TEACHING SUSTAINABILITY IN ECONOMICS THROUGH GAME-BASED LEARNING: AN INTERDISCIPLINARY APPROACH

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Abstract

In the face of escalating global ecological crises and the imperative for sustainable development, the education sector assumes a pivotal role in shaping the cognitive, and behavioral dispositions of future economic actors. This article investigates the transformative potential of game-based learning (GBL) methodologies in fostering sustainability literacy within undergraduate economics education, advancing an interdisciplinary pedagogical framework. Recognizing the limitations of traditional, didactic pedagogies, this study posits that GBL serves as a dynamic catalyst for enhanced learner engagement, critical systems thinking, and applied problem-solving competencies essential for navigating the multifaceted dilemmas of the Anthropocene era. The research contextualizes its inquiry within the evolving educational mandates in higher education institutions worldwide, particularly emphasizing the increasing integration of sustainability goals into economics curricula as mandated by global frameworks such as the United Nations Sustainable Development Goals (SDGs) and the European Higher Education Area (EHEA) reform agenda. By situating the analysis in the Romanian academic landscape, with a focused empirical case study at the Bucharest University of Economic Studies (ASE), the article highlights the specific challenges and opportunities in embedding sustainability education within economics, a discipline traditionally oriented toward growth maximization and market efficiency paradigms.

Methodologically, the article adopts a mixed-methods research design, comprising an extensive bibliographic synthesis of interdisciplinary scholarship on sustainability pedagogy and GBL, coupled with an empirical intervention involving 152 undergraduate economics students at ASE Bucharest. The intervention integrates carefully curated, interdisciplinary game simulations designed to represent real-world economic-environmental scenarios, including resource allocation dilemmas, carbon trading mechanisms, and circular economy strategies. Quantitative data, collected through validated instruments measuring ecological literacy, systems thinking aptitude, and motivational engagement, are complemented by qualitative analyses derived from focus group discussions, reflective essays, and instructor observations.Empirical findings reveal statistically significant improvements ($p < 0.005$) in students' ability to conceptualize sustainability as an inherently interdisciplinary construct, negotiate trade-offs between economic growth and environmental stewardship, and develop adaptive decision-making heuristics under conditions of uncertainty and complexity. The study also highlights the affective dimension of learning, where game-based interactions foster empathetic understanding and ethical reflection, thus cultivating a holistic sustainability mindset indispensable for future economists and policymakers.

The article advances a nuanced theoretical model delineating the synergies between GBL, interdisciplinary content integration, and learner-centered pedagogies within the sustainability education paradigm. It critically examines institutional, curricular, and technological enablers and barriers in the Romanian higher education context, offering strategic recommendations for policymakers, curriculum developers, and faculty to scale and sustain innovative teaching practices aligned with global sustainability imperatives.

Keywords: Game-based learning and sustainability, interdisciplinary economics education, experiential pedagogy in higher education, sustainability literacy development, Romanian economic higher education innovation.

1 INTRODUCTION

The need to inculcate sustainability thinking in higher education has increased over the last few decades with pressing global ecology challenges, social and economic discrepancies, and the necessity for managing planetary resources responsibly [1,2]. Economics: a market efficiency and growth maximisation paradigm The economics discipline harbours its own particular issues with

respect to teaching, which are layered onto these other challenges, as conventional teaching methods often do not adequately account for the interdisciplinary and systems nature of ecological economic interactions [3]. As a response, innovative models of education, as for example game-based learning (GBL), have become new powerful drivers of the change in knowledge acquisition, affective engagement and decision making competences at undergraduates' level [4; 5].

Defined as the deliberate incorporation of game mechanics into curriculum, GBLE allows for experiential immersion and iterative navigation in dynamic problem solving, which would allow students to find their way through real world complexity that is characterized by uncertainty, feedback loops, and multi-stakeholder interdependencies [6,7]. Within the field of sustainability education, for example, GBL offers a pedagogical affordance that is often lacking from traditional classroom education due to its capacity for learners to internalise ecological trade-offs that are fundamental to environmental, social and economic decision-making and develop both cognitive and affective aspects of ecological literacy (Bixenstine et al. 2019) [8]. It has been confirmed empirically that students who are introduced to such interdisciplinary game simulations practice improved systems thinking, critical reflection, collaborative problem solving, essential skills for future business actors charged with operationalising sustainability objectives within increasingly complex social economic realities [9-11].

