

Digital Games and Climate-Crisis Education: An Analytical Study of DOMINO: “The Little One” through Serious Games, Persuasive Games, and Ecological Literacy

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Abstract

The climate crisis constitutes not only an environmental emergency but also a fundamental communication and pedagogy problem, as traditional environmental education often fails to convert knowledge into sustained action—a gap widely recognised as the 'knowledge-behavior gap'. Digital games, with their capacity for experiential learning and complex socio-ecological system simulation, offer a promising pedagogical avenue to address this disconnect. Adopting a systems-oriented analytical lens, this study examines the design affordances of the digital game *DOMINO: The Little One* for fostering climate-crisis awareness through an integrated framework combining serious games, procedural rhetoric (persuasive games), and ecological literacy. Employing an interpretive qualitative single-case design, the Windows version was analysed across five hours of structured gameplay using observation notes and screen recordings, with data subjected to theory-driven content analysis. Findings reveal that the game concretises climate risks via visual metaphors and resource-constraint feedback loops, effectively supporting systems thinking and causal reasoning. However, its procedural rhetoric predominantly frames climate action as individual responsibility, marginalising structural and political-economic drivers. Crucially, as no player-participant data were collected, conclusions are restricted to pedagogical design features rather than demonstrated learning outcomes. This systems-oriented analysis offers transferable insights for sustainability education, particularly in tourism contexts where climate vulnerability and systemic interdependence are paramount.

JEL Classification: I23, I25, O33, Q54, Q56, Z13

1. INTRODUCTION

The climate crisis is no longer merely a physical phenomenon confined to scientific data; it is also a complex communicative and educational problem that needs to be conveyed to broad segments of society (Fjællingsdal & Klöckner, 2019, p. 2846; Becklas & Baumann, 2024). Traditional environmental education models, with their knowledge-transfer-based approaches, often fail to convert theoretical knowledge into concrete behavioral change, a structural limitation commonly referred to as the “knowledge-behavior gap” (Kollmuss & Agyeman, 2002; Moser, 2010). In overcoming this gap, digital games offer a potential that goes beyond traditional methods through their experiential learning processes and capacity to simulate complex systems (Czauderna, 2025).

Although research on climate-oriented serious games has expanded, comparatively less attention has been given to how the internal design architecture of such games constructs environmental meaning across multiple pedagogical and rhetorical dimensions. This analytical gap is particularly relevant for understanding how games can support environmental decision-making under conditions of complexity and uncertainty—a core concern of systems-oriented research (Grieger et al., 2019). Existing studies frequently evaluate games through player outcomes, engagement, usability, or learning effects, whereas fewer studies examine the game as an analytical object in its own right by systematically connecting its mechanics, narrative structures, persuasive procedures, and ecological-literacy affordances.

This distinction is important because the educational potential of a serious game is not equivalent to its demonstrated educational effectiveness. A game may contain affordances for systems thinking and reflection, even without empirical evidence that players acquire these outcomes. The present study addresses this analytical gap by examining DOMINO: The Little One through an integrated framework combining serious-game pedagogy, persuasive-game theory and procedural rhetoric, and ecological literacy.

In particular, DOMINO addresses systemic complexity and individual responsibility within an interactive narrative (Galeote & Hamari, 2021). Through its interactive structure, grounded in serious games and persuasive games, it enables users to internalize multidimensional phenomena such as climate change by experiencing them (Flood et al., 2018; Galeote et al., 2021). At this point, *DOMINO: The Little One* positions itself not merely as an entertainment tool but as a distinctive pedagogical instrument that aims to make sense of the abstract nature of the climate crisis through concrete game mechanics (Gerber et al., 2021; Galeote, 2023).

The game's ability to simulate the interdependence among ecosystems and the environmental consequences of human activities provides players with direct experience in influencing complex systems and assuming responsibility (Neset et al., 2020). In this regard, the fact that *the game is an example of the 'cli-fi' genre* in digital games, treating the climate crisis as an interdisciplinary area of struggle, necessitates academic investigation (Abraham & Jayemanne, 2017). Most existing studies in environmental education remain limited to small-scale pilot experiments with restricted capacity to raise awareness (Fjællingsdal, 2025). As Linkov et al. (2014) argue, addressing complex environmental challenges requires a systems view that emphasizes the interconnectedness of human, technological, and environmental systems. Digital games, by simulating these interconnections, offer a promising pedagogical avenue for fostering such systems thinking in climate-crisis education. This systems-oriented perspective is further reinforced by the work of Collier, Linkov, and Lambert (2014), who emphasize that effective climate change decision-making must explicitly account for uncertainty and multi-stakeholder trade-offs. They advocate for decision-analytic tools that can integrate diverse forms of knowledge and values—a requirement that aligns closely with the procedural and experiential affordances of digital games. In this regard, serious games can be understood not merely as communication devices but as participatory platforms for navigating the inherent complexities and normative dimensions of climate governance.

The relevance of this inquiry extends beyond formal environmental education to encompass sustainable tourism education—a domain in which the knowledge-behaviour gap is particularly pronounced (Scott, Hall, & Gössling, 2012; 2016). Digital games offer a promising avenue for addressing this gap through experiential learning. By examining how DOMINO operationalises climate awareness, this study offers transferable insights for tourism-specific serious games (*see Supplementary Material SM-1 for a detailed discussion*).

DOMINO: The Little One expands this limited literature with the potential of gamified simulations, embodying complex environmental dynamics within an emotional and cognitive interaction space (Galeote et al., 2023a, 2023b; Hadi & Kurniawan, 2025). This makes it valuable to examine how the game moves from a passive learner position in environmental education to an “active agent” model that develops a deep understanding of system functioning (Muenz et al., 2023, p. 293; Chen et al., 2024). Given the direct effects

of climate change on the tourism sector (Scott et al., 2012) and tourism's contribution to the climate crisis, the potential use of such games in tourism education is noteworthy. Accordingly, the research seeks answers to the following questions:

1. How do the game's narrative, visual representation, and mechanics frame the climate crisis?
2. What pedagogical affordances does the game offer in terms of serious games and procedural rhetoric criteria?
3. How does the design support the knowledge, systems thinking, affective, and action-orientation dimensions of ecological literacy, and where does it fall short?

