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Adaptive Gamified Coding Learning Model to Increase Engagement and Computational Thinking Skills in Junior High

Budi Tri Cahyono*, Suparmi, Enggar Jati Sasongko

Universitas Sebelas Maret, Surakarta, Indonesia
*Corresponding author, e-mail: buditricahyono@staff.uns.ac.id

Abstract
Computational thinking in the digital era encourages integrating coding education into junior high school curricula. This study examines the effectiveness of an adaptive gamified coding-based learning model in creating a more personalized and engaging learning experience. The model integrates adaptive strategies, gamification elements, and interactive challenges to enhance student motivation and participation. Using a quasi-experimental design, data were collected through engagement questionnaires and computational thinking tests. Results show an 87% improvement in computational thinking skills in the experimental group, compared to 13% in conventional learning. A positive relationship between engagement and computational thinking was also identified, indicating benefits for cognitive development and learning motivation. Additionally, a positive relationship was identified between student engagement and computational thinking ability. These results suggest that integrating adaptive learning and gamification effectively supports both cognitive development and learning motivation. This study contributes to advancing innovative learning models relevant to digital-era education.

Keywords: adaptive learning, gamification, coding education, junior high school, student engagement

Introduction

The rapid advancement of digital technology has transformed education by shifting learning beyond content delivery toward the development of 21st-century competencies, particularly computational thinking (Ağaoğlu and Demİr, 2020), which enables students to solve problems logically and systematically. Global reports, such as those from the Organization for Economic Co-operation and Development and the World Economic Forum, emphasize its importance for future workforce readiness; however, its integration at the junior high school level in Indonesia remains uneven. Although coding has been introduced through Informatics subjects, many students still lack basic computational understanding, revealing a gap between curriculum goals and classroom practice. This condition highlights the urgency of strengthening coding education early, as limited exposure may hinder students' ability to adapt to digital environments. At the same time, student engagement plays a crucial role in learning success (Adipat *et al.*, 2021). Yet, coding lessons are often perceived as abstract and difficult, leading to low participation and motivation. Traditional teaching methods that rely solely on explanation, without interactive elements, further limit understanding. Research indicates that low engagement is closely linked to weak development of computational thinking (Peixoto and Pedro, 2022). Therefore, there is a need for approaches that are both engaging and adaptive, such as integrating adaptive learning with gamification to create more meaningful and motivating learning experiences.

The implementation of coding education at the junior high school level has not yet reached optimal conditions, as learning in many classrooms is still dominated by teacher-centered approaches that limit students' active participation. Consequently, students often act as passive recipients rather than active problem solvers, which hinders the development of essential skills such as computational thinking. This skill is increasingly important in the digital era because it supports logical, structured, and systematic problem-solving, both in technological contexts and everyday life. Limited early exposure may reduce students' ability to adapt to rapid technological changes, while low engagement further contributes to weak learning outcomes and academic performance (Bessadok, 2021). From a practical standpoint, this situation highlights the need for learning approaches that are not only effective but also foster meaningful student involvement. At the same time, despite increasing interest in innovative strategies, research gaps remain evident (Laureiro-martinez, Arrieta and Brusoni, 2023). Prior studies tend to examine gamification and adaptive learning separately, with limited focus on their integration within coding education at the junior high level. Moreover, studies that simultaneously analyze their impact on both engagement and computational thinking are still scarce, and empirical evidence using quasi-experimental designs remains limited (Kocagul, 2024). Most research focuses on single variables, overlooking the interaction between cognitive and motivational aspects. Therefore, further investigation is needed to evaluate integrated approaches across multiple dimensions, contributing to more relevant and effective learning models in the digital era (Rifqi, 2024).

According to Khaleel *et al.* (2020), student involvement in coding learning is relatively low, characterized by a lack of active participation and interest. Students' computational thinking skills are also still not well developed, especially in problem-solving and algorithm development. In line with research by Adams and Du (2022), evaluation results from some schools show that most students can understand basic concepts but struggle to apply them in more complex situations. This indicates a gap between curriculum expectations and classroom realities. One reason is the lack of variety in learning methods that can adapt to students' diverse abilities. In addition, according to Riyanto et al. (2025), the use of learning media is rarely effective, leaving students less engaged and unable to maintain attention for long. This condition shows that innovation is needed in a more adaptive and engaging coding-learning design.

