

Experimenting With Gamification and Geogames in Urban Planning: A Systematic Literature Review

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Abstract

This systematic literature review examines the complex intersection of gamification and urban planning with particular attention to the interrelated fields of experimental urbanism, systems theory, digitalization of the urban planning system, game theory, and agent-based modelling. As such, this article addresses the critical gap of an existing systematic and detailed literature review in this emerging area of using geogames in urban planning research and practice. The review synthesises both the available scholarship and related grey literature to understand how simulations and game-based approaches are utilized in citizen engagement and urban planning policy. This article identifies the current priority themes in the application of gamification to urban planning through a temporal and thematic exploration of a mix of theoretical frameworks, empirical studies, practice-based experiments, and software applications. This has been undertaken through a multi-dimensional analysis of mixed academic and media databases. Moreover, it evaluates the effectiveness of urban simulations and game-based planning interventions, highlighting the most promising areas for future applied research. The findings suggest that gamification and urban planning simulations represent a change in focus in planning theory and practice, offering new tools for participatory scenario-based planning, urban analytics, and understanding or managing complex urban systems. The article concludes by highlighting current research gaps and proposing a dynamic future research agenda to advance the understanding and effective implementation of simulated approaches and geogames in urban design and planning.

Keywords

experimental urbanism; gamification; geogames; systems theory; urban planning; urban simulation

1. Introduction

There has been a considerable rise in scholarship in the past 10 years documenting a variety of applications of gamification in urban design and planning, with the first annual Geogames Symposium being held in 2024 in Portugal at Portucalense University. This has increased the need to take stock of this novel and expanding exciting field of research and attempt to collate and synthesise it, identifying the main caveats as well as the most promising avenues for future development and practical application. Professionals working within the built environment professions are experiencing a growing interest in the loosely defined field of “geogames” which, through a variety of different analogue and digital applications, aim to go beyond the value of “pure entertainment,” being described often as “serious games” (Connolly et al., 2012), to deal with practical real-world applications (de Sena et al., 2021) or to focus on specific educational and environmental learning outcomes (Pilote & Chiniara, 2019).

In practice, urban planning-themed games can be both analogue and digital, often transversing the boundaries between the different formats or media to the point of influencing or informing the content of each other. They demonstrate the complex and dynamic interactions among objects, agents, and events in whatever format the games are presented. Serious urban planning geogames can be understood as material representations of real-world systems, based on thematic abstraction, but also being capable of providing meaningful insights into the specific system’s behavior in the particular gameplay setting. Several writers have already undertaken research compiling large game datasets and analysing the key mechanics, components, and patterns found within these games, including the key spatial dimensions (Davidsson et al., 2004; Sintoris, 2015) of locality, proximity, navigation, race, and collection (Ahlqvist & Schlieder, 2018, p. 10). The locality and proximity patterns evident in geogames are fundamental in the sense that any location-based game engine (or board) must support at least one such pattern. These game patterns and structures refer to a range of complex core concepts such as networks, granularity, events, or values, and it is possible to identify associated clusters of patterns comprising these concepts or characteristics describing different spatial activities.

This article explores these game-based concepts by first presenting a comprehensive, systematic literature review of gamification with related fields of knowledge, highlighting the connections among them and urban planning applications. The guiding research question is understanding the current state of research on gamification and geogames in relation to urban design and planning, including the origins within the application of systems theory and game theory within urban simulations. This has been broken down into three sub-questions: Firstly, what are the key research fields that address geogames and gamification in relation to urban planning and their convergence, divergence, and possible overlaps? Secondly, what are the key applications of gamification in urban planning practice and the main limitations? Thirdly, what are the most promising avenues for future research in this novel field of enquiry?

As such, the article begins by setting out a suitable conceptual framework for exploring these linked research questions and provides a detailed methodology for the systematic review of the linked thematic literatures. It then addresses the main current applications of gamification in urban planning, identifying the limitations in practice and areas of future research.

2. Conceptual Foundations and Methodological Approach

As is often the case with city planning games, the deliberate starting point here is SimCity, with one of the original software developers, Gingold (2024), writing about the background to the game's development in the chapter "Simulation as Analogy" that analogue and digital have the same roots. They share the same underlying structures and rules. They are not opposites (a mistaken assumption within systems thinking) but are part of the same developmental timeline. In such an urban planning game or simulation, there was an emergent characteristic in the need for self-organisation and the ability to set your own goals for city building. In effect, within the game or simulation, the user has agency in decision-making within the virtual simulations, and this has strong parallels with many forms of practical urban planning (Devisch, 2008), seen as significant for pedagogical reasons (Kim & Shin, 2015) within real-world scenarios (Plass et al., 2015).

This article presents a response to this specific history in the form of a timeline of overlapping concepts and literatures relating to (a) gamification/game theory, (b) urban simulations/systems theory, (c) cellular automata/agent-based modelling, (d) experimental urbanism, and (e) digital planning, with the last two areas of literature aiming to bring some current real world applications and impact to the work undertaken in the first three areas identified. These literatures were explicitly selected in reference to Gingold's (2024) analysis of the origins of SimCity, with the identified sources of academic and popular literature crossing the analogue and digital boundary. We accept that this is a selective overview of sources and inspirations and understand that there are contrasting and evolving ideas and definitions of what virtual, augmented, and mediated reality relate to (Mann et al., 2023). However, they all have common roots in theories about urban systems and "the common denominator is that the art of the...game is not simply synonymous with entertainment, but with life" (Garriott, as cited in Donovan, 2010, p. X). The detailed search strategy, including the semantic keywords and scope of databases (Table 1), is described below as the basis of a transparent and reproducible method.

