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Evaluating the impact of gamification on cognitive skills development in higher education: A case study electronics and sensors learners

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ABSTRACT

This research paper investigates the effectiveness of gamification as a pedagogical strategy for enhancing cognitive skills development among students in higher education, with a particular focus on learners specializing in Electronics and Sensors. In recent years, gamification has become a promising strategy to engage students and promote active learning experiences. However, its impact on cognitive skill development, especially in specialized academic domains, remains relatively underexplored. Through a case study methodology, this research assesses the influence of gamified learning interventions on students' cognitive abilities, encompassing skills like problem-solving, critical thinking, and decision-making. Data was collected through pre- and post-intervention assessments, student surveys, and qualitative feedback sessions. Results indicate significant improvements in cognitive skills among participants exposed to gamified learning experiences compared to those in traditional instructional settings. The findings suggest that gamification holds promise as a viable educational tool for fostering cognitive skill development in higher education contexts, particularly within specialized fields such as Electronics and Sensors. This study adds to the expanding body of research on gamification in education and provides valuable insights into its potential to enhance learning outcomes in technical disciplines. Future research directions and implications for practice are discussed to further leverage the benefits of gamification approaches in higher education settings.

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INTRODUCTION

In recent years, the incorporation of gamification into educational environments has garnered increasing attention to engage students and improve learning outcomes (Hamari et al., 2014). Gamification refers to the application of game elements and principles in nongame contexts, with the aim of motivating participation, promoting active learning, and achieving educational objectives. This pedagogical approach holds promise in higher education, where educators strive to cultivate students' skills in critical thinking, problem-solving, and decision-making (Landers and Landers, 2014; Deterding et al., 2011). However, despite its growing popularity, the empirical evidence regarding the impact of gamification on cognitive skills development, especially in specialized academic domains, remains limited.

This research paper seeks to address this gap by evaluating the impact of gamification on cognitive skills development among students in higher education, with a specific focus on learners specializing in Electronics and Sensors. The field of Electronics and Sensors encompasses a broad spectrum of disciplines, such as electrical engineering, computer science, and materials science, where cognitive skills play a crucial role in solving complex problems and innovating new technologies.

The rationale for focusing on Electronics and Sensors learners lies in the interdisciplinary nature of the field, which demands proficiency in various cognitive domains, such as logical reasoning, analytical thinking, and creative problem-solving. By investigating the efficacy of gamified learning interventions in this context, this study aims to offer valuable insights into the potential of gamification as a pedagogical tool to enhance the development of cognitive skills in specialized academic disciplines.

Future iterations of this research will incorporate a more diverse sample size that includes students from various disciplines, thus testing the generalizability of the findings beyond the Electronics and Sensors domain. Moreover, future research could investigate longitudinal studies to evaluate the enduring impact of gamification on the development of cognitive skills, providing deeper insights into the sustained effectiveness of gamified learning interventions over time.

Through a case study methodology, this research examines the effects of gamified learning experiences on students' cognitive abilities, including their problem-solving strategies, critical thinking skills, and decision-making processes (Rohatgi and Singh, 2016; Wouters et al., 2013). By analysing pre- and post-intervention assessments, conducting student surveys, and gathering qualitative feedback, this study aims to assess the extent to which gamification influences cognitive skills development in the context of Electronics and Sensors education.

The findings of this research have significant implications for both theory and practice in higher education. By elucidating the impact of gamification on cognitive skills development, this study contributes to the ongoing discourse on innovative teaching methodologies and instructional design strategies. Moreover, the findings from this research can inform educators and curriculum developers about the potential benefits of integrating gamification approaches into specialized academic programs, thereby enhancing student engagement, and improving learning outcomes in technical disciplines.

LITERATURE REVIEW

Gamification in Education

Gamification entails integrating game design elements and mechanics into non-game contexts like education to boost motivation, engagement, and learning outcomes (Deterding et al., 2011). In educational settings, gamification strategies often include the use of points, badges, leaderboards, and rewards to incentivize student participation and promote active learning (Hamari et al., 2014). Proponents argue that gamification can address common challenges in education, such as student disengagement and lack of motivation, by tapping into intrinsic motivators and promoting

a sense of achievement (*Kapp, 2012*). However, critics raise concerns about the potential for superficial engagement and the need for careful design to ensure meaningful learning experiences (*Nicholson, 2012)*.