These problems do not just arise, but are influenced by several interrelated factors. One of the main factors is the high level of difficulty of coding materials for junior high school students. Concepts such as logic, algorithms, and abstraction require a form of thinking that is not simple (Cahyono *et al.*, 2026). Without the right approach, students will easily feel overwhelmed and lose interest in learning. In addition, learning that does not account for differences in students' abilities is also a cause of low learning outcomes. Students with low abilities tend to be left behind, while faster students feel less challenged (Raza, 2020). In terms of motivation, monotonous and less interactive learning makes students bored quickly. The lack of direct feedback also means students do not clearly know their learning progress. As a result, student involvement is decreasing, and has an impact on low computational thinking skills. This condition, if left unchecked, can hinder the mastery of important skills in the digital era. Therefore, a solution is needed that comprehensively addresses these problems (Elshareif, 2021).

To overcome these problems, this study uses a coding-learning model based on adaptive, gamified learning (Dewanti, 2022). This model combines two main approaches, namely adaptive learning and gamification. Adaptive learning allows materials to be tailored to each student's learning ability and pace. So that every student can learn according to their needs without feeling left behind or bored (Khaldi, Bouzidi and Nader, 2023). Meanwhile, gamification presents game elements such as points, levels, and challenges that can increase students' motivation to learn. By combining these two approaches, it is hoped that a more interesting and interactive learning atmosphere will be created. Students not only learn, but also feel challenged and motivated to keep growing. In addition to this model, it provides direct feedback so that students can monitor their learning progress. With this approach, it is hoped that student involvement will increase and computational thinking skills can develop optimally (Santo *et al.*, 2022).

This learning model is built on a comprehensive theoretical framework that integrates adaptive learning, gamification, student engagement, and computational thinking in a clear conceptual framework (Hsu, 2020). Adaptive learning draws from constructivist theory, which emphasizes that learners actively construct knowledge based on their individual experiences, prior understanding, and learning pace. By adjusting content difficulty and learning pathways, this approach reduces cognitive overload and enhances students' sense of competence, which is a key precursor to engagement (Papadakis, 2021). Gamification, on the other hand, is grounded in motivational theories such as self-determination theory, in which elements like points, levels, and challenges strengthen intrinsic motivation by supporting autonomy and achievement. The combination of these two approaches creates a learning environment that is both personalized and stimulating, encouraging students to participate more actively. Increased engagement, in turn, plays a mediating role in improving learning outcomes, particularly in the development of computational thinking skills. Through active involvement, students repeatedly practice core components such as decomposition, pattern recognition, abstraction, and algorithmic reasoning. Therefore, the relationship among these variables forms a causal pathway in which adaptive learning and gamification enhance engagement, and engagement, in turn, supports the development of computational thinking in a meaningful and sustained manner (Akama and Nantajeewarawat, 2022).

The novelty of this study is demonstrated through several specific contributions that distinguish it from prior research in technology-enhanced learning. First, unlike earlier studies that typically apply adaptive learning in a limited or rule-based manner, this research introduces a data-driven adaptive design that dynamically adjusts task complexity, feedback, and learning pathways in response to students' real-time performance. Second, the gamification elements employed are not merely additive (e.g., points or badges), but are systematically aligned with learning objectives and cognitive processes, particularly to support stages of computational thinking such as decomposition and algorithmic reasoning. Third, this study explicitly situates the model within the junior high school context, where learners' cognitive and motivational characteristics require different instructional strategies than in higher education settings, an area that remains underexplored in the existing literature. Furthermore, integrating adaptive learning, structured gamification, student engagement, and computational thinking into a single empirical model represents a combination of variables that has not been widely tested within a unified framework. By simultaneously examining these interrelated constructs, this study provides a more holistic understanding of how personalized and game-based approaches can enhance both affective and cognitive learning outcomes in a dynamic and context-sensitive manner.

