

Gamification Meets Science Education: Evaluating Digital Learning Toolkits for Improving Conceptual Understanding and Student Engagement

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ABSTRACT

This study explored how gamification and digital learning toolkits could transform Grade 8 Science instruction by making complex concepts more accessible, interactive, and engaging. Conducted at San Jose Integrated School, Schools Division of Santiago City, Philippines, the study employed a quasi-experimental pretest–posttest design involving experimental and comparison groups. The intervention integrated Gamified Learning Activity Sheets (GLAS), interactive quizzes, collaborative challenges, and digital assessments to enhance conceptual understanding and student engagement. Learners' academic performance was assessed through achievement tests, while behavioral, emotional, and cognitive engagement was measured using structured questionnaires. Teachers also evaluated implementation feasibility and curriculum alignment. In the hypothetical dataset, the experimental group demonstrated greater academic improvement, increasing from a pretest mean of 12.43 to a posttest mean of 24.87, compared with the comparison group's increase from 12.17 to 18.63. Student engagement received a very high overall rating ($M = 3.63$), while teachers positively evaluated implementation feasibility ($M = 3.50$). These simulated findings suggested that gamified digital learning toolkits could support meaningful Science learning experiences. However, actual effectiveness remains to be established through empirical data collection. The study offers a framework for developing engaging, accessible, and curriculum-aligned digital learning interventions in secondary Science education and future classroom research initiatives.

INTRODUCTION

Science education plays a vital role in developing learners' scientific literacy, critical thinking, problem-solving abilities, and conceptual understanding of natural phenomena. As educational systems increasingly embrace digital transformation, integrating technology-enhanced instructional strategies has become an important approach to improving teaching and learning experiences. Digital learning tools provide opportunities for interactive exploration, immediate feedback, collaborative activities, and personalized learning experiences that may help students understand complex scientific concepts. Bond et al. (2020) emphasized the importance of educational technology in supporting student engagement, while Nkomo et al. (2021) highlighted the relationship between digital technologies and meaningful learning experiences. Similarly, Rotar (2025) underscored the need to move beyond the mere availability of technological tools by emphasizing pedagogical strategies that actively support student participation. These perspectives suggest that combining gamification with technology-enhanced instruction offers a promising approach to making secondary Science education more interactive, engaging, and responsive to learners' educational needs.

Despite technological advancements in education, teaching complex scientific concepts remains challenging, particularly among Grade 8 learners who are expected to develop deeper understanding of scientific principles, processes, and applications. Traditional instructional approaches that rely heavily on lectures, textbook discussions, and conventional worksheets may provide insufficient opportunities for active participation, conceptual exploration, and immediate feedback. Consequently, some learners may experience difficulties interpreting scientific information, connecting abstract concepts with real-life situations, and sustaining engagement during classroom activities. Brown et al. (2022) emphasized the importance of instructional design in promoting meaningful engagement, while Tualaulelei et al. (2022) identified pedagogical interactions as essential elements of effective technology-supported learning environments. Furthermore, Uzorka and Odebiyi (2025) examined the relationship between digital learning tools, student engagement, and academic achievement, reinforcing the importance of investigating how technology-supported instructional approaches influence educational outcomes. Within the context of San Jose Integrated School, South Cluster, Schools Division of Santiago City, these concerns provide a relevant basis for examining instructional innovations that may strengthen Grade 8 learners' conceptual understanding and classroom engagement. However, the extent of these challenges within the school must be established through baseline assessment rather than assumed.

One promising approach to addressing these instructional challenges is the integration of gamification and digital learning toolkits into Science instruction. Gamification incorporates game-inspired elements, including points, rewards, challenges, progress indicators, and interactive tasks, into educational activities to encourage participation and sustained motivation. When combined with digital platforms, simulations, interactive quizzes, and Gamified Learning Activity Sheets (GLAS), these strategies may create learning experiences that promote scientific inquiry, collaboration, and active knowledge construction. Ahshan (2021) discussed instructional strategies for encouraging active student engagement in technology-supported learning environments, while

Shaik et al. (2023) explored interactive digital approaches for assessing students' understanding. Likewise, Agavekar et al. (2026) examined the use of Padlet to enhance students' engagement in concept learning, demonstrating the potential relevance of collaborative digital platforms. Nevertheless, meaningful learning outcomes depend not simply on the presence of technological features but also on how instructional activities are designed, facilitated, and aligned with specific learning competencies. Therefore, gamified digital learning toolkits should be implemented as pedagogically purposeful resources that support conceptual understanding rather than merely provide entertainment or technological novelty.

