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Gamified Assessment of Technical Skills in Electrical Engineering Education: A Systematic Literature Review

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ABSTRACT

Technical skill assessment in electrical engineering education is still predominantly based on conventional methods that do not fully capture students' practical competencies. Gamification has emerged as an alternative approach by integrating game elements into assessment processes to enhance motivation, engagement, and feedback quality. This study conducts a Systematic Literature Review (SLR) of 45 international publications published between 2002 and 2025, retrieved from Scopus, IEEE Xplore, SpringerLink, and Web of Science using the PRISMA protocol. The findings indicate a significant increase in research activity since 2015, accompanied by a shift toward performance-based gamified assessment. Commonly implemented gamification elements include points, badges, leaderboards, and simulation-based challenges. While gamification has been shown to improve student participation and engagement, evidence regarding its effectiveness in improving assessment accuracy remains contextual and cannot be generalized. Key challenges include pedagogical design alignment, technological infrastructure readiness, variations in learning styles, and potential conflicts between game mechanics and technical competency indicators. Overall, gamification demonstrates potential as an evidence-based assessment tool in electrical engineering education, provided that appropriate instructional design and technological support are in place.

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1. INTRODUCTION

Technical skill assessment is a critical component of electrical engineering education, as learning in this field requires not only conceptual understanding but also practical competencies such as circuit assembly, system testing, and instrument-based troubleshooting. However, numerous studies have reported that conventional assessment methods—such as laboratory reports and manual observations—often fail to authentically capture students' work processes and are prone to high levels of subjectivity (Hamari et al., 2014; Pedreira et al., 2015). This limitation highlights the need for assessment approaches that are more objective, structured, and capable of representing technical performance in real time.

With the advancement of educational technology, gamification has emerged as an alternative approach that integrates game elements such as points, badges, leaderboards, and simulation-based challenges to enhance student engagement and provide immediate feedback. Across various STEM disciplines, gamification has been shown to improve participation and learning experiences (Kapp, 2012; Koivisto & Hamari, 2019; Sailer et al., 2017). In the context of electrical engineering, gamification has begun to be applied in laboratory-based learning, troubleshooting simulations, and project-based work scenarios. Nevertheless, most existing studies continue to emphasize motivational outcomes rather than the quality and validity of the resulting technical assessments (Domínguez et al., 2013; Ivanova, 2019; Su & Cheng, 2015).

Despite the growing number of publications on gamification, there is still a lack of comprehensive synthesis that specifically examines its role as an assessment tool in electrical engineering education. Four major research gaps can be identified: (1) limited empirical evidence evaluating improvements in the accuracy or reliability of technical skill assessments; (2) insufficient consideration of the distinctive characteristics of electrical engineering laboratories, which demand high levels of precision but are rarely addressed in gamification studies; (3) the absence of systematic mapping between game mechanics and technical competency indicators; and (4) minimal discussion of pedagogical, psychological, and digital infrastructure challenges associated with implementation.

Addressing these gaps, this study conducts a Systematic Literature Review (SLR) of 45 international publications published between 2002 and 2025, following the PRISMA protocol, to examine: (a) research trends in gamification within electrical engineering education; (b) gamification design models employed; (c) empirical evidence regarding its effectiveness in technical skill assessment; and (d) implementation challenges and opportunities. Beyond summarizing prior findings, this study provides a conceptual synthesis linking game mechanics to technical skill assessment indicators, thereby offering a theoretical contribution to the development of evidence-based gamified assessment.

2. METHODS

This study adopts a Systematic Literature Review (SLR) approach to obtain a comprehensive understanding of the application of gamification in technical skill assessment within electrical engineering education (Milosz, 2020). This method was selected because it enables the identification of research patterns, gaps, and systematic synthesis based on empirical evidence rather than purely descriptive summaries. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework was employed as the primary guideline to ensure transparency, reproducibility, and accountability throughout the literature selection process.

2.1. Research questions

This review is guided by three main research questions (RQs), formulated to address existing gaps in the literature concerning gamification in technical skill assessment, as presented in **Table 2**.

Table 2. Research questions

RQ #	Research Focus
RQ1	What are the publication trends (yearly distribution, source types, and subject contexts) of research on gamification in technical skill assessment?
RQ2	Which gamification design elements (game mechanics) are most frequently implemented and considered effective in the context of technical skill assessment in engineering education?
RQ3	What is the impact (effectiveness) of gamification on the accuracy of technical skill assessment, and what are the major challenges encountered during its implementation?

