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THE EFFECTIVENESS OF MICROSITE-BASED LEARNING MEDIA TO ENHANCE STUDENTS' UNDERSTANDING OF MATRIX CONCEPTS AT SEKOLAH INDONESIA KUALA LUMPUR

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ABSTRACT

This study was motivated by the low level of students' understanding of matrix concepts, which is largely caused by conventional teaching methods that lack interactivity and visual support. To address this issue, a microsite-based learning medium was developed to present matrix material in an interactive and visually supported manner. The study aimed to examine the effectiveness of using a microsite to improve the conceptual understanding of eleventh-grade students at the Indonesian School of Kuala Lumpur. A quasi-experimental method with a pretest–posttest control group design was employed involving 33 students, consisting of 20 students in the experimental group and 13 students in the control group. The experimental group received microsite-based instruction, while the control group was taught using conventional methods. The research instrument was an essay test developed based on Kilpatrick's indicators of conceptual understanding.The results showed that the experimental group achieved a mean gain of 81.46, whereas the control group obtained a mean gain of 74. Students in the experimental group demonstrated consistently high performance across most conceptual understanding indicators, while the control group showed moderate understanding with weaknesses in higher-order indicators, particularly in applying concepts across multiple representations. The Mann–Whitney U test indicated a significance value of 0.001, which is lower than 0.05, with an effect size of 0.573 categorized as large.These findings confirm that microsite-based learning is more effective than conventional instruction in enhancing students' conceptual understanding of matrix material.

Keywords: Conceptual Understanding, Learning Media, Matrices, Microsite, Quasi-Experiment

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PRELIMINARY

Understanding is a crucial aspect of the learning process, particularly in mathematics (Wahida et al., 2025). Students' ability to comprehend a concept determines the extent to which they can apply that knowledge to solve real-world problems (Azmi et al., 2025). In the context of learning about matrices, a solid understanding is essential because the concept underpins subsequent topics such as linear transformations, systems of linear equations, and applications across various fields, including engineering and economics. Without a deep understanding, students tend to memorize procedures without grasping their meaning, which ultimately can hinder their cognitive development in mathematics (Mahendra et al., 2025). Therefore, improving understanding should be a primary focus in efforts to enhance the quality of instruction.

Understanding can be defined as an individual's ability to grasp meaning, explain, and relate a concept to other relevant concepts (Azzahra & Suryandari, 2024). According to Bloom's taxonomy, understanding is the second level after remembering, reflecting a higher order of thinking because it involves interpretation, generalization, and drawing conclusions from acquired information (Dian, 2021). Furthermore, Radiansyah et al. emphasize that deep conceptual understanding is rooted in a student's capacity to identify underlying principles and the complex relationships within mathematical structures (Radiansyah et al., 2023). In mathematics education, understanding not only includes the ability to explain a concept in one's own words but also to apply that concept in various contextual situations. If understanding is not achieved, students are likely to struggle with problem-based questions that require deep conceptual comprehension. Thus, it is important to implement teaching methods and instructional media that help students attain an optimal understanding of the material.

Although understanding is an important aspect of mathematics learning, various studies indicate that students' understanding of matrix concepts remains relatively low. A study by Cahayaningrum et al. (2019) revealed that students made various errors in understanding matrix concepts, indicating that their grasp of basic operations such as matrix multiplication was severely lacking. Of the 36 students tested, the mean score was 66.39 with a standard deviation of 18.54, and many scored below the Minimum Mastery Criterion of 75, confirming that the level of conceptual understanding of matrix operations is still low (Cahyaningrum et al., 2019). Therefore, the researchers recommended that students engage in more practice and that teachers provide motivation and guidance when teaching matrix material (Sinaga et al., 2017). These difficulties primarily occur because students tend to memorize procedures without understanding the concepts behind them. Another study by Wulan et al. also showed that in tests of basic conceptual understanding of matrices, students' average scores were below 50%, indicating that the majority of students do not yet possess sufficient understanding of this topic (Apriani et al., 2024). Similar findings were reported by Maya and Bambang, who stated that students' low understanding of mathematical concepts, including matrices, affects their ability to solve applied problems, particularly those related to systems of linear equations and geometric transformations (Indrawati & Irawan, 2021). These facts demonstrate that there remain serious problems in matrix instruction that must be addressed promptly through more effective instructional strategies and innovations.