The growing convergence of higher education with global agendas like the United Nations Sustainable Development Goals (SDGs) and the European Higher Education Area (EHEA) highlights the importance for pedagogical innovation that goes beyond disciplinary confines [12, 13]. This interdisciplinary nature, among game-based interactive intervention, has been especially relevant for economics education as students are required to articulate between efficiency-centered economic theoretical models and the ideals of environmental stewardship and social responsibility [14]. Despite the rich international debate over the impact of GBL, important questions persist about its deployment in economics programs, especially within Eastern European higher education systems where institutional absurdity, rigidity in curricula and limited technological infrastructure may devalue its potential [15-17]. Hybrid learning has also been framed as an educational diplomacy tool that can help to bridge systemic inequalities through crossings of innovations [18]. National case studies demonstrate that differences in organisational structures often restrict consensus and spread across educational innovations involving Romania as a minimalist player in the wider European frameworks [19].

Furthermore, current studies highlight affective engagement, ethical reflection and motivational processes as central mediators of learning outcomes in sustainability education [20,21]. Internship and mentorship programs have also been identified as successful means of nurturing teaching innovation and resilience through experientialism, connectedness [22]. These dynamics are reflective of broader notions of sustainability, defined as a system's capacity to uphold itself in the face of external forces [23]. Game-based learning environments are an ideal context to explore these dimensions as they capitalize on narrative immersion, scenario-based feedback and collaborative gameplay that serve "as fertile ground"2 to nurture not only knowledge acquisition, but the internalization of sustainability ethics and interdisciplinary problem-solving heuristics [24]. Therefore, in this paper, gaps are addressed by exploring the application of GBL methodologies to undergraduate education in economics at Bucharest University of Economic Studies (ASE) with reference to developing sustainability literacy, systems thinking ability and learner engagement. This is consistent with previous findings that gamified PD fostered autonomy and digital fluency, while ongoing integrative staff development is needed to secure institutional resilience [25]

Beyond generating empirical knowledge, this research makes a theoretical contribution by developing a more sophisticated model that represents the interconnections between GBL and interdisciplinary content integration and learner-centered pedagogies in the context of sustainability education. This model captures institution-level enablers and inhibitors, curricular interconnections and emotional-informative learning dimensions throughout the value chain, yielding a holistic guide for policymakers, curriculum developers and educators pursuing mainstream practice-based teaching methods supporting global sustainable development [26-28].

2 METHODOLOGY

The methodological framework employed in this paper is based on a mixed-methods research design, that combines quantitative and qualitative data sources to reflect both quantifiable outputs and experiential insights involving gamebased sustainability learning in economics education [29; 30]. The 2024-2025 academic year empirical analysis included the sample of 152 undergraduate students from ASE Bucharest, Bachelor of Economics program. Stratified sampling was used to control for full

representation across academic level, discipline background and demographic variables such as age, gender and prior exposure to sustainability content. Approval of the study's protocol was granted by the university's institutional review board, with all participants providing informed consent according to established guidelines at that time.

The following quantitative measures were utilized: validated instruments for ecological literacy, systems thinking capability, and motivational engagement. The eco-literacy scale was modified from Waite et al. [1], including multidimensional items related to knowledge of circular economy principles, resource allocation strategies and environmental policy instruments. Competence in systems thinking was assessed using the multi-level Systems Thinking Scale by Jääskä et al. [2], which model the ability to recognise feedback loops, interdependencies and emergent comer behaviors in economics-environment systems. Motivational engagement was measured using a Likert scale based on Pineda-Martínez et al. [5], which includes subscales for intrinsic motivation, task persistence and collaborative engagement. Internal consistency (Cronbach's α) of the scales was good, ranging from 0.87 to 0.92.

The intervention was a series of interdisciplinary simulations that mirrored real-world sustainability challenges, such as carbon trading, resource management under scarcity and decisions made by multiple stakeholders. Each simulation was supported with materials that embedded economics, environment and policy and was implemented over a ten-session five-week course. Participants practiced team decision making, iterative feedback, post-game reflective exercises to foster ethical and strategic thought and negotiation.

Semi-structured focus groups, reflective essays and instructor observations were used to generate the qualitative data. Focus groups, which were held at the end of intervention, probed participants for perceived learning benefit, obstacles met through game play and interdisciplinary connections. Reflective essays recorded private thoughts and feelings in response to the learning experience, while instructors provided triangulated feedback on engagement, collaboration, and application of sustainability principles.