2. THEORETICAL FRAMEWORK

2.1. Climate-Crisis Communication and Environmental Education

The complexity of the environmental and social consequences of climate change on a global scale triggers a communication crisis in which traditional communication strategies prove inadequate in conveying the message to the recipient (Shliakhovchuk et al., 2025). Traditional approaches often fail to explain non-linear climate dynamics, creating a cognitive disconnect (Ouariachi et al., 2018; Tosun, 2024). In contrast, experiential and transformative learning approaches can transform the distant relationship individuals have with this crisis into a participatory sense of responsibility by concretizing complex ecological systems through gamified simulations (Biçen et al., 2025; Araújo et al., 2024). At this point, game-based learning, through automatic feedback mechanisms, directly simulates the cause-and-effect relationship between players' actions and environmental outcomes, thereby activating critical thinking skills (Reis & Baptista, 2025).

This process allows participants to observe their effects on ecological systems through simulations, enabling them to internalize the global repercussions of their individual actions more concretely (Novaes et al., 2023, p. 321; Kaiser & Mittelberger, 2026, p. 217). This transformative process facilitates the conversion of ecological responsibility from passive knowledge into an active set of values by allowing players to experience the direct effects of their decisions in the virtual world on ecosystems (Galeote et al., 2022). In this respect, the game serves as an effective pedagogical catalyst in closing the "knowledge-behavior gap" that is felt in environmental education (Temur & Uslu, 2025, p. 33; Ferreira et al., 2024, p. 293).

Especially these tools, which simulate climate-society dynamics and decision-making under uncertainty in an interactive format, strengthen individuals' critical thinking capacities regarding environmental issues, enabling them to develop a more conscious decision-making mechanism (Faranda et al., 2025; Brakovska et al., 2024). This interactive process systematically develops systems-thinking skills that support players' shift from short-term individual goals toward collective strategies for a sustainable future (O'Garra et al., 2021, p. 1; Irabor et al., 2025). In this context, games function as dynamic laboratories that move players beyond passive observation and encourage deep reflection on environmental dilemmas (González-Robles & Vázquez-Vílchez, 2022, p. 3; Larreina-Morales & Gunella, 2023, p. 1932). This experiential potential becomes

particularly salient when considering the cross-scalar and cross-border nature of climate impacts. Groundstroem and Juhola (2019) provide a systematic framework for analysing how climate-induced changes in one sector or region can propagate across geographical and institutional boundaries, creating cascading risks that defy simplistic local solutions. Their systems approach underscores the need for educational interventions that cultivate not only awareness of immediate environmental feedbacks but also the capacity to trace distal consequences and interconnected vulnerabilities—a competence that digital games, through their rule-based simulations and multi-level feedback loops, are uniquely positioned to foster.

2.2. Serious Games and Game-Based Learning

Serious games differ from traditional digital games whose primary purpose is entertainment, focusing instead on integrating learning objectives into a systematic design process to produce concrete pedagogical outcomes such as knowledge transfer, attitude change, and behavioral transformation (Tan & Nurul-Asna, 2023). Interaction and instantaneous feedback loops enable players to observe the consequences of their interventions on complex environmental variables across the ecosystem, thus developing systems-thinking competencies (Bartolomé-Quevedo et al., 2025).

The pedagogical value of a serious game is therefore closely related to the way its game elements translate abstract environmental processes into playable experiences. This issue is particularly important in climate-change education, where the complexity and temporal scale of climate processes can make conventional information-based communication difficult to translate into meaningful learning experiences. Razali et al. (2022), for example, developed and expert-validated a guideline comprising specific game design elements for climate-change serious games, demonstrating the importance of deliberately integrating educational and game-design considerations rather than treating the game format itself as sufficient for learning. Such a design-oriented perspective supports the present study's decision to examine the internal architecture of DOMINO: “The Little One”—including its mechanics, feedback structures, choices, consequences, and environmental representations—as an analytical object.

In contrast to the knowledge-centered approach of traditional education methods, these experiential processes offered through serious games help students grasp the complex interconnections among the environmental, social, and economic dimensions of sustainable development from a holistic perspective (Roba et al., 2021, p. 2). In this context, games support the construction of a lasting sustainability mindset by establishing an iterative learning environment where players continuously evaluate their actions within complex systems and reflect on their decision-making processes (Fabricatore & López, 2012; Mochizuki et al., 2020, p. 102205).

Furthermore, this interactive environment functions as a process of “self-analysis” that allows players to question their environmental values and transform their real-world behaviors, aligning with the core objectives of effective environmental education (Mercer et al., 2017, p. 365). Such a design serves as a pedagogical bridge that enables players to go beyond an entertainment-focused experience and internalize sustainable development goals in a meaningful context (Borges & Neves, 2023, p. 3). In this scope, serious

games function as a comprehensive toolset that enables the internalization of intricate concepts such as sustainable energy management and circular economy through simulated realistic scenarios (Mendicelli & Terenzio, 2025).

Recent research increasingly conceptualizes climate-oriented serious games as designed communication and learning environments rather than merely as alternative information-delivery tools, particularly in addressing the persistent gap between climate knowledge and adaptive action. Razali et al. (2022), for example, developed and validated a set of game-design elements specifically for climate-change serious games, emphasizing the deliberate integration of educational content with game mechanics. Similarly, Sillanpää et al. (2024) examined *Minions of Disruptions™*, a collaborative climate-adaptation game, by comparing designers' intentions with participants' perceptions of its design and highlighting the importance of collaboration, accessibility, and the alignment between game-design elements and climate-adaptation communication.

Related research on the same game further suggests that serious gaming can reduce psychological distance from climate adaptation and foster a sense of agency among participants, although further research is needed to determine whether such effects persist beyond the gameplay experience (Sillanpää et al., 2024). Taken together, these studies suggest that climate-oriented games should be examined not only in terms of their measurable learning or attitudinal outcomes but also in terms of how their design architecture communicates climate-related meanings and creates conditions for experiential engagement. Building on this design-oriented perspective, the present study examines a digital climate game through the complementary lenses of serious-game pedagogy, persuasive game theory, procedural rhetoric, and ecological literacy.

In tourism education, the relevance of serious games is particularly pronounced because many competencies required in the sector involve decision-making under conditions of uncertainty, resource constraints, stakeholder interdependence, and competing sustainability objectives. Existing research has demonstrated that serious games can be integrated into tourism higher education to support the development of professional competencies, while digital and immersive technologies have also been used to enrich tourism interpretation and visitor experiences (Almeida et al., 2021; Elshahawy et al., 2023). These studies suggest that the educational value of game-based technologies in tourism cannot be reduced to entertainment or engagement. Rather, their value lies in the possibility of creating experiential environments in which complex tourism-related problems can be explored through interaction, feedback, and consequence-based decision making. From this perspective, examining how a climate-oriented game constructs ecological relationships and responsibility is relevant not only to environmental education but also to the development of sustainability-oriented learning resources for tourism education.

