

Research Article

Practicality of Gamification-Based VPDLS Media and Its Association with Elementary School Students' Digital Numeracy Achievement

Hasbiyah Srianah Amir

Institut Ilmu Sosial dan Bisnis Andi Sapada, Indonesia

hasbiyah.srianah@gmail.com

Poopathy Dhanasekaran

SJKT Tanah Rata, Malaysia

poopathid@gmail.com

Abstract: The development of digital learning media is essential in improving elementary school students' digital numeracy skills. This study aims to analyze the practicality of gamification-based VPDLS media and examine its association with elementary school students' digital numeracy achievement. A descriptive quantitative approach with comparative analysis was employed. The research involved 343 elementary school students from eight schools. Data were collected using a digital numeracy essay test and a media practicality questionnaire based on the Technology Acceptance Model. Instrument validity and reliability were analyzed using SmartPLS, while descriptive statistics and ANOVA were conducted using SPSS. The results showed that the VPDLS media demonstrated high practicality, with students perceiving it as easy to use, practical, and comfortable for learning. Students' digital numeracy scores also showed relatively high achievement, with significant differences among schools. The ANOVA results confirmed that both media practicality and digital numeracy achievement varied significantly across learning contexts. These findings indicate that gamification-based VPDLS media has the potential to support students' engagement in digital numeracy learning, although the results should be interpreted cautiously because the study employed a descriptive quantitative design. In addition, the high level of practicality contributes to students' acceptance and consistent use of digital learning media. The results are expected to support teachers and educational practitioners in designing effective and user-friendly digital learning media. This study provides empirical evidence regarding the practicality and potential contribution of gamification-based VPDLS media in supporting digital numeracy learning at the elementary school level.

Keywords: digital numeracy, gamification, learning media, practicality, VPDLS

Corresponding Author:

Hasbiyah Srianah Amir

hasbiyah.srianah@gmail.com

How to Cite: Amir, H. S., & Dhanasekaran, P. (2026). Practicality of Gamification-Based VPDLS Media and Its Association with Elementary School Students' Digital Numeracy Achievement. *LEOTECH: Journal of Learning Education and Technology*, 3(1), 20-34. <https://doi.org/10.70152/leotech.v3i1.338>

Article submitted 2026-02-20. **Revision uploaded** 2026-03-17. **Final acceptance** 2026-03-24.

Copyright © 2026 by the authors of this article. Published under CC BY-SA 4.0.



This is an **open access** article. OPEN ACCESS

INTRODUCTION

The development of digital technology has brought significant changes to learning practices in elementary schools, particularly in the use of digital learning media that support interactive, context-based mathematics learning (Zhao et al., 2021). The integration of technology into mathematics learning has been shown to enhance students' cognitive engagement and improve the quality of classroom learning interactions (Boateng et al., 2024). Digital learning environments also provide opportunities for students to explore mathematical ideas through more dynamic and visual representations. These developments highlight the growing importance of technology-supported learning in improving mathematics education at the elementary level.

However, the effectiveness of digital media use is greatly influenced by the suitability of the media to the developmental characteristics and learning needs of elementary school students (Fitriani et al., 2025). Learning media that are not designed according to students' cognitive levels may reduce their motivation and engagement during the learning process. Therefore, selecting appropriate learning media is an essential factor in supporting optimal numeracy learning (Kaban et al., 2023). Properly designed digital learning tools can help students better understand mathematical concepts and apply them in meaningful learning situations.

Despite advances in educational technology, Indonesian students' numeracy skills remain low by international standards. The PISA average numeracy score in Indonesia is 366, and about 82% of students fall short of minimum competence (OECD, 2022). This low level of numeracy skills limits students' ability to understand and apply mathematical concepts in everyday contexts (Kusuma et al., 2025). Consequently, this situation underscores the need for more effective learning strategies to improve elementary school students' numeracy skills (Daelia et al., 2025).

To improve numeracy learning, the gamification approach is widely used because it integrates game elements to increase student motivation and engagement in mathematics. Gamification is widely recognized for creating a more engaging learning atmosphere that encourages active student participation in understanding numeracy concepts (Fodale, 2025). Several studies show that gamification positively contributes to elementary school students' understanding of mathematical concepts (Tonioka et al., 2025). Thus, gamification is seen as a relevant approach to support digital numeracy learning, in line with today's students' characteristics (Pan et al., 2026).

Previous studies show that research on gamification in mathematics learning still focuses more on student motivation and engagement. At the same time, analyses of the effectiveness and practicality of the media remain relatively limited (Carolina et al., 2020). Gamification is a potential approach to improve the quality of the learning process, but its success is greatly influenced by the design of the media and its suitability to students' characteristics (Sailer & Homner, 2020). On the other hand, research specifically linking gamification to digital numeracy in elementary school students has not been widely conducted.

This condition indicates a need for research that empirically and comprehensively examines the quality of numeracy learning media (Jutin & Maat, 2024). Based on this background, this study focuses on analyzing the practicality and potential contribution of gamification-based

VPDLs (Virtual Platform Digital Learning System) media in supporting digital numeracy learning among elementary school students. The Virtual Platform Digital Learning System (VPDLs) is a web-based digital learning platform designed to support elementary school students in learning numeracy through interactive digital activities. The platform integrates mathematical learning materials, digital exercises, and gamification elements that aim to increase students' engagement during the learning process.

