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# GAMIFICATION AS A TOOL FOR ENHANCING PARTICIPATION AND LEARNING IN GREEN DIGITISATION EDUCATION

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***Abstract***

*This study evaluates the students' satisfaction with gamification tools in learning sessions on green digitization across Spain, Romania, and Portugal. Graduate participants were surveyed to assess how the gaming-based system influenced engagement, learning, and motivation. Questions focused on the effectiveness of gamification in encouraging participation, the perceived value of participation awards, the correlation between game points and progress, and the impact on learning outcomes. Results indicate that students responded positively, reporting increased participation due to gamified elements, satisfaction with awards, and a clear alignment between points and game levels. Moreover, participants highlighted improved learning outcomes and a deeper understanding of course content as a direct result of the gaming system. These findings suggest that gamification can be a powerful tool in higher education for Master`s and Doctoral programs, particularly for courses addressing digital and green transformation, fostering both motivation and effective learning among graduate students from three European universities.*

***Key words****: gamification, green, learning tools.*

## INTRODUCTION

The integration of gamification into digital education has become a prominent strategy for enhancing student engagement, motivation, and learning effectiveness in higher education environments. Gamification, defined as the use of game design elements in non-game contexts, has been increasingly applied to support active learning and improve learner participation in digitally mediated instructional settings (Christopoulos & Mystakidis, 2023). Recent studies emphasize that gamified learning environments can enhance intrinsic motivation through mechanisms such as feedback loops, points systems, and progress visualization, which align with self-determination theory and flow-based learning models (Ratinho & Martins, 2023; Oliveira & Hamari, 2024). In parallel, the concept of green digitisation education has emerged as a critical interdisciplinary domain, combining sustainability literacy with the development of digital competence. This educational paradigm aims to equip learners with the skills necessary to navigate and contribute to environmentally sustainable digital transformation processes (Spilotro et al., 2026). Within this context, gamification has been proposed as a pedagogical tool capable of bridging abstract sustainability concepts with interactive and experiential learning models (Seaborn & Fels, 2015; Oliveira et al., 2023). Despite growing theoretical support, empirical evidence regarding the effectiveness of gamification in enhancing participation and learning outcomes in green digitisation education remains limited, particularly across multi-institutional European cohorts. This study aimed to evaluate the students' perceptions regarding the use of gamified educational tools, implemented across five European universities, focusing on

engagement, perceived learning, motivation, and overall satisfaction. The digital tool with gamification elements was developed to improve students' knowledge and understanding of the European Green Deal principles across European universities in the Cycle I and II programs.

## MATERIALS AND METHODS

### Study design and participants

The studies performed were based on cross-sectional survey questionnaires involving 51 doctoral and master's students from five universities:

- University of Agronomic Sciences and Veterinary Medicine of Bucharest (USAMV), Romania (PhD Biotechnologies program);
- National University of Sciences and Technology Politehnica of Bucharest (UNSTPB), Romania (Master Computer Science program);
- University Autonoma de Barcelona (UAB), Spain (PhD Biochemistry and Environment program);
- University of Porto (UPorto), Portugal (PhD Chemical Engineering and Environment program);
- Uzhhorod National University (Uzhhorod), Ukraine (Master of Computer Science program).

Each group consisted of at least 10 participants. The Survey Questionnaires were completed anonymously

### Instrument and measurement scale

Data were structured in a survey questionnaire based on a 5-point Likert scale, as follows:

1 = No, not at all;
2 = Only to a certain extent;
3 = More or less;
4 = Mostly yes;
5 = Yes, always.

The questionnaire assessed five dimensions:

A. Gamification-induced participation;
B. Perceived correlation between points and games;
C. Perceived learning improvement;
D. Course satisfaction;
E. Motivation toward digital and green competences.

### Statistical analysis

Responses were analyzed using the mean Likert scores. Statistical analysis was made applying one-way ANOVA (to assess differences across universities), with Tukey post hoc analysis to identify the differences between pairs. The value $p < 0.05$ was considered significant.

Notation:

* $p < 0.05$;
** $p < 0.01$;
*** $p < 0.001$.

## RESULTS AND DISCUSSIONS

### Gamification-driven participation across disciplinary profiles

The results from Question A indicate a pronounced heterogeneity in perceived participation enhancement induced by gamification (Figure 1). The PhD students from the biotechnology program (USAMV of Bucharest, Romania) and biochemistry/environmental sciences (UAB Spain) reported uniformly negative perceptions of participation increase, whereas computer science students (Uzhhorod University and UNSTPB Romania) demonstrated substantially higher engagement levels, feedback loops, which may enhance perceived coherence of gamified systems.