The integration of digital learning toolkits also presents opportunities to strengthen learner-centered Science instruction through differentiated activities, formative assessment, and immediate instructional feedback. Interactive learning environments can allow students to revisit difficult concepts, participate in collaborative challenges, monitor their progress, and demonstrate understanding through varied learning tasks. Gameil and Al-Abdullatif (2023) examined the contribution of digital learning platforms to instructional design competencies and learning engagement, while Simelane-Mnisi (2023) investigated the effectiveness of learning management system tools in fostering student participation. Moreover, Yaseen et al. (2025) explored the relationships among adaptive learning technologies, personalized feedback, interactive artificial intelligence tools, and student engagement, highlighting the importance of digital literacy in technology-enhanced learning. However, much of the cited literature addresses higher education or broader digital learning contexts, creating a need for more localized evidence concerning gamified instructional approaches in junior high school Science classrooms. In particular, the effectiveness of combining digital tools and Gamified Learning Activity Sheets in improving conceptual understanding and behavioral, emotional, and cognitive engagement among Grade 8 learners warrants further investigation. Consideration must also be given to teachers' implementation readiness, curriculum alignment, available technological resources, and the practicality of integrating these innovations into everyday classroom instruction.

In response to these considerations, the present study, titled "Gamification Meets Science Education: Evaluating Digital Learning Toolkits for Improving Conceptual Understanding and Student Engagement," proposes to evaluate the effectiveness of integrating gamified and technology-enhanced learning toolkits in Grade 8 Science instruction at San Jose Integrated School, South Cluster, Schools Division of Santiago City. Specifically, the study seeks to determine the influence of digital learning tools and Gamified Learning Activity Sheets on learners' conceptual understanding of selected complex Science concepts, assess their levels of behavioral, emotional, and cognitive engagement, and examine the feasibility of implementing these instructional resources within the existing Science curriculum. The proposed intervention will incorporate curriculum-aligned gamified activities, interactive digital assessments, collaborative learning tasks, and structured feedback mechanisms to support meaningful learning experiences. Guided by the emphasis of D'Mello (2021) on improving engagement with digital learning technologies and Rotar (2025) on pedagogically grounded technology-enhanced learning, the study aims to generate empirical evidence regarding the educational value and practical implementation of gamified Science instruction. Ultimately, its findings are expected to inform the development of a localized, accessible, and sustainable digital learning toolkit that may

strengthen Science teaching practices, improve learners' conceptual understanding, and promote more active and engaging classroom experiences.

LITERATURE REVIEW

Digital Learning and Conceptual Understanding

The integration of digital learning technologies into educational instruction has transformed how students access information, interact with learning materials, and develop conceptual understanding. Digital learning tools, including interactive simulations, educational applications, online assessments, and multimedia resources, provide opportunities for learners to explore complex concepts through visualization, experimentation, and immediate feedback. Rafiq et al. (2024) examined the impact of digital tools and online learning platforms on educational outcomes, emphasizing their potential contribution to improving learning experiences and academic performance. Similarly, Hardiyanti et al. (2023) investigated the influence of digital tools on student engagement and academic outcomes across educational levels. These studies provide a foundation for understanding how technology-supported instruction may facilitate meaningful learning. In Science education, digital resources are particularly relevant because they can help learners visualize abstract scientific processes, investigate relationships among variables, and connect theoretical explanations with observable phenomena.

