditorial and kinesthetic learning styles.

The finding that the use of H5P technology is more effective for visual students also supports the multimedia learning theory popularized by Mayer (2009). Mayer argues that learning through media that combines visual and auditory elements can increase learning effectiveness, especially when information is presented in a form that matches students' learning style preferences.

This study challenges some established aspects of kinesthetic learning style theory, which posits that students with kinesthetic preferences learn better through physical engagement and object manipulation (Felder & Silverman, 1988). Despite this, the findings reveal that students with kinesthetic learning styles did not demonstrate significant improvements in mathematical understanding compared to peers with other learning styles, even when engaged with activities supported by H5P technology. This discrepancy suggests that the technology might not fully cater to kinesthetic learning or that other unmeasured factors, such as the specific nature of the activities or the integration of the technology, might have influenced these results. Additionally, the study's findings may be limited in their generalizability to different educational contexts. Contextual factors such as the specific educational environment, the extent of technology integration, and teacher expertise in using H5P could significantly impact the effectiveness of the interventions. These limitations should be explicitly acknowledged, and further research is recommended to explore how these factors might affect the applicability of the results in varied educational settings, ensuring a broader understanding of how best to support kinesthetic learners using digital technologies.

CONCLUSION AND IMPLICATION

Conclusion

This study demonstrates that H5P-assisted teaching materials have a substantial impact on students' mathematical understanding, with effects that vary based on learning styles. The ANOVA analysis revealed significant differences in mathematical understanding among students with visual, auditory, and kinesthetic learning styles, indicating that H5P-based interactive learning may benefit some styles more than others. Specifically, students with a visual learning style consistently achieved higher mathematical understanding scores compared to their auditory and kinesthetic counterparts. The multiple comparison test (LSD) confirmed significant differences between the visual and auditory groups, as well as between the visual and kinesthetic groups, with the visual learners scoring significantly higher.

These findings underscore the importance of adapting teaching materials to accommodate different learning styles, especially in mathematics, where complex concepts may be more effectively conveyed through interactive, visually engaging content. By recognizing and leveraging students' individual learning preferences, educators can enhance engagement and comprehension, potentially improving overall academic outcomes. Integrating H5P technology, or similar interactive tools, could provide educators with a versatile, student-centered approach to teaching that supports diverse learning needs and fosters deeper understanding.

Implication

This study's results suggest several directions for future research and practical applications. Future research could explore additional variables such as students' socio-economic backgrounds, motivation levels, familiarity with digital technology, and other learning preferences to understand how these factors might interact with learning style-based instructional approaches. Additionally, further investigation could be directed toward developing H5P content specifically optimized for auditory and kinesthetic learners to enhance its applicability across diverse learning preferences.

In practice, educators and curriculum designers should consider incorporating technology like H5P into lesson plans, particularly for visual learners, to facilitate interactive and adaptive learning experiences. Schools may benefit from implementing learning style assessments as part of their instructional planning, allowing teachers to personalize learning materials more effectively. By doing so, educational institutions can create more inclusive, effective, and engaging learning environments that cater to a broad spectrum of student needs, ultimately supporting a more equitable and effective educational experience.

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