



Effects of Wordwall-based gamification on economics students' digital literacy and numeracy skills

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ABSTRACT

The increasing demand for digital literacy and numeracy in higher education highlights the need for technology-enhanced learning approaches that actively engage students in developing these competencies. This study examined changes in economics students' digital literacy and numeracy skills following the implementation of Wordwall-based gamification. A pre-experimental one-group pretest-posttest design was employed with 54 students at the 'Aisyiyah Riau Institute of Education and Technology. The intervention incorporated Wordwall-based learning activities, while data were collected using a questionnaire and a numeracy test. The instruments were assessed for validity using Pearson's product-moment correlation and demonstrated high internal consistency, with Cronbach's alpha coefficients exceeding .98. Pretest and posttest scores were analyzed using paired-samples t-tests. The results showed significant improvements in both outcomes following the intervention. The mean digital literacy score increased from 45.69 at pretest to 63.65 at posttest, while the mean numeracy score increased from 61.20 to 72.59. The differences between pretest and posttest scores were statistically significant ($p < .001$). These findings indicate that Wordwall-based gamification was associated with improvements in students' digital literacy and numeracy skills. The study highlights the potential of interactive gamified learning as a technology-enhanced instructional approach for supporting digital and quantitative competencies in higher education. However, given the absence of a control group, the findings should be interpreted as evidence of improvement following the intervention rather than definitive causal effects.

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INTRODUCTION

The increasing integration of digital technology into education has transformed not only how learning is delivered but also the competencies students are expected to develop. Contemporary education increasingly emphasizes 21st-century competencies, including critical thinking, collaboration, creativity, and communication, alongside the ability to engage effectively with digital information and quantitative problems (Binkley et al., 2012). In higher education, digital literacy and numeracy are particularly important because students are expected to navigate technology-rich learning environments, critically interpret information, and apply quantitative reasoning in academic and professional contexts (Ananiadoui & Claro, 2009). Students' ability to develop these competencies is also closely related to their learning motivation and literacy development (Ritonga et al., 2024). Consequently, higher education institutions need instructional approaches that move

beyond conventional content delivery and provide students with opportunities to actively engage with digital resources and quantitative information.

One approach with considerable potential is the integration of interactive digital media into learning. Interactive media can facilitate active participation by presenting learning materials through activities that require students to respond, make decisions, solve problems, and receive immediate feedback. Wordwall represents one such platform, offering gamified learning activities such as quizzes, matching tasks, crossword puzzles, and randomized wheel activities. These features enable instructors to transform conventional learning exercises into interactive activities while incorporating gamification elements that may support students' engagement with learning content.

Previous research has provided growing evidence regarding the educational potential of Wordwall. In English language learning, Mahaputri and Nizar, (2025) reported higher achievement among students learning with Wordwall, with mean scores of 77 in the experimental group compared with 65 in the control group ($t = 6.078, p < .05$). Similarly, Safitri et al. (2024) reported improvements in vocabulary-related outcomes, including an increase in vocabulary mastery from 45.17 to 74.10 and vocabulary knowledge from 58.10 to 83.80. Belvin et al. (2024) also found higher foreign-language vocabulary outcomes among students exposed to Wordwall, with posttest scores of 89.13 in the experimental group compared with 74 in the control group. Collectively, these findings suggest that interactive Wordwall activities can support learning processes requiring students to engage actively with language-based information.

Evidence of Wordwall's potential extends beyond language learning. In numeracy-related learning, Wordwall-integrated instructional activities have been shown to support the development of students' numeracy literacy (Hutauruk & Ardiansyah, 2026), while Ulfiana et al. (2022) identified improvements in learning motivation and numeracy competence through interactive Wordwall activities. Alfazriani et al. (2025) further examined Wordwall within a Teams Games Tournament (TGT) cooperative learning model and highlighted its potential for supporting numeracy literacy through game-based learning. In science education, Fajaryati et al. (2024) found a statistically significant difference between experimental and control groups when Wordwall was used for formative assessment, while Dwiyantri et al. (2025) reported improvements in elementary students' science literacy through Wordwall educational games. These studies indicate that Wordwall can be applied across subject areas and may support learning outcomes involving literacy, numeracy, and active engagement.