Technology-enhanced learning environments also provide opportunities to strengthen conceptual understanding through interactive instructional design and formative assessment. Shaik et al. (2023) explored the development of an interactive design tool for assessing student understanding in digital environments, highlighting the relevance of technology-supported assessment in monitoring learning progress. Likewise, Elbasyouny (2021) examined the use of online formative assessment tools to enhance students' learning and engagement. Such approaches allow teachers to identify misconceptions, provide timely feedback, and adjust instructional strategies according to learners' needs. For Grade 8 Science learners, interactive assessments and digital activities may be particularly beneficial when studying complex scientific concepts that require observation, interpretation, and application. However, the effectiveness of these tools depends on their alignment with intended learning competencies, the appropriateness of instructional content, and the extent to which students actively process scientific information rather than simply complete digital tasks.

The effectiveness of digital learning resources further depends on teachers' ability to integrate technology into purposeful instructional experiences. Gameil and Al-Abdullatif (2023) investigated the use of digital learning platforms to enhance instructional design competencies and learning engagement among preservice teachers, emphasizing the relationship between technology integration and pedagogical preparation. Similarly, Simelane-Mnisi (2023) examined the effectiveness of learning management system tools in fostering student engagement. These studies suggest that successful technology-enhanced instruction requires more than technological availability; it also involves instructional planning, appropriate learning activities, and continuous monitoring of student progress. In localized secondary school settings, considerations such as internet connectivity, device accessibility, teachers' digital competencies, and curriculum

alignment may influence implementation feasibility. Consequently, evaluating digital learning toolkits in Grade 8 Science should include not only students' learning outcomes but also the practicality and sustainability of their classroom implementation.

Gamification and Student Engagement

Student engagement is an essential component of meaningful learning because it reflects learners' participation, emotional involvement, and cognitive investment in educational activities. Gamification offers an instructional approach that incorporates game-inspired elements, such as points, challenges, achievement badges, progress tracking, and collaborative competitions, into learning experiences. These features may encourage learners to participate actively, complete challenging tasks, and sustain interest in academic activities. D'Mello (2021) discussed approaches to improving student engagement with digital learning technologies, while Bond et al. (2020) mapped research concerning student engagement and educational technology. Their contributions provide a conceptual foundation for examining how interactive learning environments may support different dimensions of engagement. In Science education, gamified activities can be designed to encourage learners to investigate scientific problems, explain concepts, collaborate with classmates, and demonstrate understanding through structured challenges rather than relying exclusively on conventional classroom exercises.

The relationship between digital learning environments and student engagement has received considerable attention in educational research. Nkomo et al. (2021), through a systematic review of student engagement with digital technologies, synthesized literature examining how technological resources relate to students' participation and learning experiences. Brown et al. (2022) also presented a conceptual framework for enhancing student online learning and engagement, emphasizing the importance of purposeful course design and supportive learning environments. Furthermore, Tualaulelei et al. (2022) explored pedagogical touchpoints associated with online student engagement and course design. Collectively, these studies indicate that meaningful engagement involves more than observable participation; it also includes learners' motivation, interaction, and investment in understanding instructional content. Applied to Grade 8 Science, gamified digital learning toolkits may support behavioral engagement through task participation, emotional engagement through interest and enjoyment, and cognitive engagement through reasoning, reflection, and scientific problem-solving. Nevertheless, these potential benefits require empirical evaluation within the intended classroom setting.

Recent literature has also examined specific digital tools and instructional features that may enhance students' participation and learning experiences. Agavekar et al. (2026) investigated the use of Padlet as a collaborative platform for improving student engagement in concept learning, demonstrating the relevance of interactive digital spaces for educational participation. Similarly, Uzorka and Odebiyi (2025) examined the impact of digital learning tools on student engagement and achievement, while Yaseen et al. (2025) investigated adaptive learning technologies, personalized feedback, and interactive artificial intelligence tools in relation to student engagement and digital literacy. Rotar (2025) further emphasized the importance of moving beyond technological tools toward instructional approaches that meaningfully support student engagement. These perspectives suggest that the effectiveness of gamified instruction depends on

how digital features are integrated with learning objectives, feedback mechanisms, and collaborative activities. For the present study, combining Gamified Learning Activity Sheets with interactive digital resources provides an opportunity to examine whether structured game-based tasks can improve Grade 8 learners' conceptual understanding while strengthening their engagement in Science instruction.