2.3. Persuasive Games and Procedural Rhetoric

Persuasive games generate meaning not through textual or visual rhetoric alone, but through the systemic rules and mechanics that players experience directly—an approach Bogost (2007) terms *procedural rhetoric*. In this framework, the game's operational logic becomes an argumentative device, encoding value positions

and ethical claims within constraints, rewards, and feedback loops (Coakley et al., 2015; Wang & Li, 2026). When applied to environmental themes, procedural rhetoric enables players to confront the ethical weight of resource scarcity, pollution, and ecosystem degradation through their own in-game choices, thereby rendering visible the socio-ecological costs of alternative actions (Ouariachi et al., 2018; Torre et al., 2025). For further elaboration on the historical development of procedural rhetoric and its distinction from gamification, see Supplementary Material SM-4.

The player, facing limited resources and environmental constraints, is forced to maintain or disrupt an ecological balance, thereby directly experiencing the ethical weight of their actions on the system (Ouariachi et al., 2018). This process allows the causal links within the game to restructure the player's real-world environmental perceptions, transforming persuasive rhetoric into cognitive change (Tanenbaum et al., 2013). In this direction, persuasive games are positioned as significant tools with the potential to transform socio-cultural structures, turning the player not only into a user but into an ethical agent responsible for the future of the ecological system (Yıldırım, 2014, p. 658).

2.4. Ecological Literacy

Ecological literacy is defined as the competence to understand and evaluate the functioning of natural systems, the interdependence among living organisms, and the long-term effects of human activities on the biosphere. This competency area is based on enabling individuals to analyze ecosystem processes through systems thinking, comprehending the complex networks between humans and nature, and developing sustainable action capacities (Mao, 2025). In this context, digital games offer a procedural learning space that allows players to discover cause-and-effect relationships by modeling the complex functioning of ecosystems through rules and feedback loops (Gardeli et al., 2017, p. 153403).

Particularly, players who witness the destruction of nature in the virtual world are likely to develop more sensitive attitudes toward the environment through these simulations, thus supporting sustainable behavioral change in the real world (Ho et al., 2022, p. 215; Paul, 2025). In this way, games transform players from passive observers into proactive “environmental change agents,” integrating ecological citizenship awareness with action competence (Chang & Parham, 2017, p. 12; Georgiou et al., 2023). In this process, the acquisition of ecological literacy increases individuals' awareness, knowledge, and sensitivity about ecosystem functioning, laying the groundwork for developing concrete solutions to problems such as environmental pollution (Erciş & Türk, 2016, p. 8).

In this framework, ecological literacy defines the dynamic relationship among knowledge, beliefs, and behaviors concerning human-environment interactions, enabling individuals to establish sustainable relationships with ecosystems (Okay et al., 2022, p. 2853). Accordingly, DOMINO: The Little One provides players with the opportunity to experience the long-term consequences of their actions on the system's future by concretizing the fragility of ecological systems through visual and auditory indicators (Situmorang et al., 2024, p. 8).

2.5. Integrated Analytical Model

This study combines the educational structure of serious games, the procedural rhetoric of persuasive games, and the core competencies of ecological literacy within a single analytical framework to examine the capacity of digital games to create environmental awareness through a multi-layered model (Rebecchi et al., 2024, p. 10; Dmitriyev & Karimova, 2025). This model matches the systemic constraints offered by game mechanics with the pedagogical outcomes of serious games, while making the impact of persuasive rhetoric on player attitudes measurable through ecological literacy components (Iwendi et al., 2025; Paul, 2025). Instead, ecological literacy is used as an analytical lens through which the game's design is examined.

The framework therefore connects three complementary levels of analysis: the pedagogical affordances of serious games, the meaning-making and value orientation produced through persuasive game mechanics and procedural rhetoric, and the ecological-literacy dimensions represented or enabled by the game's narrative, rules, choices, feedback mechanisms, and environmental consequences. This approach allows the study to identify what the game is designed to make perceptible, thinkable, and potentially discussable without making claims about what players actually learn, feel, or do after gameplay. Thus, the game is transformed from a mere medium for environmental knowledge transfer into an interactive learning laboratory where the player develops proactive responsibility and ethical commitment (Escudeiro et al., 2022, p. 686).

This integrated approach establishes a direct bridge between the experiential learning processes provided by in-game simulations and ecological responsibility awareness, thereby theoretically explaining the impact of individual decision-making mechanisms on environmental sustainability (Hamdan et al., 2023; Arslan & Karakuş, 2024). This analytical model conceptualizes digital games as potential cognitive and persuasive learning environments in which knowledge transfer, reflection, and environmental value formation may be embedded within game mechanics. Importantly, these potential outcomes are treated here as pedagogical affordances rather than empirically demonstrated changes in players' attitudes or behaviors (Janakiraman, 2020; Iwendi et al., 2025). Thus, this study blends the pedagogical and rhetorical power of digital games with an interdisciplinary perspective in addressing the inherent complexity of sustainability education (Santos et al., 2018).

This coordinated structure integrates the pedagogical competence of serious games with the behavioral transformative power of persuasive rhetoric, embedding the core components of ecological literacy into the structural elements of the game (Janakiraman et al., 2018). In this way, the experiential process constructed through game mechanics creates a systematic intervention area that transforms cognitive awareness about environmental sustainability into lasting behavioral change (Dochshanov et al., 2023; Torre et al., 2025). This model places the player's in-game choices within an ethical framework, systematically enabling the transfer of digital experience to real-world decision-making processes (Silva & Barata, 2024). This integrated framework emphasizes that game design is not only a technical process but also a pedagogical intervention that deepens environmental awareness and promotes sustainable behaviors (Costin et al., 2024).

This integrated framework operationalises the three analytical dimensions—serious-game pedagogy, persuasive-game rhetoric, and ecological literacy—through a structured set of indicators, as summarised in Table 1. The table delineates how each dimension translates into specific analytical questions, observable in-game indicators, and the interpretive boundary that distinguishes design affordances from claimed learning outcomes. This heuristic device ensures analytical consistency throughout the coding process by clarifying what constitutes evidence of pedagogical design versus evidence of player learning, a distinction that is methodologically critical for the present study's design-oriented focus (Mochizuki et al., 2020; Razali et al., 2022). The framework thus serves as both an analytical guide for the qualitative content analysis and a reflexive tool for maintaining the study's interpretive boundaries.