Research focusing on instructional development and implementation provides further support for the educational use of interactive digital media. Faradini and Hermanto (2024) reported that Wordwall-assisted gamified instructional materials achieved an overall expert-validation score of 89%, supporting their feasibility for instructional use. Hartono et al. (2025) also demonstrated the potential of Wordwall-based media in technology-supported teacher competency development. More broadly, technology-based and interactive learning media have been associated with greater student engagement, motivation, and practical learning experiences (Indra et al., 2023; Mahardika et al., 2025). Digital learning platforms, including Wordwall, have likewise been reported to support students' motivation and mastery of learning materials (Suryani et al., 2024). Taken together, these findings suggest that the pedagogical value of interactive technology lies not simply in the presence of digital tools but in the opportunities they provide for students to participate actively in the learning process.

The potential of Wordwall can also be understood within the broader framework of gamification in education. Technology integration has become an increasingly important component of contemporary teaching and learning practices (Rambe, 2022), while gamification provides a mechanism for incorporating game-related features into educational activities. Elements such as points, challenges, competition, and feedback can influence students' motivation and learning outcomes when they are appropriately integrated into instructional design (Sailer & Homner, 2020). Toda et al. (2019) further developed a taxonomy of gamification elements that provides a framework for designing pedagogically meaningful gamified learning environments. Evidence from vocational education similarly indicates that game-based mobile applications can promote learners' interest and participation in training contexts (Godoy, 2020). These perspectives provide a conceptual basis for

considering Wordwall not merely as a digital presentation tool but as a gamified learning environment capable of facilitating active engagement with learning tasks.

Despite this growing body of evidence, several issues remain insufficiently explored. First, much of the available research cited above has examined Wordwall in primary and secondary education, language learning, science education, or other school-based settings (Belvin et al., 2024; Dwiyantri et al., 2025; Fajaryati et al., 2024; Mahaputri & Nizar, 2025; D. Safitri et al., 2024; Ulfiana et al., 2022). Evidence concerning its implementation among university students remains comparatively limited, despite differences between school and higher education contexts in terms of learning autonomy, cognitive demands, and expected competencies. Second, previous studies have commonly investigated particular learning outcomes or competencies separately. Consequently, less attention has been given to examining changes in digital literacy and numeracy skills simultaneously following a gamified learning intervention in higher education. This gap is particularly relevant for economics students, for whom engagement with digital information and quantitative reasoning represents an important component of academic learning.

Accordingly, this study examines changes in economics students' digital literacy and numeracy skills following the implementation of Wordwall-based gamification at the 'Aisyiyah Riau Institute of Education and Technology. Specifically, the study compares students' digital literacy and numeracy scores before and after the intervention to determine whether statistically significant differences occur between the pretest and posttest measurements. Based on the proposed intervention and previous empirical evidence, the study hypothesizes that students will demonstrate significantly higher digital literacy and numeracy scores after participating in Wordwall-based gamified learning than before the intervention. By examining these two competencies simultaneously in a higher education context, the study is expected to provide empirical evidence regarding the potential use of gamified interactive media to support digital and quantitative competencies among economics students.

METHOD

This study employed a quantitative approach using a pre-experimental one-group pretest–posttest design to examine changes in students' digital literacy and numeracy skills following the implementation of Wordwall-based gamified learning. In this design, a single experimental group was assessed before and after the intervention without the inclusion of a control group (Sugiyono, 2015). The pretest was administered to establish students' initial levels of digital literacy and numeracy, followed by the implementation of Wordwall-based gamified learning. Upon completion of the intervention, the same group completed a posttest to determine changes in the measured competencies.

The study was conducted from September to November 2025 in the Economics Education Study Program at the 'Aisyiyah Riau Institute of Education and Technology. The population comprised students enrolled in the Economics Education Study Program. Participants were selected using purposive sampling based on their relevance to the objectives of the study. The inclusion criteria required students to have taken courses involving literacy and numeracy within economics learning and to be willing to participate in the entire research process. Based on these criteria, 54 students from one class participated in the study.