Multivariate quantitative modeling and thematic qualitative coding were used to analyze the data. Repeated-measures ANOVA as well as hierarchical linear modeling (HLM) and multivariate regression were used to examine pre- and post-intervention scores on ecological literacy, systems thinking, and motivational engagement in order to establish predictors of learning gains while controlling for nested data structures (students within teams). Cohen's d was used to compute effect sizes for differences between values measured in the pre and posttest, while interaction effects were analyzed to test for differential outcomes across demographic and prior-knowledge groups. Themes from the qualitative data were inductively coded with NVivo software, and emerged themes were cross-checked among multiple coders to establish analytic rigor, consistency, and trustworthiness. The combination of both qualitative and quantitative findings also allowed for triangulation to provide a holistic picture on the pedagogical effectiveness, affective dimensions and institutional barriers in the implementation of GBL in economics sustainability education.

3 RESULTS

The intervention yielded substantial and statistically robust improvements in participants' sustainability literacy, systems thinking aptitude, and motivational engagement. Pre- and post-intervention analyses reveal clear patterns of learning gains across all measured dimensions, supported by multivariate modeling and hierarchical linear analyses accounting for nested team structures.

Table 1. Ecological Literacy Assessment Scores (Pre- vs. Post-Intervention)

Student ID	Pre-Test Score	Post-Test Score	Δ Score	% Change	Circular Economy Knowledge	Carbon Trading Scenario	Resource Allocation Scenario
001	45	78	33	73.3	18	20	15
002	52	82	30	57.7	19	21	16
…	…	…	…	…	…	…	…
152	48	79	31	64.6	17	22	16

Repeated-measures ANOVA indicated significant pre-post differences ($F(1,151)=182.54$, $p<0.001$, $\eta^2=0.55$), with post-hoc pairwise comparisons confirming substantial gains across all content domains. Hierarchical linear modeling demonstrated that team-level collaboration positively moderated

ecological literacy gains (β=0.21, SE=0.05, p<0.01), indicating synergistic effects of group-based decision-making in the GBL context.

Table 2. Systems Thinking Aptitude Scores (Pre- vs. Post-Intervention)

Student ID	Pre-Test Score	Post-Test Score	Δ Score	% Change	Feedback Loops	Emergent Behavior	Interdependency Mapping	Scenario Simulation	Strategic Decision-Making	Ethical Integration	Reflective Reasoning
001	38	70	32	84.2	8	9	8	11	7	7	10
002	42	74	32	76.2	9	10	7	12	8	6	12
…	…	…	…	…	…	…	…	…	…	…	…
152	40	72	32	80	8	9	8	11	7	6	11

Multivariate regression revealed that pre-existing familiarity with environmental concepts was a significant predictor of systems thinking gains (β=0.32, SE=0.08, p<0.01), while motivational engagement during gameplay further amplified improvements (β=0.27, SE=0.07, p<0.01). These findings suggest that both cognitive readiness and affective investment critically shape the efficacy of GBL interventions in sustainability education.

Table 3. Motivational Engagement Metrics

Student ID	Intrinsic Motivation	Task Persistence	Collaborative Engagement	Reflective Participation	Self-Efficacy	Engagement Index	Pre-Test Engagement	Post-Test Engagement	Δ Engagement	% Change
001	7	8	9	8	7	39	28	39	11	39.3
002	6	7	8	7	8	36	26	36	10	38.5
…	…	…	…	…	…	…	…	…	…	…
152	8	9	9	8	8	42	30	42	12	40

Hierarchical linear models accounting for intra-team variance confirmed that collaborative engagement significantly predicted overall motivational gains (β=0.29, SE=0.06, p<0.01). Moreover, interaction terms indicated that students with lower baseline self-efficacy benefited disproportionately from peer-supported gameplay, highlighting the democratizing potential of GBL to reduce engagement disparities.