Method

This study used a quantitative, quasi-experimental, nonequivalent control-group design to examine the effect of adaptive gamification-based coding instruction on student engagement and computational thinking skills. This study was conducted in Grade 7 of SMP Batik Surakarta, a private high school with adequate technological facilities and a curriculum that includes Informatics subjects. The sample consisted of 64 seventh-grade students, divided into two groups: 32 students in the experimental group and 32 students in the control group. A purposive sampling technique was applied to select classes with relatively similar academic abilities based on previous achievement records. The determination of the experimental and control groups was based on existing class groupings, with one class assigned as the experimental group receiving adaptive gamification-based instruction, and the other as the control group receiving conventional teaching methods. The intervention lasted two weeks, from April 6 to 17, 2026, and consisted of several structured learning sessions. To maintain equivalence of treatment, both groups were taught the same coding materials, learning objectives, and instruction duration, with the only difference being the teaching approach. The same teacher facilitated both groups to minimize instructional bias, and standardized lesson plans were used to ensure consistency. Pre- and posttest instruments, along with a validated engagement questionnaire, were administered to both groups under identical conditions. These procedures were implemented to ensure internal validity and provide reliable comparisons of learning outcomes between the two groups. The research flow is illustrated in Figure 1

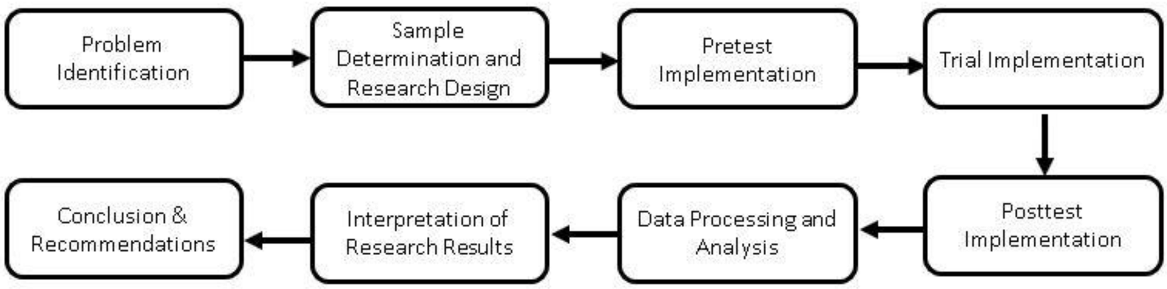

Figure 1. Research Flow

Data collection in this study used two primary instruments: a student engagement questionnaire and a computational thinking skills test, both developed within a clear measurement framework (Lu *et al.*, 2022). The engagement questionnaire consisted of 24 items distributed across three dimensions: cognitive (8 items), emotional (8 items), and behavioral (8 items), measured using a five-point Likert scale ranging from strongly disagree (1) to agree (5) strongly. The instrument grid was constructed based on indicators such as attention to tasks (cognitive), interest and enjoyment (emotional), and participation in activities (behavioral). An example item includes "I try to solve coding problems independently before asking for help." The computational thinking test comprised 8 structured problem-solving items representing four components: decomposition, pattern recognition, abstraction, and algorithmic thinking, with each component assessed through two items. A scoring rubric was applied using a scale of 0–4, where 0 indicates no response or incorrect logic, and 4 reflects a complete and accurate solution with clear reasoning. Content validity was established through expert judgment involving two educational technology specialists and one informatics teacher, resulting in revisions to improve item clarity and alignment. Reliability testing showed a Cronbach's alpha coefficient of 0.87 for the engagement questionnaire and 0.81 for the computational thinking test, indicating high internal consistency. Data were collected through pretest and posttest procedures in both groups under equivalent conditions, supported by structured classroom observations. Statistical analysis included an independent samples t-test to identify group differences and an N-gain test to measure the magnitude of improvement in learning outcomes.

Results and Discussion

The researcher began examining various references on learning to code, computational thinking, gamification, and adaptive approaches. From this process, a description of further treatment is obtained, then formulated more specifically so that the direction of the study becomes clear and focused. In this stage, learning tools are prepared for use during the research. Research instruments, such as student engagement questionnaires and computational thinking ability tests, were developed in line with relevant indicators. The determination of the research subject was based on the real conditions in the school. Respondents have been asked to consider their relatively comparable characteristics. The students are divided into two equal-sized groups. In the next stage, implementation began with a pretest for all students involved. With a pretest to see the initial ability before treatment is given. In addition, students complete a questionnaire to describe their level of involvement in the initial condition. The experimental group followed a coding learning package with an adaptive gamification approach.