The initial searches yielded over 180,000 potentially relevant articles, papers, or software applications. These results were screened and analysed chronologically, in each case, identifying the (a) earliest reference source as a proxy for the first "recorded" occurrence of the term's historical context and foundational theories; (b) the point of going "viral" or becoming mainstream, indicative of emergence of the term as a popular trend; and (c) the key reference to highlight this "peak" point of usage based on the most cited sources prior to charting any observable decline with the number of sources (up to end of 2024, albeit several pre-publication sources for 2025 were identified within the review). We have highlighted the overall number of sources by year to understand any trend(s) in the concepts where they exist. The choice of maintaining this clear focus on the important stages within the developmental timeline of the concepts was a pragmatic decision given the large number of papers in certain areas of research.

Given the scope of the meta-study and the overall numbers and scope of references, many of which were software or media-based as well as published sources, the research team adopted a pragmatic staged process of screening for the sources used in the synthesis and mapping (Figure 1). The summary outcomes from this meta-study are presented below and provide the basis for an overall pattern of progression in the use of different theories and systems.

Table 1. Summary of “semantic” or “keywords” used for the literature review and overview of databases reviewed as part of the formal literature review.

Key literature	Semantic keywords
Game theory/gamification	Game theory; gamification; geogames; serious games
Systems theory	Complex systems; complex urban systems; dynamic models; systems theory; wicked problems
Cellular automata	Agent-based modelling; biomimicry; dynamic geographic information systems (GIS); fluid dynamics; multi-agent planning; PacMan; Sims; Space Syntax
Experimental urbanism	Ad hoc urbanism; experimental urbanism; informal urbanism; temporary urbanism
Digital planning	City information modelling; computer-aided process planning; digital planning; digital twin; planning support systems; PSS; platform urbanism; smart city

Source(s)	Description
Scopus/Web of Science/Google Scholar	Academic literature database sources subject to peer-review
ResearchGate/Academia	Collection of the most well-used (van Noorden, 2014) social networking platforms for academics and researchers, albeit with a limited repository of open-source papers/documents and restricted scope for data analysis and exporting
Wolfram	Simulation database sources. Wolfram (n.d.) curated a collection of open-source programmes/demonstrators and computer models
IMDB/IGDB/Learning on Screen/Internet Archive	Linked media database sources. UK public broadcast database that includes searchable programme transcripts. A mix of video, games, and a linked publication database available as software and mixed media file formats

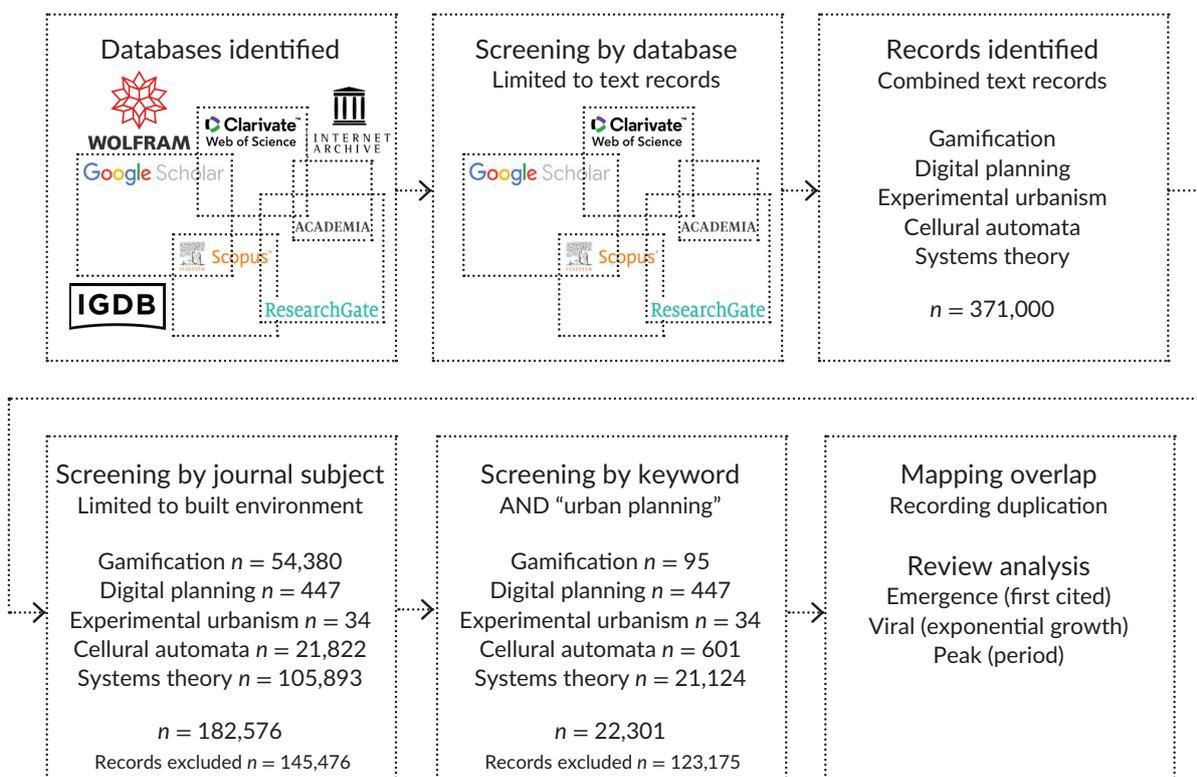


Figure 1. Process chart adapted from PRISMA showing stages undertaken as part of the systematic review.

