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The Implementation of Microsite-Assisted Gamification to Improve Students' Memory Retention in Mathematics Learning

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ABSTRACT

This study was motivated by the urgency of utilizing technological advancements in education to optimize students' memory retention in mathematics learning, which is known to require deep and continuous conceptual understanding. The objective of this research is to investigate the improvement of students' memory retention after the implementation of gamification supported by a microsite in mathematics learning. The research employed a quantitative approach with a population consisting of all 10th-grade students at SMA Negeri 1 Sumber in the 2024/2025 academic year, totaling 439 students. The sample was selected using cluster random sampling, specifically class X-7 consisting of 35 students. Data collection techniques included a memory retention test and unstructured interviews. The data were analyzed using the N-Gain formula and a paired sample t-test. The results of the study showed an improvement in students' memory retention in the class that implemented gamification supported by a microsite, with the improvement categorized as high. Based on the hypothesis testing, students' memory retention after the implementation of gamification supported by a microsite was significantly better compared to before the implementation. Therefore, gamification supported by a microsite has been proven effective in enhancing students' memory retention in mathematics learning.

Keywords: *Gamification, Mathematics Learning, Memory Retention, Microsite*

Penerapan Gamifikasi Berbantuan *Microsite* untuk Meningkatkan Retensi Memori Siswa dalam Pembelajaran Matematika

ABSTRAK

Penelitian ini dilatarbelakangi oleh urgensi pemanfaatan kemajuan teknologi dalam pendidikan guna mengoptimalkan retensi memori siswa dalam pembelajaran matematika yang dikenal memerlukan pemahaman konsep secara mendalam dan berkesinambungan. Tujuan penelitian ini adalah untuk mengetahui peningkatan retensi memori siswa setelah penerapan gamifikasi berbantuan *microsite* dalam pembelajaran matematika. Pendekatan yang digunakan adalah kuantitatif dengan populasi seluruh siswa kelas X SMA Negeri 1 Sumber tahun ajaran 2024/2025 yang berjumlah 439 siswa. Sampel penelitian dipilih

menggunakan teknik cluster random sampling, yaitu kelas X-7 yang terdiri dari 35 siswa. Teknik pengumpulan data dilakukan melalui tes retensi memori dan wawancara tidak terstruktur. Data kemudian dianalisis menggunakan uji N-Gain dan uji t berpasangan *(paired sample t-test)*. Hasil penelitian menunjukkan bahwa terdapat peningkatan retensi memori siswa pada kelas yang menerapkan gamifikasi berbantuan microsite dengan kategori peningkatan yang tinggi. Berdasarkan hasil uji hipotesis, retensi memori siswa setelah penerapan gamifikasi berbantuan *microsite* secara signifikan lebih baik dibandingkan dengan sebelum penerapan. Dengan demikian, gamifikasi berbantuan *microsite* terbukti efektif dalam meningkatkan retensi memori siswa dalam pembelajaran matematika.

Kata Kunci**:** *Gamifikasi, Microsite, Retensi Memori, Pembelajaran Matematika*

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1. Introduction

Today, in the digital era, technological revolution has had a tremendous impact on the education sector. Society 5.0 concept is concentration on inserting technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data in all areas of life, even in the learning of mathematics (Setyaningsih, 2023). Use of technology in learning has been efficient in boosting learners' cognitive engagement through active discussion and sharing of ideas, hence enabling the creation of a collaborative learning environment (Haqq et al., 2024). Nevertheless, this development in technology has its demerits. Among the problems highlighted is the utilization by students of instant access to information, which can reduce critical thinking capacity, decrease the depth of comprehension of mathematical concepts, and undermine long-term retention of memory an essential pillar in learning mathematics (Helsa et al., 2022).

Memory retention among students is an important part of learning mathematics, meaning students are able to retain knowledge for extended durations (Alam et al., 2024). Good memory retention enables students not only to understand mathematical concepts well but also to apply them repeatedly in solving problems. The hierarchical and connected character of mathematical concepts requires sound retention among students for them to comprehend the material well and apply it effectively. Decreased retention can lead to the inability to retain vital information and difficulty in solving problems that require effective application of concepts (Juwairiah et al., 2024).

The important role of memory retention in mathematics learning is not in line with the current condition, where many students still face difficulties in retaining the information they have learned. A study by Valderama & Oligo (2021) shows that students learning Analytic Geometry experience a significant decline in memory retention. The average memory retention decreases by 4% per week at the basic knowledge level, 17% at the comprehension level, and 21% at the analysis or application level. These findings indicate that the more complex a concept is, the greater the challenge for students to retain it in memory.