The low level of students' understanding of matrices does not occur without cause. Based on research by Rizki Kurniawan Rangkuti et al., one of the main factors contributing to students' poor mathematical conceptual understanding is the lack of variation in the use of instructional media. That study emphasizes the importance of employing innovative media to improve students' understanding by providing a more engaging and interactive learning experience (Rangkuti et al., 2023). In addition, development research on Problem-Based Learning–based teaching materials shows that media innovation and well-structured instructional devices can enhance students' conceptual understanding of mathematics; therefore, tools that facilitate active student involvement in discovering concepts are needed (Bimansah et al., 2025). Learning processes dominated by lectures and textbooks render students passive and make it difficult for them to comprehend abstract mathematical concepts. This is consistent with the findings of Tri et al., which indicate that verbal and written explanations without visualization hinder student understanding. The lack of innovative instructional media results in students' difficulty connecting concepts with their real-life applications (Maya Indrawati & Bambang Irawan, 2021). Thus, a more varied and interactive approach to teaching matrices is required so that students' understanding can improve significantly.

To address students' low understanding of matrices, innovation in the use of more interactive and engaging instructional media is required. One such medium is the microsite. Several studies have shown that using microsites in instruction can improve students' understanding. Faiz et al. reported that students who used a microsite-based instructional medium experienced an 18.49% gain in conceptual understanding after implementation. The mean pretest score was 69.96, while the mean posttest score increased to 82.90. This improvement was attributed to interactive microsite features such as animations, simulations, and digital practice exercises.(Keumala et al., 2024). These results support the effectiveness of microsites in enhancing student learning outcomes.

Another study by Nurfalah and Rahayu found that microsite use in mathematics teaching can increase student engagement because learners can access materials anytime and anywhere

(Nurfalah & Rahayu, 2023). In addition, Keumala et al. observed a significant increase in student learning motivation among those who used a microsite: the control class had a mean motivation score of 70, whereas the experimental class scored 76 on average. This rise in motivation directly contributed to improved conceptual understanding (Keumala et al., 2024). Research by Herwindo et al. also indicates that interactive video implementations can enhance conceptual understanding with high effectiveness scores, and problem-based or game-based approaches likewise have positive effects on mathematics learning outcomes. These findings suggest that integrating visual-interactive elements and activities that promote active thinking are key components in designing mathematics instructional media (Herwindo et al., 2025). Therefore, the utilization of microsites is a promising solution for improving students' understanding of matrix concepts, particularly in the context of teaching at Sekolah Indonesia Kuala Lumpur.

Microsites are small-scale websites created for specific purposes, such as delivering learning material in a more focused and interactive way. Unlike main websites, which typically offer many features and broad coverage, microsites are simpler while still providing rich and in-depth content(Šula & Banyár, 2021). Microsites are often used in education to present material in more attractive and easily accessible formats for students. Compared with PowerPoint (PPT), which tends to be static and limited to text and images, a microsite enables independent exploration through flexible navigation(Turnip et al., 2024). Meanwhile, instructional videos are effective for visually explaining concepts but are passive and do not allow direct interaction with the material (Aurora et al., 2024). On the other hand, Kahoot is excellent for assessment and for increasing motivation through gamification, but it is limited to practice questions and does not provide deep content delivery (Heniki & Halim, 2024). Microsites have advantages over other digital media such as PowerPoint, instructional videos, and quiz platforms because they can integrate various learning elements into a single, more interactive platform (Šula & Banyár, 2021). Their flexibility and interactivity enable students to learn independently, participate actively in the learning process, and better understand abstract concepts like matrices. Therefore, using a microsite can be an innovative solution to improve students' understanding through a more dynamic and in-depth learning experience.

Unlike earlier studies that focused more narrowly on media such as GeoGebra, instructional videos, or interactive quizzes to improve student understanding, this study offers a more comprehensive approach by using a microsite for matrix instruction. The strength of this research lies in integrating multiple interactive elements within one platform, not only presenting content as text and images but also including animations, simulations, and adaptive practice exercises that can adjust to students' levels of understanding. Moreover, compared with other media that are passive or less flexible, a microsite allows students to explore material at their own pace. Thus, this study has the potential to provide a more effective and practical solution for improving students' understanding of matrix concepts.