2.1. Gamification and Game Theory in Urban Planning

The concepts of “gamification” and “game theory” arguably have common origins in the work of von Neumann and Morgenstern (1944) and were initially developed to assess utility and risk in the prediction of human behaviour. Since then, game theory and applied forms of gamification have evolved into multiple different areas of human behaviour, including the fields of urban planning and city design. In this context, Juul (2005) argues that games are simultaneously “real” in their structure of rules and “fictional” in their narrative and representational elements. This duality is relevant to urban planning, as planners and participants attempt to navigate real-world hindrances (such as budgetary or environmental limitations) within a board and/or video game’s more malleable and extravagant confines. The rise in interest and application of gamification is in part due to the perceived benefits from dealing with complex, controversial, impractical, or problematic concerns within real-world scenarios. Increasingly, urban planning gaming applications are seen to have didactic (Seelow, 2022) or pedagogical value (Balbin, 2024; Bereitschaft, 2021; Hartt et al., 2020; Lobo, 2007; Pearson, 2020) and characterised by an underlying “deep learning,” both emotional and experiential, gained through (mostly digital) applications. Nevertheless, critics argue that these gamified approaches present a fixed technocratic and data-driven planning system (mostly based on North American land-use zoning) rather than a pragmatic, negotiated, compromising, or collaborative system. Jenney et al. (2018) examine how visualisation techniques, such as 3D modelling, layered mapping, and interactive dashboards, greatly inform communication strategies within the field of urban planning. These innovations in gaming interfaces can be understood as a simplification or the condensing of complex data into a visually accessible format to support better understanding, engagement (Akbar et al., 2024; Devisch et al., 2016; Vanolo, 2018), and potentially empowerment (Fuchs et al., 2014) for a range of urban stakeholders normally excluded from more traditional planning engagement processes, albeit with the area of application beginning to overlap with virtual reality (Özden et al., 2023) applications.

The critical text and stages in the development of game theory since the work of von Neumann and Morgenstern (1944) highlight the beginning of a “boom” arising from a highlighted gap in the scope of applications around the potential of widening participation in urban planning (Ampatzidou et al., 2018; Baušys et al., 2021; Christodoulou et al., 2018; Thiel et al., 2017), a theme that has consistently repeated itself in a series of similar case studies (Fox et al., 2022), reviews (Latifi et al., 2022; Resek et al., 2022), and exploratory experiments regarding the specification (Szot, 2024), the use of different digital interfaces or development scenario options (Muehlhaus et al., 2022), or utilisation of commercially available digital modelling or city planning games (for example, in the use of Minecraft as the world’s most popular game; Delaney, 2022), albeit variations of serious analogue games also remain effective in practice (Hügel & Davies, 2022; Sousa, 2020; Tan & Portugali, 2012). This peak level of interest is driven (Figure 2) in part by a thematic issue of the *Urban Planning* journal and by unrealised potential that so far has not been tapped.

It is important to note that while these concepts share a common origin in theory and inspiration, there is a growing differentiation between the two terms in practice and wider academic usage that is also appearing within the key literature. In respect to “game theory,” the characteristics are based on rationality and mathematical modelling, evident in the non-game with no clear objectives, akin to technological or futuristic forecasting. There is an emphasis on the mathematical properties of the model, structures, and rules. In contrast, “gamification” is understood as a growing area of games study that includes serious games, interaction, and the culture of play. There is an emphasis on applied characteristics of gameplay and design

“Foundational”/emergence of concept or application	“Going viral”/most cited	“Peak” period characteristics references
von Neumann and Morgenstern (1944), who directly inspired the theoretical background of SimCity	Ampatzidou et al. (2018), recognition of the potential and “gap” for games within public participation in urban planning (Christodoulou et al., 2018; Mueller et al., 2018)	Seelow (2022), Muehlhaus et al. (2022), Fox et al. (2022), and Latifi et al. (2022) special journal issue highlighting potential applications for digital/analogue “serious games”

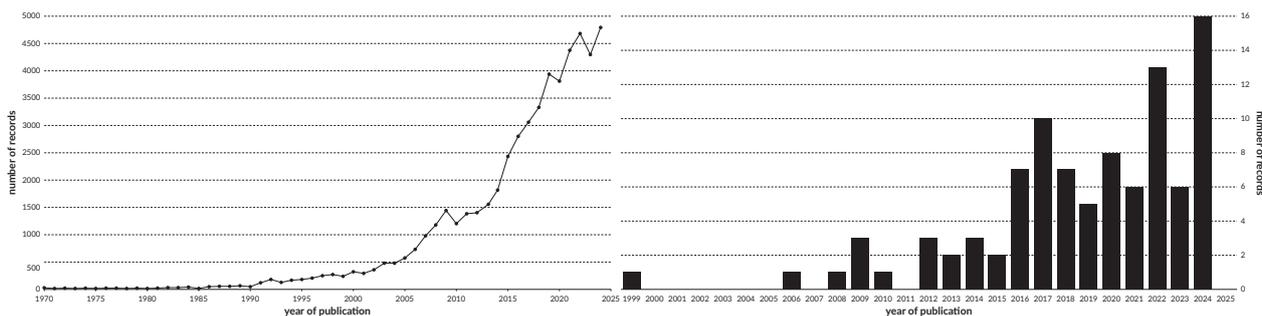


Figure 2. Key stages in the development of “game theory” and “gamification” and the number of game theory/gamification records (graph of sources selectively limited to Web of Science) by year of publication and number of similar records with the addition of “urban planning” used as a search term.

to social contexts, where there are objectives, incentives, and rewards for participants set within an overall game narrative (Aarseth, 1997; Juul, 2005).

