

Masterpolis: Simulating Urban Planning Decisions Through a Board-game Learning Environment

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Abstract: Urban planning education requires students to understand the complex interdependencies between land-use decisions, infrastructure development and sustainability outcomes. However, these dynamics are often difficult to grasp through traditional lecture-based instruction, as urban systems involve multiple actors, resource constraints and long-term consequences. Game-based learning has therefore emerged as a promising approach for enabling learners to engage with complex decision environments in a structured and experiential manner. This study presents Masterpolis, a low-cost physical board game designed as a simulation of urban planning processes within an interconnected territorial system. The research adopted a Design-Based Research (DBR) approach involving iterative cycles of design, implementation and refinement. The prototype was validated through gameplay sessions conducted in university settings, with a total of 35 undergraduate students, drawn from different course groups, from architecture, civil, chemical and environmental engineering programmes, alongside two urban planning experts. Data were collected through structured observation sheets, validation logs and post-session surveys. Session durations ranged from approximately 40 to 90 minutes, depending on the stage of implementation and participant familiarity with the rules. The analysis focused on how participants interacted with the simulation and how gameplay dynamics revealed patterns of negotiation, prioritisation and adaptation. Findings indicate that the board-game environment supported participants in recognising the systemic consequences of planning decisions and encouraged reflection on development–sustainability trade-offs. Iterative refinement of the prototype improved rule clarity, visual organisation and gameplay flow, reducing the need for rule clarification in later sessions. The study contributes to research on game-based learning for complex systems education by demonstrating how low-cost analogue simulations can support experiential engagement with urban planning processes. It also provides a Global South perspective on the use of accessible game-based tools to support the teaching of complex territorial decision-making in higher education. Analysis combined descriptive statistics with thematic coding of observational and survey data. The study contributes three transferable insights: that rule clarity and facilitation are prerequisites for engagement with complex simulations; that group size significantly shapes participation dynamics; and that analogue simulations can support the development of systems thinking in architecture and engineering programmes where such pedagogical tools remain underexplored.

Keywords: Urban planning education, Board game simulation, Experiential learning, Sustainability education, Decision-making simulation, Systems thinking, Design-based research

1. Introduction

Cities have become central arenas of social, economic and environmental transformation, where decisions regarding land use, infrastructure and resource allocation directly shape long-term sustainability. In recent decades, accelerated urban growth has frequently outpaced the capacity of planning instruments, resulting in fragmented spatial development, inadequate land occupation and uneven access to services and infrastructure (United Nations, 2018). At a global scale, urban expansion has been identified as one of the most significant transformations affecting ecosystems, infrastructure systems and human wellbeing (Seto *et al.*, 2012; Angel *et al.*, 2011). These dynamics have intensified challenges related to urban sustainability, governance and quality of life.

In contexts such as Colombia, urban expansion has often occurred through dispersed and weakly coordinated processes, limiting the effectiveness of planning frameworks in guiding equitable and sustainable development (OECD, 2022). More broadly, such dynamics are characteristic of rapidly urbanising regions in the Global South, where institutional constraints, resource limitations and accelerated growth create complex planning conditions (Watson, 2009). This highlights the need to strengthen how urban planning is taught, particularly in disciplines

such as architecture, where students must learn to navigate complex, interdependent systems involving social, economic and environmental variables.

Urban systems are increasingly understood as complex, adaptive systems in which local decisions generate cumulative and often unpredictable system-level effects (Batty, 2013; Alberti, 2016). From this perspective, planning is a negotiated and dynamic activity involving multiple actors, competing interests and uncertainty (Healey, 2006; Innes and Booher, 2010). However, traditional approaches to urban planning education tend to emphasise conceptual and technical knowledge, often with limited opportunities for students to experience these dynamics in practice. Consequently, there is a growing need for pedagogical strategies that allow students to actively engage with complexity, interdependence and decision-making processes rather than only studying them theoretically.