The VPDLs platform integrates several gamification elements to enhance student engagement during learning activities. These elements include a points system, learning challenges, interactive quizzes, and immediate feedback after students complete learning tasks. Through this system, students can access learning materials, solve contextual numeracy problems, and monitor their learning progress during the learning process. As shown in Figure 1, the platform begins with a main interface that allows students to start the learning process by selecting the learning menu. After entering the platform, students can select several topics related to two-dimensional shapes that can be studied sequentially according to their learning progress. This structured navigation helps students explore mathematical concepts more independently while maintaining an organized learning flow.

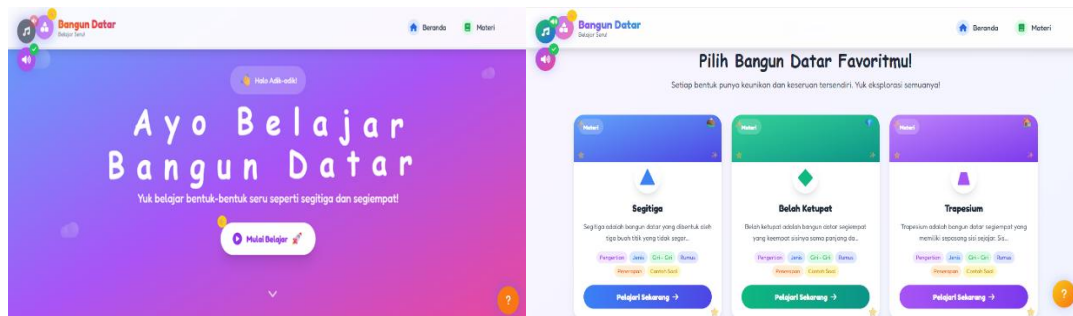


Figure 1. Main Interface of The VPDLs Platform

The learning materials presented in the platform are designed with visually engaging explanations and interactive components to help students understand geometric concepts more clearly. As shown in Figure 2, the platform provides complete learning materials about two-dimensional shapes accompanied by attractive visual displays. One of the key features included in this section is a geometry calculator that allows students to calculate the perimeter and area of shapes by entering the required numerical values. This feature helps students verify their manual calculations while strengthening their conceptual understanding of geometric formulas in a digital learning environment.

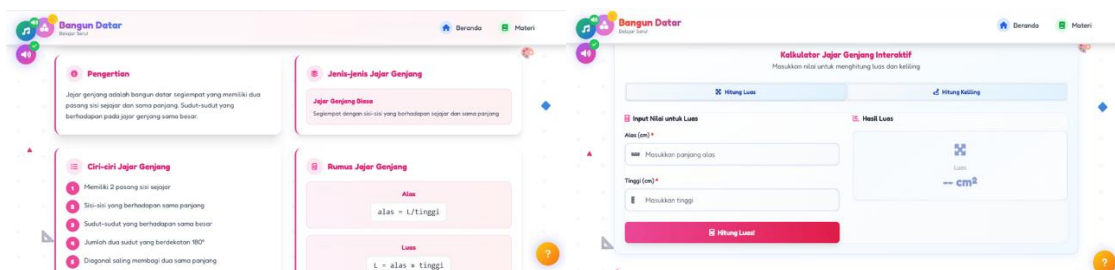


Figure 2. Interactive Geometry Learning Module

In addition to providing learning materials, the platform also includes an evaluation module designed to assess students' understanding after completing the learning activities. As

shown in Figure 3, students are required to answer evaluation questions directly within the platform to measure their comprehension of the material. After completing the questions, the system automatically displays the evaluation results so that students can immediately see their performance. This immediate feedback mechanism helps students reflect on their understanding and encourages them to improve their learning outcomes.

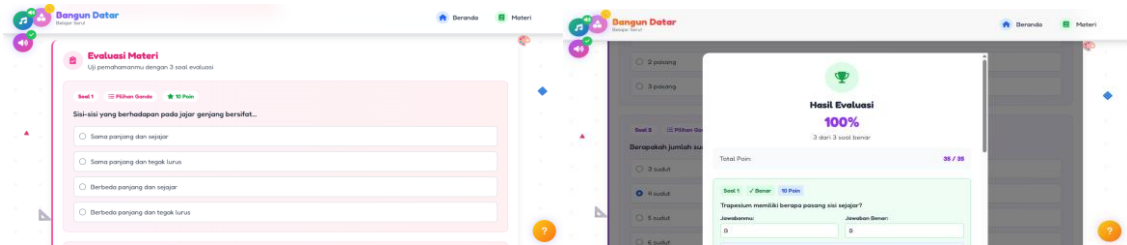


Figure 3. Digital Numeracy Evaluation Module

Through the integration of learning materials, interactive tools, and digital evaluation features, the VPDLS platform aims to create a more engaging learning environment for elementary school students and support the development of digital numeracy skills. Therefore, this study examines students' perceptions of the practicality of the VPDLS media and explores its relationship with students' digital numeracy achievement. This study also contributes to the literature by examining the practicality of gamification-based digital learning media and analyzing its association with students' digital numeracy achievement across different school contexts.