These questions are structured hierarchically to reflect a progressive analytical flow, ranging from publication characteristics (RQ1), to gamification design elements (RQ2), and finally to effectiveness and implementation challenges (RQ3). This structure enables the SLR to provide a comprehensive analytical framework for understanding the research landscape of gamification in electrical engineering education.

2.2 Search protocol and selection criteria

The literature search was conducted across reputable academic databases in engineering education and information technology, namely Elsevier/Scopus, IEEE Xplore Digital Library, ACM Digital Library, and Web of Science (WoS). A comprehensive search string was formulated to maximize the retrieval of relevant studies:

(Gamification OR "Game-based learning") AND (Assessment OR Evaluation OR "Performance Measurement") AND ("Technical Skills" OR "Practical Skills" OR "Lab Skills") AND ("Electrical Engineering" OR "Engineering Education")

This search strategy was designed to capture studies that examine the integration of gamification as a mechanism for assessing technical skills in higher education and vocational engineering contexts.

All retrieved documents were systematically evaluated using predefined inclusion and exclusion criteria to ensure both relevance and methodological quality. Eligible studies included peer-reviewed journal articles (particularly Scopus Q1–Q4), conference proceedings indexed in Scopus or WoS, and relevant systematic reviews. Studies were required to focus on gamification as an assessment or measurement tool for technical competencies within engineering education (including electrical and computer engineering) and to have been published between 2010 and 2025. Excluded publications comprised non-conceptual books (except key theoretical references), theses and dissertations, non-peer-reviewed reports, studies focusing solely on serious games or general motivational outcomes without assessment components, studies conducted in primary or secondary education, non-educational contexts, and publications released prior to 2010.

2.3 Literature selection process (PRISMA flow)

The literature selection followed the PRISMA flow across four main stages. During the identification stage, the initial search yielded 500 records, resulting in 380 unique articles after duplicate removal. In the screening stage, titles and abstracts were reviewed, leaving 234 articles deemed topically relevant. During the eligibility stage, 127 full-text articles were assessed, with several excluded due to their exclusive focus on motivational outcomes without evaluating technical skills. The final inclusion stage resulted in 45 studies that met all inclusion criteria and formed the primary basis for synthesis.

This multi-stage selection process ensured that the SLR not only aggregated relevant literature but also identified research patterns, anomalies, and gaps, which were subsequently used to develop a conceptual model in the discussion section.

2.4. Data extraction and synthesis

Data extraction was conducted using a thematic synthesis approach to identify recurring patterns across the 45 selected studies. Each article was analyzed based on publication year and type, course or laboratory context, gamification mechanisms employed, types of technical skills assessed, and reported evidence of effectiveness and implementation limitations. The extracted findings were synthesized into three analytical frameworks aligned with RQ1, RQ2, and RQ3, resulting in a comprehensive understanding of research trends, gamification design characteristics, and their impact on technical assessment in electrical engineering education. This approach ensured that the SLR not only summarized existing studies but also constructed a conceptual model explaining the role of gamification as a performance-based assessment instrument.

2.5. Quality assessment

To evaluate the methodological quality of the 45 studies included in this SLR, a combination of three widely recognized evaluation frameworks was employed: CASP (Critical Appraisal Skills Programme), SRQR (Standards for Reporting Qualitative Research), and Kitchenham’s Quality Checklist. Each study was assessed using six indicators: (1) clarity of research objectives, (2) methodological appropriateness, (3) data and instrument quality, (4) validity of findings, (5) relevance to the research questions, and (6) originality of contribution.

A three-point scale was applied—1 (not met), 2 (partially met), and 3 (strongly met)—to ensure consistency across evaluations. Based on total scores, studies were classified into three quality categories: High (≥15), Medium (12–14), and Low (≤11). An overview of the quality assessment results is presented in **Table 2.3**.