METHODOLOGY

The study employed a quasi-experimental research design using a pretest–posttest approach to evaluate the effectiveness of gamified digital learning toolkits in improving conceptual understanding and student engagement in Grade 8 Science. The research was conducted at San Jose Integrated School, South Cluster, Schools Division of Santiago City, Philippines. The target population consisted of Grade 8 students enrolled in Science, while the respondents were selected through purposive sampling based on their enrollment and participation in the identified classes. The study involved an experimental group that received instruction using digital learning tools and Gamified Learning Activity Sheets (GLAS) and a comparison group that underwent conventional Science instruction. Both groups completed pretests and posttests to measure conceptual understanding of selected Science concepts. Student engagement was assessed using a structured questionnaire covering behavioral, emotional, and cognitive dimensions. Grade 8 Science teachers also evaluated the implementation feasibility, usability, and curriculum alignment of the learning toolkits. Necessary permissions, informed consent, confidentiality, and ethical research procedures were observed throughout the study.

The collected data were analyzed using descriptive and inferential statistical tools. Frequency counts, percentages, means, and standard deviations were used to summarize respondents' characteristics, conceptual understanding scores, student engagement levels, and teachers' implementation evaluations. A paired-samples t-test was used to determine significant differences between pretest and posttest scores within each group, while analysis of covariance (ANCOVA) was employed to compare posttest performance between groups after controlling for baseline differences. Cohen's d was calculated to determine the magnitude of observed learning improvements, while Cronbach's alpha was used to assess the internal consistency of the engagement and implementation questionnaires. Teacher evaluations were summarized using means and standard deviations, and qualitative feedback, when available, was analyzed through thematic analysis. Statistical significance was evaluated at the 0.05 level, and the findings were interpreted to determine the effectiveness and practical applicability of gamified digital learning toolkits in Grade 8 Science instruction.

RESULTS AND DISCUSSIONS

Table 1. Pretest and Posttest Performance of Grade 8 Learners in Science

Group	Assessment	Mean	SD	MPS (%)	Interpretation
Experimental	Pretest	12.43	3.21	41.43	Low

Experimental	Posttest	24.87	2.95	82.90	High
Comparison	Pretest	12.17	3.08	40.57	Low
Comparison	Posttest	18.63	3.42	62.10	Moderate

Table 1 shows that the experimental group demonstrated an increase in mean Science achievement scores from 12.43 (SD = 3.21) in the pretest to 24.87 (SD = 2.95) in the posttest, representing a gain of 12.44 points. The mean percentage score increased from 41.43% to 82.90%, indicating a substantial improvement in conceptual understanding following the integration of digital learning tools and Gamified Learning Activity Sheets. In comparison, the comparison group improved from 12.17 (SD = 3.08) to 18.63 (SD = 3.42), representing a gain of 6.46 points. Although both groups demonstrated improvement, the experimental group recorded a larger increase in performance. This pattern is consistent with the educational potential of interactive digital learning environments discussed by Rafiq et al. (2024) and Hardiyanti et al. (2023). The findings suggest that structured gamified activities may support conceptual understanding by providing opportunities for active participation, immediate feedback, and repeated engagement with complex scientific concepts.

Table 2. Paired-Samples t-Test Results for Pretest and Posttest Scores

Group	Mean Gain	SD of Differences	t(29)	p	Decision
Experimental	12.44	3.50	19.47	< .001	Significant
Comparison	6.46	3.20	11.06	< .001	Significant

Table 2 presents the within-group differences in learners' conceptual understanding before and after the instructional interventions. The experimental group demonstrated a statistically significant improvement, $t(29) = 19.47$, $p < .001$, with a mean gain of 12.44 points. Similarly, the comparison group demonstrated a statistically significant improvement, $t(29) = 11.06$, $p < .001$, with a mean gain of 6.46 points. The larger improvement observed in the experimental group suggests that gamified digital learning toolkits may offer additional instructional benefits compared with conventional Science instruction. These findings align with the emphasis of Shaik et al. (2023) on interactive digital assessment and Elbasyouny (2021) on technology-supported formative assessment as approaches that may strengthen learning experiences. Nevertheless, the significant within-group improvements alone do not establish the superiority of the gamified intervention; a between-group analysis is necessary to evaluate its comparative effectiveness.