METHODS

This study employs a quantitative approach with a quasi-experimental method to measure the effectiveness of a microsite-based instructional medium in improving students' understanding of matrix material. The design used is a pretest–posttest control group design, which compares two groups: an experimental group that learns using the microsite and a control group that is taught using conventional methods. With this design, the researcher can observe changes in students' understanding before and after instruction.

The subjects of the study were Grade XI students at Sekolah Indonesia Kuala Lumpur who were randomly selected, taking into account their previous mathematics scores so that the resulting groups would be relatively homogeneous. The sample comprised 20 students in the experimental group and 13 students in the control group. This sample size allows a more objective comparison between the microsite-based instructional method and the conventional method.

The study formulates two hypotheses. The null hypothesis (H_0) states that students' understanding of matrix material after the implementation of the microsite is not better than their understanding before the microsite was implemented. The alternative hypothesis (H_1) states that students' understanding of matrix material after the implementation of the microsite is better than their understanding before the microsite was implemented.

To measure students' understanding, an essay test on matrix concepts was administered in two stages: before instruction (pretest) and after instruction (posttest). The indicators of understanding refer to Kilpatrick's theory and cover six aspects: (1) recalling the concept, (2) classifying objects, (3) applying the concept algorithmically, (4) providing examples and non-examples, (5) relating various mathematical concepts, and (6) applying concepts across multiple forms of representation (Reska Novarni Musa et al., 2024).

Data were analyzed using statistical tests to ensure the validity of the results. A normality test was conducted to determine whether the pretest and posttest data were normally distributed, while a homogeneity test ensured that the variances of the two groups were equivalent. If the data are normally distributed, an independent-samples t-test is used to examine differences in posttest scores. If not, the Mann–Whitney U test is employed as an alternative.

The decision to accept or reject the hypotheses is based on the results of these statistical tests. If $p \geq .05$, H_0 is accepted, meaning that students' understanding of matrix material after the microsite implementation is not better than before implementation. If $p < .05$, H_1 is accepted, indicating that students' understanding of matrix material after the microsite implementation is better than before. In addition, the effectiveness of the microsite is also analyzed using effect size (Cohen's d) to determine the magnitude of its impact on improving students' understanding

RESULT AND DISCUSSION

The following are the posttest data from the experimental class, which will be compared with the control class. Each item was assessed using the Thompson Scoring Scale with a score range of 1 to 4.

Table 1. Posttest Results of the Experimental Class

No	Name Initials	Question Indicator						Total	Score
		Q1	Q2	Q3	Q4	Q5	Q6		
1	HW	4	4	4	4	4	4	24	100
2	AK	4	4	4	4	4	2	22	92
3	SN	4	4	4	4	4	4	24	100
4	NH	4	4	4	4	4	4	24	100
5	SS	4	4	4	4	4	4	24	100
6	AM	4	4	4	4	4	2	22	92
7	AN	4	4	4	4	4	4	24	100
8	MI	4	4	4	4	4	2	24	92
9	NS	4	4	4	4	4	4	24	100
10	NF	4	4	4	4	4	4	24	100
11	AA	4	4	4	4	4	4	24	100
12	AR	4	4	4	4	4	4	24	100
13	RA	4	4	4	4	3	2	21	88
14	YP	4	4	4	4	4	4	24	100
15	KV	4	4	4	2	2	4	20	83
16	SA	4	4	4	4	4	4	24	100
17	MF	4	4	4	4	4	4	24	100
18	FS	4	4	4	4	4	4	24	100
19	HN	4	4	4	2	2	4	20	83

No	Name Initials	Question Indicator Q1	Q2	Q3	Q4	Q5	Q6	Total	Score
20	RY	4	4	4	4	4	4	24	100
Average		80	80	80	76	75	72	23,15	96

Based on the posttest results, it was observed that out of 20 students, 14 achieved the maximum score, while the remaining 6 obtained lower scores. When examining the average scores for each indicator, the first, second, and third items showed excellent results, as all students answered correctly. This indicates that the indicators of understanding such as recalling concepts, classifying objects, and applying concepts algorithmically were well mastered by the students. However, on the fourth, fifth, and sixth items, several students responded incorrectly. This suggests that the indicators of understanding, including providing examples and non-examples, relating various mathematical concepts, and applying concepts in multiple forms of representation, were not fully mastered. Among these three indicators, applying concepts across different forms of representation scored the lowest. This means that students still experienced difficulties in understanding and applying concepts in various forms, such as graphs, tables, and verbal descriptions. Therefore, further reinforcement and practice are needed in this area.