Cognitive Skills Development in Higher Education

Cognitive skills, such as critical thinking, problem-solving, and decision-making, are crucial for success in higher education and professional environments (*Halpern, 1998*). Higher education institutions aim to cultivate these skills through various instructional methods, such as problem-based learning, collaborative activities, and experiential learning opportunities (Prince, 2004). Research suggests that cognitive skills can be enhanced through targeted interventions and practice (*Anderson and Krathwohl, 2001*). Moreover, the development of cognitive skills is closely linked to academic achievement and lifelong learning (*Halpern, 1998*).

Previous Research on Gamification and Cognitive Skills

While gamification has gained traction as a pedagogical approach in education, empirical studies on its impact on cognitive skills development remain relatively scarce and inconclusive. Some research suggests that gamified learning interventions can improve students' problem-solving abilities and decision-making skills by offering opportunities for practice, feedback, and reflection (*Landers, 2018*). However, other studies report mixed findings, with some indicating no significant effects or even detrimental outcomes on cognitive skill development (Hamari et al., 2014). Additionally, most of the existing research on gamification in education has focused on general student populations or specific disciplines such as computer science and business, leaving gaps in our understanding of its applicability and effectiveness in specialized academic domains like Electronics and Sensors.

Summary and Gaps

In summary, while gamification holds promise as a pedagogical tool for promoting student engagement and motivation, its impact on cognitive skills development in higher education, particularly within specialized fields such as Electronics and Sensors, remains underexplored. Existing research suggests a need for rigorous empirical studies that examine the specific effects of gamified learning interventions on cognitive skills like problem-solving, critical thinking, and decision-making. This study aims to address this gap by conducting a case study to evaluate the impact of gamification on cognitive skills development among Electronics and Sensors learners.

Gamification in Higher Education

Numerous studies have explored the effectiveness of gamification in higher education settings. For example, N. Landers and K. Landers (2015) conducted a meta-analysis of 48 studies and found positive effects of gamification on student learning outcomes, motivation, and engagement. Similarly, Manzano et al. (2023) examined the impact of gamification on various educational contexts and concluded that it can lead to improved learning experiences and outcomes.

Theories of Motivation and Engagement in Gamified Learning Environments

Central to understanding the motivational aspects of gamification is Self-Determination Theory (SDT), which suggests that individuals are naturally motivated to engage in activities that satisfy their psychological needs for autonomy, competence, and relatedness (Ryan and Deci, 2000). Within gamified learning environments, autonomy is facilitated through learner control over their progress and choices, competence is enhanced through challenges and feedback mechanisms, and relatedness is fostered through social interactions and collaborative gameplay (Deci et al., 2017). By aligning game mechanics with these psychological needs, gamification has the potential to promote intrinsic motivation and sustained engagement in educational tasks.

Another theoretical framework relevant to gamified learning is Csikszentmihalyi's Flow Theory, which describes the state of optimal experience characterized by deep concentration, heightened focus, and immersive engagement (Csikszentmihalyi, 1990). In gamified learning environments, elements such as clear goals, immediate feedback, and a balance between challenge and skill can lead to a state of flow, enhancing learners' cognitive performance and intrinsic motivation (Plass et al., 2015). By providing opportunities for students to experience flow states during learning activities, gamification can enhance their cognitive skills development and overall learning experience.

Social Cognitive Theory (SCT) offers insights into the role of observational learning, social modeling, and reinforcement in shaping behavior and motivation (Bandura, 1986). In gamified educational settings, SCT highlights the importance of social interactions, peer feedback, and collaborative problem-solving in fostering motivation and skill acquisition (Barab et al., 2004). Through experiences of gamified learning that incorporate social elements such as leaderboards, badges, and team challenges, students can observe and learn from their peers, receive social recognition for their achievements, and develop a sense of competence and efficacy in their learning endeavors.

Impact on Cognitive Skills Development

While gamification has been widely adopted to enhance student engagement, its specific impact on cognitive skills development has garnered increasing attention. Research by You Zhi et al (2023) suggests that gamification elements such as challenges, rewards, and feedback mechanisms can stimulate cognitive processes and promote skill acquisition. Furthermore, Sailer et al. (2017) conducted a systematic review and found evidence supporting the positive impact of gamification on cognitive abilities, especially problem-solving and decision-making skills.