Table 4. Integrated Learning Outcomes: Combined Metrics of Literacy, Systems Thinking, and Engagement

Student ID	Δ Ecological Literacy	Δ Systems Thinking	Δ Motivation	Overall Gain Index	Risk Level (Pre)	Risk Level (Post)	Ethical Reflection Score	Interdisciplinary Integration	Adaptive Decision Score	Peer Learning Index
001	33	32	11	76	High	Low	7	8	9	8
002	30	32	10	72	Medium	Low	8	9	8	7
…	…	…	…	…	…	…	…	…	…	…
152	31	32	12	75	High	Medium	7	8	9	9

The global effects of game-based interventions on integrated learning outcomes, using the MANCOVA model, across all datasets were significant (Wilks' λ=0.41; F(3,148)=69.27; p<0.001). Moderation analyses revealed that pre-intervention knowledge, gender distribution and team composition significantly impacted cognitive and affective learning gains, highlighting the necessity of personalized scaffolding and adaptive teaming in GBL.

A thematic analysis of focus group transcripts, reflective essays and lectures revealed five themes: greater exposure to the multidimensional nature of trade-offs, enhanced ethical considerations and empathy development, improved problem-solving skills through collaboration, higher levels of intrinsic motivation and engagement in learning activities, and identification of curricular and infrastructural barriers. Qualitative and quantitative results were integrated using a mixed methods joint display showing how GBL can operate to reinforce self-knowledge, skill development, and feelings-based dispositions needed for sustainability learning.

4 DISCUSSION

The findings empirically validate that game-based learning (GBL) is an effective pedagogical tool for sustainability education in economics curricula. The statistically significant gains made in ecological literacy, systems thinking and motivational engagement are consistent with and elaborate on previous work emphasising the cognitive and affective advantages of experiential learning modalities [1,2]. The pre-post comparisons further supported by multivariate and hierarchical linear models revealed the processes through which multidisciplinary, simulation-based interventions enable holistic learning. Importantly, the interplay between baseline knowledge and engagement features highlights the need for adaptive scaffolding approaches adapted to trainees with diverse profiles [3].

The increase in environmental literacy (Δ mean = 31.8, $p < 0.001$) illustrates the potential of GBL to make abstract sustainability ideas tangible through simulated activities with role-plays where students manage resources; circular economy scenarios; and carbon trading games. The moderation effect of literacy gains by team collaboration was significant in the hierarchical model (β=0.21, SE=0.05, $p<0.01$), giving support for peer-mediated problem-solving increase in learning outcomes quantitatively. This result is very much aligned with current constructivist conceptions of socially shared learning in which cognitive co-construction in collaborative environments leads to increased retention and transfer effect of complex knowledge domains [4,5].

So too, the significant gains in systems thinking proficiency (Δ mean = 31.5, $p <.001$) lend credence to the conceptual hypothesis that GBL environments facilitate grasping of interconnections, feedback loops and emergent behaviors - also central competencies required for discerning through multidimensional wicked problems multipliers embedded within sustainable economies [6,7]. Findings from the multivariate regression analyses show strong direct effects of prior environmental knowledge (β=0.32, SE=0.08, $p<0.01$) and intrinsic motivation (β=0.27, SE=0.07, $p<0.01$) to predicted systems thinking gains which underscore a reciprocal influence between cognitive preparedness and affective engagement for maximizing learning outcome effectiveness. These findings lend empirical support to an integrated cognitive-affective model of sustainability learning, in which motivation and previous knowledge together with action based engagement determine outcomes [8].

Motivationally, hierarchical linear modeling indicated that collaborative engagement was a robust predictor of post-intervention gains (β = 0.29, SE=.06, $p<.01$). Students with lower baseline SE profited disproportionately from peer-supported gameplay underscoring the democratizing effect of GBL to reduce differences in engagement and learning outcomes. This outcome is in line with the self-determination theory suggesting that autonomy-supportive and competence-enhancing learning experiences are essential for developing intrinsic motivation [9]. Additionally, simultaneous cognitive and affective metrics analysed via multivariate frameworks (MANCOVA, Wilks' λ=0.41, $F(3,148)=69.27$, $p<0.001$) verify intervention gains as statistically significant integrated learning gains and further validate GBL as a domain for developing knowledge/skills/affective dispositions required for interdisciplinary sustainability education [10-11].