[Insert Table 1 here]

3. METHODOLOGY

3.1. Research Design and Case Selection

The research is an interpretive qualitative single-case study. The case examined is *DOMINO: The Little One*, a free, single-player, hand-drawn 2D adventure game developed by LÖRN (2023) and released on November 23, 2023, which places the climate crisis and ecological destruction at the center of its main narrative. The selection of the case was determined by the climate theme being not merely decorative but central to the narrative and gameplay, as well as the game's accessibility in both Turkish and English.

This research is designed as an instrumental single-case study aiming to deeply understand a digital game's design potential for climate-crisis awareness (Stake, 1995). The study is grounded in the interpretive phenomenological tradition, which assumes that social reality is constructed through intersubjective meaning-making processes (Merriam & Tisdell, 2016). This paradigmatic stance allows the researcher to interpret the game's narrative, mechanics, and visual elements by considering the subjective and contextual dimensions of player experience.

3.2. Data Generation and Units of Analysis

The Windows version of the game was examined in three sessions totaling five hours. The first session was allocated to identifying the overall narrative and gameplay flow; the second to recording environmental cues and mechanical feedback; and the third to re-checking codes and deviant cases. The data set consisted of structured observation notes, screen recordings, and in-game textual/visual records. The units of analysis were scene, task, dialogue/narrative segment, environmental cue, choice point, mechanical constraint, success/failure condition, and feedback loop.

3.3. Coding and Analysis Process

Directed qualitative content analysis was applied. Initial codes were derived from the literature on serious games (*learning objective, task, trial-and-error, feedback*), persuasive games (*choice-consequence link, procedural claim, reward/punishment, value orientation*), and ecological literacy (*ecological knowledge, interdependence, systems thinking, affective proximity, and action orientation*). After the initial coding,

overlapping codes were merged, open coding was performed for cases that did not fit the framework, and the entire data set was reviewed a second time. Since the study was conducted by two researchers, inter-coder reliability was assessed by having 20% of the total data set (16 coding units) independently coded by both researchers, and the agreement was calculated using Cohen's Kappa coefficient (Cohen, 1960).

The analysis yielded a Kappa value of $\kappa = 0.83$, indicating an “almost perfect” level of agreement according to Landis and Koch's (1977) classification. In cases of coding disagreements (e.g., units 7 and 13), the researchers discussed until a consensus was reached and revisited code definitions. This process aimed to enhance the objectivity and reliability of the findings (Lincoln & Guba, 1985). Coding details, including the full coding scheme, MAXQDA procedures, and analytical traceability, are available in Supplementary Material SM-3.

3.4. Trustworthiness, Ethics, and Limitations

Analytical traceability was supported by clearly defining data units and coding criteria, comparing different sessions, and grounding findings directly in game features. As the research involved no human participants, personal data, or intervention, no ethics committee approval was required. The findings are limited to a single game, a single platform version, and the interpretations of the researchers. Therefore, the study does not claim that players experienced changes in learning, attitudes, or behaviors. Future research is advised to cover different platform versions and a broader player population.

To enhance the credibility of the research, the researchers engaged in prolonged engagement with the data by playing the game in three different sessions, thus capturing nuanced meanings across various stages of the game (Lincoln & Guba, 1985). To strengthen transferability, the game's features, analytical units, and coding process were reported in detail, enabling readers to compare the study with their own contexts. Additionally, all observation notes, screen recordings, and coding decisions were digitally archived and stored for confirmability. These strategies aim to demonstrate that the researchers' interpretations are grounded in the data and free from personal bias (Shenton, 2004).

The researchers are active advocates on the climate crisis and are aware that this may affect the analysis and interpretations of the game. To minimize this bias, reflexive strategies such as systematic coding procedures, negative case analysis, and researcher journaling were employed (Berger, 2015). Furthermore, all coding decisions were verified with data sources to ensure that personal value judgments did not reflect on the analysis process.

4. FINDINGS

4.1. Narrative and Visual Representation of the Climate Crisis

DOMINO: The Little One, rather than presenting ecological destruction merely as a statistical data set, combines spatial changes in the character's living environment with a dramatic narrative pattern to concretize the environmental crisis. The game's visual indicators transform the climate crisis into a palpable

reality for the player by depicting destroyed ecosystems and settlements suffering from resource scarcity. This visual narration makes the abstract and long-term effects of climate change visible through the constraints of the character's daily life, creating an emotional connection in the player regarding the vulnerability of the system (Kaiser & Mittelberger, 2026, p. 231).

These spatial transformations allow the player to directly observe the environmental consequences of their strategic decisions, thereby reducing the global effects of climate change to an individual experiential level (Ouariachi et al., 2017, p. 210). This visual language offered by the game increases the player's causal mastery over the process by concretizing the complexity of large-scale problems such as climate change through the character's encounters with limited resources and environmental destruction (Galeote et al., 2021; Shliakhovchuk et al., 2025). Thus, the spatial collapse depictions in the game's narrative background evolve the climate crisis from a merely theoretical concept for the individual into an urgent crisis awareness requiring ecological responsibility (Galeote, 2023; Jubair, 2025).

In this context, the game blends the character's survival struggle with the ecological imbalances caused by climate change, positioning the player not merely as an observer but as an active agent responsible for this fragile future (Moosdorff & Vervoort, 2026). This experience offered by the game frees the climate crisis from an "unrepresentable" complexity and functions as a powerful communication tool that directs the player's imagination and strategic competence toward ecological solutions (Woolbright, 2017, p. 88). This narrative strategy offered by the game concretizes the measurable impact of individual actions on global climate systems, creating a simulation experience that strengthens the player's sense of collective responsibility (Makai, 2024).

Especially considering that environmental problems are generally perceived as spatially and temporally distant, the game's local-scale visualizations shorten this distance, concretizing the invisible effects of the climate crisis (Schroth et al., 2014). This visual and narrative concretization builds an "imagination bridge" that enables the player to perceive climate change not as a distant future projection but as an immediate crisis requiring direct intervention (Woolbright, 2017). Through this narrative structure, the game translates the abstract and psychologically distant effects of climate change into tangible losses within the character's everyday life, thereby enhancing players' sensory and cognitive engagement with environmental issues and reframing the climate crisis not merely as a scientific problem but as an emotionally resonant experiential narrative that can evoke a stronger sense of responsibility toward systemic change (Galeote et al., 2023a, 2023b; Galeote et al., 2024; Shahu et al., 2024).