THEORETICAL FRAMEWORK

Digital numeracy is understood as students' ability to understand, use, and interpret numerical concepts in meaningful ways within digital technology contexts (Sari et al., 2025). In the context of basic education, digital numeracy is an essential competency because students begin to interact with various technology-based numerical representations in their daily learning activities (Anggun et al., 2025). Empirical studies show that strengthening digital numeracy from the elementary school level contributes to improving students' academic readiness for the next level of education. Therefore, digital numeracy includes numeracy skills, logical reasoning, and adaptive abilities in using technology to solve mathematical problems in context (Kusumawardani et al., 2025).

In supporting the development of digital numeracy skills, digital learning media serve as a means of bridging abstract mathematical concepts with more concrete and visual learning experiences (Jutin & Maat, 2024). Research shows that appropriate digital media for elementary school students can increase cognitive engagement and understanding of numeracy concepts (Yusri & Zainal, 2025). Digital learning media not only serve as tools but also as strategic components in improving the quality of numeracy learning.

In the context of digital learning media, gamification is the application of game elements to learning activities to increase student motivation and engagement (Gini et al., 2025). The gamification approach allows students to be actively involved through mechanisms of challenges, rewards, and feedback that encourage continuous participation in mathematics learning (Mattar et al., 2025). Research results show that gamification can increase students' emotional and cognitive engagement in numeracy learning (Sari et al., 2025). Therefore, gamification is considered relevant for supporting digital numeracy learning that aligns with the characteristics of elementary school students (Gini et al., 2025).

In evaluating learning quality, the effectiveness of learning media is understood as the extent to which learning objectives are achieved, as reflected in student learning outcomes (Ramdhani et al., 2024). Effective learning media can help students understand numeracy concepts more deeply through structured and meaningful learning experiences (Salam et al., 2024). Research shows that the effectiveness of digital media is greatly influenced by the suitability between media content and mathematical learning objectives (Keji, 2024). Therefore, media effectiveness is a key indicator in assessing the success of using digital media in elementary school students' numeracy learning (Hermita et al., 2023).

In addition to effectiveness, the practicality of learning media refers to the ease with which students use them in their daily learning process (Hermita et al., 2023). Practical learning media allow students to use the platform independently without significant technical difficulties, so their learning focus remains on numeracy material (Rostika et al., 2025). Research shows that the practicality of media affects students' acceptance and comfort with using digital learning media (Linus et al., 2025). Thus, the practicality of media is an essential indicator in assessing the quality of learning media use in elementary schools (Rostika et al., 2025).

Based on these perspectives, the implementation of gamification-based digital learning media is expected to influence students' perceptions of media usability and learning experiences. In the context of this study, gamification elements implemented in the VPDLS platform are expected to increase students' engagement when interacting with digital learning activities. Increased engagement may influence students' perceptions of usefulness and ease of use as described in the Technology Acceptance Model (TAM). When students perceive the platform as useful and easy to use, they are more likely to participate actively in learning activities, which may support the development of their digital numeracy skills.

Gamification-based VPDLS media are understood to have the potential to enhance students' digital numeracy skills through interactive, meaningful learning experiences (Dewi et al., 2025). In this regard, the effectiveness of the media is reflected in students' achievement of numeracy learning outcomes after using the media (Erviana & Sepriansyah, 2024). At the same time, the practicality of the media shows the extent to which the media can be used easily and consistently in everyday learning (Linus et al., 2025). Therefore, this theoretical framework provides a conceptual basis for analyzing the relationship between the practicality of gamification-based VPDLS media and students' digital numeracy achievement in elementary school learning contexts (Rostika et al., 2025).

METHODS

Research Design

This study employed a descriptive quantitative approach with comparative analysis to examine the practicality of gamification-based VPDLS media and its association with students' digital numeracy achievement. This approach was chosen because it allows researchers to describe students' learning outcomes and perceptions using numerical data and to compare the results across different schools through statistical analysis (Creswell & Creswell, 2023). Through this approach, students' learning achievements and media practicality levels are presented as averages, percentages, and comparative test results.

Therefore, this study focuses on describing and comparing learning outcomes following the implementation of VPDLS media in natural classroom settings (Nwabuko et al., 2024). The implementation of the VPDLS platform was conducted during mathematics learning

activities on two-dimensional shapes. The platform was integrated into regular classroom instruction for several learning sessions, allowing students to access learning materials, complete interactive tasks, and receive immediate feedback through the system.

Sample

The research subjects were elementary school students who participated in digital numeracy learning using gamified VPDLs media. The participants were selected using a total sampling technique, in which all students who participated in the implementation of the VPDLs platform during mathematics learning activities were included as research participants. The research sample comprised 343 students, including 174 males and 169 females. Total sampling was applied because all students involved in the learning activities using the VPDLs platform were included in the study. Adequate sample size and diversity are essential in quantitative research to improve data representation and strengthen the generalization of research findings in similar learning contexts (Ahmed, 2024).

Data Collection

Data collection was conducted using two instruments, namely a numeracy test and a media practicality questionnaire. The numeracy test was used to measure students' understanding of digital numeracy concepts after participating in learning using VPDLs media. The test was designed as essay questions because it could reveal students' conceptual understanding and reasoning abilities in greater depth. Meanwhile, the media practicality questionnaire was used to obtain data on students' perceptions of the ease of use, usefulness, and acceptance of digital learning media (García et al., 2024).