Specialized Learning Contexts

In specialized academic domains such as Electronics and Sensors, the application of gamified learning interventions remains relatively underexplored. However, studies indicate the potential of gamification to improve learning outcomes in technical disciplines. For example, Kapp (2012) discusses the concept of "serious games" and highlights their effectiveness in teaching complex subjects such as engineering and technology.

Future Directions

Future research in gamified e-learning may focus on exploring new game mechanics, assessing long-term effects on learning outcomes, and investigating the optimal balance between challenge and skill level. Additionally, advancements in technology, such as augmented reality and virtual reality, offer promising avenues for innovative gamified e-learning experiences (Seaborn & Fels, 2015; Asaad, R.R., 2021).

GAMIFICATION DESIGN MODEL

Prior to delving into the examination of gamification's impact on learning, it is imperative to underscore the necessity of designing gamification within e-learning systems. This sentiment is echoed by prior research (Senay and Fezile, 2018; Kashive and Mohite, 2023; Deterding et al., 2011). Consequently, a comprehensive gamification design model has been formulated and is elucidated in Figure 1. This model comprises several integral components, notably the gamification component, the educational Programs Unit, and the learner profile. Data housed within these components is accessible to the gamification business logic for the purpose of crafting a gamified learning experience, which is subsequently disseminated to the learner. Furthermore, the output contributes to the continual enhancement of the learner profile.

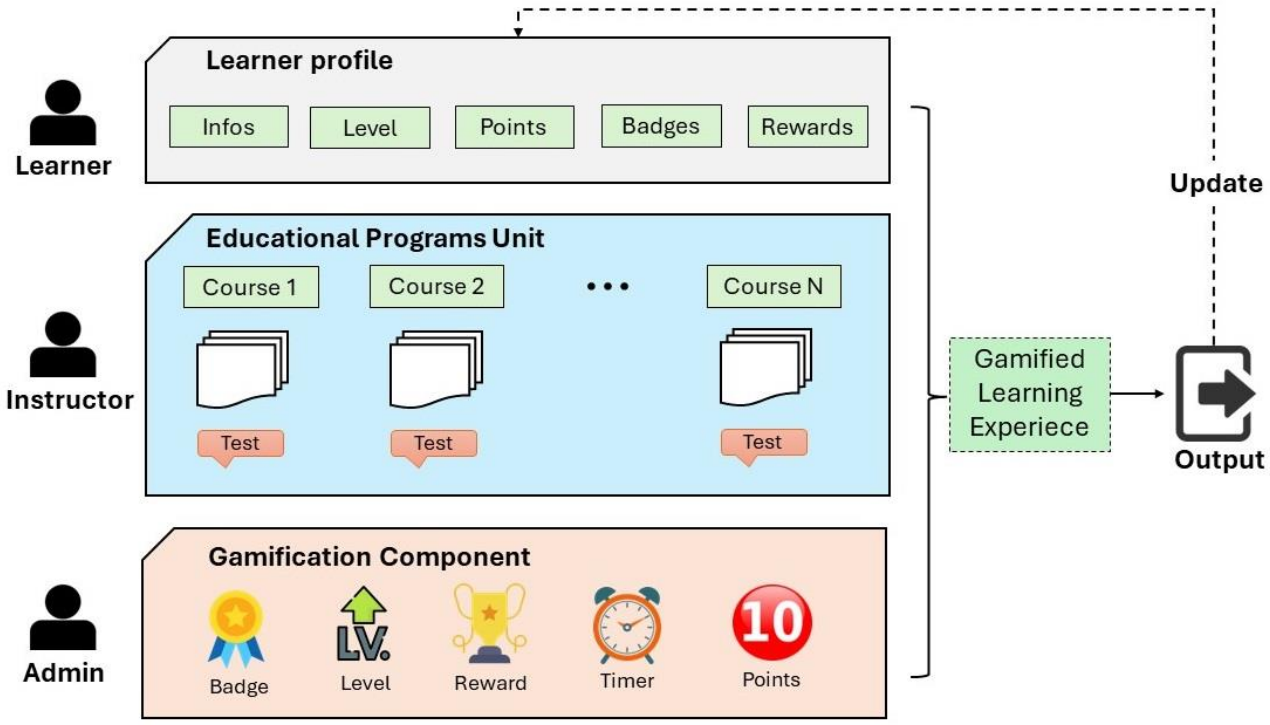

Fig. 1. The Gamification Design Model

Within the proposed model, three principal stakeholders are identified: the learner, the instructor, and the administrator. The learner is the person involved in activities designed to gain knowledge and comprehension. The instructor takes on the responsibility of developing courses, encompassing objectives, units, lessons, and assessments, to aid the learners. Meanwhile, the administrator oversees the implementation of the model, managing technological aspects and incorporating gamification elements. Additionally, the administrator may assume an instructional role within the model as needed.