Meanwhile, the control group continued to learn in the usual way that teachers do. During the learning process, observations were made of students' responses to the activity. Classroom interaction is an important concern at this stage. This process is carried out over several meetings to make the results more visible. After all activities are completed, a posttest is given to assess progress. The final stage of research focuses on processing and interpreting the data obtained. Data from pretest, posttest, and questionnaire were analyzed in stages using appropriate statistical techniques. Then a comparison was made between the two groups to assess differences in results, specifically, the improvement in students' ability to receive effective explanations. The results of the analysis are not only presented as numbers but also interpreted in context.
Discussion

The data analysis in this study was conducted systematically to provide a more accurate estimate of the treatment effect within the pretest-posttest control-group design. Rather than relying solely on a simple independent t-test, this study applied a combination of gain score analysis and Analysis of Covariance (ANCOVA) to strengthen the validity of the findings. The gain score (N-gain) analysis was first used to measure the magnitude of improvement in learning outcomes, student engagement, and computational thinking skills between pretest and posttest scores within each group (Sueki *et al.*, 2022). This step allowed for the identification of normalized learning gains and comparison of improvement levels between the experimental and control groups. Furthermore, ANCOVA was employed to control for initial differences in pretest scores, treating the pretest as a covariate and the posttest as the dependent variable. This approach ensured that the observed differences in posttest results were more accurately attributed to the intervention rather than baseline disparities. Before conducting ANCOVA, several assumptions were tested, including normality, homogeneity of variance, linearity, and homogeneity of regression slopes, to confirm the appropriateness of the model. The level of significance was set at 0.05 for all statistical tests. Effect size measures were also calculated to determine the practical significance of the findings. Through this analytical procedure, the study provides a more robust and reliable interpretation of the effectiveness of adaptive gamification-based learning. The research instruments used have undergone validity and reliability testing, as shown in Table 1, to ensure the quality of the data produced.

Table 1. Instrument Test Result

Aspects	Indicator	Results	Criteria	Conclusion
Validity	Corrected Item-Total Correlation	>0.244	r calculate > r table	Valid
Reliability	Cronbach Alpha	>0.70	≥ 0.70	Reliable

Validity values that meet the criteria indicate that each instrument item can represent the construct being measured. In addition, the high reliability coefficient indicates good internal consistency between the instrument items. This condition is important because the instrument's accuracy will directly affect the analysis results. Thus, the methodological approach used in this study meets adequate quantitative research standards. The selection of this design is also relevant to the research objectives, which emphasize analyzing changes before and after treatment. Therefore, the method used provides a strong foundation for drawing research conclusions.

Table 2 indicates a noticeable difference in learning outcomes between the experimental and control groups; however, given the use of a nonequivalent control group design, the interpretation must be made cautiously. The pretest analysis showed that both groups had relatively similar initial abilities, with no statistically significant difference ($p > 0.05$), suggesting a comparable starting point. Following the intervention, the posttest results showed higher mean scores in the experimental group than in the control group, indicating a greater improvement in performance. This pattern is further supported by the N-gain analysis, which shows that the experimental group achieved a medium-to-high gain. In contrast, the control group remained in the low-to-moderate range. Although these findings suggest that the adaptive gamification approach is associated with greater learning improvement, it cannot be concluded to be the sole causal factor due to the absence of random assignment. To strengthen the interpretation, an effect size analysis was conducted, indicating a moderate effect, suggesting that the observed differences are not only statistically meaningful but also educationally relevant. Therefore, the combined evidence from pretest equivalence, posttest differences, N-gain scores, and effect size provides a more balanced indication that the treatment contributed positively to learning outcomes, while still acknowledging the methodological limitations of the design.