2.2. Systems Dynamics in Urban Planning

Urban planning games are almost exclusively grounded in the systems theory, which is the transdisciplinary study of the abstract organisation of interconnected phenomena and complex entities (von Bertalanffy, 1968), using (usually mathematical) models to describe them (Heylighen & Joslyn, 1992). Systems theory emerged from the physical sciences, specifically engineering, computing, and ecology, to be applied in the social systems and urban planning sectors from the 1970s onwards to describe the operation of complex social phenomena. “The [systems theory] discipline sports a distinguished pedigree” in its potential to shape urban planning decision making (Berlinski, 1976, p. 5) using urban simulation models for analytical planning (Hull, 1969). The use of the systems theory has proved useful in identifying and calculating transitions in all aspects of planning, including urban sustainability (Grin et al., 2010) and resilience (Shi et al., 2021; Sun et al., 2024). Modelling these systems has taken many forms, with GIS as the most notable and a spatial evolution of earlier approaches to linked database management, decision/planning support, and expert systems (Kontokosta, 2021). In planning practice, complex urban system simulations were first used (Kelly, 1974) to produce a large-scale, data-dependent, interactive set of computer models for the Vancouver urban area. This novel application evolved through practice in “anticipating the future and evaluating policies” (Engelen, 1988, p. 44) for a variety of urban contexts.

Since the 2010s, complex urban systems have become more substantially common (Figure 3) for exploring dynamic simulations in the urban planning discipline, including disaster planning and mitigation (Galderisi, 2014; Grinberger & Felsenstein, 2014), policy options for public health (Tonne et al., 2021), and the relationship with

urban planning. There is an overlap with the “cellular automata” for modelling geographical phenomena (Yeh & Li, 2006) and the spatial and temporal dimensions of planning processes and systems (Sante et al., 2010) in transport planning simulations (Waddell et al., 2007) changes on land use, and the consequent feedback effects allowing for cost effective testing and evaluation of possible policy interventions.

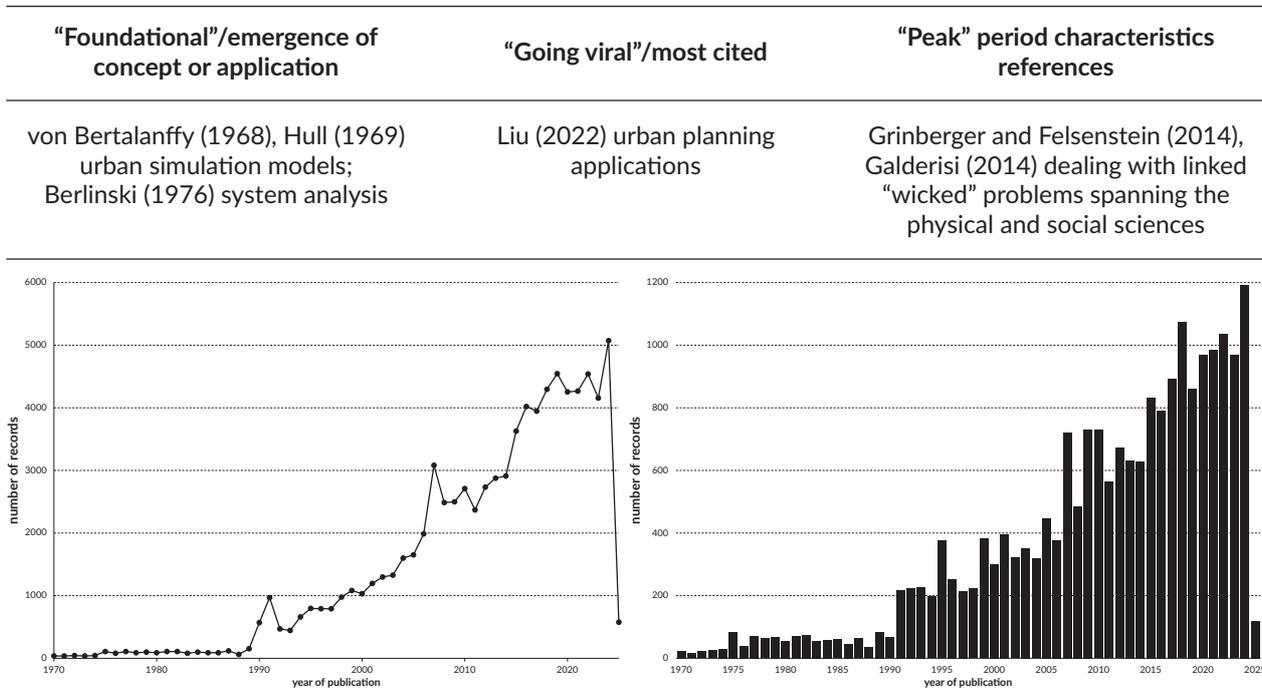


Figure 3. Key stages in the development of “systems modelling” and the number of “systems theory” or “complex systems” records (graph of sources selectively limited to Web of Science) by year of publication and number of similar records with the addition of “urban planning” used as a search term.