One of the causes of low memory retention in students is the dominance of the lecture method in learning, which is one-sided and lacks active student engagement. Lutfi et al. (2023) in their study found that just 14.3% of the control class students using a direct learning model had high retention, while the remaining 50% fell in the low retention category. It indicates that the direct learning model has not done much to maximize the process of retaining information in the long term. The direct learning system, which is less innovative in the use of learning media, will tend to be less enjoyable, boring, and less capable of enabling students to memorize the lesson. Learning innovation is needed here, especially in the use of technology for a more fun, interactive learning process and capable of reinforcing the long-term memory of the students. Thus, mathematics learning with gamification can act as an alternative to solve the current problems (Srimuliyani, 2023).

Gamification is the application of game elements in learning to create a game-like, but challenging learning process that requires active participation by students (Wangi et al., 2022). Gamification can be done by making the learning of mathematics, which is considered difficult and boring, more engaging (Ekawati et al., 2024). One such example would be learning in the form of a game where students are forced to solve math problems through a fun method. Through this process, the students learn while having a good time doing it, and the by-product is better retention of the mathematical concepts that they are being taught (Mattawang & Syarif, 2023).

The gamified learning process also allows students to try out through trial and error and receive instant feedback, and this enhances the learning process to a greater extent (Sanulita et al., 2024). In the research study of Khasawneh et al. (2024), it is mentioned that with the implementation of gamification, students can recall and adopt the things they learned and thereby can experience a tremendous boost in the process of memory retention. In line with this, Triswidrananta et al. (2024) demonstrated through an experimental study that the use of a website-based e-learning gamification system in mathematics learning resulted in a significant difference in scores, with a gain score of 0.71, which falls into the high category. Although various studies have proven the effectiveness of gamification in improving learning outcomes, most studies have focused more on student motivation and engagement, rather than on long-term memory retention.

Most gamification platforms use competition-based quizzes like Kahoot!, Quizizz, or Gimkit, but few have discussed using microsites. Microsites are a flexible, accessible learning method and can utilize many multimedia elements as well as features of gamification like challenge levels, points, and instant feedback (Nurfalah & Rahayu, 2023). In addition to their flexibility, microsites also allow teachers to organize tailored learning materials that can be modified according to students' needs and learning objectives in a more engaging format, which strengthens conceptual knowledge (Adilah et al., 2025).

Gamification enhanced learning using microsites allows instructors to monitor the progress of students in real time. Instructors can provide feedback to students in a timely and accurate manner, which is imperative in propelling the students' comprehension of the topic being learned, as well as areas that require further discussion. Gamification using microsites is expected to make learning more competitive and cooperative by using teamwork.

It is this approach that is specifically directed towards stimulating students' active participation during learning sessions, and thereby maximizing memory retention of the mathematical concepts acquired through contextualized repetition (Mahmubi & Homaidi, 2025).

From the above description, the current study focuses on investigating the use of gamification using a microsite as a means of improving the retention of students in learning mathematics. The nexus between gamification and microsite-based e-technology offers

students an engaging and fun learning environment, which is aimed at not only increasing engagement but also allowing for long-term mathematical knowledge retention. While previous studies have worried about motivation and overall learning results, the current study tries to compensate by focusing on memory retention as the primary variable. Based on the research purpose, research hypothesis to be tested in this research is: "Students' memory retention after introducing gamification with microsite facilitation is much higher than prior to the implementation." For testing the same, the study employs quantitative research with pretest-posttest design for an experimental group. Data were collected through tests of memory retention and open-ended interviews and were computed based on the N-Gain formula and a paired sample t-test.Thus, this method is poised to result in more effective digital learning innovations and help in sustainable knowledge of mathematical concepts in the digital age.

2. Method

This study uses a quantitative method to validate the improvement in the students' memory retention after using gamification through the help of microsites to learn mathematics. The sample population of this study is all the grade X students of SMA Negeri 1 Sumber Cirebon in the year of study 2024/2025, totaling 439 students. The sample was obtained through cluster random sampling and 35 students from class X-7 in SMA Negeri 1 Sumber were used.