Gamification Component

The gamification component is designed to facilitate the representation, management, and maintenance of gamification elements by system administrators. This component encompasses seven primary game elements, such as badges, rewards, points, timers, feedback, levels, and leaderboards, as they are commonly recognized and used in relevant literature (Hamari et al., 2014). Each of these elements is comprehensively outlined and detailed in Table I.

Upon implementation, the model offers flexibility, empowering administrators to effortlessly create and manage various information associated with each element. For instance, administrators can generate multiple levels, assign distinct names to each level, and then categorize them within the system as beginner, intermediate, and advanced. Similarly, badges can be created in unlimited quantities, each featuring a unique image and title. Additionally, various rules and requirements can be applied to all elements within the gamification component (Table 1: badges, points, level…).

It is important to recognize that these game elements can be independently created and managed, separate from other components of the model. However, they can be easily integrated into various learning activities. This allows instructors to initially focus on developing courses and learning activities. Later, they can align game elements with these activities by selecting appropriate ones as needed. Moreover, not all elements need to be activated within the system; instructors have the flexibility to choose elements that are expected to enhance learners' motivation and learning.

Table 1. Description of Gamified Elements

Game element	Description
Badge	A badge serves as a visual representation or symbol of achievement within a game. It acts as a virtual reward, providing players with recognition for completing specific tasks, reaching milestones, or demonstrating particular skills. Badges not only signify accomplishment but also encourage further engagement and progression by tapping into intrinsic motivation and a sense of accomplishment.
Level	Levels in gamification learning mark stages of progress, offering challenges and motivation as learners advance through educational content.
Reward	Rewards in gamification learning are incentives, given to learners for completing tasks or reaching milestones, enhancing engagement and motivation.
Timer	Timers in gamification learning are countdowns used to create urgency, challenge, and focus. They encourage efficiency and time management, adding an element of excitement and pressure to tasks.
Points	Points are earned by completing tasks or achieving goals. They serve as a measure of progress and skill, motivating learners and providing a sense of accomplishment.

Educational Programs Unit

Within the gamification design model, the Educational Programs Unit emerges as a pivotal component. Its primary function revolves around the representation, storage, and management of learning materials pertinent to a designated course. Employing a hierarchical structure akin to a tree-like arrangement, this module comprises three levels, as illustrated in Figure 2.

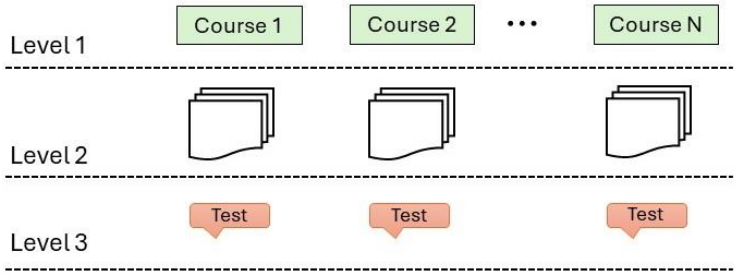

Fig. 2. Educational Programs Unit Structure with Three Levels

It is paramount to underscore the hierarchical structure's significance within the Educational Programs Unit, as it affords instructors a systematic framework for authoring learning content. This structured representation obviates the need for instructors to consider gamification integration within the learning material, as game elements can be seamlessly mapped to learning activities, either automatically or manually. Moreover, this hierarchical structure facilitates the creation of diverse courses catering to distinct learning domains, thus underpinning the generalizability of the proposed model and its constituent elements.