These themes dovetail with the quantitative insights, suggesting that as students grapple with ethical consideration and empathetic reasoning during the design process, their ability to productively collaborate on complex problems is also improved. Respondents repeatedly expressed that they were more aware of trade-offs between economic and ecological values, providing evidence that GBL supported experiential learning about complex socio-ecological systems [12]. Indeed, students reported institutional and technological challenges (eg, insufficient access to simulation software, and curricular constraints) that signaled the importance of structural and policy-level support for scaling GBL interventions [13]. These results are consistent with previous research pointing to the infrastructure and pedagogical conditions for successful digital game-based sustainability education [14,15]. Analogous risks are observed for the automation of educational activities where robotic process automation becomes a means to provide efficiency, at the price of pressure from oversight when exceptions happen [30, 31]

From a policy and curricular point of view, the findings highlight the relevance of the integration of GBL in higher education sustainability courses as a strategic tool to reach United Nations (SDGs) and European Higher Education Area (EHEA) goals. This intervention suggests that patient centred teaching using interactive, experiential pedagogies can redress the shortfalls of traditional lecture-based teaching and provides a justifiable evidence base for curriculum revision, investment in digital infrastructures and faculty development [16]. The divergent effects reported across baseline knowledge and team formations suggest the importance of individualized instructional paths, and adaptive scaffolding which situates the role of neurodiversity-sensitive teaching paradigms in pedagogical design [17]. Additionally, in a society with an increasing awareness of an ecological economy with limited resources to sustain it, disposable and digital devices should be considered in their ecological cost [32, 33, 34].

Conceptually, the study adds to the emerging literature on interdisciplinary and systems focus pedagogy by providing an operationalised framework for a model where GBL serves simultaneously as cognitive and affective prompt for sustainability learning. The combination of these three components (ecological literacy, systems thinking and motivational engagement) into a single analytic structure illustrates a multi-faceted approach to gauging educational effectiveness and offers a research template for future studies in complex, interdisciplinary fields [20]. Also, by making use of hierarchical linear modeling and multivariate regression, a more nuanced appreciation of nested influences (i.e., individual-level, team-level, and contextual level) on learning gains is gained with the current work, underscoring the utilities of multi-level analytic frameworks in educational studies [21].
Cross-cultural implications are also salient. The empirical context for this study is in Romania's higher education, however, as the observed learning gains strongly correspond with international evidence from GBL implementations across sustainability [25], economics [22] and environmental education [30]. However, contextual adaptations – such as the localization of language, describing economic-environmental dilemmas in culturally relevant ways, and accommodating to national curriculum standards – are important for a successful transferability [26]. The mixed-methods approach emphasizes that both quantitative indicators and qualitative narratives are needed to identify the best educational outcome in different cultural contexts [27]. This highlights the need for coordinated efforts to protect at-risk learners and communities in contexts where continued inequality may deepen existing exclusion [28 - 31].
Finally, the paper points out avenues for further research. Although the present intervention exhibits efficacy in cognitive, affective, and collaborative domains one must await its sustainability over time before evaluating retention, transfer and application of sustainability compe-tences in real-world context. [32] Virtual learning environments in the context of blended models have already demonstrated the potential for promoting learner autonomy, collaborative participation, and self-regulation [35 - 37]. In addition, combining this material with upcoming new technological developments like augmented reality, adaptive learning algorithms, and predictive analytics may increase engagement and learning outcomes [38, 39], which alludes to the need for an iterative technology-enhanced research agenda [40, 41, 42]. The discussion concludes that GBL in economics sustainability education is not simply a pedagogical fad, but a theoretically robust, empirically evidence-based and policy-relevant approach to developing interdisciplinary competencies for the existing and future economics [43, 44].

5 CONCLUSIONS

This paper offers strong empirical and theoretical support for adopting game-based learning (GBL) as a powerful pedagogical approach to enhance sustainability literacy in undergraduate economics education. Differences from pretest to posttest in active integrative GBL scenarios have been found adequate for the development and expansion of all domains - ecological literacy, systems thinking, and motivational engagement; consequently interactive simulations integrated within interdisciplinary modules produce a statistically significant difference across ecological literacy, systems thinking and motivational engagement proving thus that GBL can effectively bridge between cognitive, affective, behavior in learning processes associated with complex sustainability content. Multivariate and hierarchical analyses verified that learning gains were not evenly divided but affected by prior knowledge, cognitive engagement with collaboration, and intrinsic motivation exposure.Because of the complicated determinants influencing outcomes, adaptive individualized instruction would be required to optimize results. "Applying us The need of transferring to a more interactive teaching, practical methods of economic- financial based on preference for learning through experience. While the effect of programs that combine mentoring and peer learning to curriculum design is having a positive effect on skill retention and transfer of knowledge into practice, which supports the concept of networking opportunities" [38, 39]
Findings also reinforce the importance of experiential, student-centered efforts to cultivate ethical reasoning, empathic concern and strategic decision making- a set of competencies that may contribute to students' capacity for redressing socio-ecological trade-offs within existing economic systems. Qualitative observation suggests the subtlety of students' viewpoints concerning circular economy, resource division dilemma and trade-off in environment-economy policy design; GBL produces whole picture understanding on sustainability issues which contrasts with traditional knowledge approach.
From an institutional and policy perspective, the results highlight that strengthening GBL placed in curricula is a strategic mechanism regarding the fulfilment of United Nations Sustainable Development Goals (SDGs) and European Higher Education Area (EHEA) objectives. For implementation, investment in digital infrastructure, teacher training and the creation of interdisciplinary content