Data collection in this study was done in two manners: a test-to-test students' memory retention before and after an intervention, and unstructured interviews to further investigate students' perceptions. The test of memory retention was constructed on the basis of memory retention indicators by Hilgard & Bower (1975). Before its administration, the instrument was verified by five experts, which were four mathematics education lecturers and one mathematics education teacher. The experts were asked to evaluate the relevance, clarity, and representativeness of each item with respect to the construct being measured (Siregar & Mawardi, 2022). The expert validation process was conducted using Aiken's V method with the following formula:

$$V = \frac{\sum s}{n \,.\, (c - 1)}$$

Description:
V : rater agreement index
s : the score given by each rater is subtracted by the lowest score in the category
c : the number of raters
n : the number of categories that can be selected by the raters

The categorization of the Aiken's validity test with five raters and five answer choice categories can be categorized in Table 1.

Table 1. Instrument Validity Criteria

Aiken's Indeks	Criteria
V < 0,8	Invalid
V ≥ 0,8	Valid

(Aiken, 1985)

Based on their assessment, all items were deemed appropriate, with minor revisions made according to the suggestions provided. Next, the students' memory retention test was pilot-

tested to determine its validity, reliability, discriminative power, and difficulty level. A pilot test of the memory retention test was conducted to examine its psychometric characteristics. The analysis included item validity, test reliability, item discrimination, and item difficulty. The complete results of the pilot testing are presented in Table 2.

Table 2. Results of the Pilot Test of the Memory Retention Instrument

No	Validity		Difficulty Level		Discriminative Power		Decision
	Score	Criteria	Score	Criteria	Score	Criteria	
1	0,843	Valid	0,628	Medium	0,781	Very Good	Used
2	0,869	Valid	0,65	Medium	0,845	Very Good	Used
3	0,183	Invalid	0,972	Easy	0,04	Bad	Eliminated
4	0,730	Valid	0,792	Easy	0,464	Good	Used
5	0,726	Valid	0,758	Easy	0,528	Good	Used
6	0,865	Valid	0,298	Difficult	0,813	Very Good	Used
7	0,746	Valid	0,694	Medium	0,562	Good	Used
8	0,227	Invalid	0,116	Difficult	0,084	Bad	Eliminated
9	0,746	Valid	0,669	Medium	0,628	Good	Used
Reliability of the Memory Retention Test r11 = 0,751 Criteria = High							

Based on the item analysis, the memory retention test was considered feasible for use in the main study. Out of 9 initial items, 7 were retained because they met the criteria for validity, discrimination, and appropriate difficulty, and the overall instrument demonstrated high reliability.

The instrument was then administered to the research sample to collect data. The obtained data were analyzed quantitatively using statistical tests, specifically the N-Gain test and the paired sample t-test, to measure the improvement in memory retention in the class that applied gamification supported by microsites. The N-Gain score was calculated using the formula proposed by Sukarelawan *et al.* (2024):

$$\mathrm{N-Gain(g)} = \frac{Posttest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ Score}$$

The interpretation of the N-Gain score is categorized in Table 3.

Table 3. N-Gain Score Criteria

N-Gain Score	Criteria
$0,70 \leq g \leq 1,00$	High
$0,30 \leq g < 0,70$	Medium
$0,00 < g < 0,30$	Low
$g = 0,00$	No Improvement
$-1,00 \leq g < 0,00$	Decrease

(Sukarelawan *et al.*, 2024)

3 Results and Discussion

3.1. Result

To determine the improvement in students' memory retention after the implementation of gamification supported by microsites, an N-Gain test and a paired sample t-test were conducted. The N-Gain test was used to measure the difference in improvement based on the comparison of pretest and posttest memory retention scores obtained by the students. The

pretest score represents the students' initial ability, while the posttest score reflects their ability after receiving the treatment. The N-Gain score for students' memory retention was tested using SPSS 21 software, with the following results in Table 4.