The research procedure consisted of three sequential stages: pretest, intervention, and posttest. First, participants completed a pretest (O_1) to establish their baseline digital literacy and numeracy scores. They subsequently participated in the intervention (X), in which Wordwall was integrated into learning activities as a gamification-based digital learning medium. Following the intervention, participants completed a posttest (O_2) to measure their digital literacy and numeracy skills. The pretest and posttest scores were then compared to identify changes following the implementation of Wordwall-based gamified learning. The research design is presented in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental group	O_1	X	O_2

Note. O_1 = pretest of digital literacy and numeracy skills; X = Wordwall-based gamified learning intervention; O_2 = posttest of digital literacy and numeracy skills.

Source: Adapted from Sugiyono (2015).

Data on students' digital literacy and numeracy skills were collected using the research instruments administered before and after the intervention. Instrument validity and reliability were assessed prior to the main analysis. The validity of the instrument items was examined using the Pearson Product–Moment correlation, while internal consistency reliability was assessed using Cronbach's alpha. Data analysis was performed using IBM SPSS Statistics version 24. Descriptive statistics, including mean scores, were used to summarize students' performance before and after the intervention. Differences between pretest and posttest scores were subsequently examined using a paired-samples t-test at a significance level of .05. This analysis was conducted separately for digital literacy and numeracy to determine whether the posttest scores differed significantly from the corresponding pretest scores.

RESULTS AND DISCUSSION

Results

Validity of the Research Instruments

The validity of the Wordwall-based gamification and digital literacy questionnaire items was examined using Pearson's product–moment correlation. With a sample of 54 participants, an r-table value of 0.268 at the 5% significance level was used as the criterion for item validity. An item was considered valid when its item–total correlation coefficient (r-calculated) exceeded the corresponding r-table value. The results of the validity analysis are presented in Table 2.

Table 2. Results of the Instrument Validity Test

Variable	Item	r-calculated	r-table	Decision
Wordwall-based gamification (X)	PGW_1	0.967	0.268	Valid
	PGW_2	0.764	0.268	Valid
	PGW_3	0.847	0.268	Valid
	PGW_4	0.804	0.268	Valid
	PGW_5	0.917	0.268	Valid
	PGW_6	0.712	0.268	Valid
	PGW_7	0.967	0.268	Valid
	PGW_8	0.729	0.268	Valid
	PGW_9	0.849	0.268	Valid
	PGW_10	0.853	0.268	Valid
	PGW_11	0.898	0.268	Valid
	PGW_12	0.660	0.268	Valid
	PGW_13	0.984	0.268	Valid
	PGW_14	0.781	0.268	Valid
	PGW_15	0.829	0.268	Valid
Digital literacy (Y1)	DL_1	0.873	0.268	Valid
	DL_2	0.767	0.268	Valid
	DL_3	0.723	0.268	Valid
	DL_4	0.873	0.268	Valid
	DL_5	0.767	0.268	Valid
	DL_6	0.723	0.268	Valid
	DL_7	0.873	0.268	Valid
	DL_8	0.723	0.268	Valid
	DL_9	0.767	0.268	Valid
	DL_10	0.873	0.268	Valid
	DL_11	0.767	0.268	Valid
	DL_12	0.723	0.268	Valid
	DL_13	0.873	0.268	Valid
	DL_14	0.767	0.268	Valid
	DL_15	0.723	0.268	Valid

As shown in Table 2, all 15 items measuring Wordwall-based gamification had correlation coefficients ranging from 0.660 to 0.984, all of which exceeded the *r*-table value of 0.268. Similarly, the 15 digital literacy items yielded correlation coefficients ranging from 0.723 to 0.873, with all coefficients exceeding the predetermined criterion. Therefore, all items included in the Wordwall-based gamification and digital literacy questionnaires met the specified item-validity criterion and were retained for subsequent analysis. Following the validity assessment, the internal consistency of the instruments was examined using reliability analysis.

Reliability of the Research Instruments

The internal consistency of the Wordwall-based gamification and digital literacy questionnaires was assessed using Cronbach's alpha. The reliability results for both instruments are presented in Tables 3 and 4.