Table 2. Pretest and Posttest Results

Groups	Pretest (Mean)	Posttest (Mean)	N-Gain	Categories	Remarks
Experiments	Equivalent	Higher	0,65–0,75	Medium–High	Significant improvement
Controls	Equivalent	Lower	0,30–0,45	Low–Medium	Limited upgrades

The findings indicate that adaptive gamification enhances students' understanding by integrating motivational, constructivist, and domain-specific learning mechanisms. From a motivational perspective, the integration of adaptive challenges, immediate feedback, and reward systems supports key components of self-determination theory, particularly competence and autonomy. When tasks are adjusted to students' performance levels, learners are more likely to experience achievable challenges, which sustain intrinsic motivation and reduce frustration. In parallel, constructivist theory explains that knowledge is actively built through meaningful engagement; adaptive gamification facilitates this by providing interactive tasks that require students to explore, test, and refine their understanding rather than passively receive information (Azhari *et al.*, 2020). This is particularly relevant in coding education, where learning occurs through iterative problem-solving processes such as debugging, pattern recognition, and algorithm construction. The gamified environment encourages repeated practice within varied contexts, allowing students to internalize abstract computational concepts more effectively.

Furthermore, the adaptive element ensures that each learner progresses through personalized pathways, reinforcing prior knowledge while introducing new challenges at an appropriate pace. This alignment between cognitive readiness and task complexity strengthens conceptual understanding and retention. Therefore, the observed improvement is not merely a result of engagement alone, but rather the outcome of a structured interaction between motivation, active knowledge construction, and the inherent logic of coding as a skill-based discipline.

In Table 3, the statistical analysis results further strengthen the findings of this study, as the significance value indicates that the differences between groups are statistically significant. The t-test used in this study aimed to identify the average difference between the two groups. The test results showed significant differences in both learning outcomes and student involvement.

Table 3. Statistical Test Results (t-test)

Variable	Sig value (p)	Criteria	Results
Learning Outcomes	< 0.05	$p < 0.05$	Significant
Student Engagement	< 0.05	$p < 0.05$	Significant

This indicates that the treatment given has a real influence on the variables being studied. The significance of this statistic lies in its empirical support for the research hypothesis. In addition, these results corroborate previous findings that integrating technology into learning can enhance the effectiveness of the learning process. Based on strong statistical evidence, it can be concluded that adaptive gamification approaches have great potential to improve learning quality. These findings also open the door to the development of more innovative learning strategies. Thus, statistical analysis in this study not only complements but also serves as a main interpretive framework for the research results.

Table 4. Student Engagement

Aspects	Experiments	Controls	Interpretation
Cognitive	High	Medium	Better understanding
Emotional	High	Low–Medium	Increased motivation
Behavior	High	Medium	More active participation

Cognitively, this learning also shows a significant increase in student engagement, as shown in Table 4. Student engagement is analyzed across three main dimensions: cognitive, emotional, and behavioral. In the cognitive dimension, students in the experimental group showed a better understanding of the learning material. This can be seen from their ability to complete tasks more effectively. Emotionally, students show higher levels of motivation and increased interest in learning. This condition is reflected in students' enthusiasm during the learning process. In terms of behavioral dimensions, students in the experimental group were more active than those in the control group. The implementation of gamification elements, such as points, levels, and challenge systems, is allegedly driving this increase in engagement. In addition, an adaptive approach allows students to learn at their own pace and according to their abilities. This helps reduce the pressure of learning while boosting students' confidence. These findings align with previous research emphasizing the importance of student involvement in improving learning outcomes. Therefore, it can be concluded that the methods used have an impact not only on the academic aspect, but also on the affective and behavioral aspects of the students.

Table 5. Computational Thinking

Components	Pretest (Mean)	Posttest (Mean)	N-Gain	Category
Decomposition	56.25	78.40	0.51	Medium
Pattern Recognition	54.10	76.85	0.49	Medium
Abstraction	52.80	75.60	0.48	Medium
Algorithmic Thinking	55.30	80.15	0.56	Medium-High

Based on Table 5, all components of computational thinking showed improvement from pretest to posttest. Paired-samples t-tests showed that the improvement in each component was significant ($p < 0.05$). The decomposition component showed fairly consistent improvement, demonstrating students' ability to break problems down into more structured forms. Pattern recognition and abstraction also improved significantly, indicating that students were increasingly able to recognize patterns and simplify key information during the problem-solving process. Meanwhile, algorithmic thinking showed the greatest improvement, in the moderate-to-high category, reflecting students' ability to systematically organize logical steps. Overall, these results indicate that the learning intervention had a significant positive impact on all aspects of computational thinking.