The digital numeracy test consisted of essay-based tasks designed to assess several aspects of students' numeracy competence. The assessment tasks were designed to represent several numeracy competencies, including understanding geometric concepts, applying perimeter and area formulas, and solving contextual mathematical problems related to two-dimensional shapes. The use of essay-based tasks allows students to demonstrate their reasoning processes and problem-solving strategies more clearly, which are essential components of numeracy competence in elementary mathematics learning.

The validity of the numeracy test instrument was examined using item analysis based on students' responses, which determined item validity by calculating the correlation between each item score and the total test score. Items with correlation coefficients above 0.70 were considered valid and suitable for measuring students' digital numeracy skills (Isaac & Uwaks, 2022). The results showed that all assessment tasks met the minimum validity criterion, indicating that the instrument was appropriate for measuring students' digital numeracy skills (Sheptian et al., 2024).

The media practicality questionnaire was developed based on the Technology Acceptance Model construct, which includes perceived ease of use, perceived usefulness, attitude, behavioral intention, satisfaction, and acceptance. The questionnaire used a five-point Likert scale, with scores ranging from 1 (strongly disagree) to 5 (strongly agree). The use of a five-point Likert scale was intended to increase the sensitivity with which students' attitudes and perceptions regarding digital learning media could be measured. This scale also facilitated the descriptive analysis and interpretation of quantitative data (Kim et al., 2025).

Before use, the media practicality questionnaire was tested for validity and reliability using factor loadings and Cronbach's Alpha. The validity test aimed to ensure that each indicator represented the construct being measured, while the reliability test assessed the instrument's internal consistency (Hair et al., 2021). The results of the validity and reliability tests for the media practicality questionnaire are presented in **Table 1** to determine the feasibility of the research instrument.

Table 1. Convergent Validity

Construct	Item	Outer Loading	Decision	Cronbach's Alpha	Decision
PEOU	P1	0.488	Not Valid	0.503	Unreliable
	P2	0.533	Not Valid		
	P3	0.866	Valid		
	P4	0.468	Not Valid		
PU	P5	0.864	Valid	0.844	Reliable
	P6	0.847	Valid		
	P7	0.767	Valid		
	P8	0.822	Valid		
ATT	P9	0.850	Valid	0.747	Reliable
	P10	0.748	Valid		
	P11	0.850	Valid		
BI	P12	0.797	Valid	0.732	Reliable
	P13	0.806	Valid		
	P14	0.816	Valid		
SS	P15	0.838	Valid	0.788	Reliable
	P16	0.839	Valid		
	P17	0.836	Valid		
ACC	P18	0.854	Valid	0.800	Reliable
	P19	0.823	Valid		
	P20	0.858	Valid		

Based on Table 1, indicators with outer loading values ≥ 0.70 were considered valid and retained for further analysis. Indicators with outer loading values below the recommended threshold (P1, P2, and P4) were identified as not meeting the validity criterion. Therefore, these indicators were excluded from the subsequent analysis to improve the construct validity of the measurement model. After removing the indicators with low outer loadings, the measurement model was re-evaluated to ensure acceptable reliability. The remaining indicators demonstrated improved internal consistency and were considered appropriate for further statistical analysis.

Data Analysis

The data obtained from the digital numeracy test and media practicality questionnaire were analyzed using descriptive and inferential statistics. Descriptive statistics were used to calculate the mean, percentage, and standard deviation to describe students' digital numeracy achievement and media practicality levels (Son & Ha, 2025). Instrument validity and reliability were analyzed using SmartPLS version 4.0 to obtain outer loading and Cronbach's Alpha values. Inferential analysis using Analysis of Variance (ANOVA) was conducted with SPSS version 25 to examine differences in digital numeracy achievement and

media practicality among schools. All analyses were performed at the 0.05 significance level (Harmawati et al., 2024).

RESULTS

The research results present an overview of students' digital numeracy achievement and their perceptions of the use of gamification-based VPDLs media across different school contexts. To provide an overview of students' perceptions of media practicality and their digital numeracy achievement after the implementation of the gamification-based VPDLs media, the distribution of scores across schools is summarized in **Table 2**.

Table 2. Results of Data Description

	School	N	Mean	Median	SD	Min	Max
Media Practicality	School A	43	68.3	78	25.24	25	100
	School B	41	87.0	88	7.12	70	100
	School C	48	81.4	82.5	10.06	51	96
	School D	55	86.4	89	11.69	37	100
	School E	51	86.7	88	9.04	56	98
	School F	67	87.8	90	7.50	66	99
	School G	16	91.4	92.5	6.46	78	100
	School H	22	79.4	82.0	12.65	40	95
Digital Numeracy	School A	43	11.2	11	2.87	4	15
	School B	41	13.5	14	1.58	11	15
	School C	48	13.5	14.0	2.25	5	15
	School D	55	13.3	15	2.76	4	15
	School E	51	13.2	14	2.26	7	15
	School F	67	11.9	14	2.83	3	15
	School G	16	13.6	14.0	1.63	9	15
	School H	22	13.6	15.0	2.48	6	15

Based on Table 2, students' perceptions of media practicality varied across schools. School G obtained the highest mean score, indicating very positive perceptions regarding the ease of use, usefulness, and acceptance of the VPDLs media. In contrast, School A showed the lowest mean score, accompanied by a relatively high standard deviation, suggesting greater variability in students' responses. Overall, most schools demonstrated high average scores, indicating favorable perceptions of the practicality of the gamification-based learning media.