Game-based learning has emerged as a promising approach to address this gap. When appropriately designed, games can function as simulation environments in which learners interact with complex systems, test decisions, receive feedback and observe consequences in real time (Gee, 2003; Plass *et al.*, 2015; Boyle *et al.*, 2016). In the context of urban planning, serious games and simulations have been increasingly used to support participatory learning, collaborative decision-making and the exploration of complex urban scenarios (Poplin, 2012; Ampatzidou *et al.*, 2018). These approaches are particularly valuable for fostering systems thinking and helping learners understand the relationships between individual actions and collective outcomes.

Within this context, this paper presents an applied experiential learning initiative developed in Colombia, in which architecture students engage with urban planning concepts through a low-cost physical board game simulation. The project illustrates how interdisciplinary collaboration between design and urban studies can translate complex territorial decision-making processes into playable learning environments. Furthermore, it contributes a Global South perspective to ongoing discussions in game-based learning by demonstrating how analogue game design can support experiential learning in sustainability and urban development contexts. In this sense, the study is part of a broader emerging line of interdisciplinary experiential learning initiatives that employ low-cost physical games to model real-world systems (Marrugo-Salas, 2025).

While this study is situated in Colombia, the challenges addressed, such as fragmented urban growth, interdependent decision-making and sustainability trade-offs, are widely observed across rapidly urbanising regions globally. In this sense, Colombia provides a relevant case for examining broader urban planning dynamics in the Global South, where institutional coordination and resource constraints shape planning processes. Although grounded in a specific context, the insights generated are transferable to similar educational environments where students must engage with complex territorial systems under conditions of uncertainty.

Within this framework, *Masterpolis* was developed through an iterative prototyping process, evolving from an initial low-fidelity prototype into the high-fidelity physical board game presented in this paper, designed to simulate urban planning processes. The game places participants in the role of urban planners responsible for guiding the development of a growing city, requiring them to make decisions related to land use, resource management, licensing and collective sustainability indicators. Through these interactions, the game seeks to translate complex urban dynamics into an accessible and participatory learning experience.

This study adopts a Design-Based Research (DBR) approach to explore the pedagogical potential of *Masterpolis* within a real educational context. The research examines how participation in a collaborative game-based simulation influences students' interpretation of interdependent territorial decision-making processes.

Accordingly, the study is guided by the following research question:

How does participation in a collaborative game-based urban planning simulation influence students' interpretation of interdependent territorial decision-making processes?

By addressing this question, the paper contributes to emerging discussions on the role of game-based simulations in urban planning education, particularly in higher education contexts where experiential and systems-oriented learning is increasingly required.

2. Theoretical Framework

Contemporary urban expansion has prompted a reconsideration of how urban planning is conceptualised and practised. Rapid and often fragmented growth patterns, characterised by unequal access to infrastructure and services, reveal the limitations of static or reactive planning approaches. In response, urban planning is increasingly understood as a dynamic and adaptive process in which decisions generate cumulative effects

across spatial and temporal scales. This perspective aligns with the conceptualisation of cities as complex and adaptive systems, where local interventions can produce emergent and sometimes unpredictable outcomes (Batty, 2013; Alberti, 2016). Planning, therefore, extends beyond technical problem-solving to involve the management of uncertainty, interdependence and ongoing transformation.

Within this systemic framework, urban planning can be understood as a process of negotiation among multiple actors, interests and constraints. Cities operate as arenas in which competing priorities must be balanced, positioning planning as a form of strategic mediation under conditions of limited resources and uncertainty (Healey, 2006; Innes and Booher, 2010). This highlights the relational nature of decision-making, where individual actions acquire meaning in relation to broader system performance. For educational contexts, this implies that students must develop the capacity to interpret interdependencies and negotiate trade-offs, reinforcing the need for pedagogical approaches that allow learners to experience these dynamics in practice.

Game-based learning has emerged as a promising approach to address this need. When appropriately designed, games function as simulation environments in which learners engage with complex systems, test decisions and observe consequences in real time (Gee, 2003; Plass et al., 2015). These environments enable active experimentation and facilitate deeper conceptual understanding compared to traditional lecture-based instruction. In urban planning education, serious games and simulations have been increasingly used to support participatory learning and collaborative exploration of complex scenarios (Poplin, 2012; Ampatzidou et al., 2018, 2022). By integrating decision-making, feedback and progressive challenge, such approaches help learners understand the relationships between individual actions and collective outcomes.