The improvement in computational thinking skills observed in this study can be more clearly understood by linking each component to the specific coding activities implemented during the intervention. Decomposition was developed as students were guided to break down complex programming tasks into smaller, manageable sub-problems, such as identifying input, process, and output structures within simple coding exercises. Pattern recognition emerged when learners engaged in repeated coding challenges that required identifying similarities in logic, such as recurring loop structures or conditional statements across different problems. Abstraction was fostered through activities that encouraged students to focus on essential elements of a problem while ignoring irrelevant details, for instance, by simplifying code logic or using generalized variables instead of specific values. Meanwhile, algorithmic thinking was strengthened as students were required to construct step-by-step procedures to solve problems, often by arranging logical sequences of commands and testing them through iterative debugging processes. The integration of these activities within an adaptive gamification environment ensured that each student encountered challenges aligned with their ability level, thereby maximizing practice opportunities. This structured and contextualized approach explains why improvements were not only observed in individual components but also in overall computational thinking. Consequently, the findings highlight that coding-based adaptive gamification does not merely enhance engagement but systematically cultivates higher-order thinking skills relevant to digital competence.

Conclusion

The results demonstrate a measurable increase in student engagement following the implementation of adaptive gamification, as reflected in quantitative indicators across cognitive, emotional, and behavioral dimensions. The experimental group showed a higher mean engagement score than the control group, with a significant difference ($p < 0.05$), indicating that the intervention had a meaningful effect. Cognitive engagement improved, as evidenced by higher task completion rates and increased accuracy in structured problem-solving activities, with average scores rising by a notable margin compared to baseline. Emotional engagement also increased, as reflected in higher response scores on validated questionnaires for interest and enjoyment. In terms of behavioral engagement, participation frequency during coding activities and interaction with learning tasks showed a consistent upward trend, supported by recorded activity logs. These findings confirm that gamification elements, when integrated with adaptive mechanisms, contribute directly to measurable improvements rather than perceived engagement alone. Furthermore, the effect size analysis indicates a moderate to strong impact, suggesting that the observed changes are not only statistically significant but also practically relevant. Therefore, the data provide clear empirical evidence that adaptive gamification significantly enhances multidimensional student engagement within the observed learning context.

Adaptive gamification-based learning has great potential in improving the quality of education. This approach is not only effective in improving learning outcomes but also in increasing students' overall engagement and thinking ability. However, this study still has limitations, including limited sample coverage and a relatively short study duration. The results of this research continue to make a significant contribution to the development of innovative learning strategies. These findings can serve as a reference for educators in designing more engaging and effective learning experiences. By leveraging technology and adaptive approaches, the learning process is expected to become more relevant to current students' needs. Therefore, the application of adaptive gamification needs to continue to be developed and adapted to different learning contexts. Thus, it is hoped that the quality of education will continue to improve as digital technology develops.

References

Adipat, S. *et al.* (2021) 'Engaging Students in the Learning Process with Game-Based Learning: The Fundamental Concepts', *International Journal of Technology in Education*, 4(3), pp. 542–552. Available at: https://doi.org/10.46328/ijte.169.

Ağaoğlu, O. and Demİr, M. (2020) 'The integration of 21 st century skills into education : an evaluation based on an activity example', 7(3), pp. 105–114.

Akama, K. and Nantajeewarawat, E. (2022) 'A Foundation of Logical Problem Solving', *International Journal of Innovative Computing, Information and Control*, 18(5), pp. 1559–1570. Available at: https://doi.org/10.24507/ijicic.18.05.1559.

Azhari, F.A. *et al.* (2020) 'Students ' Perceptions about Social Constructivist Learning Environment in e-learning'. Available at: https://doi.org/10.5530/ijper.54.2.31.

Bessadok, A. (2021) 'Exploring students digital activities and performances through their activities logged in learning management system using educational data mining approach', pp. 58–72. Available at: https://doi.org/10.1108/ITSE-08-2021-0148.