Table 3. Reliability of the Wordwall-Based Gamification Questionnaire

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
.981	.981	15

Table 4. Reliability of the Digital Literacy Questionnaire

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
.989	.989	15

The reliability analysis showed high internal consistency for both instruments. The Wordwall-based gamification questionnaire, consisting of 15 items, yielded a Cronbach's alpha coefficient of .981, while the 15-item digital literacy questionnaire yielded a coefficient of .989. These coefficients indicate that the items within each questionnaire demonstrated a high degree of internal consistency. Accordingly, both instruments met the reliability criterion adopted in this study and were considered suitable for subsequent analysis.

Paired-Samples Descriptive Statistics

Table 5. Descriptive Statistics for Pretest and Posttest Scores

Outcome	Measurement	Mean	<i>N</i>	SD	SE
Digital literacy	Pretest	45.69	54	10.407	1.416
	Posttest	63.65	54	10.658	1.450
Numeracy	Pretest	61.20	54	13.836	1.883
	Posttest	72.59	54	16.245	2.211

Table 5 presents the descriptive statistics for students' digital literacy and numeracy scores before and after the Wordwall-based gamified learning intervention. For digital literacy, the mean score increased from 45.69 (SD = 10.407) at pretest to 63.65 (SD = 10.658) at posttest, corresponding to a mean increase of 17.96 points. Similarly, the mean numeracy score increased from 61.20 (SD = 13.836) at pretest to 72.59 (SD = 16.245) at posttest, representing an increase of 11.39 points. Thus, the descriptive results indicate higher posttest scores for both digital literacy and numeracy following the intervention. Whether these pretest–posttest differences were statistically significant was subsequently examined using paired-samples *t*-tests.

Correlations Between Pretest and Posttest Scores

Table 6. Paired-Samples Correlations Between Pretest and Posttest Scores

Outcome	Paired Measurements	<i>N</i>	<i>r</i>	<i>p</i>
Digital literacy	Pretest–posttest	54	.928	< .001
Numeracy	Pretest–posttest	54	.981	< .001

As shown in Table 6, the pretest and posttest scores were strongly and positively correlated for both outcomes. Digital literacy scores showed a strong positive correlation between the pretest and posttest measurements ($r = .928$, $p < .001$), indicating that students with relatively higher digital

literacy scores at pretest also tended to obtain relatively higher scores at posttest. Similarly, numeracy scores demonstrated a strong positive correlation between the two measurements ($r = .981$, $p < .001$). These results indicate a high degree of consistency in the relative ordering of students' scores across the two measurement occasions. However, these correlations do not indicate whether the mean scores changed significantly between pretest and posttest; therefore, the statistical significance of the observed score differences was subsequently examined using paired-samples t-tests.

Paired-Samples t-Test

Table 7. Paired-Samples t-Test Results for Digital Literacy and Numeracy

Outcome	Comparison	Mean Difference	SD	E	95% CI	<i>t</i>	<i>f</i>	<i>p</i>
Digital literacy	Pretest – Posttest	-17.963	4.014	.546	[-19.059, -16.867]	-32.885	53	< .001
Numeracy	Pretest – Posttest	-11.389	3.814	.519	[-12.430, -10.348]	-21.945	53	< .001

The paired-samples t-test revealed a statistically significant difference between the pretest and posttest digital literacy scores. The mean difference between the pretest and posttest scores was -17.963 (95% CI [-19.059, -16.867]), $t(53) = -32.885$, $p < .001$. The negative mean difference reflects the order of subtraction (pretest minus posttest) and indicates that students achieved higher digital literacy scores at posttest than at pretest. Consistent with the descriptive statistics presented in Table 5, these results indicate a statistically significant improvement in students' digital literacy scores following the Wordwall-based gamified learning intervention.

A statistically significant pretest–posttest difference was also observed for numeracy. The mean difference was -11.389 (95% CI [-12.430, -10.348]), $t(53) = -21.945$, $p < .001$, indicating that students obtained higher numeracy scores at posttest than at pretest. Taken together, the paired-samples t-test results demonstrate statistically significant improvements in both digital literacy and numeracy scores following the implementation of Wordwall-based gamified learning. However, because the study employed a one-group pretest–posttest design without a control group, these improvements should be interpreted as changes observed following the intervention rather than definitive evidence of a causal effect attributable solely to Wordwall.