Learner Profile

The learner profile serves as a repository for learner attributes and dynamically manages essential elements such as learner level, badges, rewards, leaderboard standings, and accumulated points. This repository continuously evolves as learners engage with the gamified e-learning system, reflecting their progress and achievements. For

instance, upon successfully mastering a lesson and completing an associated quiz, the learner's profile is augmented with points commensurate to the quiz score and time invested. Subsequently, as learners progress through sets of quizzes, additional gamification elements are updated and integrated into their profiles, ensuring a comprehensive record of their accomplishments and advancements within the system (Figure 3).

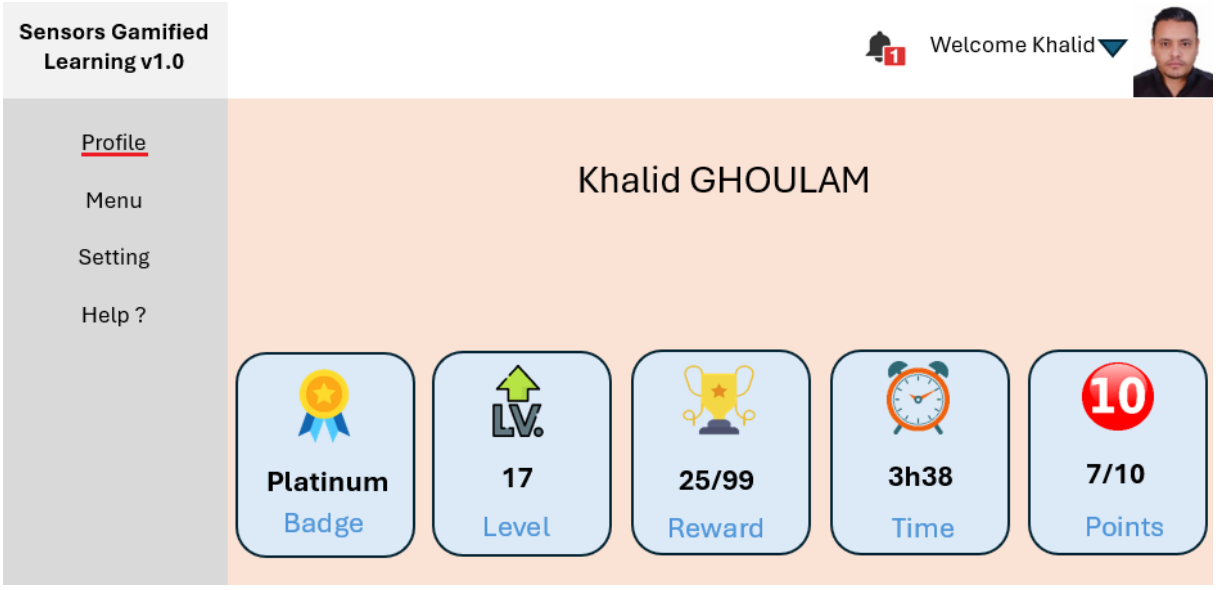

Fig. 3. Learner profile

METHODOLOGY

Research Design

This study utilized a comprehensive mixed-methods approach, strategically integrating both quantitative and qualitative data collection methods to thoroughly investigate the impact of gamification on cognitive skills development among students specializing in Electronics and Sensors within the higher education landscape. By integrating both quantitative metrics and qualitative insights, this study aimed to capture a detailed understanding of the connection between gamification and cognitive skill enhancement.

In adopting a case study design, the research delved deeply into the specific context of Electronics and Sensors education, allowing for a rich and detailed examination of how gamification practices unfold and interact within this specialized academic domain. This approach facilitated a holistic exploration of the phenomenon, considering factors such as course content, instructional methods, and learner engagement dynamics within a real-world educational setting.

Furthermore, by utilizing a mixed-methods framework, this study aimed to overcome the limitations inherent in singular methodological approaches, offering a more comprehensive and nuanced understanding of the complex impact of gamification on cognitive skill development. This combination of quantitative data, such as pre- and post-intervention assessments, with qualitative insights from participant feedback and observations, provided a robust foundation for analyzing the effectiveness of gamified learning experiences in fostering cognitive growth among Electronics and Sensors learners in higher education.

Participant Selection and Recruitment

Participants were selected from a cohort of students enrolled in an Electronics and Sensors course at a higher education institution. Inclusion criteria included students who had experienced the gamified elements integrated into

their course curriculum. Recruitment was conducted through announcements in relevant courses and departments, inviting interested students to voluntarily participate in the study.