Game-based learning environments have also been associated with increased motivation, strategic thinking and the ability to visualise system dynamics through interactive feedback mechanisms (Kavouras et al., 2025). These characteristics make them particularly suitable for disciplines that require engagement with uncertainty and interdependence. In architecture education, these approaches resonate with disciplinary modes of thinking that emphasise creation, experimentation and transformation. Learning environments that allow direct interaction with complex systems support the development of deeper understanding through experiential engagement.

In the context of urban planning education, game-based simulations have demonstrated particular value in fostering collaboration, negotiation and interdependent decision-making (Stigt, 2021; Robinson et al., 2021; Sousa, 2020). Collaborative map-based games enable students to co-design urban models while engaging in continuous discussion and negotiation. Simulations grounded in governance scenarios expose learners to conflicting interests and collective decision-making, while evidence from urban tourism games shows a shift from competitive to cooperative strategies as participants recognise long-term consequences and systemic trade-offs. More broadly, city simulators such as SimCity (Minnery and Searle, 2014) illustrate how urban environments function as interconnected systems, where decisions related to land use, transport or density generate unintended effects and require balancing competing objectives. These experiences support the development of spatial reasoning and critical reflection on the relationship between local decisions and broader urban outcomes.

Within this framework, *Masterpolis* is conceptualised as a pedagogical tool designed to translate complex urban planning processes into an accessible and interactive learning environment. By simulating relationships between land use, resource allocation and sustainability, the game enables learners to engage with interdependent variables through action and interaction. The game supports the construction of understanding through participation, negotiation and reflection, offering a structured yet exploratory environment in which students can develop a critical understanding of urban planning as a dynamic, collaborative and context-dependent process.

3. Methodology

This study employed a Design-Based Research (DBR) approach to explore and iteratively refine *Masterpolis* as a pedagogical tool for urban planning education. DBR integrates the design and implementation of interventions in real learning contexts, enabling the generation of both practical and theoretical insights (Jong et al., 2017; McKenney and Reeves, 2018; Wang and Hannafin, 2005). The study was conducted at a higher education institution in northern Colombia, with a total of 35 undergraduate students drawn from distinct course groups across architecture, civil, chemical and environmental engineering programmes, alongside two urban planning experts. The intervention took place within courses in Environmental Management and Geoplanning, and Urbanism, offered by the School of Engineering, Architecture and Design. These courses provided a context aligned with urban planning and sustainability-oriented decision-making, enabling an authentic evaluation of

the game. Participants represented varying levels of prior knowledge, and all provided informed consent in accordance with ethical research principles.

Masterpolis is a high-fidelity physical board game designed as a simulation of sustainable urban planning processes (See Figure 1 and 2). The game was developed to translate complex concepts, such as land use allocation, urban licensing and collective decision-making, into an interactive and structured learning environment. The gameplay is based on simulated urban scenarios in which participants assume the role of planners responsible for guiding the development of a growing city. Through individual and collective decisions, players interact with core elements of urban planning, including resource management, project allocation and the resolution of urban challenges. The system incorporates interdependent variables, requiring participants to balance social, economic and environmental factors while considering both short- and long-term impacts. The design of the game allows players to experience the cumulative effects of decisions within a controlled simulation, reflecting key dynamics of real-world urban systems (See Table 1).