Table 2 also shows variations in students' digital numeracy achievement across schools. The mean scores ranged from 11.2 to 13.6 out of a maximum score of 15, indicating generally good achievement levels. Schools B, C, G, and H obtained higher mean scores, while Schools A and F demonstrated comparatively lower performance. These variations suggest differences in students' numeracy learning outcomes following the use of the gamification-based VPDLs media. To examine the relationship between students' perceptions of media practicality and their digital numeracy achievement, a correlation analysis was conducted, and the results are presented in Table 3.

Table 3. Correlation Analysis

		Media Practicality	Digital Numeracy
Media Practicality	Pearson Correlation	1	.196**

	Sig. (2-tailed)		.000
	N	343	343
	Pearson Correlation	.196**	1
Digital Numeracy	Sig. (2-tailed)	.000	
	N	343	343

As shown in Table 3, a positive and statistically significant relationship was found between media practicality and students' digital numeracy achievement. These results indicate that students who perceived the VPDLS media as easier to use and more useful tended to achieve higher digital numeracy scores. The positive relationship suggests that favorable perceptions of learning media tend to be associated with higher digital numeracy achievement.

Although the relationship is statistically significant, the correlation coefficient indicates a weak association. This finding suggests that positive perceptions of digital learning media may support students' learning outcomes but do not fully determine their numeracy achievement. Other factors, such as instructional strategies, teacher guidance, student motivation, and school learning environments, may also play important roles in influencing students' digital numeracy performance. To further investigate whether students' perceptions of media practicality and digital numeracy achievement differed across schools, an Analysis of Variance (ANOVA) was conducted, with the results presented in **Table 4**.

Table 4. Result of ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Media Practicality	Between Groups	14305.726	7	2043.675	12.990	.000
	Within Groups	52703.131	335	157.323		
	Total	67008.857	342			
Numeracy	Between Groups	252.537	7	36.007	4.857	.000
	Within Groups	2488.314	335	7.428		
	Total	2740.851	342			

The results in Table 4 indicate significant differences in students' perceptions of media practicality across schools. This finding suggests that students' acceptance and perceived ease of use of the VPDLS media varied across school contexts. Differences in implementation conditions, teacher support, and school readiness may have contributed to variations in students' perceptions of media practicality.

Table 4 also shows significant differences in students' digital numeracy achievement across schools. This result indicates that students' learning outcomes were not uniform following the implementation of the gamification-based VPDLS media. The observed differences suggest that school-related factors may influence the effectiveness of digital learning media in supporting students' achievement in digital numeracy. To identify specific school differences that contributed to the significant results in media practicality, a post hoc analysis was conducted, as presented in Table 5.

Table 5. Post Hoc Test Results for Media Practicality

School	N	Subset for alpha = 0.05		
		1	2	3

Media Practicality	School A	43	68.2558		
	School B	41		79.3636	
	School C	48		81.3542	
	School D	55		86.4364	86.4364
	School E	51		86.6863	86.6863
	School F	67		87.0244	87.0244
	School G	16		87.7761	87.7761
	School H	22			91.3750

The post hoc results in Table 5 indicate that School A formed a distinct subgroup with significantly lower media practicality scores than most other schools. Several schools appeared in overlapping subsets, indicating no significant differences in students' perceptions of media practicality among those schools. These results suggest similarities in media acceptance across multiple school contexts.

Table 5 also indicates that School H formed a separate subset with the highest mean media practicality score. This finding reflects stronger student acceptance and more positive perceptions of the gamification-based VPDLs media in School H. The results highlight differences in how students across schools perceived and experienced the use of digital learning media. To further clarify differences in students' digital numeracy achievement across schools, a post hoc analysis was also conducted, with the results summarized in Table 6.

Table 6. Post Hoc Test Results for Digital Numeracy

	School	N	Subset for alpha = 0.05	
			1	2
Digital Numeracy	School A	43	11.2093	
	School B	41	11.8806	11.8806
	School C	48		13.2157
	School D	55		13.3273
	School E	51		13.4583
	School F	67		13.4878
	School G	16		13.5625
	School H	22		13.5909

As shown in Table 6, School A demonstrated significantly lower digital numeracy achievement compared to most other schools. This result confirms that School A contributed substantially to the ANOVA-identified significant differences. The lower performance indicates the need for additional instructional support or improved learning conditions in this school context. In contrast, Schools C, D, E, F, G, and H were grouped within the same subset, indicating relatively similar levels of digital numeracy achievement. These findings suggest that despite differences in school contexts, students in these schools achieved comparable learning outcomes after using the gamification-based VPDLs media.

DISCUSSION

The findings of this study indicate that gamification-based VPDLs media have the potential to support student engagement and learning outcomes in digital numeracy, which is in line with the results of a systematic review stating that the integration of gamification can increase motivation, engagement, and academic achievement in mathematics learning (Karnilah & Fitri, 2024). Gamification creates an engaging learning environment through

game elements, such as points and challenges, that enhance students' learning experience (Ahmed et al., 2025). The use of gamification in learning has been shown to help students better understand mathematical concepts and reduce boredom in learning (Rijal & Maharani, 2025). This finding supports the idea that gamification elements can encourage active participation in digital learning environments, which may indirectly contribute to the development of students' numeracy skills (Karnilah & Fitri, 2024).