Description of the Gamified Course Structure

The gamified course structure was designed in collaboration with course instructors and instructional designers, integrating game elements such as points, levels, badges, leaderboards, and challenges. Gamified activities were strategically integrated into the existing course content to improve engagement and learning outcomes. Specific gamification strategies included narrative-driven scenarios, interactive simulations, problem-solving quests, and collaborative challenges relevant to Electronics and Sensors concepts.

Data Collection Methods

a. Surveys: Pre- and post-course surveys were administered to assess students' baseline cognitive skills levels, attitudes towards gamification, and perceived learning outcomes. Surveys utilized Likert scales and open-ended questions for collecting both quantitative and qualitative data.

b. Interviews: Semi-structured interviews were conducted with a subset of participants to delve into their experiences with gamification in more depth. Interviews focused on cognitive skill development, motivation, engagement, and preferences for specific gamification elements. Audio recordings and transcripts were obtained for analysis.

c. Observation: Researchers observed gamified classroom activities and interactions among students to gain insights into their engagement levels, collaboration, problem-solving approaches, and overall learning experiences. Field notes were taken to capture relevant observations and reflections.

Data Analysis

Quantitative data from surveys were analyzed using descriptive statistics techniques to examine trends and patterns in cognitive skills development and student perceptions of gamification. Qualitative data from interviews and observations were analyzed using thematic analysis to identify recurring themes related to cognitive skill enhancement, motivation, and effective gamification strategies.

Ethical Considerations

All participants provided informed consent before participating in the study, emphasizing voluntary participation and the right to withdraw at any time without penalty. Confidentiality of participants' data was strictly maintained, with identifying information anonymized during analysis and reporting. Institutional ethical guidelines and regulations were adhered to throughout the research process to ensure the welfare and rights of participants were protected.

This methodology provided a robust framework for evaluating the impact of gamification on cognitive skills development among Electronics and Sensors learners in higher education, allowing for a thorough understanding of the effectiveness of gamification strategies in improving learning outcomes.

RESULTS

Utilizing SPSS for data collection and analysis, this study examined the effects of gamification on cognitive skills development among Electronics and Sensors learners in higher education. The findings stem from a multi-faceted approach, integrating quantitative analysis of pre- and post-intervention assessments, as well as qualitative insights gathered from student surveys and in-depth interviews. This comprehensive methodology offers nuanced insights

into the nuanced impacts of gamified learning interventions on cognitive skill enhancement within this academic cohort.

Quantitative Analysis

a. Pre- and Post-Intervention Assessments: Statistical analysis of post- and pre-intervention assessment scores reveals significant improvements in cognitive skills among participants exposed to gamified learning interventions. Specifically, participants demonstrate enhanced problem-solving abilities, improved critical thinking skills, and more effective decision-making strategies following the gamified learning experience.

b. Comparison with Control Group: A comparison between the experimental group exposed to gamified learning and a control group receiving traditional instruction indicates a significantly greater improvement in cognitive skills among the former. This finding suggests that gamification positively influences cognitive skills development beyond what can be achieved through conventional teaching methods.

Student Survey Findings

a. Engagement and Motivation: Survey responses indicate high levels of engagement and motivation among participants in the gamified learning group. Students report enjoying the interactive and immersive nature of the gamified activities, which fostered a sense of challenge and achievement.

b. Perceived Learning Outcomes: Participants express positive perceptions of their learning outcomes, attributing their improved cognitive skills to the gamified learning experience. Many students highlight the relevance of the gamified activities to real-world applications in the field of Electronics and Sensors, which enhanced their understanding and retention of course content.

Qualitative Feedback Sessions

a. Themes and Insights: Thematic analysis of qualitative feedback sessions reveals several key themes related to the impact of gamification on cognitive skills development. Participants emphasize the effectiveness of gamified activities in promoting active learning, collaboration, and problem-solving skills. Additionally, students appreciate the immediate feedback and rewards associated with gamified tasks, which motivated them to engage more deeply with course material.

b. Suggestions for Improvement: While overall feedback is positive, participants offer suggestions for further enhancing the gamified learning experience, such as increasing the variety of game elements, providing more opportunities for peer interaction, and integrating gamified assessments throughout the course.