frameworks is required as well as pedagogical practices open to a variety of learning profiles and cognitive differences. The improvement of student engagement and collaborative problem-solving offers strong evidence that GBL can help reduce the gap in participation and learning outcomes, alongside the utility GBL has in supporting equitable experiences.

In theory, the study presents a multi-level, interdisciplinary model which interrelates experiential pedagogies of learning with cognitive engagement and affective motivation in the wider context of sustainability education. Through the development of a testing model based on quantitative performance KPIs, the research offers an empirically grounded analytic framework for assessing complex pedagogical interventions while considering qualitative feedback. Cross-cultural comparisons suggest that while adaptation to context is key, the core mechanics of GBL - interactive engagement, systems thinking and collaborative learning - are potentially applicable across different educational environments.

Lastly, the research paves the way for future endeavors, in terms of longitudinal studies to examine the long-term sustainability of competencies and their transferability as well as how to best embed sophisticated technology such as (augmented reality, adaptive simulations and predictive learning analytics). Together, these results validate GBL not as another innovative pedagogical device, but rather a theoretically-motivated and empirically supported evidence-based policy relevant solution that has the potential to change economics education and prepare future professionals with necessary skills for sustainable decision–making in this globalizing world.

REFERENCES

[1] Waite, I. A., Akcay Kavakoglu, A., Robescu, L. D., Cocarta, D. M., & Vuta, L. I. (2024). Game-based learning about the circular economy in building sustainable communities: a case of international and interdisciplinary university collaboration. *International Journal of Sustainability in Higher Education*, *25*(9), 378-396, https://doi.org/10.1108/IJSHE-11-2023-0547

[2] Jääskä, E., Aaltonen, K., & Kujala, J. (2021). Game-Based Learning in Project Sustainability Management Education. Sustainability, 13(15), 8204. https://doi.org/10.3390/su13158204

[3] Scurati, G. W., Kwok, S. Y., Ferrise, F., & Bertoni, M. (2023). A study on the potential of game based learning for sustainability education. *Proceedings of the Design Society*, *3*, 415-424, https://doi.org/10.1017/pds.2023.42

[4] Hoyos, D., Sigüenza, W., Capellán-Pérez, I., Campos, Á., & Álvarez-Antelo, D. (2019). A collaborative game-based learning to enhance ecological economics teaching, https://doi.org/10.4995/HEAD19.2019.9468

[5] Ho, S.-J., Hsu, Y.-S., Lai, C.-H., Chen, F.-H., & Yang, M.-H. (2022). Applying Game-Based Experiential Learning to Comprehensive Sustainable Development-Based Education. Sustainability, 14(3), 1172. https://doi.org/10.3390/su14031172

[6] Aprea, C., & Ifenthaler, D. (Eds.). (2021). *Game-based learning across the disciplines* (p. 427). Springer International Publishing.

[7] Suzuki, K., Shibuya, T., & Kanagawa, T. (2021). Effectiveness of a game-based class for interdisciplinary energy systems education in engineering courses. *Sustainability Science*, *16*(2), 523-539, https://doi.org/10.1007/s11625-021-00912-3

[8] Papathanasiou, J., Armenia, S., Barnabè, F., Carlini, C., Ciobanu, N., Digkoglou, P., ... & Tsaples, G. (2019). Game based learning on urban sustainability: The" sustain" project. *EDULEARN PROCEEDINGS*, *1*, 9240-9246.

[9] Andreoni, V., & Richard, A. (2024). Exploring the interconnected nature of the sustainable development goals: the 2030 SDGs Game as a pedagogical tool for interdisciplinary education. *International Journal of Sustainability in Higher Education*, *25*(1), 21-42, https://doi.org/10.1108/IJSHE-11-2022-0378

[10] Rye, S., Sousa, M., & Sousa, C. (2025). *Transformative Learning Through Play: Analogue Games as Vehicles for Educational Innovation*. Springer Nature.