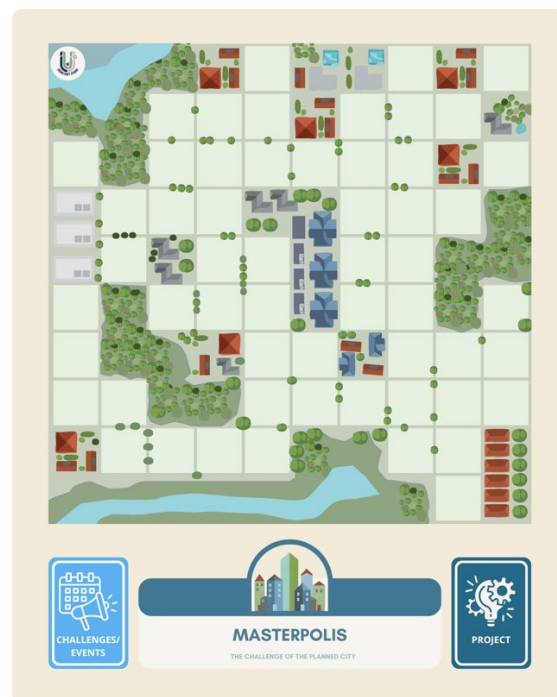


Figure 1: Masterpolis board



Figure 2: Final high-fidelity prototype of Masterpolis, showing integrated game components (board, cards, tokens and resources)

Final version of the Masterpolis game kit, illustrating the integrated set of components (board, cards, tokens and resources) used to simulate urban planning processes during the validation sessions.

Table 1: Game Components and Iconographic System of Masterpolis

Component	Type	Description	Functional Role
Project tokens	Game elements	Set of 60 tokens representing urban activities, distributed across five categories: residential, commercial, institutional, industrial and public space (12 each)	Enable players to develop and transform the simulated territory
Project cards	Card system	60 cards corresponding to project types (12 per category), indicating possible urban developments	Guide player decisions regarding land use and development
Event cards	Card system	15 challenge/event cards representing global situations affecting all players each round	Introduce uncertainty and collective dynamics
Licences	Resource system	Set of 50 licences required to construct projects, obtained and used strategically	Regulate access to development and resource allocation
Occupation symbols	Board markers	Indicators of spaces where construction is not allowed	Introduce spatial constraints and planning limitations

The study adopted an applied exploratory approach focused on analysing the use of *Masterpolis* within a real educational context. The design process was guided by the need to represent complex urban planning processes in an accessible and playable format. To achieve this, key urban concepts, such as land use, resource allocation and collective decision-making, were translated into game mechanics and rules (See Table 1). The development process involved iterative refinement based on participant interaction and feedback, with adjustments aimed at improving gameplay clarity, balance and coherence. This approach enabled the evaluation of how effectively the game facilitated engagement with urban planning concepts and supported the interpretation of territorial dynamics.

Data collection followed an exploratory mixed-methods design, combining quantitative descriptive indicators with qualitative observational and narrative data. Three instruments were used. First, structured observation sheets were completed by a member of the research team during each gameplay session, applying a predefined coding scheme with three behavioural categories: negotiation, system understanding and signs of frustration or disengagement. Observations were recorded in real time and reviewed after each session. Second, a validation log was maintained across all iterations of the prototype, documenting design decisions and the rationale for each adjustment. Third, digital post-session surveys were administered to participants at the end of each session. These instruments collectively enabled the documentation of rule comprehension, participation dynamics, decision-making processes and overall gameplay experience. The findings informed iterative adjustments to the game mechanics, visual design and overall system coherence.

The validation of *Masterpolis* was conducted through three main phases:

- **Content Validation:** Subject-matter experts evaluated the coherence of the urban content, clarity of the rules and alignment between the game design and its pedagogical objectives. Their feedback focused on academic relevance, didactic potential and the game's capacity to simulate real planning processes. Prior to the implementation sessions with students, two subject-matter experts independently evaluated the prototype (October 2025 and March 2026 respectively; see Table 3). Their assessment focused on the coherence of the urban content, clarity of the rules and alignment between the game design and its pedagogical objectives. Expert feedback directly informed design adjustments implemented before and between the student implementation cycles
- **Pilot Testing in Academic Contexts:** The game was implemented in eight validation sessions conducted in both face-to-face and virtual university settings. Session durations ranged from 40 to 90 minutes. The first sessions, involving expert participants, lasted approximately 90 minutes, while later sessions were shorter (40–50 minutes) due to adjustments in game dynamics and increased familiarity with the rules (See Figure 3 and 4). Participants played *Masterpolis* in groups following the established rules, while the research team observed and recorded interactions using structured observation sheets and validation logs.