Students' perceptions of the practicality of using VPDLs media indicate that they generally find the media easy to use and valuable for digital numeracy learning. Previous studies also show that gamification in education improves learning experiences and student satisfaction with the learning process (Linus et al., 2025). This positive perception can be understood through the comfort and engagement offered by responsive interactive media design (Ahmed et al., 2025). The practicality of media is not only about the interface but also about students' adaptation to digital learning technology. These findings reinforce the importance of practicality in strengthening the adoption of digital learning media by students and teachers (Linus et al., 2025).

Variations in digital numeracy achievement and perceptions of practicality among schools in this study indicate that the implementation context and learning environment support influence learning outcomes with gamification media, a finding consistent with the literature showing that the success of gamification is influenced by instructional design, teacher readiness, and learning facilities (Triantafyllou et al., 2025). Gamification is not merely a game element but requires integration with appropriate teaching strategies to achieve optimal learning outcomes (Indarti & Sunanto, 2026). Factors such as school technical readiness and teacher support are essential determinants in the effectiveness of digital media implementation (Nurhayati & Fathurrohman, 2025). These findings confirm that VPDLs media should be implemented with support from a mature learning system to maximize its benefits (Indarti & Sunanto, 2026).

The results of this study are consistent with the literature showing that gamification can increase student motivation, engagement, and learning experiences, which are essential components in achieving numeracy learning outcomes (Nurhayati & Fathurrohman, 2025). Gamification elements such as challenges, feedback reinforcement, and rewards trigger students' interest and encourage active participation in learning activities. Further studies indicate that gamification helps students build critical thinking and contextual numeracy skills in meaningful ways. Therefore, integrating gamification into digital learning media such as VPDLs can make numeracy learning more effective, relevant, and engaging for elementary school students (Indarti & Sunanto, 2026).

CONCLUSION

This study concludes that gamification-based VPDLs media demonstrates high practicality and positive acceptance among elementary school students and shows the potential to support digital numeracy learning. However, because the study employed a descriptive quantitative design without a pre-test or control group, the findings should be interpreted as evidence of association rather than causal effectiveness. The integration of game elements in learning media enhances student engagement, facilitates understanding of numeracy concepts, and creates an interactive and meaningful learning environment. The high level of media practicality indicates that VPDLs is easy to use and well accepted by students in classroom activities. Although the items were designed to assess conceptual

understanding and problem-solving skills, future studies are encouraged to include a broader range of numeracy indicators. These differences suggest that the effectiveness of gamified digital learning media is influenced by learning environments, teacher support, and school readiness in implementing educational technology. However, this study is limited by its descriptive, quantitative design and by the use of post-test data without a pre-test comparison. Therefore, future studies are recommended to employ experimental or quasi-experimental designs, include pre-test and post-test measurements, and involve broader samples to strengthen the generalizability and causal interpretation of research findings.

REFERENCES

- Ahmed, H. M. M., Sabagh, H. A. El, & Elbourhamy, D. M. (2025). Effect of gamified, mobile, cloud based learning management system (GMCLMS) on student engagement and achievement. *International Journal of Educational Technology in Higher Education*, 22(49), 1–35. <https://doi.org/10.1186/s41239-025-00541-1>
- Ahmed, S. K. (2024). How to choose a sampling technique and determine sample size for research: a simplified guide for researchers. *Elsevier*, 12, 1–7. <https://doi.org/10.1016/j.oor.2024.100662>
- Anggun, M. S., Fakhruddin, Arbarini, M., Subali, B., & Widiarti, N. (2025). Implementing creative learning with technology to improve literacy and numeracy in primary schools. *Journal of Innovation and Research in Primary Education*, 4(3), 430–437. <https://doi.org/10.56916/jirpe.v4i3.1299>
- Boateng, S. L., Penu, O. K. A., Boateng, R., Budu, J., Marfo, J. S., & Asamoah, P. (2024). Educational technologies and elementary level education – a bibliometric review of scopus indexed journal articles. *Heliyon*, 10, 1–17. <https://doi.org/10.1016/j.heliyon.2024.e28101>
- Carolina, A., Klock, T., Gasparini, I., Pimenta, M. S., & Hamari, J. (2020). Tailored gamification: a review of literature. *International Journal of Human-Computer Studies*, 144, 1–22. <https://doi.org/10.1016/j.ijhcs.2020.102495>
- Creswell, J. W., & Creswell, J. D. (2023). *Research design qualitative, quantitative, and mixed methods approaches* (Sixth Edit). SAGE Publications.
- Daelia, V., Telaumbanua, Y. N., Lasec, S., & Mendrofad, R. N. (2025). Analisis kemampuan numerasi siswa dalam menyelesaikan soal asesmen kompetensi minimum di SMA Negeri 1 Gunungsitoli. *Jurnal Edukasi Matematika Dan Sains*, 14(1), 59–77. <https://doi.org/10.59672/emasains.v14i1.4553>
- Dewi, M., Apriza, B., & Dinata, K. B. (2025). The effectiveness of wordwall interactive media in teaching mathematics in elementary school: a systematic literature review. *Jurnal Mimbar PGSD Undiksha*, 13(1), 127–137. <https://doi.org/10.23887/jjpgsd.v13i1.92352>
- Erviana, V. Y., & Sepriansyah, Y. (2024). The effectiveness of virtual reality media on primary school students' learning outcomes. *International Journal of Elementary Education*, 8(1), 141–149. <https://doi.org/10.23887/ijee.v8i1.67734>
- Fitriani, N. P., Erico, A., Krisna, J., Samsiyah, I. F., Fitriyani, R., & Kusbiarsi, A. (2025). The impact of digital learning technology on the quality of education in indonesia: a systematic literature review. *Jurnal Ilmiah Ilmu Pendidikan Dan Nasional*, 14(4), 3142–3154. <https://ejournal.unibabwi.ac.id/index.php/sosioedukasi/index>
- Fodale, M. F. (2025). Gamification in educational technology: a scoping review of trends and effectiveness. *Universal Journal of Educational Research*, 4(3), 1–8. <https://doi.org/10.64637/629052>
- García, J. A. M., Gomez, C. G., Lopez, A. T., & Schlosser, M. J. (2024). Applying the technology acceptance model to online self-learning: a multigroup analysis. *Journal of*