Table 3. Comparison of Posttest Scores Between Experimental and Comparison Groups

Group	n	Posttest Mean	SD	Mean Difference
Experimental	30	24.87	2.95	6.24
Comparison	30	18.63	3.42	

Table 3 reveals that the experimental group obtained a higher posttest mean score ($M = 24.87$, $SD = 2.95$) than the comparison group ($M = 18.63$, $SD = 3.42$). The mean difference of 6.24 points was statistically significant, $t(58) = 7.57$, $p < .001$. The estimated Cohen's d of 1.95 indicated a large standardized difference between the groups. These results suggest that the integration of gamified digital learning toolkits was associated with higher conceptual understanding scores in the demonstrated dataset. The pattern supports the instructional relevance of interactive and feedback-oriented digital learning environments discussed by Uzorka and Odebiyi (2025) and Rotar (2025). However, because the study employed a quasi-experimental design, the observed differences should be interpreted cautiously. Potential differences in prior achievement, classroom conditions, and instructional delivery must be considered before attributing improvements exclusively to the intervention.

Table 4. Student Engagement Levels of the Experimental Group

Engagement Dimension	Mean	SD	Interpretation
Behavioral Engagement	3.62	0.39	Very High
Emotional Engagement	3.71	0.34	Very High
Cognitive Engagement	3.55	0.42	Very High
Overall	3.63	—	Very High

Table 4 indicates that learners in the experimental group demonstrated very high engagement across all three dimensions. Emotional engagement obtained the highest mean ($M = 3.71$, $SD = 0.34$), suggesting that learners generally experienced interest, enjoyment, and positive attitudes toward gamified Science activities. Behavioral engagement followed ($M = 3.62$, $SD = 0.39$), indicating active participation, task completion, and involvement in classroom activities. Cognitive engagement also received a very high rating ($M = 3.55$, $SD = 0.42$), suggesting that learners invested mental effort in understanding scientific concepts and solving learning challenges. The overall mean of 3.63 reflected a highly engaging instructional environment. These patterns are consistent with the conceptualization of technology-supported student engagement presented by Bond et al. (2020), Nkomo et al. (2021), and D'Mello (2021). The findings further suggest that gamified instructional resources may support multiple dimensions of engagement when learning activities are purposefully designed around curricular objectives.

Table 5. Learners' Evaluation of Gamified Digital Learning Activities

Indicator	Mean	SD	Interpretation
Digital activities made Science lessons more interesting.	3.78	0.31	Very High
Gamified worksheets helped explain difficult concepts.	3.64	0.40	Very High
Interactive quizzes encouraged active participation.	3.70	0.36	Very High

Digital feedback helped identify learning mistakes.	3.59	0.43	Very High
Collaborative challenges improved classroom interaction.	3.66	0.38	Very High
Overall Mean	3.67	—	Very High

Table 5 demonstrates that learners positively evaluated the integration of gamified digital learning activities in Science instruction. The highest-rated indicator concerned the ability of digital activities to make Science lessons more interesting ($M = 3.78$, $SD = 0.31$), suggesting that interactive features and game-inspired challenges contributed to learners' perceived enjoyment of Science lessons. Interactive quizzes also received a high evaluation ($M = 3.70$, $SD = 0.36$), indicating their perceived usefulness in encouraging participation. The lowest-rated indicator, although still interpreted as very high, concerned digital feedback ($M = 3.59$, $SD = 0.43$), suggesting opportunities to strengthen the clarity and usefulness of feedback mechanisms. The overall mean of 3.67 indicates favorable learner perceptions of the toolkit. These results correspond with the discussion of collaborative digital learning tools by Agavekar et al. (2026) and the importance of pedagogically meaningful technology integration emphasized by Rotar (2025). The results imply that digital toolkits may be particularly valuable when they combine engaging activities with opportunities for conceptual explanation, collaboration, and formative feedback.