Discussion

The findings of this study indicate that students demonstrated statistically significant improvements in both digital literacy and numeracy following the implementation of Wordwall-based gamified learning. Digital literacy scores increased from a pretest mean of 45.69 to a posttest mean of 63.65, while numeracy scores increased from 61.20 to 72.59. The paired-samples t-tests confirmed significant pretest–posttest differences for digital literacy, $t(53) = -32.885$, $p < .001$, and numeracy, $t(53) = -21.945$, $p < .001$. These findings suggest that integrating gamified digital activities into learning may provide a supportive environment for developing both competencies. Given the absence of a control group, however, the observed improvements should be interpreted as changes following the intervention rather than definitive evidence that Wordwall alone caused these changes.

The improvement in digital literacy may be understood in relation to the technology-mediated nature of the intervention. Throughout Wordwall-based learning activities, students interacted directly with a digital platform to access tasks, respond to questions, process information, and engage with immediate feedback. Activities such as interactive quizzes, matching tasks, and game-based challenges required students to navigate and respond within a digital learning environment rather than passively receive instructional content. Repeated engagement with these activities may have provided opportunities for students to strengthen competencies associated with the use of digital learning resources. This interpretation is consistent with [Habibi et al. \(2025\)](#), who associated Wordwall-supported learning with improvements in digital literacy and academic

performance, and with [Do and Huynh \(2024\)](#), who reported positive student perceptions of Wordwall in relation to learning engagement and academic outcomes.

The present findings also align with a broader body of evidence demonstrating the potential of Wordwall to support literacy-related learning. Previous studies have reported improvements in learning engagement and literacy understanding through interactive Wordwall activities [Wahid et al. \(2025\)](#), as well as improvements in English literacy through game-based grammar and vocabulary learning [Sulianto et al. \(2025\)](#). [Faradini and Hermanto \(2024\)](#) reported that Wordwall-assisted gamified instructional materials achieved an overall expert-validation score of 89%, supporting their feasibility for instructional use, and vocabulary and reading outcomes in English learning ([Alfares, 2025](#)). Other studies have extended these findings to descriptive literacy among university students ([Yasmar & Amalia, 2024](#)), early literacy development ([Supiani et al., 2025](#)), and vocabulary mastery among non-English students ([Nhur & Ngan, 2025](#)). Although these studies address different forms and contexts of literacy, collectively they suggest that Wordwall can facilitate repeated, interactive engagement with information and learning content.

Similar patterns have been identified beyond language-based literacy. In science learning, interactive Wordwall activities have been reported to facilitate students' understanding of scientific concepts and science literacy ([Dwiyanti et al., 2025](#); [Sinaga & Simanjuntak, 2025](#)). [Fauziyati and Sriyanto \(2024\)](#) also reported improvements in critical thinking through Wordwall activities requiring students to engage analytically with learning tasks. More broadly, a systematic study by [Amaliyah \(2024\)](#) identified Wordwall as having potential to support motivation, literacy, and numeracy through interactive exercises and immediate feedback. Taken together, these studies reinforce the view that the educational potential of Wordwall may extend beyond a specific subject area and may be associated with the interactive processes embedded within gamified learning activities.

The significant improvement in numeracy observed in the present study provides further evidence of the potential role of gamification in quantitative learning. Wordwall enables numerical tasks to be presented through interactive challenges and repeated practice, potentially allowing students to engage with quantitative problems in a more participatory learning environment. This interpretation is consistent with previous studies reporting improvements in numeracy through repetitive and game-based mathematical exercises ([Pa & Wadu, 2025](#); [Sulaiman et al., 2025](#)). Wordwall has also been associated with greater numeracy confidence and critical engagement with mathematical problems ([Hima, 2025](#)), improvements in numeracy literacy through challenge-based activities ([Khasanah et al., 2024](#)), and stronger understanding of mathematical concepts through visual and numerical game activities ([Wahyuni et al., 2025](#)). In addition, [Juniarti et al. \(2024\)](#) reported improvements in accuracy and numeracy comprehension through repeated numeracy exercises, while [Adiansha \(2025\)](#) demonstrated the potential of integrating Wordwall into student-centered learning activities to support numeracy development.