- Innovation & Knowledge*, 9, 1–12. <https://doi.org/10.1016/j.jik.2024.100571>
- Gini, F., Bassanelli, S., Bonetti, F., Hadi, R., Bucchiarone, A., & Marconi, A. (2025). The role and scope of gamification in education: a scientometric literature review. *Acta Psychologica*, 259, 1–16. <https://doi.org/10.1016/j.actpsy.2025.105418>
- Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., & Ray, S. (2021). A primer on partial least squares structural equation modeling (PLS-SEM) using R. In *Structural Equation Modeling: A Multidisciplinary Journal* (Vol. 30, Issue 1). <https://books.google.co.id/books?id=y8JyzgEACAAJ>
- Harmawati, Y., Abdulkarim, A., Bestari, P., & Sari, B. I. (2024). Data of digital literacy level measurement of Indonesian students: based on the components of ability to use media, advanced use of digital media, managing digital learning platforms, and ethics and safety in the use of digital media. *Elsevier*, 54, 1–14. <https://www.sciencedirect.com/science/article/pii/S2352340924003664>
- Hermita, N., Wijaya, T. T., Yusron, E., Abidin, Y., Alim, J. A., & Putra, Z. H. (2023). Extending unified theory of acceptance and use of technology to understand the acceptance of digital textbook for elementary school in Indonesia. *Frontiers in Education*, 1–16. <https://doi.org/10.3389/educ.2023.958800>
- Indarti, S., & Sunanto, L. (2026). Systematic literature review: gamification in mathematics learning. *Ar-Rasyid: Jurnal Publikasi Penelitian Ilmiah*, 2(1), 1–20. <https://journal.sahakreasindo.co.id/index.php/ar-rasyid>
- Isaac, E., & Uwaks, G. (2022). Content validity in educational assessment. *International Journal of Innovative Education Research*, 10(2), 57–69. <https://www.seahipublications.org/wp-content/uploads/2024/12/IJIER-J-7-2022>
- Jutin, N. T., & Maat, S. M. B. (2024). The effectiveness of gamification in teaching and learning mathematics: a systematic literature review. *International Journal of Academic Research in Progressive Education and Development*, 13(1), 1290–1309. <https://doi.org/10.6007/IJARPED/v13-i1/20703>
- Kaban, L., Sari, M. P., Yoki, M., & Sihombing, M. (2023). Interactive learning through digital media: enhancing elementary math instruction. *Jurnal Arjuna: Publikasi Ilmu Pendidikan, Bahasa Dan Matematika*, 1(6), 250–257. <https://doi.org/10.61132/arjuna.v1i6.331>
- Karnilah, N., & Fitri, H. K. (2024). Gamifikasi dalam pembelajaran matematika di sekolah: a systematic literature review. *Jurnal Ilmiah Ilmu Pendidikan*, 7(8), 465–476. <https://doi.org/10.54371/jiip.v7i8.5035>
- Keji, S. S. (2024). Relationship among perceived usefulness, ease of use, attitude and intention to use emerging technology among undergraduate in South-West Nigeria. *Journal for Lesson and Learning Studies*, 7(1), 126–132. <https://doi.org/10.23887/jlls.v7i1.72043>
- Kim, J., Kim, J., & Youn, B. (2025). Using a technology acceptance model to explore the intention to use digital health technologies among people with disabilities: cross-sectional survey study table of contents. *JMIR Preprints*. <https://preprints.jmir.org/preprint/79595>
- Kusumawardani, S., Efendi, A., & Sumaryati, S. (2025). When math meets play: a meta-analysis of digital game-based learning effectiveness. *Proceeding of the 7th International Conference on Teacher Training and Education*, 178–187. <https://jurnal.uns.ac.id/ictte/article/view/114723>
- Linus, A. A., Aladesusi, G. A., Monsur, I. A., & Elizabeth, F. J. (2025). Perceived usefulness, ease of use, and intention to utilize online tools for learning among college of education students. *Indonesian Journal of Multidisciplinary Research*, 5(1), 41–52. <http://ejournal.upi.edu/index.php/IJOMR/>