Table 2.3. Quality assessment of included studies

Quality Category	Score Range	Number of Studies	Percentage
High	≥15	24 studies	53%
Medium	12–14	14 studies	31%
Low	≤11	7 studies	16%

The results indicate that more than half of the studies (53%) fall into the high-quality category, characterized by robust methodologies, clear methodological reporting, and empirically sound findings. Approximately 31% of the studies were classified as medium quality, mainly due to limitations in instrument reporting, analytical methods, or relatively small sample sizes. The remaining 16% were categorized as low quality, primarily due to insufficient instrument validation, limited methodological description, and unclear alignment between findings and research objectives.

Overall, this quality distribution suggests that the evidential foundation of the SLR is strong, allowing the synthesized findings to be considered reliable. Nevertheless, interpretations involving medium- and low-quality studies were treated cautiously to avoid overgeneralization.

2.5. Conceptual framework

The conceptual framework of this study was developed to guide the literature synthesis process and ensure that all stages of the review were conducted systematically and aligned with the research questions (RQ1–RQ3). The framework integrates three main components: (1) input, consisting of selected studies obtained through the PRISMA protocol; (2) process, comprising thematic analysis governed by Quality Assessment (QA); and (3) output, consisting of synthesized thematic findings related to research trends, gamification design elements, and their impact on technical skill assessment.

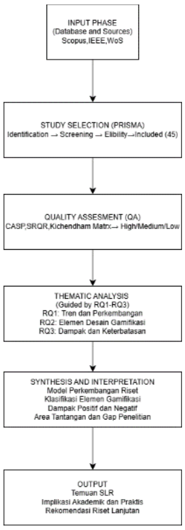

Figure 2. Conceptual framework

As illustrated in **Figure 2.1**, the literature synthesis follows three main phases. The input phase involves collecting articles from four major databases and applying the PRISMA protocol to obtain 45 eligible studies. The analysis phase includes Quality Assessment (QA) and thematic synthesis, where QA functions as a quality filter to ensure that findings are grounded in credible evidence. The synthesis is then conducted according to the three research questions: RQ1 (research trends), RQ2 (gamification design elements), and RQ3 (impact on technical assessment). The output phase consists of synthesized findings, academic and practical implications, and recommendations for future research. This framework ensures that the SLR process is transparent, structured, and reproducible.

3. RESULTS AND DISCUSSION

3.1. General characteristics of the literature

The identification and selection of literature were conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. The initial search across four major databases—IEEE Xplore, Scopus/Elsevier, SpringerLink, and Web of Science—yielded 500 potential publications. After the removal of duplicates, this number was reduced to 234 unique articles. Title and abstract screening retained all 234 articles as topically relevant. Subsequently, during the eligibility stage, full-text assessment was conducted on 127 articles, of which only 45 publications met all inclusion criteria and were selected for further analysis. The complete selection process is illustrated in **Figure 3.1**.

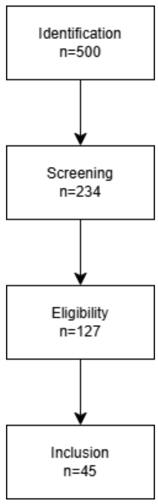

Figure 3.1. PRISMA-based literature selection flow

The included literature spans the period 2002–2025, with a sharp increase observed in the last five years (2020–2025). This surge indicates a shift in research orientation toward the use of gamification as an evaluative strategy rather than merely a motivational tool. Most articles were published in high-impact journals (SJR Q1–Q2), such as Computers in Human Behavior, Computers & Education, Educational Research Review, and Heliyon, suggesting that this topic has gained substantial attention within the engineering education and educational technology communities.

In terms of publication types, 31 articles (68.9%) were journal papers, 7 articles (15.5%) were conference proceedings from reputable venues such as IEEE EDUCON and HICSS, 4 articles (8.9%) were book chapters or preprints, and 3 articles (6.7%) were conceptually relevant but non-indexed publications. This distribution highlights the dominance of empirical and experimental research in electrical engineering education, computer engineering, STEM education, and software engineering.