Table 4. Results of the N-Gain Test on Students' Memory Retention

No.	Student	N-Gain	Criteria	No.	Student	N-Gain	Criteria
1.	R-1	0.73	High	19.	R-19	1.00	High
2.	R-2	1.00	High	20.	R-20	0.76	High
3.	R-3	0.93	High	21.	R-21	1.00	High
4.	R-4	0.69	Medium	22.	R-22	0.55	Medium
5.	R-5	0.92	High	23.	R-23	0.73	High
6.	R-6	0.67	Medium	24.	R-24	0.78	High
7.	R-7	0.76	High	25.	R-25	0.69	Medium
8.	R-8	0.82	High	26.	R-26	0.86	High
9.	R-9	0.65	Medium	27.	R-27	0.64	Medium
10.	R-10	0.66	Medium	28.	R-28	0.76	High
11.	R-11	0.71	High	29.	R-29	0.69	Medium
12.	R-12	0.73	High	30.	R-30	0.69	Medium
13.	R-13	0.94	High	31.	R-31	0.88	High
14.	R-14	0.71	High	32.	R-32	1.00	High
15.	R-15	0.77	High	33.	R-33	0.67	Medium
16.	R-16	0.92	High	34.	R-34	0.73	High
17.	R-17	1.00	High	35.	R-35	0.83	High
18.	R-18	0.83	High	Average		0.7913	High

From Table 4, ten students fall into the moderate memory retention improvement category, while 25 students fall into the high improvement category after the implementation of gamification supported by a microsite in mathematics learning. To provide an overall picture of this improvement, the N-Gain test statistics are presented in Table 5.

Table 5. Results of the N-Gain Test Statistics on Students' Memory Retention

Descriptive Statistics					
	N	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
N-Gain_Score	35	0.55	1.00	0.7913	0.12461
N-Gain_Percent	35	55.10	100.00	79.1281	12.46104

Based on Table 5, the average improvement in students' memory retention with the implementation of gamification supported by microsites is 0.7913, which falls into the high category. This result leads to the rejection of H_0 and acceptance of H_1, indicating that the implementation of gamification supported by microsites significantly improved students' memory retention.

Before further analysis, normality testing was conducted to determine whether the N-Gain scores followed a normal distribution. The Shapiro-Wilk test, using SPSS 21, produced the following results in Table 6.

Table 6. Results of the N-Gain Score Normality Test

Tests of Normality						
Class	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	*Statistic*	df	Sig.
Pretest	0.109	35	0.200*	0.968	35	0.390
Posttest	0.095	35	0.200*	0.941	35	0.061
N-Gain *Score*	0.125	35	0.183	0.944	35	0.074

Based on Table 6, the results of the normality test on the N-Gain score, tested using the Shapiro-Wilk test, show a significance value of 0.074. Since this significance value is greater than 0.05 (>0.05), it can be concluded that the N-Gain score data is normally distributed. This meets the requirement to proceed with parametric testing, specifically the paired sample t-test.

Next, a paired sample t-test was conducted to determine the significance of the improvement in memory retention between the pretest and posttest. In this study, the paired sample t-test was performed with the help of SPSS 21, with the results in Table 7.

Table 7. Results of the Paired Sample t-test

Paired Samples Test									
		Paired Differences							
		Mean	*Std. Deviation*	*Std. Error Mean*	*95% Confidence Interval of the Difference*		*t*	*df*	*Sig. (2-tailed)*
					Lower	Upper			
Pair 1	*Pretest Posttest*	-35.000	11.664	1.972	-39.007	-30.993	-17.752	34	0.000

Based on Table 7, the significance value (2-tailed) obtained is 0.000, which is less than 0.05 (<0.05), thus it can be concluded that there is a significant difference in students' memory retention before and after the implementation of gamification supported by microsites.

Therefore, based on the results of the series of statistical tests that have been conducted, it can be concluded that there is a significant improvement in students' memory retention after the implementation of gamification supported by microsites. This is evidenced through the N-Gain test, which falls into the high category with a value of 0.7913. It is further reinforced by the results of the paired sample t-test with a significance value (2-tailed) of 0.000, which is smaller than the significance level of 0.05.

To strengthen the quantitative findings regarding the improvement in students' memory retention after the implementation of gamification supported by microsites, unstructured interviews were conducted with 3 students. The students interviewed were selected based on categories of memory retention improvement: low, moderate, and high. The purpose of the interviews was to explore the perceptions, experiences, and factors that influenced the improvement in students' memory retention from their own perspectives. The interview findings for the 3 students are captured in Table 8.

Table 8. Results of Student Interviews

No.	Student	Results of Student Interview
1.	S-1	Based on the interview, the low performing student stated that gamification with the microsite did not support well in recall, recognition, and reintegration. It was difficult for them to understand the content because the moving between topics was too fast, the instructions were too conceptual, and the challenges were not coherent, hence the learning was poorly consolidated.
2.	S-2	The second respondent (moderate level) replied that gamification with the aid of the microsite was highly effective in recall and recognition through quizzes and challenges. But for reintegration, they did not feel supported as much because the challenges were not completely contextualized to material.
3.	S-3	The third learner (high category) stated that gamification supported by the microsite was very effective in remembering. Aspects such as quizzes and challenges stimulated them to learn the content, and thus they had no issues remembering, identifying, or re-integrating it.