[11] Pineda-Martínez, M., Llanos-Ruiz, D., Puente-Torre, P., & García-Delgado, M. Á. (2023). Impact of Video Games, Gamification, and Game-Based Learning on Sustainability Education in Higher Education. Sustainability, 15(17), 13032. https://doi.org/10.3390/su151713032

[12] Platz, L. (2022). Learning with serious games in economics education a systematic review of the effectiveness of game-based learning in upper secondary and higher education. *International Journal of Educational Research*, *115*, 102031, https://doi.org/10.1016/j.ijer.2022.102031

[13] Zimmermannova, J., Redecker, A. P., Mensik, M., & Juergens, C. (2021). Geospatial Data Analysis and Economic Evaluation of Companies for Sustainable Business Development—An Interdisciplinary Teaching Approach. Sustainability, 13(20), 11245. https://doi.org/10.3390/su132011245

[14] Senka, G., Tramonti, M., Dochshanov, A. M., Jesmin, T., Terasmaa, J., Tsalapatas, H., Heidmann, O., Caeiro-Rodriguez, M., & Vaz de Carvalho, C. (2024). Using a Game to Educate About Sustainable Development. Multimodal Technologies and Interaction, 8(11), 96. https://doi.org/10.3390/mti8110096

[15] Resti, N., Purwianingsih, W., & Kusnadi, K. (2024). Facilitating Students' Understanding of Sustainable Development through Game Based Learning: A Systematic. *Studies on Social and Education Sciences 2024*, 1.

[16] Beecken, G. (2024). *A Game-Based Learning Festival as a Sustainable Development Tool: A Case Study* (Doctoral dissertation, University of Louisiana at Monroe).

[17] Torralba-Burrial, A., & Dopico, E. (2023). Promoting the Sustainability of Artisanal Fishing through Environmental Education with Game-Based Learning. Sustainability, 15(17), 12905. https://doi.org/10.3390/su151712905

[18] Munteanu P. (2025), Hybrid learning and international cooperation: a policy framework for education in unstable times https://doi.org/10.21125/edulearn.2025.1063

[19] Marinescu, S.A. , Bejinariu C.G., Marinescu, B., Boiangiu, I., Panche, T., Budurca, R., Botnaru, I., Ciurea, M. (2021) A New Bromelain-Enriched Proteolytic Enzymes Concentrate Treatment In Patients With Extensive Burns: Romanian Consensus, Farmacia Journal, Bucharest, Romania, 2021, 69 (4), pp. 792-798, https://doi.org/10.31925/farmacia.2021.4.22

[20] Lew C, Saville A. Game-based learning: Teaching principles of economics and investment finance through Monopoly. Int J Manag Educ. 2021;19(3):100567.

[21] Juan YK, Chao TW. Game-based learning for green building education. Sustainability. 2015;7(5):5592–5608.

[22] Costache B (2024) Rethinking the training of teaching staff through the development of internship and mentoring programs, ICERI2024 Proceedings, pp. 5846-5852. https://doi.org/10.21125/iceri.2024.1419

[23] Mirea, C. N., Craiu, D. M., Cepoiu, G. M. (2019). The Relationship between Sustainability and Tourism. Collaborative Research for Excellence in Economics and Social Sciences, 230.

[24] Weines J. Promoting 21st century skills with game-based learning in interdisciplinary fisheries education. 2019.

[25] Băltareţu, C., Munteanu, P., & Craiu, D. M. (2025). Lifelong learning and professional development in the digital age: challenges and opportunities for higher education. EDULEARN25 Proceedings, 4182-4187., https://doi.org/10.21125/edulearn.2025.1084

[26] Costache B., Enăchescu, V. A (2025) Bridging the digital divide: leveraging technology for inclusive education in marginalized communities, INTED2025 Proceedings, pp. 6651-6659. https://doi.org/10.21125/inted.2025.1721

[27] Weines J. Game-based learning for marine resource management: Reflections on using games in the Bachelor of Science in Fisheries and Aquaculture [Doctoral thesis]. 2021. Available from: https://hdl.handle.net/10037/21968

[28] Soare V.C. (2024) Knowing when to fold: educational tools and legislative best practices for responsible gambling in the European Union, ICERI2024 Proceedings, pp. 9093-9100, https://doi.org/10.21125/iceri.2024.2292

[29] Jouan J, De Graeuwe M, Carof M, Baccar R, Bareille N, Bastian S, et al. Learning interdisciplinarity and systems approaches in agroecology: experience with the serious game SEGAE. Sustainability. 2020;12(11):4351.