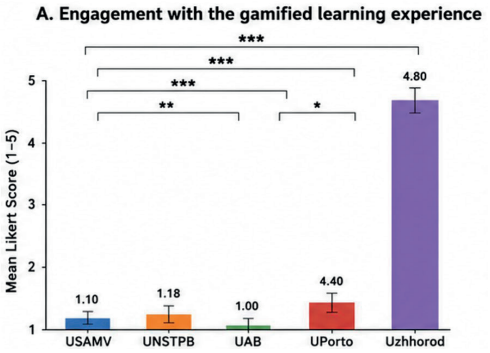



Figure 1. Engagement with the gamified learning experience of the students from USAMV, UNSTPB, UAB, UPorto and Uzhhorod

This disciplinary divergence aligns with recent findings suggesting that learners with stronger computational or systems-oriented backgrounds exhibit higher receptivity to

structured gamified environments, particularly those involving point systems and progression logic (Oliveira et al., 2025; Klock et al., 2026). Computer science students are typically more familiar with algorithmic reward structures and iterative. Conversely, students in biotechnology and biochemical engineering domains often engage in problem-based and experimental learning environments where intrinsic cognitive engagement is less dependent on external reward mechanisms. This may explain their lower responsiveness to gamified participation triggers, consistent with evidence that gamification effects are mediated by prior exposure to digital learning ecosystems (Dicheva et al., 2015). These results indicate statistically significant inter-university differences in perceived engagement (ANOVA $p < 0.05$), suggesting that gamification effectiveness is context-dependent and may be influenced by disciplinary or pedagogical culture.

**Perceived coherence of gamification mechanics (points–game alignment)**

Across all institutions, Question B (Figure 2) revealed generally positive evaluations regarding the alignment between points and game mechanics.

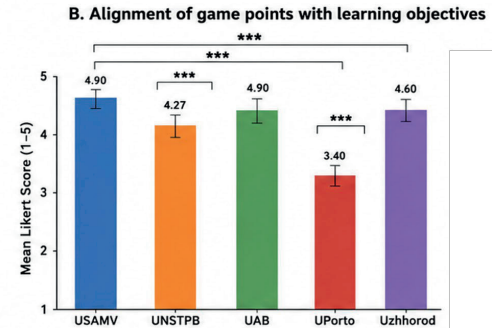



Figure 2. Alignment of the gamification tools with the learning objectives. Answers of the students from USAMV, UNSTPB, UAB, UPorto, and Uzhhorod

However, variation was observed in environmental and chemical engineering students (University of Porto), who reported lower coherence perception compared to computer science cohorts. This finding supports the argument that perceived transparency and structural clarity of gamified reward systems are critical determinants of engagement (Seaborn & Fels, 2015). In particular, students trained in computational disciplines may more easily interpret rule-based scoring systems as logically consistent, while students from life sciences or environmental engineering backgrounds may require more explicit contextual framing of gamification logic. The strong positive responses from USAMV, Uzhhorod University and UAB Spain suggest that when gamification is clearly mapped onto learning tasks, even interdisciplinary cohorts can achieve high perceived system coherence, reinforcing the importance of instructional design consistency (Seaborn & Fels, 2015; Toda et al., 2019; Rodriguez-Calzada et al., 2024).

**Perceived learning outcomes and cognitive integration**

The results for Question C (Figure 3) indicate moderate but consistent perceived learning improvements across all disciplines, with the highest scores observed in computer science students and the lowest in environmental chemical engineering students (University of Porto). This pattern may reflect differences in how gamified systems interact with domain-specific cognitive processing. In computer science education, learning tasks are often procedural and modular, which aligns naturally with gamified structures such as levels, scoring, and incremental progression. This structural compatibility enhances perceived learning gains, as supported by prior studies on gamification in STEM education (Rodrigues et al., 2022; Buenadicha-Mateos et al., 2025). In contrast, biotechnology and biochemical engineering education relies heavily on conceptual integration and experimental reasoning, which may not be directly enhanced by point-based gamification alone. As Ryan and Deci (2020) emphasize, perceived competence and autonomy are key mediators of learning motivation, suggesting that gamification must be carefully calibrated to avoid reducing complex scientific reasoning to superficial reward accumulation (Sailer & Homner, 2020; Ryan & Deci, 2020). Overall, ANOVA results indicate moderate but significant differences between institutions ($p < 0.05$), suggesting that gamification contributes to perceived learning

improvement, but with varying effectiveness across educational contexts.

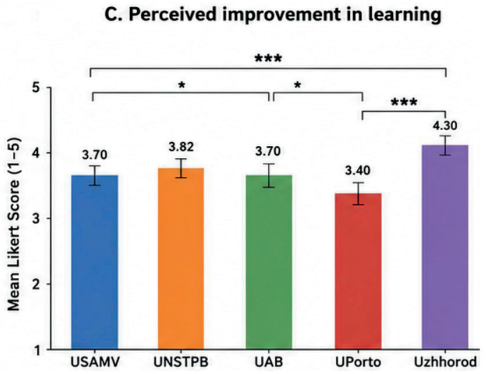



Figure 3. Perceived improvement in the learning process. Opinion of students from USAMV, UNSTPB, UAB, UPorto and Uzhhorod

## Course satisfaction as a function of disciplinary alignment

Overall satisfaction (Question D, Figure 4) was highest among computer science students and lowest among environmental chemical engineering students. This suggests that satisfaction is not only influenced by gamification design but also by disciplinary alignment between pedagogy and cognitive expectations.