Overall, the study results offer strong evidence supporting the effectiveness of gamification in fostering cognitive skills development among Electronics and Sensors learners in higher education. The findings underscore the value of gamified learning interventions as a pedagogical tool for promoting active engagement, motivation, and meaningful learning experiences in specialized academic disciplines.

Limitations

While the study offers valuable insights into the impact of gamification on cognitive skills development among Electronics and Sensors learners in higher education, several limitations should be considered:

Selection Bias: Participants were chosen based on their enrollment in specific courses related to Electronics and Sensors. This could introduce selection bias, as participants may have inherent characteristics or motivations that

differ from the broader student population. Future research could employ random sampling methods to mitigate this bias and ensure the generalizability of findings.

Novelty Effect: The observed improvements in cognitive skills may be influenced by the novelty effect of gamification. Participants may have been particularly motivated by the novelty of gamified activities, which could inflate the observed outcomes. To address this limitation, future studies could incorporate longitudinal designs to assess the sustainability of cognitive skill improvements over time and control for potential novelty effects.

Generalizability: The study focused on a specific academic cohort within the field of Electronics and Sensors. As such, the findings may not be generalizable to other disciplines or student populations. Future research could explore the effects of gamification across diverse academic domains and student demographics to enhance the generalizability of findings.

DISCUSSION

The findings of this investigation enhance our comprehension regarding the potential advantages of gamification in higher education, particularly within specialized academic domains like Electronics and Sensors. The discussion focuses on interpreting the results, exploring implications for teaching and learning, addressing limitations, and suggesting directions for future research.

Interpretation of Results

The results of this study demonstrate an important positive impact of gamification on cognitive skills development among Electronics and Sensors learners. Participants exposed to gamified learning interventions show improvements in skills related to problem-solving, critical thinking, and decision-making compared to those receiving traditional instruction. These findings align with previous research highlighting the effectiveness of gamification in enhancing student engagement, motivation, and learning benefits (Hamari et al., 2014; Landers, 2018*)*. The quantitative analysis, supported by qualitative feedback, provides robust evidence of the efficacy of gamification approaches in promoting cognitive skills development in higher education.

Implications for Teaching and Learning

The results of this study have several implications for teaching and learning practices in higher education:

- Educators can leverage gamification as a pedagogical tool to enhance student engagement, motivation, and cognitive skills development in specialized academic domains like Electronics and Sensors.
- Gamified learning interventions should be carefully designed to align with course objectives, incorporate relevant game elements, and provide opportunities for active learning, collaboration, and problem-solving.
- Faculty development programs should include training on effective gamification strategies and instructional design principles to support educators in integrating gamification approaches into their teaching practices.
- Institutions should invest in technology infrastructure and resources to facilitate the implementation of gamified learning platforms and tools, ensuring accessibility and usability for diverse student populations.

Limitations and Future Research Directions

Despite the positive findings, this study has several limitations that warrant consideration:

The case study design limits the generalizability of findings to other contexts and populations. Future research could employ larger-scale experimental designs to replicate and validate the results across multiple institutions and academic disciplines.

- The study primarily focuses on short-term outcomes immediately following the gamified learning intervention. Longitudinal studies are needed to assess the sustainability of cognitive skills development over time and its impact on academic and professional success.
- Additional research is needed to explore the optimal design features, implementation strategies, and effectiveness of gamified learning interventions in diverse educational settings and subject areas.
- Further investigation is warranted to examine the differential effects of gamification on various cognitive skills and the underlying mechanisms driving these effects.

In conclusion, this study underscores the potential of gamification as a valuable educational tool for fostering cognitive skills development in higher education, particularly within specialized academic domains like Electronics and Sensors. By providing empirical evidence of its efficacy and offering insights into effective implementation strategies, this research contributes to the ongoing dialogue on innovative teaching methodologies and instructional design practices. Continued research in this area is essential to further elucidate the influence of gamification on student learning outcomes and to guide evidence-based practices in higher education.

CONCLUSION AND RECOMMENDATION

The findings of this research paper add to the expanding body of literature on the efficacy of gamification in higher education, specifically within the context of cognitive skills development among Electronics and Sensors learners. Through a comprehensive case study approach, this study has demonstrated the positive impact of gamified learning interventions on students' abilities.