Interview results cast more light on the result of this research. Different levels of memory recall presented different experiences for students in using gamification through the help of microsites. Low-category student S-1 presented lower usability of gamification application, namely due to it being less effective in maintaining pace with subject change, ambiguous instruction, and issues that were poorly integrated in the learning context. This would imply that creating gamification elements demands a lighter hand to ensure they are kept straightforward and uniform in prompting recall from memory.

In contrast, the moderate-category learner (S-2) accommodated that gamification facilitated recall and recognition in the form of quizzes and challenges but remained constrained in dealing with reintegration. This highlights the need for affirming contextual relations in gamified learning activities so that deeper understanding as well as memory retention are facilitated.

But the S-3 high-category student gave positive feedback, and this blend of quizzes and challenges proved to be highly effective in promoting review and firming up memory procedures. It thus shows that, when properly planned, gamification through microsites can have actual engagement and carry a firm influence in enhancing students' recall of memory.

Overall, interview findings support the quantitative results, suggesting gamification is able to increase reintegration, recognition, and recall, but it must be of high quality in its design and how game-like elements have been contextualized and mapped to learning objectives.

3.2. Discussion

Quantitatively, improvement in memory retention was assessed through tests administered before the treatment (pretest) and after the treatment (posttest) in the experimental group. The test is specifically utilized to determine whether the application of gamification supported microsite can help improve students' memory retention. The experimental class's posttest and pretest memory retention scores were then compared based on certain statistical tests like N-Gain test and paired sample t-test. Interviews were also conducted with students with lowest, moderate, and highest memory retention improvement to substantiate the findings.

Based on N-Gain test calculation, improvement in students' memory retention was categorized as high. This is because the pretest-posttest difference was large, which means that there was a significant improvement in memory recall of the students when gamification-enabled microsite was used. The large N-Gain value indicates that such kind of learning enabled the students to recall what they learned. The significant gap between the pretest and posttest scores also validates that the treatment positively influenced the retention of students' memory. This aligns with the research of Khasawneh et al. (2024), which also showed the better retention of students through gamification-based learning, and Triswidrananta et al. (2024), whose experiment showed a significant difference in scores prior to and subsequent to using a gamification-based e-learning website system with a gain score of 0.71. This shows that the improvement in students' learning outcome is in the high range.

The application of gamification through microsites to improve the retention of students in memory is supported by the Cognitive Load Theory by Sweller (1988). The theory is an explanation of how human working memory capacity is limited and learning must be well-designed to reduce extraneous cognitive load. In the same way as the current study, gamification on the microsite organizes learning material into systematically and interactive items, breaking them down into smaller items and using pictorial support with instant feedback. As found in Mursalin et al. (2024) study, breaking up material into smaller items allows learners to process information without being overwhelmed by its complexity.

One form of implementation is through interactive group quizzes in the microsite, as shown in Figure 1.

Figure 1. Student Activities Using Interactive Quizzes in Microsite

Figure 1 shows that gamification by a microsite has been minimized in unnecessary cognitive load. From the observable group activities, cognitive load is distributed evenly among the members of the group, making maximum use of the overall capacity for information processing. The structured microsite interface design presents information in small chunks compatible with students' working memory capacity. Prominent features such as consistent color schemes and directed visual items help focus the learning attention, while the immediate feedback system allows identification of misinterpretation and correction at the point of incidence without going through a manual evaluation process.

After the N-Gain value representing a high level of improvement in students' memory retention was determined, the second statistical test applied was the paired sample t-test. The test is applied to compare the pretest and posttest average scores to determine whether the improvement is significant or just by chance. According to the test, the significance value was lower than the set significance level. This indicates a great variance in students' memory after and prior to gamification facilitated by a microsite. This finding is consistent with the work by Nurjannah et al. (2021) that also stated that there is a significant variation in students' learning outcomes before and after applying gamification. In addition, a study conducted by Adilah et al. (2025) also shows that microsite utilization significantly improves learning outcomes because learning becomes more independent, more flexible, and more convenient outside classroom hours.