Table 2. Posttest Results of the Control Class

No	Name Initials	Question Indicator						Total	Score
		Q1	Q2	Q3	Q4	Q5	Q6		
1	LP	4	4	4	3	2	2	19	79
2	GM	4	4	4	4	4	2	23	96
3	SA	4	4	3	3	2	2	18	75
4	MY	4	4	4	4	4	4	24	100
5	RS	4	4	4	4	3	3	22	92
6	AS	4	4	4	3	3	2	18	75
7	MAR	4	3	3	3	2	2	17	71
8	AH	4	4	3	3	3	2	19	79
9	MFR	4	4	4	4	4	3	23	96
10	MJ	3	3	4	3	2	1	16	67
11	DF	3	3	3	2	2	3	16	67
12	LT	4	3	3	3	3	2	18	75
13	AL	4	4	4	4	2	2	20	83
Average		50	48	47	45	38	30	19,46	81

Based on the posttest results of the control class consisting of 13 students, the average score obtained was 81. When analyzed per indicator, the total scores for Q1, Q2, and Q3 were relatively good, although not all students achieved the maximum score. However, in Q4, Q5, and particularly

Q6, a noticeable decline in scores was observed. The indicator related to applying concepts across multiple forms of representation (Q6) obtained the lowest score among all indicators. This suggests that students in the control class still experienced difficulties in connecting and applying matrix concepts in different forms, such as tables, graphs, or verbal descriptions. Therefore, conceptual understanding in the control class was not evenly distributed across all indicators.

A comparison of each question indicator between the experimental and control classes reveals consistent differences in students' conceptual understanding. In indicators Q1, Q2, and Q3, the experimental class achieved perfect scores, indicating that all students demonstrated excellent mastery in recalling concepts, classifying objects, and applying concepts algorithmically. In contrast, although the control class showed relatively good results on these indicators, several students did not achieve maximum scores, resulting in lower total scores compared to the experimental class. In indicators Q4 and Q5, both classes experienced a decline in performance. However, the experimental class still obtained higher scores than the control class, reflecting better ability in providing examples and non-examples as well as relating various mathematical concepts. The most noticeable difference was observed in indicator Q6, which measures the ability to apply concepts across multiple forms of representation. While the experimental class maintained relatively high performance in this indicator, the control class showed a considerable decrease. This suggests that students who learned through microsite-based instructional media demonstrated stronger ability in understanding and applying concepts in different representational forms compared to those who received conventional instruction. Furthermore, the distribution of conceptual understanding levels revealed that students in the experimental class achieved consistently high performance across most indicators, reflecting strong conceptual mastery. Conversely, students in the control class demonstrated moderate conceptual understanding with noticeable weaknesses in higher-order indicators, particularly in applying concepts across multiple representations. This confirms that microsite-based learning not only improved scores statistically but also enhanced the depth and consistency of students' conceptual understanding.

Table 3. Table of Pretest and Posttest Mean Scores

Class	Average Pretest	Average Postest	Average Increase
Control	7,05	81,09	74
Eksperimen	15	96,46	81,46

Based on the table, both classes experienced an improvement in learning outcomes after the instructional process. In the pretest stage, the average score of the control class was 7.05, while the experimental class scored 15, indicating that students' initial abilities were still relatively low. After the treatment, the average posttest score of the control class increased to 81.09, whereas the experimental class reached 96.46. The average increase in the control class was 74, while the experimental class showed a higher increase of 81.46. These results indicate that although both classes improved, the experimental class that used microsite-based learning media achieved a greater improvement, suggesting that it was more effective than conventional teaching methods.