Table 3.1. Publication analysis

No	Analysis Category	Key Findings
1	Number of included studies	45 publications
2	Publication period	2002–2025
3	Peak distribution	2020–2025 (71% of total studies)
4	Source types	Journals (31), Proceedings (7), Book chapters/Preprints (4), Others (3)
5	Dominant fields	Electrical engineering education, computer engineering, STEM, software engineering
6	Journal ranking (SJR/Scopus)	Q1 (21), Q2 (8), Q3 (6), Q4 & non-indexed (10)
7	Research approaches	Empirical (62%), Systematic reviews (24%), Conceptual/Framework-based (14%)
8	Educational context	Higher education and vocational education
9	Geographic distribution	Europe (31%), Asia (27%), Americas (24%), Others (18%)

Overall, the literature characteristics indicate a steady evolution of gamification research in electrical engineering education, with increasing emphasis on assessment validity, technical performance measurement, and digital technology integration. This trend confirms that gamification is no longer positioned solely as a motivational strategy, but has evolved into a measurable, evidence-based evaluative approach.

3.2. Research trends and directions (RQ1)

Analysis of the 45 publications reveals a consistent development pattern in research on gamification for technical skill assessment in electrical engineering education. This evolution is reflected in publication growth, shifts in research focus, and a paradigm transition from gamification as a motivational tool to a data-driven technical evaluation instrument. Overall, these developments can be observed through three dimensions: temporal trends, research contexts, and paradigm shifts.

Figure 3.2. Publication trends in gamification for electrical engineering education (2002–2025)

The publication trend demonstrates three evolutionary phases. The initial phase (2002–2015) was characterized by a limited number of studies focusing primarily on motivation and learning engagement, employing basic game mechanics such as points, badges, and leaderboards. The second phase (2016–2019) marked a transition toward engineering laboratory contexts, where gamification was applied to support experimental activities and troubleshooting tasks. In the third phase (2020–2025), the number of publications increased sharply alongside the emergence of technology-enhanced gamified assessments incorporating IoT, AR/VR, and learning analytics. During this phase, gamification began to function as an evaluative tool capable of measuring students' technical performance in real time.

Disciplinary distribution analysis shows that approximately 40% of studies were situated within engineering and technology fields, particularly electrical and software engineering. Gamification was implemented across various instructional models, including circuit simulations, gamified laboratory assessments, and automated point- and badge-based evaluation systems. These applications indicate that gamification has increasingly served not only as a motivational strategy but also as an evaluative component within competency-based assessment frameworks.

The literature synthesis further reveals an epistemological transformation. Early studies emphasized learning experiences and engagement, while research between 2016 and 2020 shifted toward laboratory-based applications. From 2021 to 2025, the paradigm advanced toward adaptive, performance-based assessment, integrating analytics, IoT, and AR/VR technologies to enable automated evaluation of technical competencies.

Table 3.2. Phases of research development

Phase	Period	Main Focus	Research Characteristics	Representative Studies
Phase I: Exploratory	2010–2015	Motivation & Engagement	Examining the effects of game elements on learning motivation	(Domínguez et al., 2013; Hamari et al., 2014)
Phase II: Implementative	2016–2020	Integration in Engineering Education	Application of gamification in laboratory and engineering classes	(Díaz-Ramírez, 2020a; Sailer et al., 2017)
Phase III: Evaluative & Adaptive	2021–2025	Performance-Based and Intelligent Assessment	Integration with analytics, AR/VR, and IoT for real-time assessment	(Lampropoulos et al., 2023; Mushtaq et al., 2025; Zhang & Huang, 2024)

Geographically, publications were dominated by Europe (31%) and Asia (27%), followed by North America (24%), with Spain, Germany, and China as leading contributors. Many studies appeared in high-impact journals such as Computers in Human Behavior, Computers & Education, Education Sciences, and Heliyon, indicating broad academic recognition of gamification as an assessment instrument.

3.3. Gamification design elements in technical assessment (RQ2)

Analysis of the 45 publications indicates that the success of gamification in technical skill assessment depends not on the isolated use of game elements, but on the alignment between game mechanics and assessment objectives (Zhang & Huang, 2024). Most studies conclude that gamification mechanisms serve a dual function: (1) enhancing motivation and engagement, and (2) generating objective evidence of technical performance. Consequently, gamification has evolved from a mere motivational layer into an assessment mechanism contributing to the validity and reliability of technical competency measurement.These elements were classified into four main categories, as presented in **Table 3.3**.