2.3. Agent-Based Modelling and Cellular Automata

The origins of the links between urban systems and cellular automata also lie in von Neumann’s aspiration to create a model of a “self-reproducing machine,” presented at the Hixon Symposium in 1948 (Damerow, 2010). Practically, this can be defined as a “discrete” computational model that consists of a regular finite grid of standard dimensioned cells arranged uniformly in a grid (Bhardwaj & Upadhyay, 2017) and then subject to change throughout various stages, depending on transition rules (O’Sullivan & Perry, 2013) applied to the system. Such a cellular automata approach was made famous by John Conway’s Game of Life in the 1970’s, which arguably remains the most famous application of agent-based modelling that has been revisited in many digital forms since its initial publication. This Game of Life had a different aim than that of von Neumann, it being to create a “playerless” game (Numberphile, 2015). The game is considered by academics to be Conway’s most famous creation and “the most interesting and fundamental cellular automata construction,” because of how the rules of the game manifest complexity (Pena & Sayama, 2021). The Game of Life is also widely recognised as the first game to contain cellular automata, and the method has been continuously used within video games ever since. Some of the earliest games utilising cellular automata were a genre known as falling-sand games (for example, Falling Sand and Powder) that involved players selecting and inserting a range of materials into the world, and, like Conway’s game, do not have any winning criterion. Minecraft also contains cellular automata for certain essential gaming functions and

demonstrates “transition rules” very similar to the Game of Life (Pagáč, 2022). However, SimCity is likely to be the most widespread example of cellular automata being used to simulate the outcomes of a city. Utilisation of cellular automata as a basis for city experimentation in a professional capacity has been explored with increasing interest since the 1990’s, exploring forms, dynamics, and alternative future land use scenarios (Engelen, 1988; X. Li, 2008).

Similarly, agent-based modelling traces its origins to the advent of cellular automata (Chen, 2012) and has been used for advancing the sophistication and complexity within geographical models and simulations (Crooks & Heppenstall, 2012) as part of the growth in agent-based applications (Figure 4). Macal (2016) adds to the specific definition of the different characteristics of agent-based models (individual, autonomous, interactive, and adaptive typologies), each with its own specific behavioral characteristics, with the key perspective for urban planning being the overall complexity and corresponding unpredictability of outcomes arising from the interaction of multiple agents within the simulation. Yet there are clear limitations and weaknesses in cellular automata applied to real-life situations. It is challenging to model the influence of “human” political or behavioural factors, such as political factors (X. Li & Liu, 2007).

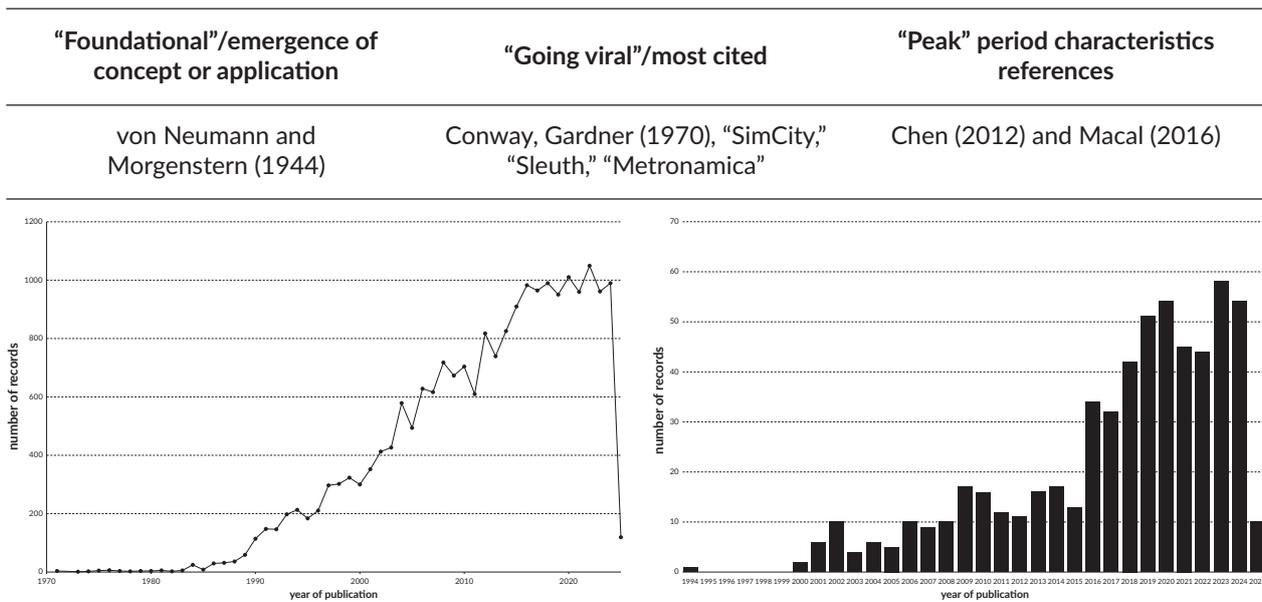


Figure 4. Key stages in the development of “agent-based modelling” and number of “cellular automata” records (graph of sources selectively limited to Web of Science) by year of publication and number of similar records with the addition of “urban planning” used as a search term.

2.4. Digital Planning

The history of digital technology within the development and operation of the UK planning system began with leveraging “mainframe computing and cybernetics” (Goodspeed, 2015), progressed through the use of desktop tools for data analysis, forecasting, and plan production (Klosterman & Landis, 1988) especially GIS, public participatory GIS (Feneri, 2016) and recently the application of virtual/augmented reality and the rise of social media: “platforms [that] have provided planners with new tools and opportunities to collect and analyse information, and create dialogue between stakeholders” (Wilson et al., 2019, p. 289). There has been a focus on the use of “capturing and digitalizing data and mapping to visualise existing and proposed

land-use” (Hussnain et al., 2020, p. 2) in the use of GIS spatial analysis, making this resource accessible to non-technocratic professions (Sheppard et al., 1999). To a lesser extent, there has been an overlap with urban simulations seeking practical applications, albeit these have been largely restricted by the cost of realistic data, licensing, and computing power required by individual planning authorities. As such, cost restrictions have reduced, and applications have become more accessible and affordable. Through the corresponding number of internet of things (IoT) devices (Syed et al., 2021), digital planning has gone viral (Figure 5) and become the basis for the emergence (Mahizhnan, 1999) and growth of “smart cities” and “digital twins” (Piras et al., 2024) or virtual replicas of cities that can be used to simulate theories and experiment relatively risk free by utilising live data gathered from installed IoT sensors (Carrasco et al., 2022), albeit with the growth of big and real time data there are also challenges with the quality of data (accuracy and bias) that is derived from smart city platforms (Green, 2019; Matheus et al., 2020).