Normality Test

The normality test was carried out using the Shapiro–Wilk Test to determine whether the pretest and posttest data were normally distributed. The results of the analysis are presented in the following table:

Table 4. Results of the Normality Test (*Shapiro-Wilk Test*)

Group	Statistic	p-value	Description
Control Class Pretest	0.946	0.540	Normal
Control Class Posttest	0.828	0.015	Not Normal
Experimental Class Pretest	0.924	0.116	Normal
Experimental Class Posttest	0.509	0.000	Not Normal

Based on the results of the normality test, the pretest data from both the control and experimental classes were normally distributed, whereas the posttest data were not normally distributed (p-value < 0.05). Therefore, parametric tests could not be applied, and the analysis was continued using the non-parametric Mann–Whitney U test.

Homogeneity Test

The homogeneity test was conducted to determine whether the variances of the two groups were equal. The results of the analysis using Levene's Test are presented in the following table:

Table 5. Result of the Homogeneity Test (*Levene's Test*)

Method	Statistic	p-value	Description
Based on Mean	0.412	0.526	Homogen
Based on Median	0.272	0.606	Homogen
Based on Adjusted df	0.272	0.606	Homogen
Based on Trimmed Mean	0.412	0.526	Homogen

The results of the homogeneity test show that the p-value was greater than 0.05 for all methods, indicating that the variances of the two groups were homogeneous.

Mann-Whitney U Test

Since the posttest data were not normally distributed, the non-parametric Mann–Whitney U test was employed to determine whether there was a significant difference between the experimental and control groups. The results of the analysis are presented in Table 4 below:

Table 6. Results of the Mann–Whitney U Test

Statistical Test	Value	p-value	Description
Mann–Whitney U Statistic	63.000	0.001	Significant difference

Based on the results of the Mann–Whitney U test, a p-value of 0.001 ($p < 0.05$) was obtained, indicating a significant difference between the posttest results of the experimental and control classes. This means that students' understanding after the implementation of the microsite was better than before. Therefore, H_0 is rejected and H_1 is accepted. In other words, the use of microsite-based media is proven to be effective and can enhance students' understanding of matrix material.

Effect Size Analysis

To determine the magnitude of the impact of using the microsite in matrix learning, the effect size (r) was calculated using the following formula:

$$r = \frac{Z}{\sqrt{N}} \dots\dots\dots (1)$$

Z = the z-score corresponding to the p-value

N = The total number of samples from both groups (control class + experimental class) is:

$$N = 13 + 20 = 33$$

We were given a p-value = 0.001 from the Mann–Whitney U test. To obtain the Z-value, the inverse cumulative distribution function (norm.ppf) of the standard normal distribution was used.

$$Z = norm.ppf(1 - \frac{p}{2})$$

$$Z = norm.ppf(1 - \frac{0{,}001}{2})$$

$$Z = norm.ppf(1 - 0{,}0005)$$

$$Z = norm.ppf(0{,}9995)$$

Using Python or the standard normal distribution table, the following value was obtained:

$$Z \approx 3{,}2905$$

Calculating the Effect Size (r) :

$$r = \frac{3{,}2905}{\sqrt{33}}$$

$$r = \frac{3{,}2905}{5{,}774}$$

$$r \approx 0.573$$

According to Cohen, the interpretation of Effect Size (r) is as follows:

Table 7. Interpretation of Effect Size (r) According to Cohen (Pallant, 2020)

Nilai r	Interpretasi
$\boldsymbol{r < 0,3}$	Small Effect
$\boldsymbol{0,3 \leq r < 0,5}$	Medium Effect
$\boldsymbol{r \geq 0,5}$	Large Effect

The calculations indicate an effect size (r) of 0.573, which according to Cohen's conventions represents a large effect, suggesting that the use of the microsite has a substantial impact.

In this study, Microsite-Based Instruction (MBI) was implemented as the primary instructional media during the learning process of matrix concepts. The microsite contained structured learning materials, including explanations of matrix definitions, operations, and examples, as well as interactive exercises that students completed independently. During the learning sessions, students accessed the microsite using their devices, allowing them to explore the material at their own pace while receiving guidance from the teacher when necessary. This implementation enabled students to actively engage with the content through visual representations, step-by-step explanations, and practice questions, which supported deeper conceptual understanding.