Table 3.3. Classification of gamification design elements in technical assessment

Main Category	Common Elements	Pedagogical Purpose	Example Implementation	Key References
Feedback & Reinforcement Mechanics	Points, badges, levels, progress bars	Provide instant feedback and measure technical achievement	Automated scoring in electronics and IoT laboratories	(Cheng et al., 2023; Sailer et al., 2017; Zainuddin et al., 2020)
Competitive & Social Mechanics	Leaderboards, challenges, team collaboration	Foster social interaction and peer motivation	Circuit design or troubleshooting competitions	(Díaz-Ramírez, 2020b; García et al., 2017; Kim et al., 2024)
Adaptive & Cognitive Mechanics	Adaptive difficulty, tiered missions, scenario-based challenges	Assess skills under varying levels of complexity	Scenario-based simulations with adaptive difficulty	(Krath et al., 2021; Lampropoulos, 2023; Zhang & Huang, 2024)
Experiential & Evaluative Mechanics	Game-based simulations, virtual labs, activity logs	Measure practical skills and technical reasoning in real time	Gamified virtual labs for electrical experiments	(Diéguez et al., 2024; Domínguez et al., 2013)

Points and badges were the most dominant mechanics (≈80% of studies), as they can be directly mapped to technical indicators such as measurement accuracy or troubleshooting effectiveness. Leaderboards appeared in approximately 60% of studies and were found to enhance participation, although they require careful design to avoid unhealthy competition. Recent research (2020–2025) shows a strong trend toward adaptive gamification and simulation-based assessment, which enables real-time performance capture and produces more reliable evaluative data than manual assessment.

Based on the synthesis, three key design principles were identified:

1. Alignment Principle – alignment between game mechanics and competency indicators;
2. Transparency and Feedback Principle – provision of immediate feedback to enhance diagnostic awareness;
3. Adaptive Challenge Principle – adjustment of task difficulty to maintain assessment validity.

These principles confirm that well-designed gamification can function as a performance-based evaluation instrument, rather than merely a motivational tool.

3.4. Impact of gamification on technical skill assessment (RQ3)

The literature identifies several implementation challenges that influence the effectiveness of gamification in technical skill assessment. Four major categories of challenges are summarized in **Table 3.4**, encompassing pedagogical design, infrastructure readiness, student learning diversity, and limitations in empirical evaluation.

Table 3.4. Implementation challenges

Challenge Category	Description	Supporting References
Pedagogical Design	Misalignment between game elements and technical learning objectives; excessive focus on entertainment	(Marache-Francisco & Brangier, 2012; Muntean, 2011)
Infrastructure Limitations	Limited LMS capacity, laboratory system integration, and high hardware/connectivity demands	(Díaz-Ramírez, 2020a; Sabornido et al., 2022)
Student Learning Diversity	Not all students respond positively to competitive or visualized progress elements	(Gee, 2003; Zainuddin et al., 2020)
Empirical Evaluation Limitations	Lack of longitudinal studies and reliability measurement of gamified assessment outcomes	(Baptista & Oliveira, 2019; Hamari et al., 2014; Toda et al., 2019)

These findings highlight that effective gamification requires synchronization among instructional design, technological readiness, and student characteristics. Poorly designed game elements risk reducing gamification to a gimmick that undermines assessment quality.

3.5. Challenges in implementing gamification in engineering education

Although gamification demonstrates significant potential to enhance motivation and the quality of technical skill assessment, the synthesis of 45 studies reveals that its implementation in engineering education—particularly in electrical engineering—still faces several critical challenges. These challenges extend beyond pedagogical aspects and include technological limitations, learner diversity, and assessment validity. For clarity, the identified barriers are classified into four main dimensions, as summarized in **Table 3.5.**

Table 3.5. Implementation challenges of gamification

Challenge Dimension	Main Description	Impact on Implementation
Pedagogical and Instructional Design Challenges	Misalignment between game elements and technical learning outcomes; excessive focus on entertainment rather than assessment objectivity	Leads to misalignment between game mechanics and technical competency indicators
Technological and Infrastructure Challenges	Limited integration of gamification systems with LMS and engineering laboratories	Hinders assessment automation, especially in hardware-based laboratories
Psychological Challenges and Learning Style Differences	Diverse student responses to competitive elements such as leaderboards and time pressure	Creates engagement gaps and risks long-term motivation decline
Evaluative and Assessment Validity Challenges	Lack of standardized measures to ensure reliability of gamified assessment outcomes	Difficulty distinguishing between game performance and actual technical competence

These four dimensions directly affect the effectiveness of gamified assessment. From a pedagogical perspective, many studies report that gamification fails when game mechanics are not aligned with technical learning objectives, weakening the validity of assessment outcomes. Technological challenges arise from limited LMS, laboratory, and IoT integration, particularly in institutions with constrained infrastructure, which restricts automated and objective evaluation.