Thus, while reducing complex environmental processes to an experiential narrative, the game reduces the psychological distance the player has with climate change, thereby triggering motivation for action (Zhou et al., 2024, p. 14). At this point, game design successfully manages the balance between threat perception and reinforcement, positively transforming the player's cognitive attitudes toward environmental issues (Daiiani et al., 2024a; Daiiani et al., 2024b).

Nevertheless, the high level of interaction offered by the game models the impact of human action on ecological systems, examining the delicate balance between individual responsibility and systemic realities (Makai, 2024). This structure offers players direct intervention opportunities at points where traditional

knowledge transfer proves insufficient, transforming climate change from an abstract phenomenon detached from daily life into a concrete area of responsibility (Steinhauser et al., 2026; Zhou & Lc, 2025). This process concretizes the risk perception created by climate change, helping the player reduce psychological distance and perceive environmental threats as more real and urgent experiences (Beek et al., 2022). In this context, game design forces players to confront the long-term effects of the climate crisis while facilitating future-oriented perspective-taking, thereby increasing interest in and empathy for environmental discussions (Muradova & Beauvais, 2025).

4.2. Construction of the Learning Experience through Game Mechanics

The game offers a systemic learning space that allows players to comprehend environmental changes through an experiential process (Hadi & Kurniawan, 2025). The game's dynamic feedback mechanisms concretize the immediate or delayed effects of the player's strategic moves on the ecosystem, bringing problem-solving skills into a practical context (Bjørner & Schoenau-Fog, 2024). Especially in-game simulations offer players the opportunity to experience decision-making and discussion processes in the face of complex environmental problems, strengthening cognitive and affective learning outcomes (Fischer et al., 2024, p. 2). This continuous feedback loop provided by the game allows players to optimize their problem-solving strategies regarding ecological issues through trial-and-error, thus constructing an active and lasting experiential learning process rather than passive transfer of knowledge (Carrillo-Nieves et al., 2024, p. 2; Gigante et al., 2025). This mechanical structure enables players to experience the strategic importance of individual decisions in ecological balance as concrete data through curated choices and instantaneous feedback (Czauderna, 2025). Thus, the game encourages the player toward a critical mindset regarding climate action processes in a simulation environment where time is manipulated and immediate outcomes are made visible (Czauderna, 2025).

The trial-and-error processes offered by the game, unlike traditional educational tools, enable players to gain control over complex climate models by adopting an emotionally triggered "*learning by doing*" model (Pérez-Fernández et al., 2019, p. 1030). In this context, the interactive feedback loops offered by the game enable players to observe the long-term effects of their strategic choices in high-uncertainty processes such as climate change, making possible a "double-loop" learning experience (Mochizuki et al., 2020, p. 102211).

4.3. Procedural Rhetoric and Environmental Responsibility

The procedural rhetoric of the game connects the player's decisions directly with environmental consequences, transforming ecological literacy from merely theoretical knowledge into action-based value transfer (Gedikkaya, 2022, p. 591). This structure establishes a direct causal link between individual preferences and systemic environmental changes through choice-and-consequence mechanics, helping the player internalize the ecological responsibility created by their actions (Brakovska et al., 2024).

Thus, this interactive model, built on the functioning of complex climate-energy systems, allows players to discover the long-term environmental consequences of their own decisions, thereby fostering a critical awareness of system dynamics (Rooney-Varga et al., 2019; Miani et al., 2025). In this process, the game forces the player to make certain environmental choices, functioning as an ethical decision mechanism that

simulates the effects of decisions on the ecosystem (Faranda et al., 2025). Through these mechanics, the game makes sustainability visible in relation to in-game gains and losses, allowing the player to perceive environmental issues not merely as something they observe but as a system of which they are a part (Ali, 2025; Farias et al., 2026).

This situation serves as a “procedural pedagogy” that, through the rules of the game, instills in the player that maintaining environmental balance is not merely a technical necessity but an ethical responsibility (Torre et al., 2025). By experiencing these scenarios offered by the game, the player understands that environmental problems are not merely scientific data sets but the result of value-based choices (Neset et al., 2020; González-López et al., 2025). Thus, the game places uncertainties about the climate crisis within a manageable framework, transferring the connection between the player’s actions and the construction of the collective environmental future to a tangible level of consciousness (Schaik, 2023). This configuration creates a rule-based rhetoric that directly integrates the value systems coded by the designer into the user’s experience, triggering attitudinal changes regarding sustainability (Coakley et al., 2015; Backe, 2018, p. 2). This procedural functioning enables players to perceive climate change not as an inevitable phenomenon but as a process shaped by their own strategic choices and requiring responsibility, thus establishing a strong bridge between individual behaviors and global ecological outcomes (Iwendi et al., 2025; Chang et al., 2025). In this direction, the game places the player in a strategic actor position, offering a dynamic simulation universe that deepens ecological literacy (Capellán-Pérez et al., 2019; Bjørner & Schoenau-Fog, 2024).

4.4. Dimensions of Ecological Literacy

In this context, the game establishes a holistic connection among the core components of ecological literacy—knowledge, affect, and behavioral tendencies—by moving the climate crisis from the conceptual level to the implementation stage (Cogo & Gualdi, 2021). Particularly, the direct association of in-game actions with environmental impacts allows participants to analyze their ecological footprints with concrete data and internalize sustainable living practices (Romano et al., 2022, p. 236). Thus, the game provides the skill to read environmental problems through complex system dynamics while reconstructing the player’s beliefs and behavioral models along the axis of sustainability, functioning as a powerful pedagogical tool (Paul, 2025; Bărbulescu et al., 2026).

At this point, the narrative and mechanical structure offered by the game allows players to question the reflections of their individual choices on the ecological system from an experiential perspective, revealing the critical importance of the interaction between values and evidence in combating climate change (Stoeth & Carter, 2022). Additionally, through different climate scenarios presented to players, the game optimizes social learning opportunities, developing adaptation capacity and social responsibility awareness in the face of complex environmental problems (Flood et al., 2018). Particularly simulation-oriented tasks such as sustainable energy management and resource consumption make the impact of individual choices on the ecosystem visible, thereby increasing users’ environmental literacy levels (Novaes et al., 2023, p. 321). Thus, digital games evolve from mere theoretical knowledge transfer into an applied learning platform that internalizes the functioning of complex ecological systems and sustainability principles (Goynov et al., 2025).