The results of this study indicate that the use of microsite-based instructional media significantly improved students' understanding of matrix material. This finding is consistent with Keumala et al., who reported enhanced student learning outcomes following the use of microsites, and with Nurfalah & Rahayu, who found that microsites encourage independent learning and increase student motivation. (Keumala et al., 2024; Nurfalah & Rahayu, 2023)

Overall, nearly all indicators of conceptual understanding based on Kilpatrick's theory were satisfactorily achieved by the students. However, imperfections remain in the sixth indicator, namely the ability to apply concepts across various forms of representation. This suggests that although students have grasped procedures and basic concepts, they are not yet fully able to transfer that understanding to broader or different contexts. This condition corroborates the findings of Mahendra et al., which state that students tend to have difficulty relating abstract material to visual or contextual representations (Mahendra et al., 2025).

The microsite's success in enhancing students' understanding is closely linked to its carefully designed, integrated interactive features that support various cognitive aspects of learning. One indicator of understanding recalling concepts is greatly facilitated by concise summaries that highlight key terms in bold type, as shown in Figure 1 below. This approach helps students remember the main points and strengthens their retention.

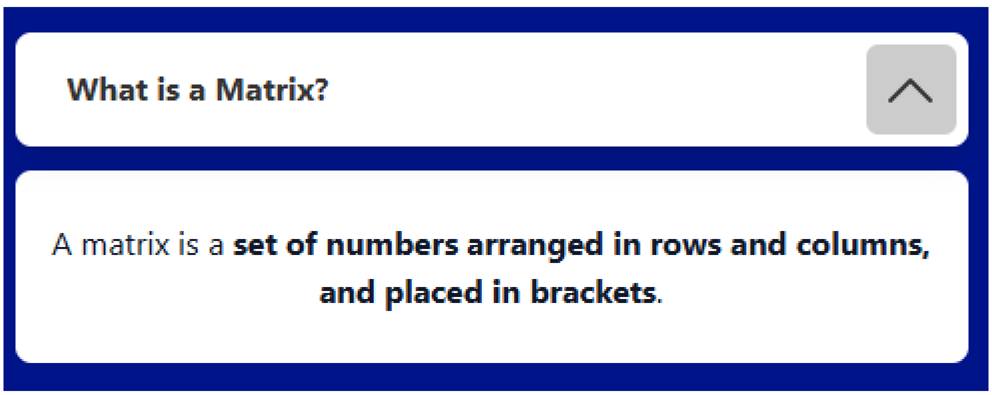

Figure 1. Bold Text Feature

Regarding object classification, the microsite's visual displays such as clear and engaging images of different types of matrices help students distinguish and group mathematical objects according to their defining characteristics. Students can more easily grasp the differences between matrix types by directly observing their forms and examples. Moreover, the microsite presents examples and non-examples of a concept; for instance, it shows which matrices are identity matrices and which are not. This approach helps students more clearly understand a concept's boundaries and avoid misconceptions. In this way, students find it easier to classify objects and identify examples and non-examples of the material studied.