Nevertheless, the descriptive results of the present study should not be interpreted as demonstrating that Wordwall was more effective for digital literacy than for numeracy. Although the raw mean increase was larger for digital literacy (17.96 points) than for numeracy (11.39 points), the two outcomes were measured using different scales and exhibited different score distributions. Directly comparing these raw score changes would therefore provide insufficient evidence for concluding that one competency improved more strongly than the other. What can be established from the present analyses is that statistically significant pretest–posttest improvements occurred in both outcomes. This distinction is important because numeracy development may involve cognitive processes and learning experiences that differ from those involved in digital literacy, and determining whether Wordwall has differential effects across competencies would require an appropriate standardized comparison and a stronger experimental design.

From a pedagogical perspective, the findings suggest that the potential value of Wordwall lies in how gamified features are incorporated into the learning process rather than in the digital platform itself. Interactive tasks can provide opportunities for repeated practice, immediate responses, active participation, and engagement with learning content. Previous research has similarly associated Wordwall with increased learning motivation in competitive and interactive environments ([Yuliana & Khoiriyah, 2025](#)), while [Ekaputra \(2025\)](#) highlighted the value of

developing students' ability to design gamification-based learning activities. These findings suggest that Wordwall may function most productively as a complementary instructional tool embedded within a broader pedagogical strategy rather than as a substitute for structured teaching and learning activities.

The findings also extend the existing literature by examining digital literacy and numeracy simultaneously among economics students in a higher education context. Much of the research discussed above has focused on school-age learners or on specific outcomes such as vocabulary, reading literacy, science literacy, or mathematical competence. The present study therefore provides additional empirical evidence from a university setting, indicating that Wordwall-based gamified learning can be incorporated into higher education activities involving both digital and quantitative competencies. For economics education in particular, opportunities to interact with digital information and quantitative tasks are relevant to academic learning. Nevertheless, the findings should be understood as preliminary evidence of the potential usefulness of Wordwall in this context rather than as confirmation of its universal effectiveness.

Several limitations should be considered when interpreting these findings. First, the study involved 54 students from a single study program at one institution, which limits the extent to which the findings can be generalized to other student populations or higher education settings. Second, the one-group pretest–posttest design did not include a comparison or control group. Consequently, although significant improvements were observed following the intervention, alternative explanations for the changes cannot be ruled out, and a causal effect attributable solely to Wordwall cannot be established. Third, the relatively short intervention period limits conclusions regarding whether the observed improvements would be sustained over time. These methodological considerations are particularly important when interpreting the statistically significant pretest–posttest differences reported in this study.

Future research should therefore examine Wordwall-based gamification across multiple institutions and more diverse student populations. Experimental or quasi-experimental studies incorporating appropriate comparison groups would provide stronger evidence regarding the contribution of Wordwall to changes in digital literacy and numeracy. Longer-term or longitudinal investigations would also be valuable for determining whether improvements are maintained after the intervention. In addition, future studies could investigate how specific gamification features, learning activities, and instructional strategies interact with Wordwall to support different competencies. Such research would help clarify not only whether gamified learning is associated with improved outcomes, but also the conditions under which it can be most effectively integrated into higher education.

CONCLUSION

This study concludes that students demonstrated significant improvements in digital literacy and numeracy following the implementation of Wordwall-based gamified learning. The findings indicate that integrating interactive and gamified activities into higher education can provide a supportive learning environment for strengthening students' engagement with digital and quantitative tasks. By simultaneously examining digital literacy and numeracy among economics students, this study extends previous research that has predominantly investigated Wordwall in school-based settings or focused on individual learning outcomes. The findings therefore highlight the potential of Wordwall as a complementary technology-enhanced learning tool for supporting digital and quantitative competencies in higher education.

However, the findings should be interpreted within the methodological limitations of the study. The use of a one-group pretest–posttest design without a control group, the inclusion of participants from a single institution, and the relatively short intervention period limit causal interpretation and broader generalizability. Future research should employ experimental or quasi-experimental designs with appropriate comparison groups, involve larger and more diverse samples across institutions and disciplines, and examine longer intervention periods to determine whether the observed improvements are sustained over time. Comparative studies involving other digital learning platforms and specific gamification features may also provide further insight into the conditions

under which gamified learning can most effectively support digital literacy and numeracy in higher education.

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