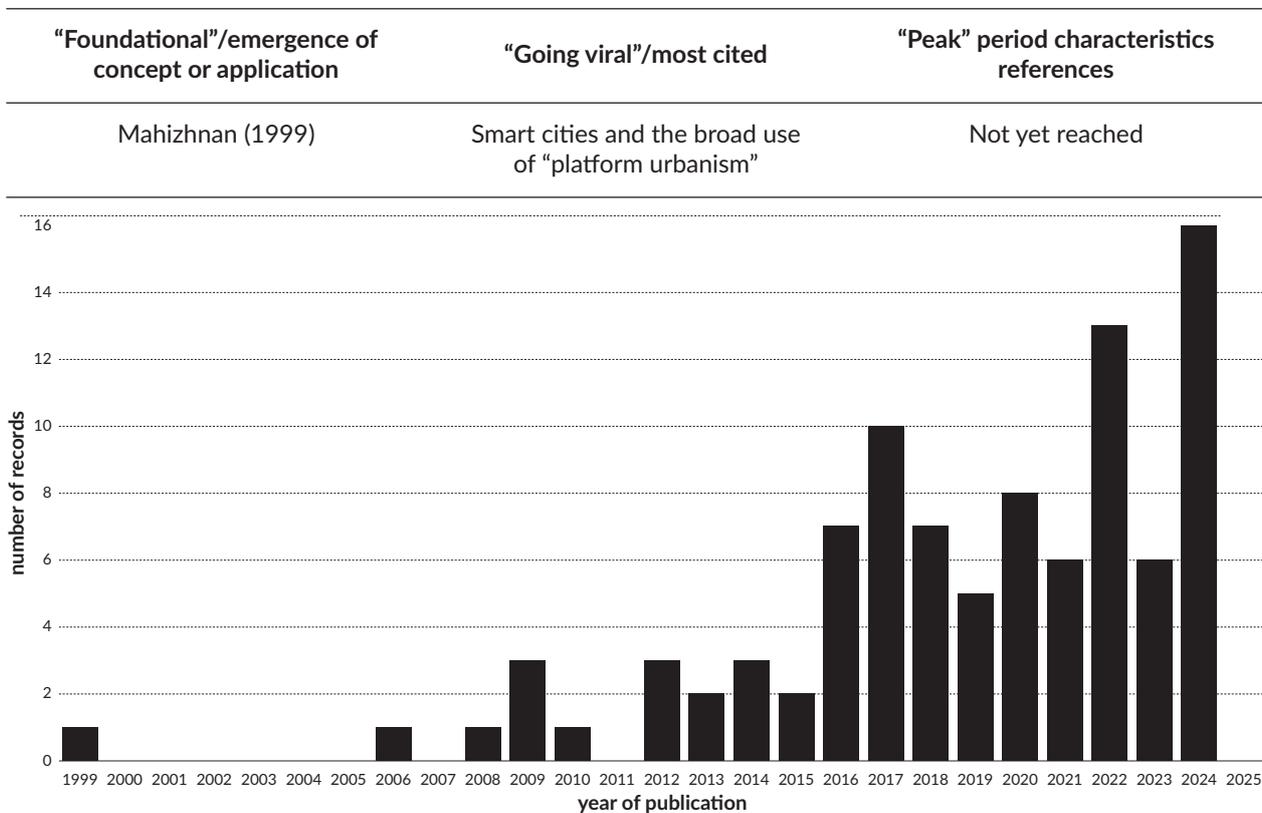


Figure 5. Key stages in the development of “digital planning” and number of “digital planning” records (graph of sources selectively limited to Web of Science) by year of publication.

The focus of digital planning to date has been promoting better understanding and engagement within non-professionals (Göçmen & Ventura, 2010), maintaining an “emphasis on the relevance and user-friendliness of software, cost of technology, skills of planners, and data availability” (Potts & Milz, 2024, p. 329). Effectively, the literature shows there is currently very little dynamic modelling and/or simulation aspects and that the weight of this literature remains with the effective, mostly graphic, presentation of data rather than any exploration of the underlying structures and rules regarding how different spatial data sets interact.

2.5. Experimental Urbanism

Linking all the mentioned literature is the novel concept of “experimental urbanism.” “Urban experimentation” as a term was first used, albeit in a significantly different meaning from current usage, in the 1960s (Lubove, 1967) and was increasingly used in the following decades to refer to space travel and settlement (Paine, 1969). It is a self-explanatory concept, as it deals with very complex urban issues through testing, piloting, trial, and error. It is the act of “viewing the city as a laboratory for field-testing new practices, or as a setting for experimental sites” (Evans, 2016, p. 429). This literature (Figure 6) shows quite a variety of terms and concepts used in relation to urban experimentation, such as “guerrilla urbanism” (E. Wilson, 2022), the “experimental city” (Evans et al., 2016), “unplanned urbanism” (Lehmann, 2023), “do-it-yourself urbanism” (Talen, 2014), and “tactical urbanism” (Webb, 2018). Recently, urban experimentation has received attention as a method of non-traditional planning with potential to address urban sustainability and climate change through innovation and “progressive potentials” (Bulkeley, 2022; Karvonen & van Heur, 2014; Y. Li & Li, 2022).