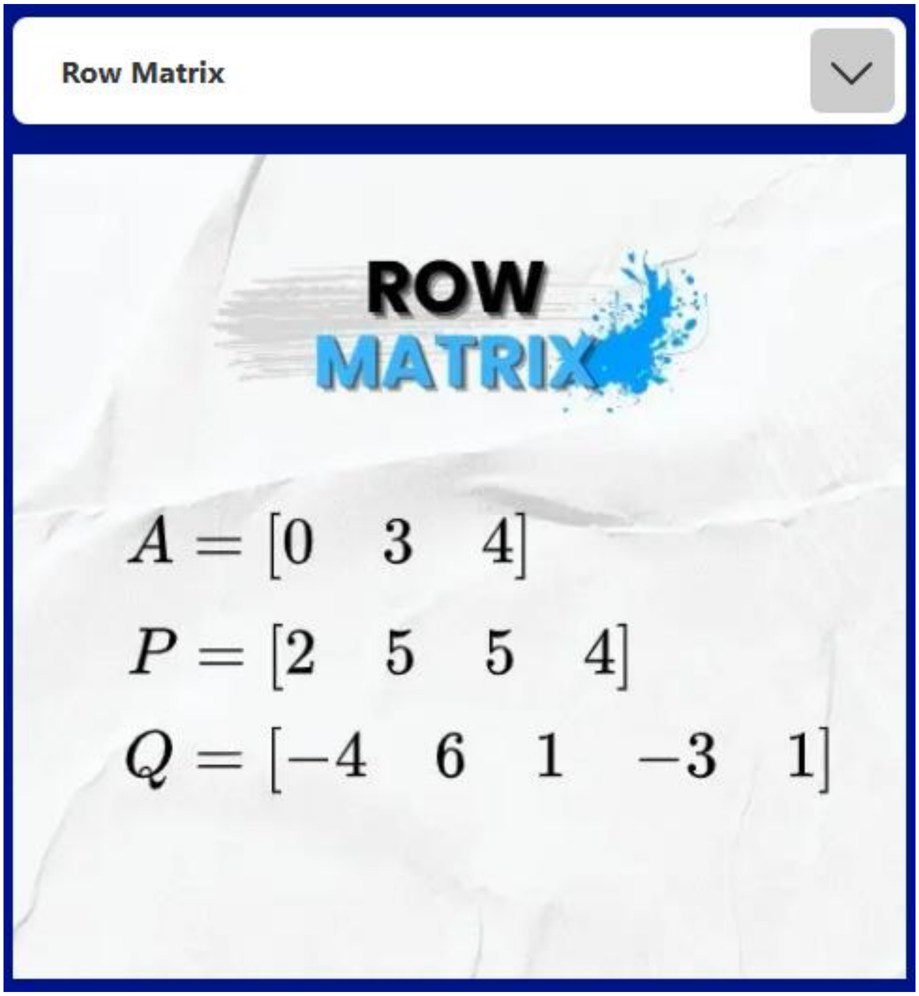

Figure 2. Matrix Classification

Meanwhile, the ability to apply concepts algorithmically is developed through practice exercises and interactive quizzes that provide immediate feedback. This feedback not only displays students' answers but also gives them the opportunity to reflect on the problem-solving steps they took. This finding is consistent with Maulidita et al., who report that interactive quiz features such as Kahoot enhance engagement; experimental studies further show that game-based cooperative approaches effectively improve students' numeracy skills and AKM scores. Therefore, integrating competitive-cooperative elements into the microsite has the potential to reinforce its instructional impact (Maulidita et al., 2025).

Figure 3. Kahoot Quiz Feature

The microsite helps students connect various mathematical concepts because the material is arranged sequentially and is mutually interconnected. Students can observe how one concept relates to others, resulting in a more comprehensive understanding. This is in line with the study conducted by Anwar et al., which found that microsites can help students understand the relationship between concepts in a systematic way (Anwar et al., 2025). The quizzes provided also encourage students to think by requiring them to link several concepts within a single item. In addition, the microsite presents content in multiple formats such as text, images, illustrations, videos, and animations so students can understand and apply concepts not only from written explanations but also from visual displays and spoken narration. This was also stated by the study of Hafis and Kasmirah, which explained that microsites present learning materials in various formats that make it easier for students to understand abstract concepts in a more interactive way (Hafis & Kasmirah, 2024). This multimodal presentation makes it easier for students to grasp the material and apply it in different representational forms.

Moreover, the microsite provides immediate, formative feedback and adaptive practice paths that support self-regulated learning. Quiz feedback highlights misconceptions and suggests targeted review materials, enabling students to correct errors and consolidate understanding. Built-in analytics let instructors monitor student progress and identify widespread difficulties, informing timely pedagogical interventions.