4.5. Educational and Persuasive Limitations

Despite this strong pedagogical framework offered by the game, oversimplifying the complexity of the climate crisis into a merely mechanical causal loop may lead to the neglect of the structural and political dimensions of the problem (Galeote & Hamari, 2021). This may cause players to perceive the climate crisis merely as a technical problem solvable through managing in-game variables, potentially superficializing their comprehension of the macro-scale socio-economic dynamics behind the problem. Moreover, the transfer of this awareness gained in the virtual environment to everyday real-life behaviors faces significant limitations due to the disconnection between the controlled simulation universe offered by the game and the complexity of the external world (Hognon et al., 2026). In this context, the '*gap between emotional engagement and sustainable resilience*'—that is, between the emotional engagement provided by digital games and the goal of developing sustainable climate resilience—arises from the lack of structural supports beyond the in-game experience (Xu et al., 2026).

While virtual experiences are effective tools for demonstrating the urgency of environmental problems, the direct applicability of in-game strategies remains limited in the face of the complex and unpredictable variables of the real world (Pressick-Kilborn et al., 2018, p. 5). This makes it difficult for the environmental awareness provided by digital games to translate into concrete behavioral change in the real world, where structural barriers and individual habits are far more dominant (Vuong et al., 2021, p. 101531; Boncu et al., 2022).

Consequently, at the stage of transitioning from ecological sensitivity gained through the game to action, environmental complexities, social constraints, and structural challenges often trap this awareness in an "*intention-behavior inconsistency*" (Bilbay, 2024, p. 17; Situmorang et al., 2024, p. 8). Indeed, when motivational gains from in-game simulations lack structural and pedagogical support mechanisms, they generally remain at a superficial level of awareness rather than transforming into sustainable climate resilience.

Therefore, in order to fully exploit the potential of digital games, game experiences need to be supported by pedagogical curricula and in-game outcomes need to be linked with structural obstacles in external reality (Fjællingsdal, 2025; Xu et al., 2026). At this point, for the experiential learning opportunities offered by games to influence real-world environmental decision-making, simulations need to be blended with deeper reflective tools that support individuals' cognitive and emotional capacities (Chen et al., 2024; Chuang et al., 2025, p. 2). In this context, the cognitive, emotional, and attitudinal effects of in-game experiences on real life need to be evaluated using more systematic methods to enable the environmental awareness provided by digital games to evolve into lasting behavioral change (Hognon et al., 2026). In this context, by examining how the affordances offered by the game interact with real-world constraints and negative perceptions, a more holistic pedagogical model that can close the "knowledge-behavior gap" is proposed (Janakiraman, 2020).

Table 2 synthesises the principal findings of the analysis by mapping in-game indicators onto their corresponding theoretical dimensions while articulating the cautious inferences warranted by the study's design-oriented approach. The table distils the five thematic clusters identified through the coding process—

visual concretisation, choice and feedback mechanisms, trial-and-error learning, representation limits, and the predominance of individual responsibility—and aligns each with the theoretical constructs of persuasive games, serious-game pedagogy, and ecological literacy. This mapping reveals that while the game's procedural rhetoric effectively renders ecological interdependence perceptible through choice-consequence mechanics and affective visual metaphors, its narrowing of climate complexity to individual behavioural frames may simultaneously obscure the structural and political-economic drivers of environmental degradation (Galeote & Hamari, 2021; Mochizuki et al., 2020). By organising the findings in this manner, Table 2 provides a concise analytical bridge between the empirical observations and the theoretical framework, facilitating a systematic discussion of the game's pedagogical affordances and limitations.

[Insert Table 2 here]

5. DISCUSSION

The findings of this study offer several theoretical and practical insights that extend beyond the mere description of the game's features. From a theoretical standpoint, the integrated analytical model—combining serious games, persuasive games, and ecological literacy—proves to be a robust heuristic for deconstructing how digital games can function as multi-layered pedagogical interventions. The game's procedural rhetoric, particularly its use of choice-consequence mechanics, exemplifies how rule-based systems can encode environmental values and foster systems thinking without resorting to didactic instruction (Bogost, 2007). Moreover, the game's visual and narrative concretization of abstract climate threats resonates with research on emotional engagement and risk perception, suggesting that affective pathways are as critical as cognitive ones in driving pro-environmental intentions (Rooney-Varga et al., 2019; Swim et al., 2011). Practically, the study underscores the importance of embedding feedback loops that reveal both immediate and delayed consequences of player decisions—a design feature that can be directly translated into classroom-based environmental simulations and even corporate sustainability training programmes. However, the identified limitation of the game's narrow focus on individual responsibility also highlights the need for future designs to incorporate systemic and structural dimensions of climate change, such as policy frameworks and collective action, thereby avoiding the risk of promoting a simplistic, consumer-centric view of environmental solutions (Galeote & Hamari, 2021; Mochizuki et al., 2020).

The central contribution of this study is analytical rather than evaluative. Rather than demonstrating that gameplay produces measurable changes in climate knowledge, attitudes, or behavior, the study identifies how these possibilities are encoded within the game's design. The analysis shows that DOMINO: The Little One brings climate-related processes into the player's perceptual field through narrative, visual representation, resource constraints, choice-consequence relationships, and feedback loops. These features constitute pedagogical and persuasive affordances because they create opportunities for systems thinking, causal reasoning, reflection, and environmental value formation. Whether such affordances translate into measurable learning or behavioral outcomes remains an empirical question requiring participant-based research. This distinction is particularly important in the context of recent scholarship calling for more rigorous evaluation of serious games for climate education, where the existence of an educational design does not in itself constitute evidence of its effectiveness (Hognon et al., 2026).

The experience provided by DOMINO: The Little One directly parallels the challenge of “*transfer*” in serious games literature—the difficulty of transferring learning from the game environment to the real world (Hoffmann & Pfeiffer, 2021, p. 476). Nevertheless, to enhance the game’s pedagogical success, strengthening the mechanics that present the direct and long-term reflections of the player’s choices on environmental systems with a more transparent causal link would fortify the bridge to real-world applications (Fjællingsdal & Klöckner, 2017, p. 1098; Stanitsas et al., 2018, p. 934). In this context, designing game mechanics not merely around problem-solving but also around transforming collective responsibility and social norms in the real world could deepen the educational impact of persuasive games (Mosca et al., 2024, p. 1234367; Stevens et al., 2024, p. 637).