Figure 3: Gameplay session (pilot testing)



Figure 4: Expert validation

- Iterative Improvement of the Prototype: Feedback from students, experts and facilitators was systematically analysed and used to refine the game (See Table 2 and 3). Adjustments were made to the rule system; visual design elements; balance of gameplay mechanics. These changes aimed to improve clarity, visual legibility and the pace of gameplay. The final version of *Masterpolis* incorporates these refinements to enhance usability and applicability in interdisciplinary academic contexts.

4. Results and Discussion

The findings are presented in relation to the implementation and validation of *Masterpolis* as a pedagogical tool for urban planning education. Table 2 presents the iterative validation process across six gameplay sessions, highlighting how participant observations informed successive design adjustments. Early sessions revealed challenges related to rule complexity and initial gameplay understanding, particularly in independent contexts without expert facilitation. Subsequent iterations show a progressive improvement in usability, with players demonstrating greater autonomy in navigating the game system. Notably, later sessions conducted within classroom settings exhibited increased negotiation and collaboration among participants, although challenges related to rule interpretation and participation balance persisted. The iterative adjustments, such as simplifying rules, redefining roles and modifying game mechanics, contributed to improving gameplay clarity and supporting more consistent engagement. These findings illustrate how the DBR approach enabled the systematic refinement of the game based on real user interaction.

Table 2: Iterative validation process Masterpolis

Session	Date	Participants (n)	Programme(s)	Session Type	Duration	Key Observations	Design Adjustments
1	Oct 2025	3	Architecture	Independent (expert-facilitated)	90 min	High rule complexity; low understanding of movements and resources	Simplification of rules and resource system
2	Oct 2025	4	Architecture	Independent (no expert)	100 min	Improved rule comprehension; difficulty initiating gameplay	Standardised game start procedure
3	Apr 2026	7	Civil, Environmental, Chemical Engineering	In-class (Environmental Management & Geoplanning)	50 min	Easier gameplay execution; difficulty understanding curator role	Strengthened curator role with defined responsibilities
4	Apr 2026	7	Civil, Chemical Engineering, Architecture, Environmental Engineering	In-class (Urbanism)	40 min	Increased negotiation; confusion due to inverse rule logic	Reformulation of rule explanation
5	Apr 2026	7	Civil, Chemical Engineering, Architecture, Environmental Engineering	In-class (Urbanism)	40 min	Effective teamwork; difficulty managing tokens and cards	Introduction of rule to support accumulation and continuity
6	Apr 2026	7	Civil, Chemical Engineering, Architecture, Environmental Engineering	In-class (Urbanism)	30 min	Increased communication; reduced individual participation	Strategies introduced to promote broader participation

The overall sample (n = 35) comprised different students in each of the eight sessions, drawn from several course groups and programmes across two academic terms rather than from a single repeated cohort, and included 54.3% female and 45.7% male participants, indicating a relatively balanced gender distribution. As participants were drawn from several distinct course groups, a direct comparison against one course-level gender baseline was not applicable. The balance observed nonetheless indicates that the reported perceptions and engagement patterns reflect contributions from both genders.

Table 3: Expert and Instructor Validation of Masterpolis

Session	Date	Expertise	Source	Key Feedback
1	Oct 2025	Architect -Urban Planner	Expert	Identified strong pedagogical potential and capacity to simulate real planning processes in a controlled environment. Suggested application in institutional planning contexts.
2	Mar 2026	Civil & Environmental Engineer -Urban Law	Expert	Confirmed relevance for academic use and proposed application as an evaluation tool. Suggested improvements in game dynamics.
3	Apr 2026	Course Instructor	Classroom Implementation	Reported high student engagement and progressive learning through gameplay. Noted initial difficulties due to limited understanding and time constraints, followed by improved performance among students with prior exposure. Highlighted the need for clearer onboarding and structured explanation.

Across the validation sessions, participants demonstrated active involvement in the gameplay process. Observational data were collected using structured observation sheets, incorporating a simple coding scheme to categorise gameplay behaviours (e.g. negotiation, system understanding and frustration). This approach enabled the systematic recording and analysis of participant interactions during the sessions.