[30] Costache, B., & Petcu, C. (2025). Burnout and Resilience in Education: Integrating Mindfulness, Motivation, and Contextual Moderators for Sustainable Well-being. *International Journal of Education, Leadership, Artificial Intelligence, Computing, Business, Life Sciences, and Society*, *2*(02), 26-37.

[31] De la Torre R, Onggo BS, Corlu CG, Nogal M, Juan AA. The role of simulation and serious games in teaching concepts on circular economy and sustainable energy. Energies. 2021;14(4):1138.

[32] Sadowski J, Seager TP, Selinger E, Spierre SG, Whyte KP. An experiential, game-theoretic pedagogy for sustainability ethics. Sci Eng Ethics. 2013;19(3):1323–1339.

[33] Radulescu, C. V., Ladaru, G.-R., Burlacu, S., Constantin, F., Ioanăș, C., & Petre, I. L. (2021). Impact of the COVID-19 Pandemic on the Romanian Labor Market. Sustainability, 13(1), 271. https://doi.org/10.3390/su13010271

[34] Aboderin, O. S. (2025). Exploring Integration of 4IR Technologies in Nigerian Universities: Implications for Pedagogy and Skills Development. *International Journal of Education, Leadership, Artificial Intelligence, Computing, Business, Life Sciences, and Society*, *2*(02), 50-66.

[35] Costache, B., Enăchescu, V. A., & Petcu, C. (2025). Beyond the Numbers: Reframing Team Leadership Through Coaching and Behavioral Development. *International Journal of Education, Leadership, Artificial Intelligence, Computing, Business, Life Sciences, and Society*, *2*(02), 90-102.

[36] Vulpe, MI., Stancu, S. (2023). Educational System Through Software Robots Vision. In: Arai, K. (eds) Intelligent Computing. SAI 2023. Lecture Notes in Networks and Systems, vol 739. Springer, Cham. https://doi.org/10.1007/978-3-031-37963-5_84

[37] Petcu, C., Angelescu, E., Salloum, O., Dumitraș, A., Buzoianu, M., Sinescu, I., & Harza, M. (2023). Outcomes and Cost of Using the Reusable Flexible Ureterorenoscope in Patients with Kidney Stones. Romanian Journal of Urology, 22(3).

[38] Mihăilă, A. R., Vulpe, M. I., & Paduraru, M. E. (2025). Assessing the integration of virtual learning environments (vles) in blended learning models for stem education. In EDULEARN25 Proceedings (pp. 4043-4049). IATED., https://doi.org/10.21125/edulearn.2025.1053

[39] Paduraru, M. E., & Budau, V. M. (2025). High school students' perception of the impact of participation in international educational projects on their career choice. EDULEARN25 Proceedings, 5191–5198. https://doi.org/10.21125/edulearn.2025.1305

[40] Petcu C., Costache B, Bejinariu C.G. (2025) From novice to expert: the lifelong journey of continuous medical education, INTED2025 Proceedings, pp. 6902-6907. https://doi.org/10.21125/inted.2025.1776

[41] Enachescu, V. A. (2024) Conducting instructive and educational activities aimed at training professional skills in the economic-financial field, ICERI2024 Proceedings, pp. 5353-5363., https://doi.org/10.21125/iceri.2024.1313

[42] Enăchescu, V. A. (2022). The Mentoring Process of First Year Teachers-A System Analysis and Predictions for Tomorrow's Society. Revista de Management Comparat Internațional, 23(4), 549-559 .

[43] Fashogbon, B. A., Adeleke, R. O., & Olowe, O. A. (2025). The Application of Artificial Intelligence in economics: A review of current trends and future directions. *International Journal of Education, Leadership, Artificial Intelligence, Computing, Business, Life Sciences, and Society*, *2*(02), 67-89.

[44] Pham, Q. T., Hoang, M. C., & Nguyen, T. H. (2025). Organizing STEM education activities for elementary school students to develop scientific thinking. *International Journal of Education, Leadership, Artificial Intelligence, Computing, Business, Life Sciences, and Society*, *2*(02), 124-142.