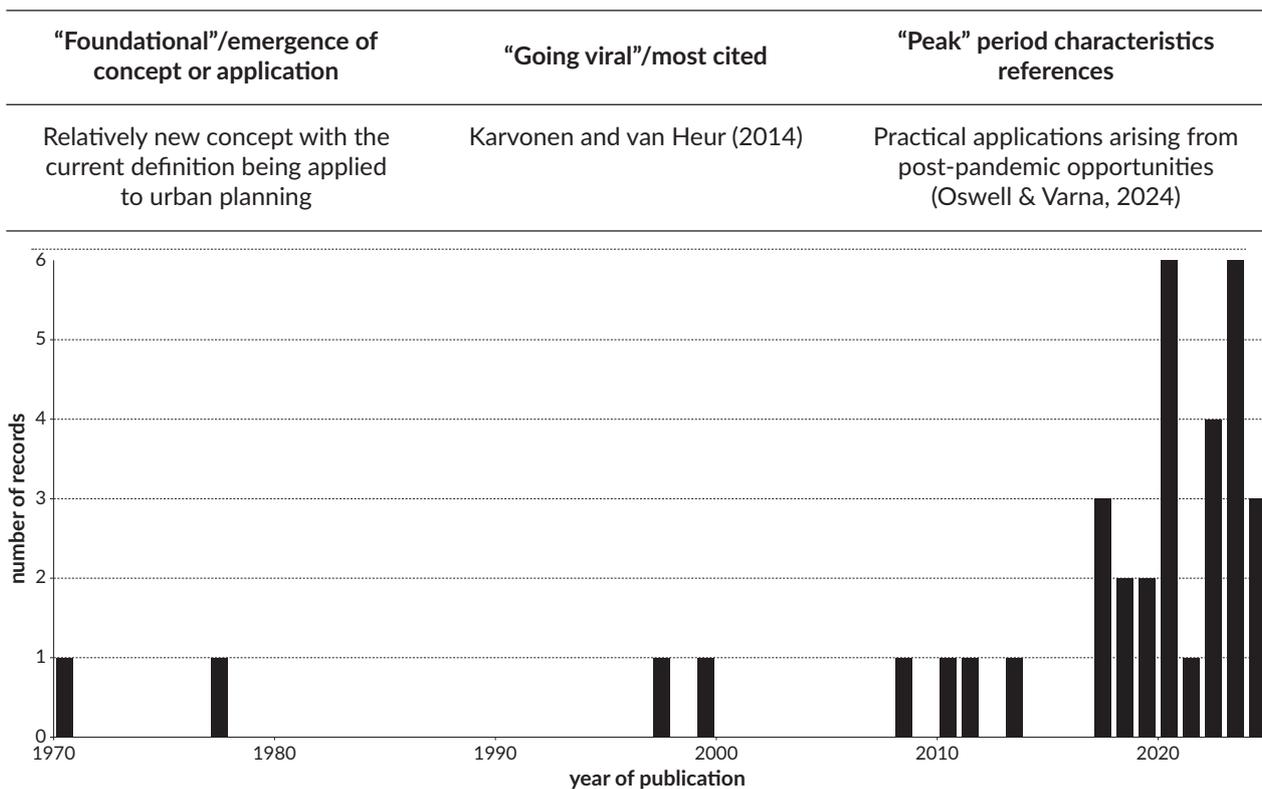


Figure 6. Key stages in the development of “experimental urbanism” and number of “experimental urbanism” records (graph of sources selectively limited to Web of Science) by year of publication.

However, it should be noted that multiple authors suggest that any relationship between planning and experimentation hinges on the planning culture in any context, with local governance and planning arrangements influencing any experimentation outcomes, be they practical testing, simulations, or simply thought experiments around policy options and scenario outcomes. Furthermore, Mukhija and Loukaitou-Sideris (2015, p. 1) argue that urban experimentation isn’t limited to testing pre-planned hypotheses through a structured and organised research process, but that “there is ample evidence that

These areas of overlapping literature have also been represented as conceptual “islands” of research, inspired by Will Wright’s (the creator of SimCity) “possibility spaces” and the concept of thinking of a “game as a map.” In several social media interviews and panel discussions, Wright provides examples of different dimensions of material and social success within The Sims, which were subsequently mapped in relation to the achievements of multiple players (Long Now Foundation, 2006). In this form of “mapping,” generative algorithms (Figure 8) were used to amplify dimensions, from the individual agents using simple sets of rules, including cellular automata, to spatial rules based on proximity and other more complex agents. With a large dataset derived from the behaviour of online gamers, Wright and his software collaborators have been able to describe the most successful criteria and paths of gameplay within The Sims.

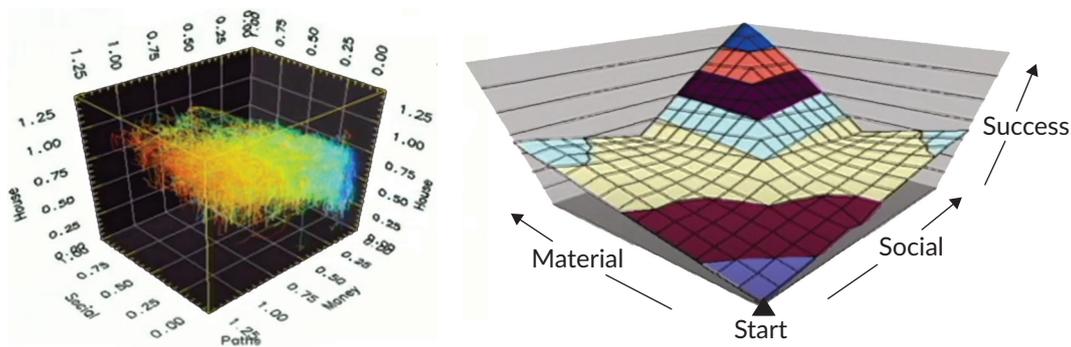


Figure 8. Mapped dimensions of assumed success in The Sims as mixed social, financial/material extracted from video. Source: Long Now Foundation (2006).