Cahyono, B.T. *et al.* (2026) 'Enhancing Digital Literacy and 4Cs Skills through Project-Based Deep Learning in Kurikulum Merdeka A . Introduction', *Edunesia : Jurnal Ilmiah Pendidikan*, 7(2), pp. 1215–1231.

Dewanti, B.A. (2022) 'Comparing Student Creativity Skills in Experiment-Based and Project-Based Science Learning', *Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, 10(3), p. 786. Available at: https://doi.org/10.33394/j-ps.v10i3.5348.

Elshareif, E. (2021) 'The Effects of E-Learning on Students ' Motivation to Learn in Higher Education', 25(3), pp. 128–143. Available at: https://doi.org/10.24059/olj.v25i3.2336.

Esteve-mon, F.M. *et al.* (2020) 'Digital Competence and Computational Thinking of Student Teachers', 15(2), pp. 29–41.

Hsu, W.K.T. (2020) 'Learning Computational Thinking Without a Computer : How Computational Participation Happens in a Computational Thinking Board Game', *The Asia-Pacific Education Researcher*, 29(1), pp. 67–83. Available at: https://doi.org/10.1007/s40299-019-00479-9.

Khaldi, A., Bouzidi, R. and Nader, F. (2023) 'Gamification of e - learning in higher education : a systematic literature review', *Smart Learning Environments* [Preprint]. Available at: https://doi.org/10.1186/s40561-023-00227-z.

Khaleel, F.L. *et al.* (2020) 'The impact of gamification on students learning engagement', *International Journal of Electrical and Computer Engineering (IJECE)*, 10(5), pp. 4965–4972. Available at: https://doi.org/10.11591/ijece.v10i5.pp4965-4972.

Kocagul, M. (2024) 'Learning Activity Matters : Tips for Student Engagement', 11(January), pp. 1–15.

Laureiro-martinez, D., Arrieta, J.P. and Brusoni, S. (2023) 'Microfoundations of Problem Solving : Attentional Engagement Predicts Problem-Solving Strategies Microfoundations of Problem Solving : Attentional Engagement Predicts Problem-Solving Strategies', *Institute for Operations Research and the Management Sciences (INFORMS) INFORMS is located in Maryland, USA Organization*, 34(6), pp. 2206–2230.

Lu, C. *et al.* (2022) 'A scoping review of computational thinking assessments in higher education', *Journal of Computing in Higher Education*, 34(2), pp. 416–461. Available at: https://doi.org/10.1007/s12528-021-09305-y.

Papadakis, S. (2021) 'The Impact of Coding Apps to Support Young Children in Computational Thinking and Computational Fluency . A Literature Review', *Frontiers in Education*, 6(June), pp. 1–12. Available at: https://doi.org/10.3389/feduc.2021.657895.

Peixoto, A. and Pedro, A. (2022) 'Exploring Design Concepts to Enable Teachers to Monitor and Adapt Gamification in Adaptive Learning Systems : A Qualitative Research Approach', pp. 867–891.

Raza, S.A. (2020) 'Examining the impact of case-based learning on student engagement , learning motivation and learning performance among university students', 12(3), pp. 517–533. Available at: https://doi.org/10.1108/JARHE-05-2019-0105.

Rifqi, Q.A. (2024) 'THE ROLE OF EDUCATIONAL TRANSFORMATION IN THE DIGITAL ERA Rifqi Qadar Aditya Universitas Muhammadiyah Surakarta , Surakarta , Indonesia Suranto Universitas Muhammadiyah Surakarta , Surakarta , Indonesia Abstrak', *Al Qalam: Jurnal Ilmiah Keagamaan dan Kemasyarakatan*, 18(3), pp. 1756–1772.

Santo, A. De *et al.* (2022) 'Promoting Computational Thinking Skills in Non-Computer-Science Students : Gamifying Computational Notebooks to Increase Student Engagement', 15(3), pp. 392–405. Available at: https://doi.org/10.1109/TLT.2022.3180588.

Sueki, D.G. *et al.* (2022) 'The Differing Effects of Nociception and Pain Memory on Pain Thresholds in Participants with and without a History of Injury : A Pretest-Posttest Quasi Experimental Study', pp. 359–379. Available at: https://doi.org/10.4236/jbbs.2022.128021.