Furthermore, supporting the in-game experience with structured reflection processes and discussion sessions after the game could increase players’ capacity to transfer the system knowledge they acquire into real-life environmental behaviors (Foltz et al., 2019, p. 10; Irabor et al., 2025). When games are approached from such a holistic perspective, they can move beyond being mere entertainment content to function as powerful “*communities of practice*” that reshape individuals’ attitudes toward the complex ecological processes of the real world by engaging cognitive processes that align players’ attitudes and motivations with real-world practices; accordingly, designers and educators should conceptualize such games not merely as knowledge-transfer tools but as experiential structures that foster meaningful connections between learning, motivation, and real-world action (Yamori, 2008, p. 90; Ferreira et al., 2024, p. 301). With this approach, by enabling players to relate their in-game experiences to real-life environmental challenges, the potential for lasting behavioral change can be concretized (Larreina-Morales & Gunella, 2023, p. 1932; Celestine et al., 2025). Thus, the game transcends being merely an environmental disaster simulation, transforming into a dynamic learning platform where players confront the consequences of their actions within complex systems and gain motivation for pro-environmental behaviors (Ho et al., 2022, p. 215; Tan & Nurul-Asna, 2023).

In this context, designers’ structuring of game mechanics to foreground the player’s environmental responsibility makes the complex structure of the climate crisis more understandable while positively influencing participants’ attitudes and behaviors regarding sustainability (Ouariachi et al., 2017, p. 210; Iwendi et al., 2025). Furthermore, strengthening the cognitive, emotional, and behavioral dimensions offered by the game within a systematic framework could raise players’ awareness of climate actions to a more conscious level, thereby increasing their motivation for environmental activism (Ouariachi et al., 2018).

The findings suggest that the game's strongest aspect is its construction of the climate crisis through playable constraints and visual metaphors rather than explanatory texts, a result consistent with the foundational assumption of procedural rhetoric that claims are produced through rules. However, translating systemic environmental dynamics into playable mechanics inevitably involves choices about which variables to foreground and which to simplify. Marcellin et al. (2024) recently demonstrated, in the context of water-energy-infrastructure systems, that even well-calibrated simulations can obscure critical feedback loops if the underlying resource interdependencies are not adequately represented. Their analysis highlights the importance of explicitly modelling scarcity, trade-offs, and time lags—design features that DOMINO partially implements but could further develop to avoid reducing climate complexity to a set of individual

behavioural levers. This resonates with the broader critique that procedural rhetoric, however powerful, remains inherently selective and must be complemented by reflective debriefing to counteract oversimplification. The emphasis on individual behavioural change over structural factors in the game's design echoes broader debates in environmental decision-making about the relative importance of agency versus systemic constraints in achieving sustainability outcomes (Groundstroem & Juhola, 2019). However, the narrative's focus on individual choices pushes structural dimensions of the climate crisis—such as production regimes, energy policies, inequality, and climate justice—into the background. Therefore, the game should be evaluated not as a stand-alone instructional material for classroom use but as an introductory text supported by discussion, comparative source reading, and reflective activities. For a detailed discussion on the implications for sustainable tourism education, including case examples and critical reflections on transferability, see Supplementary Material SM-1.

These findings reveal the potential of game-based approaches in increasing climate-crisis awareness and suggest that similar mechanisms could be applied in the context of sustainable tourism. The tourism sector is both a significant contributor to and one of the most affected sectors by climate change (Scott et al., 2016). Therefore, enhancing the climate literacy of personnel working in tourism enterprises and tourists is critical for the sector's long-term sustainability. The procedural rhetoric and feedback loops used in *DOMINO: The Little One* can be adapted to develop environmental responsibility awareness in tourism destinations. For instance, simulations regarding water and energy consumption in a holiday resort could help tourists make more conscious decisions about resource use (Font & McCabe, 2017). Moreover, systems-thinking skills gained through games could contribute to tourism planners' development of climate-change adaptation strategies (Becken & Hay, 2007).

The findings of this study resonate with emerging research on the role of digital technologies in shaping collective perceptions of cultural and environmental heritage. In a recent investigation, Çetin, Islak, Çınar, Hassan (2026) employed a mixed-methods approach integrating visual semiotic analysis and NLP-based sentiment classification to examine how social media narratives represent three major heritage sites in Ankara, Turkey—Hamamönü, Ankara Castle, and the Museum of Anatolian Civilizations (Çetin et al., 2026). Their study revealed that user-generated content not only reflects but also actively constructs place identities, with Hamamönü being predominantly framed through traditional architecture and gastronomic experiences, Ankara Castle through archaeological and spatial dimensions, and the Museum through educational and interactive values. Sentiment analysis further indicated significant polarisation, with overwhelmingly positive sentiment toward museum experiences juxtaposed with critical discourses on infrastructure and visitor management at the castle site. Although their study focused on heritage communication rather than climate-crisis awareness, the parallels with our findings are instructive. Just as social media analytics can guide evidence-based strategies for sustainable cultural heritage communication, the procedural rhetoric and feedback mechanisms identified in *DOMINO: The Little One* can inform the design of digital interventions that foster environmental responsibility and systems thinking. Both studies underscore the potential of digitally mediated experiences—whether through social media platforms or serious games—to shape public perceptions, influence behavioural intentions, and support sustainable practices in tourism and beyond. This convergence suggests that future research should explore synergies

between game-based learning and social media analytics, particularly in the context of sustainable tourism education and destination management.

From a tourism education perspective, the significance of the findings lies less in the direct transferability of DOMINO: The Little One as a ready-to-use instructional intervention and more in the design principles that can be derived from its environmental representation. Tourism education increasingly requires learning environments capable of addressing climate change as a systemic issue involving destinations, infrastructure, resource consumption, mobility, communities, and business operations. A climate-oriented serious game can potentially provide such an environment by allowing learners to explore relationships between decisions and consequences in a controlled setting. Previous research on serious games in tourism education demonstrates the feasibility of using game-based environments to develop tourism-related competencies, while research on digital and immersive tourism technologies shows the growing relevance of interactive experiences for tourism learning and interpretation (Almeida et al., 2021; Elshahawy et al., 2023). The contribution of the present study is therefore to extend this discussion toward the design analysis of climate-oriented game experiences and to identify mechanisms that could inform future tourism-specific educational game development.