Observational records indicated that students engaged with both the mechanics of the game and the underlying structure of urban planning decisions. Participation was evident in collaborative discussions related to land use allocation, project prioritisation and resource management. In several sessions, players made decisions collectively, particularly during shared decision points.

Differences in participation dynamics were observed depending on group composition and session format. Smaller groups showed more continuous interaction and shorter waiting times between turns, while larger groups occasionally experienced pauses or reduced individual participation, especially during more complex decision phases.

Participants also engaged with urban planning concepts during gameplay. Observational data indicated that many students explored relationships between decisions and their effects on the simulated system, particularly regarding land use, resource allocation and sustainability indicators. In several cases, decisions related to infrastructure or development projects were discussed in relation to broader system outcomes.

Some participants initially experienced difficulties in interpreting specific concepts, particularly those related to regulatory processes and sequencing of decisions. These challenges were more evident during early sessions and decreased as gameplay progressed or when facilitation was provided.

The gameplay process also involved instances of negotiation and collective decision-making. Participants discussed options, prioritised projects and managed limited resources, particularly in situations involving shared indicators or constraints.

Post-session survey responses ($n = 35$) indicated broadly positive perceptions of *Masterpolis* as a learning tool. The majority of participants agreed or strongly agreed that the game supported their understanding of urban planning processes, particularly regarding the interdependence of decisions and collective outcomes. The dimensions receiving strongest positive ratings were negotiation awareness, collaborative decision-making and recognition of trade-offs between development and sustainability. Ratings were more mixed regarding the clarity of initial rules and familiarity with planning-specific terminology, consistent with the observational data from early sessions. These results should be interpreted with caution given the absence of a pre-session measure of prior knowledge, which limits claims regarding learning gains attributable to the game.

The findings indicate that *Masterpolis* supports engagement with complex urban planning processes by enabling participants to interact with interdependent decision-making scenarios. The observed progression from initial confusion to smoother gameplay suggests that learning emerges through interaction and repeated exposure, consistent with experiential learning principles. The presence of negotiation, collaboration and shared decision-making aligns with the relational and collective nature of urban planning (Healey, 2006; Innes and Booher, 2010), while the recognition of interdependence reflects perspectives of cities as complex systems (Batty, 2013; Alberti, 2016). The iterative adjustments documented across sessions further highlight the role of DBR in refining both usability and pedagogical coherence (McKenney and Reeves, 2018; Wang and Hannafin, 2005). However, the results also emphasise the importance of facilitation and onboarding, particularly in early stages of gameplay.

The findings of this study are consistent with existing research on game-based learning in urban planning education (Sousa, 2020; Koens *et al.*, 2020; Robinson *et al.*, 2021). Prior studies indicate that participation in collaborative simulations enhances students' understanding of planning as a collective process, strengthening awareness of shared decision-making and the value of coordination among actors. This is reflected in the observed negotiation and group-based interactions within *Masterpolis*. Similarly, the literature highlights improvements in students' ability to recognise competing interests and trade-offs in sustainable urban development, which aligns with the patterns of prioritisation and resource management identified during gameplay. Finally, previous research suggests that simulation environments support the development of systems thinking by increasing awareness of interdependencies and competing demands within urban systems. The observational data from this study suggest that participants began to recognise how individual decisions shaped broader system outcomes, particularly in later sessions when rule complexity had been reduced. This pattern is consistent with systems thinking as described in the literature; however, the study did not include a validated instrument to measure this capacity directly, and such claims should therefore be understood as exploratory observations.

Although the study is context-specific, it suggests that low-cost analogue simulations can support experiential learning in urban planning education, especially in contexts with limited access to digital tools (Watson, 2009). These findings can also be contextualised in relation to existing urban simulation tools. Digital environments such as *Cities: Skylines* (Sanz *et al.*, 2025) provide detailed representations of interconnected urban systems,

enabling experimentation with rules and procedures and supporting the understanding of causal chains between territorial decisions. In contrast, analogue formats, including board-game adaptations and similar collaborative simulations, tend to facilitate group discussion, role-based interaction and critical reflection.