- Mattar, C., Oueida, S., Awad, P., Militaru, G., & Baalbaki, H. El. (2025). A gamified learning approach for a better educational experience: a case study in the middle east. *International Journal of Game-Based Learning*, 15(1), 1–23. <https://doi.org/10.4018/IJGBL.391349>
- Nurhayati, & Fathurrohman. (2025). Gamification in school education: a systematic review of its effectiveness in improving student motivation and academic outcomes. *Al-Islah: Journal of Education*, 17(2), 2356–2368. <https://doi.org/10.35445/alishlah.v17i2.6516>
- Nwabuko, O. C., Iwu, L. O., Njoku, P. U., & Nwamoh, U. N. (2024). An overview of research study designs in quantitative research methodology. *American Journal of Medical and Clinical Research & Review*, 3(5), 1–6. <https://doi.org/10.58372/2835-6276.1169>
- OECD. (2022). PISA 2022 Result.
- Pan, Z., Wang, K., Zhu, J., & Smith, M. (2026). Levels, stickers, and strategies: how gamified math tasks foster elementary student engagement. *Education and Information Technologies*, 03, 1–23. <https://doi.org/10.1007/s10639-025-13866-1>
- Rahayu, S., Yaqin, N., Pranawukir, I., Awaludin, D. T., & Rahayu, S. (2025). Effectiveness of digital game based learning on improving numeracy literacy of elementary school students. *International Journal of Educational Insights and Innovations*, 2(2), 32–36. <https://ijedins.technolabs.co.id/index.php/ijedins>
- Ramdhani, L. I., Soeharno, S., Refni, E., Sarifah, I., & Mahdiyah, M. (2024). Meta-analysis the effectiveness of digital learning media on literacy numeracy: implications for education based technology. *Jurnal Penelitian Pendidikan*, 41(2), 153–161. <https://doi.org/10.15294/jpp.v41i2.18926>
- Rijal, A., & Maharani, T. (2025). Upaya meningkatkan hasil belajar matematika menggunakan model pembelajaran gamifikasi berbantuan kahoot siswa kelas II sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 10(02), 39–49.
- Rostika, N., Abidin, Y., & Kurniawan, D. T. (2025). Usability analysis of digital learning media based on google sites using the SUS scale. *Journal of Basic Education Research*, 6(3), 481–487. <https://doi.org/10.37251/jber.v6i3.1860>
- Sailer, M., & Homner, L. (2020). The gamification of learning: a meta-analysis. *Educational Psychology Review*, 32, 77–112. <https://doi.org/10.1007/s10648-019-09498-w>
- Salam, N., Suyanto, S., & Ningsih, S. N. (2024). Maximizing the potential of digital learning media in primary education: insights from a systematic literature review. *Indonesian Journal of Educational Research and Review*, 7(3), 615–629. <https://doi.org/10.23887/ijerr.v7i3.80617>
- Sari, N. M., Yaniawati, P., Supianti, I. I., & Indriani, R. (2025). Digital game-based learning interventions on students ' numeracy skills and engagement. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 15(148), 39–50. <https://doi.org/10.30998/formatif.v15i1.23356>
- Sheptian, R., Ocy, D. R., Triana, D. D., & Wahyuni, L. D. U. (2024). Developing a validated essay-based assessment instrument to measure science literacy in energy topics. *Journal of Indonesian Student Assessment and Evaluation*, 10(2), 88–100. <https://doi.org/10.21009/JISAE>
- Son, M., & Ha, M. (2025). Development of a digital literacy measurement tool for middle and high school students in the context of scientific practice. *Education and Information Technologies*, 30(4), 4583–4606. <https://doi.org/10.1007/s10639-024-12999-z>
- Tonioka, N. H., Sutopo, Y., Ellianawati, E., Avrilianda, D., & Kurniawan, Y. (2025). Systematic literature review: the implementation of gamification in mathematics learning at primary schools. *Journal of Innovation and Research in Primary Education*, 4(4), 2764–2774. <https://doi.org/10.56916/jirpe.v4i4.1877>
- Triantafyllou, S. A., Georgiadis, C., & Sapounidis, T. (2025). Gamification in education and training: a literature review. In *International Review of Education* (Vol. 71, Issue 3).

- Springer Netherlands. <https://doi.org/10.1007/s11159-024-10111-8>
- Yarsasi, S., Tahyudin, I., & Hariguna, T. (2025). Analysis of validity and reliability of questionnaires using partial least squares structural equation modeling method on SMARTPLS application. *Jurnal Pendidikan Dan Teknologi Indonesia*, 5(7), 1905–1913. <https://doi.org/10.52436/1.jpti.885>
- Yusri, A. A., & Zainal, M. Z. (2025). Unleashing gamification: a systematic review in primary schools. *Journal of Education and Learning*, 19(4), 2313–2321. <https://doi.org/10.11591/edulearn.v19i4.22009>
- Zhao, Y., Llorente, A. M. P., & Gomez, M. C. S. (2021). Digital competence in higher education research: a systematic literature review. *Computers & Education Journal*, 168, 1–14. <https://doi.org/10.1016/j.compedu.2021.104212>