Table 6. Teachers' Assessment of Digital Learning Toolkit Implementation

Implementation Indicator	Mean	SD	Interpretation
Alignment with Grade 8 Science competencies	3.83	0.29	Very High
Ease of integration into lesson delivery	3.50	0.50	Very High
Accessibility of digital learning resources	3.17	0.58	High
Suitability for classroom assessment	3.67	0.58	Very High
Sustainability of toolkit implementation	3.33	0.58	Very High
Overall Mean	3.50	—	Very High

Table 6 shows that teachers generally perceived the gamified digital learning toolkits as feasible and aligned with Grade 8 Science instruction. Curriculum alignment received the highest mean ($M = 3.83$, $SD = 0.29$), indicating favorable evaluations of the toolkit's compatibility with intended learning competencies. Suitability for classroom assessment also obtained a very high rating ($M = 3.67$, $SD = 0.58$), suggesting that teachers considered the digital activities useful for monitoring learner progress and evaluating conceptual understanding. Accessibility of digital resources received the lowest mean ($M = 3.17$, $SD = 0.58$), indicating potential implementation challenges associated with device availability, internet connectivity, and technological resources. The overall mean of 3.50 suggests positive teacher perceptions of implementation feasibility.

These findings are consistent with the importance of instructional design competencies discussed by Gameil and Al-Abdullatif (2023) and the pedagogical considerations associated with digital learning platforms examined by Simelane-Mnisi (2023). Nevertheless, the small number of teacher evaluators limits the generalizability of these assessments and highlights the need for further evaluation under varying classroom conditions.

CONCLUSION AND RECOMMENDATION

Based on the hypothetical findings presented, the integration of gamified digital learning toolkits demonstrated promising potential for improving conceptual understanding and student engagement in Grade 8 Science. Learners exposed to Gamified Learning Activity Sheets (GLAS), interactive digital assessments, and technology-enhanced instructional activities exhibited greater improvements in academic performance than those receiving conventional instruction. The findings also suggested that gamification supported behavioral, emotional, and cognitive engagement by promoting active participation, motivation, collaboration, and meaningful interaction with complex scientific concepts. Furthermore, teachers positively evaluated the instructional relevance, curriculum alignment, and implementation feasibility of the digital learning toolkits, although technological accessibility and resource availability remained important considerations. These results suggest that gamified and technology-enhanced instruction could serve as a supplementary pedagogical approach for strengthening learner-centered Science education, subject to confirmation through actual classroom data.

The proposed findings may serve as a basis for developing and implementing a Gamified Science Learning Enhancement Program at San Jose Integrated School, South Cluster, Schools Division of Santiago City. The program could incorporate curriculum-aligned Gamified Learning Activity Sheets, interactive quizzes, digital simulations, collaborative challenges, and formative assessments into regular Grade 8 Science instruction. Science teachers could undergo targeted professional development activities focusing on gamification strategies, digital instructional design, and technology-supported assessment to strengthen implementation competencies. School administrators could support the initiative by providing accessible digital resources, improving technological infrastructure, and encouraging collaborative instructional planning. Regular monitoring through achievement assessments, student engagement surveys, classroom observations, and teacher feedback could be conducted to evaluate effectiveness and identify areas for improvement. Following validation of the study's actual results, the program could be refined and considered for wider implementation across other grade levels and secondary schools within the Schools Division of Santiago City.

FURTHER STUDY

Future researchers are encouraged to conduct longitudinal and multi-school studies involving larger and more diverse samples to establish the broader effectiveness of gamified and technology-enhanced Science instruction. Randomized controlled trials, where feasible, may provide stronger evidence of the intervention's effects on conceptual understanding and student engagement. Subsequent investigations could examine long-term knowledge retention, scientific reasoning, critical thinking, and problem-solving skills while comparing different gamification

strategies and digital learning platforms. Mixed-methods approaches incorporating classroom observations, student interviews, learning analytics, and teacher reflections are also recommended to provide deeper insights into learners' experiences and implementation challenges. Additionally, future studies could explore the cost-effectiveness, accessibility, and sustainability of Gamified Learning Activity Sheets (GLAS), particularly in resource-constrained secondary schools, to support the development of inclusive, scalable, and curriculum-aligned digital Science learning interventions.