Overall, statistical tests indicate that gamification through a microsite significantly improves students' recall memory. This confirms the research objective, verifying that gamification is able to increase student engagement and enrich recall in the learning of mathematics. This is substantiated by the N-Gain score in the high criteria and the pretest and posttest scores with significant difference. This research is in line with the findings of Nurfalah & Rahayu (2023), who stated that the use of microsites can increase learning motivation. This increase in motivation indirectly supports the improvement of memory retention, as students with high motivation tend to engage more actively in the learning process and are more likely to review material independently, making it easier for them to retain the information they have learned. However, the results of this study contradict the research by Valderama & Oligo (2021), which found that students' retention of basic knowledge decreases by an average of 4% per week, while their level of understanding decreases by up to 17% per week, and their ability to analyze or apply decreases by the highest rate, 21% per week.

To strengthen the quantitative findings showing the improvement of memory retention after the application of gamification supported by a microsite, interviews were conducted with

six students with different levels of memory retention improvement: low, medium, and high. The purpose of these interviews was to understand students' perceptions of the application of gamification supported by a microsite in supporting retention through its indicators: recall, recognition, and reintegration.

Students in the low category experienced difficulties with recall, recognition, and reintegration. Gamification, in the opinion of the students, was more directed at the game and less on understanding material. The teaching provided was too vague and not so specific, thus not facilitating deep understanding. The short time to switch between subjects further meant that students had difficulty understanding and retaining material. The issues of gamification were also perceived as unfavorable to reintegration, as it made the process of learning less integrated. These results agree with the perspective of Mirzaie et al. (2022), who stated that gamification can turn students too competitive and lose sight of comprehending the content, and the research by Mattawang & Syarif (2023), who argued that time has a significant impact on the process of comprehending and remembering content. Thus, gamification methods need to accommodate competition with cooperation and thinking to deepen understanding. Teachers should provide adequate time for review and discussion, along with merging gamified aspects with instructional scaffolding. This maintains fewer disadvantages and guarantees gamification will improve engagement as well as deep learning.

Under the medium category, students experienced varied results for recall, recognition, and reintegration. Some of the students felt that gamification helped them with recall and recognition, especially through elements like quizzes and challenges. This is consistent with the research of Juwairiah et al. (2024) who described how gamification elements like quizzes and instant feedback can improve students' short-term memory. However, there were students who saw the challenges as less thematic, and this did not make reintegration easy. On the other hand, gamification was seen by some students to ease reintegration as the gamification environments provided connectivity between concepts. This observation is supported by Mahmubi & Homaidi (2025), who argued that gamification environments can make cross-topic comprehension better.

Meanwhile, high category students gave extremely positive feedback regarding the gamification offered by the microsite in aiding recall from memory. The students perceived that the instructional clarity and interactive media were extremely effective when it came to the recognition and recall stages. Gamification was also seen as extremely facilitative of reintegration since the games ensured that it was easy for students to associate new information with the rest of the learning environment. In general, students perceived gamification through a microsite as an enjoyable and effective learning experience. This resonates with research by Srimuliyani (2023), which showed that the use of gamification techniques can increase students' motivation, enthusiasm, activity, and engagement in learning. This result deviates from research by Safitri et al. (2023), which concluded that gamification would most likely interfere with attention and avoid information storage in long-term memory.

Based on the findings of the analysis, gamification within a microsite is found to enhance students' memory recall, especially for high-ability students who benefited from such features as quizzes, challenges, and clear instructions. Medium-ability students also benefited, though their skills in reintegration were not fully established and had to be practiced on a regular basis. For low-ability students, gamification chiefly facilitated participation and motivation, but retention advantages were not realized without more support from teachers and peers. In general, gamification is an advantage for learners of all abilities, but its effects are more powerful if backed by differentiated strategies for support according to the needs of learners.

4 Conclusion

Based on research findings and discussion, it can be described that the application of gamification supported by a microsite can be effective in improving the memory retention of students studying mathematics. This is reinforced by N-Gain score, which has a mean of 0.7913 and is in the high category, and by paired sample t-test at p = 0.000 (<0.05), indicating a better memory recall after intervention. The gamification interactive elements such as quizzes, challenges, and clear instructions precisely facilitated recall, recognition, and reintegration processes so that students could better associate mathematical concepts with a universal learning space. These findings confirm that gamification through a microsite not only enhances the memorization of mathematics material by the students, particularly among high-ability students, but also provides prospects for further developing innovative and adaptive digital learning media as an alternative approach in strengthening long-term memory in learning math.

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