Beyond the classroom, the procedural rhetoric and feedback mechanisms identified in this study hold substantial potential for application in the tourism and hospitality sector, which is both a significant contributor to climate change and particularly vulnerable to its impacts (Scott et al., 2016; Scott et al., 2016). Tourism enterprises—from hotels and resorts to tour operators and destination management organisations—could adapt these game mechanics to design internal training modules that enhance employees' environmental awareness and decision-making skills regarding resource efficiency, waste management, and carbon-footprint reduction. For instance, a gamified simulation could enable hotel staff to experience the consequences of energy-consumption choices in real-time, fostering a culture of sustainable operations without relying on top-down regulations (Font & McCabe, 2017). Similarly, tourist-facing applications could embed choice-consequence scenarios to encourage pro-environmental behaviour during holidays—e.g., selecting eco-friendly transport, minimising water usage, or supporting local conservation efforts. These applications would not only increase tourists' ecological literacy but also align with the growing demand for responsible travel experiences (Ruhanen & Shakeela, 2013). To realise this potential, collaboration between game designers, tourism educators, and industry stakeholders is essential. Future research should pilot co-designed game-based interventions in real-world tourism settings, measuring both immediate attitudinal shifts and long-term behavioural outcomes, thereby contributing to a more resilient and climate-conscious tourism industry.

6. CONCLUSION AND RECOMMENDATIONS

This study indicates that digital games have the potential to serve as pedagogical tools in concretizing complex systems related to the climate crisis and developing ecological literacy. However, given the limitations of the research, supporting the obtained data with different demographic groups and longitudinal behavioral follow-up studies would strengthen the validity of game-based environmental education models (Celestine et al., 2025; Kaiser & Mittelberger, 2026, p. 230).

Future studies should conduct longitudinal analyses to measure the correlation between in-game simulations and real-world actions, and evaluate the long-term effects of game experience on environmental activism from interdisciplinary perspectives (Galeote et al., 2021). In this context, integrating digital games into educational curricula in alignment with serious game design principles would significantly contribute to the formation of a proactive and conscious individual profile in combating the climate crisis. Thus, the systematic implementation of digital game-based learning processes within a curriculum could play a key role in transforming students' individual responsibilities regarding the climate crisis into institutional and social actions (Galeote, 2023; Shliakhovchuk et al., 2025). In this process, enriching the in-game experience with guidance materials supporting teachers' climate literacy would facilitate the transfer of environmental awareness provided by digital tools to out-of-school actions and attitude transformation (Biçen et al., 2025).

Moreover, increasing environmental literacy levels regarding the climate crisis is directly related to mechanisms that support individuals' participation in policy development and emission reduction actions (Korkmaz & Gülsoy, 2020, p. 435). Additionally, comparative analysis of technology-supported teaching processes with experimental designs involving experimental and control groups would help more comprehensively reveal the net effect of game-based interventions on environmental sensitivity (Balçın & Çavuş, 2020, p. 312). Future studies should experimentally test the integration of such game types into tourism education programs and their effects on tourists' environmental attitudes and behaviors. The use of serious games to increase climate-change awareness in tourism enterprises could support the sector's efforts to reduce its carbon footprint. In this context, collaboration between game designers and tourism professionals would allow for the development of innovative educational tools.

In conclusion, DOMINO: The Little One provides a useful case for examining how climate-related meanings can be embedded within the architecture of a digital serious game. The integrated analytical framework developed in this study demonstrates how serious-game pedagogy, persuasive game mechanics, procedural rhetoric, and ecological-literacy dimensions can be examined simultaneously at the level of game design. The findings indicate that the game's narrative, visual metaphors, resource constraints, choice-consequence structures, and feedback mechanisms create identifiable pedagogical affordances for representing ecological interdependence and environmental responsibility. These affordances, however, should not be interpreted as evidence of learning, attitude change, or behavioral transformation among players. Establishing such effects requires participant-based empirical designs involving pre-test/post-test measures, comparison groups, longitudinal follow-up, and appropriate psychological or behavioral indicators. This distinction between design affordances and demonstrated outcomes constitutes an important methodological implication for future research on climate-oriented serious games.

Additionally, the integration of such games into tourism education programs and their effects on tourists' environmental attitudes and behaviors should be experimentally tested, as serious games could support the sector's efforts to reduce its carbon footprint through collaboration between game designers and tourism professionals. In conclusion, DOMINO: The Little One offers a meaningful example at the intersection of serious games, persuasive games, and ecological literacy perspectives, thanks to its visual narrative language that brings the climate crisis closer to the player and its mechanics that link progression with environmental threats. However, this conclusion does not constitute evidence that the game creates

awareness or behavioral change in players. Future research is recommended to test cognitive, affective, and behavioral outcomes separately using pre-test/post-test designs, different age groups, comparison groups, and delayed measurements, alongside comparative studies with games that more strongly represent climate justice and collective action dimensions. Detailed recommendations for educators, game designers, and policymakers are provided in Supplementary Material SM-2.

Table 1
Integrated Analytical Framework

Dimension	Analytical Question	Indicators	Interpretation Boundary
Serious Game	How is the learning objective articulated into gameplay?	Task, rule, challenge, feedback	Design affordance; not learning outcome
Persuasive Game	What environmental claim does the game advance through its rules?	Choice-consequence link, reward/punishment, constraint	Rhetorical structure; player persuasion not assumed
Ecological Literacy	Which ecological competencies are addressed?	Knowledge, systems thinking, affect, action orientation	Represented competence; not a measure of acquisition

Table 2
Mapping Findings onto the Theoretical Framework

Theme	In-Game Indicator	Theoretical Correspondence	Cautious Inference
Visual Concretization	Representation of ecological threats through monsters and degraded spaces	Affective engagement; ecological awareness	Metaphorical design makes abstract crisis visible
Choice & Feedback	Linking progress, risk, and environmental outcomes	Procedural rhetoric; systems thinking	May support reasoning about causality
Trial-and-Error	Obstacles, failure, and retrying	Serious game; experiential learning	Offers a safe exploration space
Representation Limit	Predominance of individual responsibility over structural causes	Critical ecological literacy	May narrow political-economic complexity

Declarations

Author Contribution

Authors’ Contributions:• Y.Ç.: Conceptualization, methodology, formal analysis, writing – review & editing, supervision. • Y.B.: Data curation, investigation, writing – original draft preparation, supervision. • M.E.: Validation, writing – review & editing, supervision. All authors read and approved the final manuscript.

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Data Availability

The datasets generated and analysed during the current study are not publicly available due to the nature of the research, which involved observational data from gameplay sessions. The data are not archived in a public repository but are available from the corresponding author on reasonable request.

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