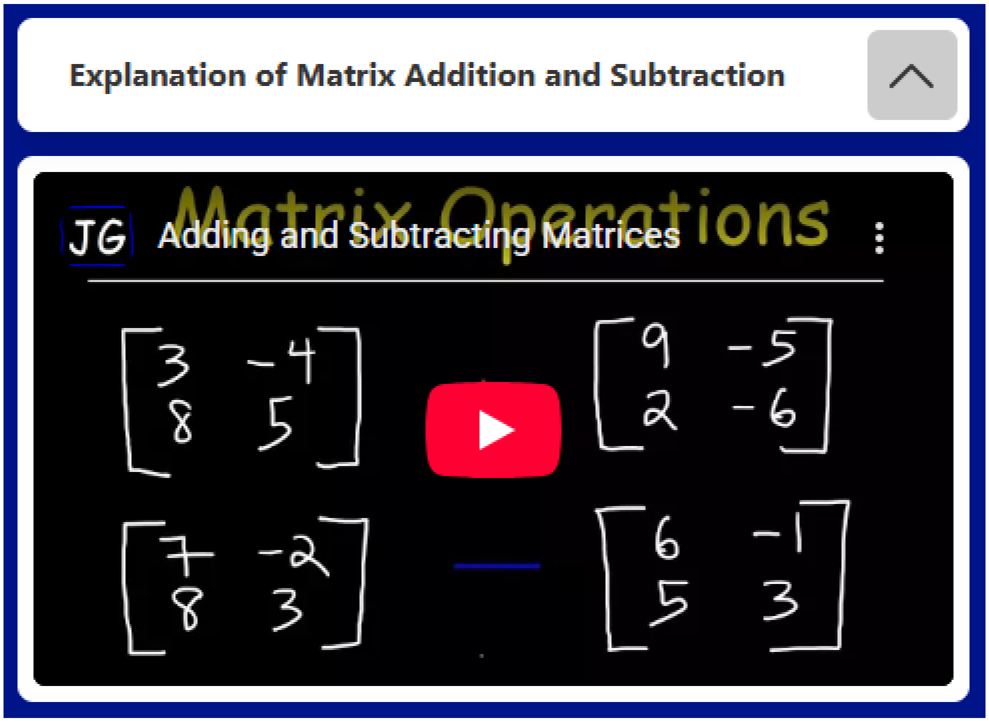

Figure 4. YouTube Video Feature

Students can also access the material anytime, review sections they have not yet mastered, and immediately attempt practice problems with automated feedback. This makes the microsite not only an information delivery tool but also a means for active exploration that fosters comprehensive student engagement. This study aligns with Rangkuti et al., who reported that instructional media combining visualization, animation, and self-assessment are highly effective in improving students' mathematical concept understanding (Rangkuti et al., 2023). Furthermore, the findings are supported by Aurora et al., who found that student engagement with interactive media can strengthen absorption of abstract material (Aurora et al., 2024). Compared with conventional media such as textbooks or passive instructional videos, microsites offer more structured, adaptive, and enjoyable learning because students are directly involved in constructing their own understanding.

Overall, these findings confirm that microsite-based instructional media can not only improve learning outcomes quantitatively but also have a qualitative impact on how students understand and apply concepts. However, weaknesses in the representation indicator indicate the need for further development, for example by increasing contextual visualization features, providing more real-world problem-based exercises, or integrating interactive simulations that support cross-representational understanding.

CONCLUSION

Based on the findings of this study, it can be concluded that the use of microsite-based instructional media was effective in enhancing Grade XI students' conceptual understanding of matrices at Sekolah Indonesia Kuala Lumpur. Interactive features, material visualization, and flexible learning time promoted active student engagement, with understanding indicators such as recalling concepts, classifying objects, and applying concepts algorithmically showing significant improvement. The calculated effect size was 0.573, which according to Cohen's interpretation falls into the large impact category, reinforcing that microsite use had a substantial effect on improving student understanding. Although most indicators were achieved satisfactorily, a weakness remained in students' ability to apply concepts across various representational forms, indicating that learners require further reinforcement in linking abstract concepts to visual or contextual representations. Therefore, the alternative hypothesis (H_1) which states that students' understanding of matrix material after the microsite implementation is better than before is supported, although there are still areas for improvement regarding concept representation.

As a follow-up, future development of the microsite should place greater emphasis on integrating representational features such as interactive graphs, contextual animations, and real-world scenario–based problems. Teachers are also encouraged to integrate this medium actively into instruction to maximize its benefits. In addition, further research is recommended on other topics and grade levels to expand the use of microsites as an innovative instructional medium in the digital era.

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