Psychological challenges stem from differences in student learning styles. While competitive mechanics may motivate some learners, they can also induce stress or disengagement in others, leading to uneven participation. The most critical issue remains assessment validity, as several studies report bias where high scores reflect strategic gameplay rather than genuine mastery of technical procedures.

Overall, these findings emphasize that successful gamification in engineering education requires well-aligned instructional design, adequate laboratory infrastructure, and validated assessment mechanisms. Without strong integration of these elements, gamification risks becoming a superficial tool that reduces, rather than enhances, the accuracy of technical skill assessment.

3.6. Academic and Practical Implications

The SLR findings indicate that gamification has evolved from a purely motivational strategy into an evidence-based assessment mechanism capable of improving objectivity and accuracy in technical skill evaluation within electrical engineering education. Academically, this highlights the need for gamification designs that align closely with laboratory competencies, are fully integrated with digital campus systems and IoT technologies, and are supported by improved instructor literacy in gamified assessment design.

From a practical perspective, institutions are encouraged to develop standardized gamified assessment systems that connect game elements—such as badges, performance points, and adaptive challenges—to technical indicators (e.g., measurement accuracy and troubleshooting effectiveness), while leveraging real-time data for objective evaluation. Although gamification can enhance student motivation and retention, its effectiveness depends strongly on evidence-based design, technological readiness, and pedagogical competence. When these conditions are met, gamification holds strong transformative potential for technical assessment in engineering education.

4. CONCLUSION

This systematic literature review of 45 studies demonstrates that gamification in electrical engineering education has evolved from a primarily motivational strategy into a performance-based and adaptive assessment approach. Recent research trends indicate a clear shift toward aligning gamification elements with technical competency indicators, supported by emerging technologies such as simulations, IoT, and learning analytics to enhance assessment accuracy and objectivity. While most studies report positive effects on student motivation, engagement, and assessment quality, the evidence also highlights critical risks, including competitive pressure, assessment bias, and strong dependence on technological readiness and instructional design quality. Therefore, the effectiveness of gamified assessment largely depends on the alignment between game mechanics and learning objectives, robust integration of digital systems, and instructors' capacity to design evidence-based assessment frameworks. Overall, gamification holds significant potential to enrich technical skill assessment in electrical engineering education; however, its successful implementation requires a careful, context-sensitive, and empirically grounded approach to ensure validity, reliability, and pedagogical credibility.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

7. REFERENCES

Baptista, G., & Oliveira, T. (2019). Gamification and serious games: A literature meta-analysis and integrative model. *Computers in Human Behavior*, *92*, 306–315. https://doi.org/10.1016/j.chb.2018.11.030

Cheng, Z., Wang, H., Zhu, X., West, R. E., Zhang, Z., & Xu, Q. (2023). Open badges support goal setting and self-efficacy but not self-regulation in a hybrid learning environment. *Computers & Education*, *197*, 104744. https://doi.org/https://doi.org/10.1016/j.compedu.2023.104744

Díaz-Ramírez, J. (2020a). Gamification in engineering education–An empirical assessment on learning and game performance. In *Heliyon*. cell.com. https://www.cell.com/heliyon/fulltext/S2405-8440(20)31815-6

Díaz-Ramírez, J. (2020b). Gamification in engineering education – An empirical assessment on learning and game performance. *Heliyon*, *6*(9), e04972. https://doi.org/10.1016/j.heliyon.2020.e04972

Diéguez, Á., Canals, J., Moreno, S., & Vilà, A. (2024). Gamification for teaching integrated circuit processing in an introductory VSLI design course. *Education Sciences*, *14*(8), 921. https://doi.org/10.3390/educsci14080921

Domínguez, A., Saenz-De-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers and Education*, *63*, 380–392. https://doi.org/10.1016/j.compedu.2012.12.020

García, F., Pedreira, O., Piattini, M., Cerdeira-Pena, A., & Penabad, M. (2017). A framework for gamification in software engineering. *Journal of Systems and Software*, *132*, 21–40. https://doi.org/10.1016/j.jss.2017.06.021