The contribution of *Masterpolis* can be further understood through comparison with existing board games addressing spatial, architectural or urban themes. Contemporary games such as *Architects of the West Kingdom*, *Sustainability Futures Game* and *euPOLIS Game* (Ampatzidou et al., 2022; Kavouras et al., 2024) offer distinct approaches to decision-making and system representation. While *Architects of the West Kingdom* emphasises resource management and ethical decision-making within a historical context, *Sustainability Futures Game* focuses on exploring future-oriented sustainability scenarios through strategic and speculative thinking. Similarly, *euPOLIS Game* centres on the implementation of nature-based solutions in specific urban environments. In contrast, *Masterpolis* integrates collaborative decision-making as a core mechanic and introduces scenario-based challenges that simulate contemporary urban planning dynamics. The incorporation of player roles and the explicit interrelation of social, environmental and economic variables position the game as a pedagogical device oriented towards systems thinking and critical analysis.

Furthermore, within architecture education, few documented examples of analogue board games specifically designed for that disciplinary context have been identified in the peer-reviewed literature. In this context, *Masterpolis* contributes to an emerging yet still limited body of practice that explores how physical games can support experiential learning in disciplines traditionally dominated by representational and technical approaches.

This distinction highlights how physical game environments, such as *Masterpolis*, can complement digital simulations by strengthening collaborative decision-making processes and supporting the exploration of urban planning as a collective and negotiated activity.

Future research should incorporate formal assessment measures and broader samples to strengthen evidence of learning outcomes.

5. Conclusion

This study explored the design and implementation of *Masterpolis* as a game-based learning tool to support urban planning education within a higher education context. Through a Design-Based Research approach, the study examined how participation in a collaborative board game simulation enabled students to engage with complex urban planning processes.

The findings suggest that the use of a physical, low-cost game environment facilitated active participation, interaction and reflection among students. Participants engaged in decision-making processes involving land use, resource allocation and sustainability considerations, allowing them to explore the interdependent nature of urban systems.

A key contribution of the study lies in demonstrating that a low-cost analogue simulation can sustain active engagement with complex urban planning decisions across multiple iterative sessions. The observed interactions suggest that participants began to recognise cumulative effects of individual decisions on collective outcomes, a pattern consistent with systems thinking, though not formally measured in this study. Future research incorporating validated instruments for systems thinking assessment would strengthen evidence for this relationship. The iterative refinement of *Masterpolis* further demonstrates the value of Design-Based Research for educational innovation. Adjustments to rules, visual design and gameplay mechanics improved usability and clarity, suggesting that continuous testing and adaptation are essential when developing tools to represent complex systems.

Although the study focused on participant interaction and perception not a formal measurement of learning outcomes, the findings indicate that analogue game-based approaches may offer meaningful opportunities for experiential learning in urban planning education. This is particularly relevant in contexts where access to digital simulation tools may be limited, and where low-cost, adaptable solutions are required.

Finally, while the study was conducted in Colombia, the insights generated are transferable to similar educational settings where students must engage with complex territorial systems under conditions of uncertainty. Future research could expand this work by incorporating longitudinal assessment, broader participant samples and hybrid learning environments that combine physical and digital simulation tools.

Ethics Declaration: This study was conducted within a regular educational innovation context and involved low-risk pedagogical activities. Formal ethics committee review was not required under the applicable institutional context. Participation was voluntary. All participants were informed about the purpose of the study, the use of anonymised data for academic research purposes, and their right to withdraw at any time without consequence. No sensitive personal data were collected. All responses were anonymised prior to analysis and handled in accordance with applicable Colombian personal data protection regulations.

AI Declaration: Artificial intelligence tools were employed in a supportive capacity during the preparation of this manuscript, particularly for the translation of content from Spanish into academic English, language refinement and stylistic improvement. Machine-assisted outputs were critically reviewed, edited and validated by the authors to ensure technical accuracy, contextual coherence and disciplinary appropriateness. All substantive intellectual contributions, methodological decisions and final interpretations remain the responsibility of the authors. This human-supervised approach preserved academic integrity while enhancing the clarity and communicative quality of the manuscript.

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