The results indicate that gamification holds promise as a pedagogical tool for enhancing cognitive skills development in specialized academic domains. Participants exposed to gamified learning experiences exhibited significant improvements in cognitive skills compared to those receiving traditional instruction. These findings highlight the potential of gamification to engage students, motivate learning, and facilitate meaningful skill acquisition in technical fields such as Electronics and Sensors.

The implications of this study extend to educators, curriculum developers, and policymakers in higher education. By incorporating gamification into instructional design, educators can craft dynamic and immersive learning experiences that encourage active engagement and cultivate the development of cognitive skills. Furthermore, curriculum developers can leverage gamification approaches to enhance the relevance and applicability of course content to real-world contexts, thereby better preparing students for professional practice.

However, it is important to recognize the limitations of this study, including the case study design, sample size, and potential confounding variables. Future research should address these limitations by employing larger-scale experimental designs, longitudinal studies, and rigorous control measures to further validate the effectiveness of gamification in promoting cognitive skills development.

In conclusion, this research underscores the value of gamification as a viable educational strategy for enhancing cognitive skills development in higher education. By embracing innovative teaching methodologies and leveraging technology-enabled learning platforms, educators can empower students to actively engage in their own learning journey, equipped with critical thinking, problem-solving, and decision-making skills essential for success in the 21st-century workforce.

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APPENDIX

Pre-Course Survey

- ✓ On a scale of 1 to 5, how familiar are you with the concept of gamification?
- ✓ Have you used any gamified educational apps or platforms in the past? If yes, please specify.
- ✓ Please indicate your level of agreement with the following statements on a scale of 1 to 5, where 1 represents "Strongly Disagree" and 5 represents "Strongly Agree"
    - I feel confident in my ability to solve problems related to Electronics and Sensors.
    - I believe gamification can enhance my learning experience.
    - I am motivated to engage in gamified activities.
    - I am excited about the prospect of participating in a gamified course.
- ✓ What are your expectations regarding the incorporation of gamification into the Electronics and Sensors course?
- ✓ Are there any specific gamification elements or strategies you would like to see implemented in the course? Please elaborate.
- ✓ Do you believe gamified learning approaches can be effective in enhancing understanding and skills in Electronics and Sensors?

Post-Course Survey

- ✓ On a scale of 1 to 5, How would you rate your overall experience with the gamified learning activities implemented in this course?
- ✓ Please assess the degree to which you agree or disagree with the following statements based on your personal experience with gamification in the Electronics and Sensors course:
    - Gamification enhanced my understanding of course concepts.
    - Gamification increased my engagement with course material.
    - Gamification improved my problem-solving skills.
    - Gamification motivated me to actively participate in course activities.
    - Overall, I found gamification to be a valuable addition to the course.
- ✓ Reflecting on your experience with gamification, what aspects of the approach do you believe were most effective in supporting your learning?
- ✓ Do you believe the gamified learning approach was more effective than traditional instructional methods for enhancing cognitive skills development? Why or why not?
- ✓ In what ways, if any, did gamification influence your perceptions of the Electronics and Sensors course compared to non-gamified courses?
- ✓ What recommendations would you propose for enhancing the design and execution of gamified learning activities in future courses?

Interview Questions

A. Can you describe your overall experience with gamification in the Electronics and Sensors course?
B. How do you feel gamification impacted your cognitive skills development, particularly in problem-solving and critical thinking?
C. Did any specific gamification elements stand out to you as particularly effective or engaging? Why do you think they were effective?
D. In what ways did gamification contribute to your motivation and engagement with the course material?
E. Were there any challenges or limitations associated with the gamified approach? If so, how did you overcome them?
F. How do you perceive the value of gamification in enhancing learning outcomes compared to traditional instructional methods?
G. Based on your experience, what recommendations would you offer for improving the implementation of gamification in future courses?
H. These survey instruments and interview questions were designed to gather comprehensive feedback from participants regarding their perceptions and experiences with gamification in the Electronics and Sensors course, as well as its impact on cognitive skills development.
I. Were there any specific gamification elements or techniques that you found less effective or engaging? If so, please describe them and suggest improvements.
J. How do you think the gamified approach in this course compared to traditional teaching methods in terms of fostering collaboration and peer interaction?
K. Did you notice any differences in your motivation and engagement levels during gamified activities compared to non-gamified activities within the course?
L. Reflecting on your experience with gamification in this course, do you believe it has influenced your perception of learning and education in general? If so, how?