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment*, *1*(1), 20–20. https://doi.org/10.1145/950566.950595

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? -- A literature review of empirical studies on gamification. *Proceedings of the 2014 47th Hawaii International Conference on System Sciences* (pp. 3025–3034). IEEE. https://doi.org/10.1109/HICSS.2014.377

Ivanova, G., Kozov, V., & Zlatarov, P. (2019). Gamification in software engineering education. In *Proceedings of the 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics.* MIPRO. (pp. 1445–1450). https://doi.org/10.23919/MIPRO.2019.8757200

Kapp, K. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education.* Pfeiffer.

Kim, K. A., Bagci, F. S., & Ho, A. (2024). Using a partially flipped classroom and gamification to improve student performance in a first-year electronic circuits course. *IEEE Transactions on Education,* *67*(5), 785-766. https://ieeexplore.ieee.org/abstract/document/10616214/

Koivisto, J., & Hamari, J. (2019). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management*, *45*, 191–210. https://doi.org/10.1016/j.ijinfomgt.2018.10.013

Krath, J., Schürmann, L., & von Korflesch, H. F. O. (2021). Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning. *Computers in Human Behavior*, *125*, 106963.

https://doi.org/10.1016/j.chb.2021.106963

Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2023). Integrating Augmented Reality, Gamification, and Serious Games in Computer Science Education. *Education Sciences*, *13*(6), 618. https://doi.org/10.3390/educsci13060618

Marache-Francisco, C., & Brangier, E. (2012). Redefining gamification. In *Proceedings of the IADIS International Conference Interfaces and Human Computer Interaction 2012* (pp. 227–231). https://www.iadisportal.org/digital-library/redefining-gamification

Milosz, M. (2020). Gamification in engineering education - A preliminary literature review. *Proceedings of the 2020 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1975–1979). IEEE. https://doi.org/10.1109/EDUCON45650.2020.9125108

Muntean, C. (2011). Raising engagement in e-learning through gamification. *Proceedings of the 6th International Conference on Virtual Learning ICVL* (pp. 323–329). https://iris.cnr.it/bitstream/20.500.14243/525921/2/11_ICVL2011.pdf

Mushtaq, N., Nazeer, N., Fayaz, I., & Gulzar, F. (2025). Next-gen learning: Gamifications impact on higher education. *Education and Information Technologies*, *30*(11), 15691–15717. https://doi.org/10.1007/s10639-025-13431-w

Pedreira, O., García, F., Brisaboa, N., & Piattini, M. (2015). Gamification in software engineering - A systematic mapping. *Information and Software Technology*, *57*(1), 157–168. https://doi.org/10.1016/j.infsof.2014.08.007

Sabornido, E. B., Garma, V. A., Niepes, G. L., & Cabria, F. M. N. (2022). Key challenges and barriers in gamification: A systematic review. *APJAET - Journal Ay Asia Pacific Journal of Advanced Education and Technology*, *1*(1), 13–19. https://doi.org/10.54476/apjaetv1i1mar20221054

Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior*, *69*, 371–380. https://doi.org/10.1016/j.chb.2016.12.033

Su, C. H., & Cheng, C. H. (2014). A mobile gamification learning system for improving the learning motivation and achievements. *Journal of Computer Assisted Learning*, *31*(3), 268–286. https://doi.org/10.1111/jcal.12088

Toda, A. M., Klock, A. C. T., Oliveira, W., Palomino, P. T., Rodrigues, L., Shi, L., Bittencourt, I., Gasparini, I., Isotani, S., & Cristea, A. I. (2019). Analysing gamification elements in educational environments using an existing gamification taxonomy. *Smart Learning Environments, 6*(1). https://doi.org/10.1186/s40561-019-0106-1

Zainuddin, Z., Chu, S. K. W., Shujahat, M., & Perera, C. J. (2020). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review*, *30,* 100326. https://doi.org/10.1016/j.edurev.2020.100326

Zhang, Z., & Huang, X. (2024). Exploring the impact of the adaptive gamified assessment on learners in blended learning. *Education and Information Technologies*, *29*(16), 21869–21889. https://doi.org/10.1007/s10639-024-12708-w