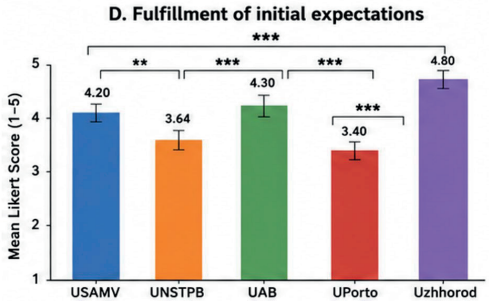



Figure 4. Students' initial expectations fulfilment at USAMV, UNSTPB, UAB, UPorto, and Uzhhorod

Gamified systems appear particularly effective when they reinforce structured problem-solving workflows, as is typical in computer science curricula. This is consistent with findings that gamification increases satisfaction when it supports goal clarity and immediate feedback mechanisms (Ratinho & Martins, 2023; David & Weinstein, 2024). However, in disciplines such as biotechnology and biochemical engineering, where learning is often exploratory and experimental, overly structured gamification may reduce perceived authenticity of learning experiences, leading to lower satisfaction despite similar instructional quality.

## Synthesis: disciplinary mediation of gamification effectiveness

Overall, the data suggest that gamification effectiveness in green digitization education is strongly mediated by disciplinary background. Computer science students consistently exhibit higher engagement, satisfaction, and perceived learning gains, likely due to cognitive alignment with structured digital systems (Question E, Figure 5).

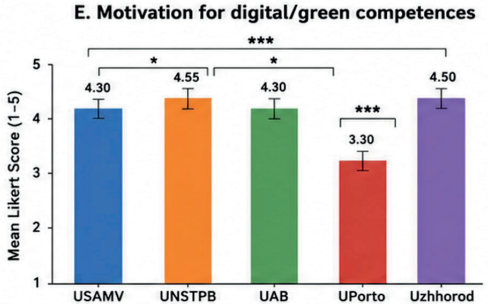



Figure 5. Motivation for digital/green competencies of students from USAMV, UNSTPB, UAB, UPorto and Uzhhorod

In contrast, biotechnology and biochemical engineering students demonstrate more selective responsiveness, indicating that gamification alone may not be sufficient to enhance engagement in domains requiring deeper conceptual reasoning or experimental interpretation. Environmental chemical engineering students occupy an intermediate position, benefiting from gamification when sustainability contexts are explicitly emphasized (Question E, Figure 5). This supports the notion that gamification is not universally effective but rather context-sensitive, requiring alignment with disciplinary epistemologies (van Roy & Zaman, 2018; Santiago et al., 2025; Klock et al., 2026). These findings reinforce the importance of adaptive

gamification design in higher education, particularly in interdisciplinary sustainability-oriented curricula. Across all five questions, a consistent pattern emerges: gamification tends to be more effective in institutions where participants report higher alignment between game mechanics and learning structure. The strongest overall effects were observed in Uzhhorod University, while the University of Porto consistently reported lower engagement and motivation scores. This heterogeneity highlights the importance of contextual factors such as disciplinary background, prior exposure to digital learning tools, and instructional design quality.

The integration of European Green Deal principles into educational processes through gamification-based tools facilitates the understanding of systemic relationships among the environment, production systems, and human well-being. In agriculture, such tools contribute to strengthening the transition toward sustainable and circular production models by simulating the impacts of resource-use decisions on soil degradation, greenhouse gas emissions, and biodiversity loss, as well as by promoting regenerative practices and the valorisation of biological residues in alignment with circular bioeconomy principles.

In the field of healthcare, gamification supports the development of an integrated One Health perspective, highlighting the interdependencies between environmental quality, food safety, and the incidence of diseases associated with ecological factors (Dima et al., 2007; Ciric et al., 2023). By incorporating game mechanics such as simulation, feedback loops, and structured progression, gamified learning environments enhance systems thinking across human, animal, and environmental health domains (Deterding et al., 2011; Ying & Wan Yahaya, 2026). Scenario-based serious games and outbreak simulations, in particular, improve engagement and facilitate applied learning in interdisciplinary contexts. Furthermore, gamified approaches contribute to the development of collaborative competencies essential for One Health practice, including cross-sector communication, coordinated decision-making, and data-driven reasoning. Such methods have been associated with improved knowledge retention and behavioral alignment in areas such as antimicrobial resistance stewardship and outbreak preparedness (Gan & Duan, 2026; van den Broek et al., 2026). However, limitations remain, including the risk of oversimplifying complex ecological systems and the potential disconnect between simulated environments and real-world operational performance. Therefore, gamification should be considered a complementary educational tool rather than a standalone methodology.

## CONCLUSIONS

This multi-university European study demonstrates that gamification can significantly enhance participation, motivation, and perceived learning outcomes in green digitization education. However, its effectiveness is not uniform across institutions and is strongly influenced by contextual and pedagogical factors. The results suggest that successful implementation of gamified learning systems requires careful alignment between game mechanics and educational objectives, as well as adaptation to disciplinary and cultural differences.

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