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REFERENCES

- Agavekar, R., Bhore, P., & Moharir, M. (2026). Effective use of Padlet as a tool to enhance students' engagement with the concept learning: A case study. *Journal of Engineering Education Transformations*, 163–171.
- Ahshan, R. (2021). A framework of implementing strategies for active student engagement in remote/online teaching and learning during the COVID-19 pandemic. *Education Sciences*, 11(9), 483.
- Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., & Kerres, M. (2020). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International Journal of Educational Technology in Higher Education*, 17(1), 1–30.
- Brown, A., Lawrence, J., Basson, M., & Redmond, P. (2022). A conceptual framework to enhance student online learning and engagement in higher education. *Higher Education Research & Development*, 41(2), 284–299.
- D'Mello, S. K. (2021). Improving student engagement in and with digital learning technologies. In *Pushing the frontiers with artificial intelligence, blockchain and robots* (pp. 79–104).
- Elbasyouny, T. R. B. (2021). Enhancing students' learning and engagement through formative assessment using online learning tools [Master's thesis, The British University in Dubai].

- Gameil, A. A., & Al-Abdullatif, A. M. (2023). Using digital learning platforms to enhance the instructional design competencies and learning engagement of preservice teachers. *Education Sciences*, 13(4), 334.
- Hardiyanti, E., Fitriani, V., & Ashari, W. (2023). The influence of digital tools on student engagement and academic outcomes across educational levels. *Educia Journal*, 1(2), 57–66.
- Kausar, F. N. (2025). Effect of digital learning tools on students' engagement and learning outcomes in higher education. *Policy Journal of Social Science Review*, 3(9), 204–223.
- Nkomo, L. M., Daniel, B. K., & Butson, R. J. (2021). Synthesis of student engagement with digital technologies: A systematic review of the literature. *International Journal of Educational Technology in Higher Education*, 18(1), 34.
- Nyongesa, W. J., & Van Der Westhuizen, J. (2025). The impact of digital teaching tools on student engagement and learning outcomes in higher education in Africa.
- Rafiq, S., Iqbal, S., & Afzal, A. (2024). The impact of digital tools and online learning platforms on higher education learning outcomes. *Al-Mahdi Research Journal (MRJ)*, 5(4), 359–369.
- Rafique, R. (2023). Using digital tools to enhance student engagement in online learning: An action research study. In *Local research and glocal perspectives in English language teaching: Teaching in changing times* (pp. 229–248). Springer Nature Singapore.
- Rotar, O. (2025). Beyond technology tools: Supporting student engagement in technology enhanced learning. *Education Sciences*, 15(12), 1617.
- Shaik, A. H., Prabhu, M., Hussain, S. M., & Poloju, K. K. (2023). An interactive design tool for assessing student understanding in digital environments. In *SHS Web of Conferences* (Vol. 156, Article 09004). EDP Sciences.
- Simelane-Mnisi, S. (2023). Effectiveness of LMS digital tools used by the academics to foster students' engagement. *Education Sciences*, 13(10), 980.
- Tualaulelei, E., Burke, K., Fanshawe, M., & Cameron, C. (2022). Mapping pedagogical touchpoints: Exploring online student engagement and course design. *Active Learning in Higher Education*, 23(3), 189–203.
- Uzorka, A., & Odebiyi, O. A. (2025). Impact of digital learning tools on student engagement and achievement. *Journal of Digital Learning and Distance Education*, 4(1), 1436–1445.
- Yaseen, H., Mohammad, A. S., Ashal, N., Abusaimh, H., Ali, A., & Sharabati, A. A. A. (2025). The impact of adaptive learning technologies, personalized feedback, and interactive AI tools on student engagement: The moderating role of digital literacy. *Sustainability*, 17(3), 1133.