In writing about the theoretical grounding and background influences on the development of SimCity, Gingold (2024, p. 107) suggests that this “history reveals many islands of practice separated by time, terminology, agenda, and forum....As a result, every history of cellular automata is partial...[and] this archipelago thwarts neat historical narratives.” This inspiration is also an established analogical approach (Figure 9) to mapping literature that has been utilised in similar academic contexts (Burnett et al., 2013; Di Renzo et al., 2021) to highlight the connections between what appear as disparate areas of research.

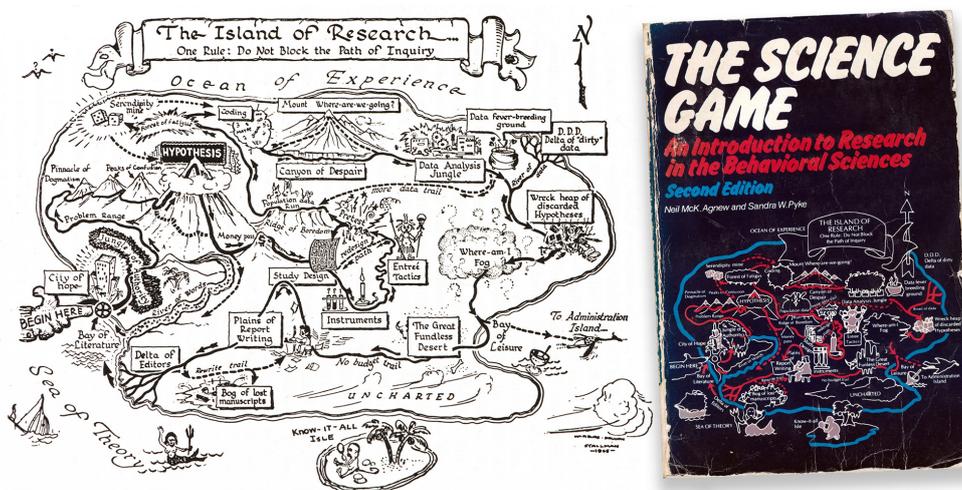


Figure 9. Earnest Harbury’s Island of Research as reproduced in *American Scientist*, 1966. Source: Harbury (1966), recreated on the front cover of Agnew and Pyke (1969).

In this tradition of mapping data, we have represented the systematic literature review in the form of a “map” drawn using the SimCity terraforming function. In this map, we have included the emergence or date of first occurrence of the concept (represented by the height), the scope/quantify of sources (diameter), and the archipelago interconnections (isthmus connections) between them (Figure 10). This is intended to visually summarise the complex relationship between disparate data sources.

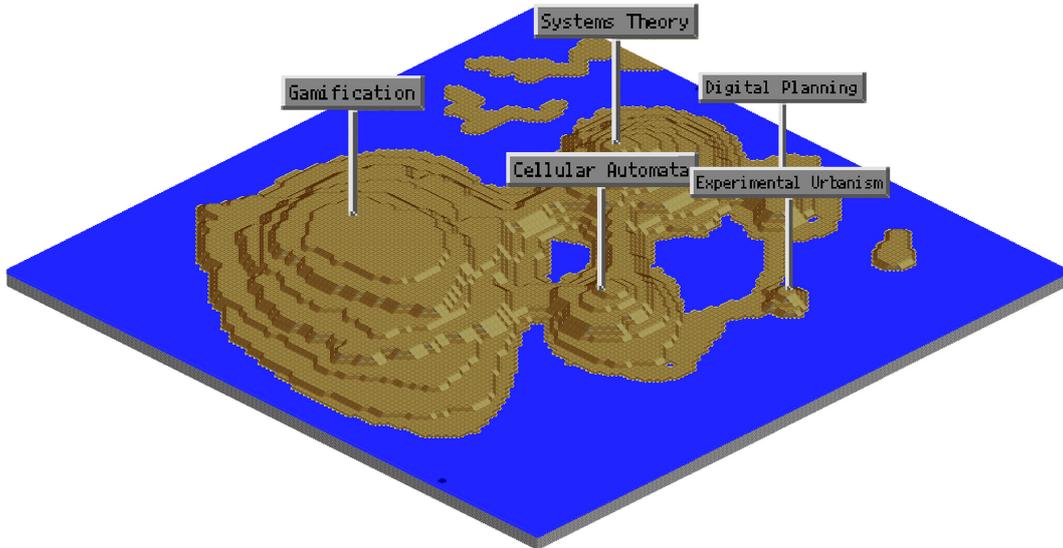


Figure 10. Representation of “islands of research” and their connections in relation to gamification in urban planning.

The scale of these “islands of research” is based on a quantitative analysis set out in tabulated form (Figure 11) relating to the number and origin dates of references for the specific keywords used to construct the research island. The origin date is largely based on the first keyword occurrence but checked against any individual paper and/or reference to identify any specific error or potential outlier in the dataset. In a few

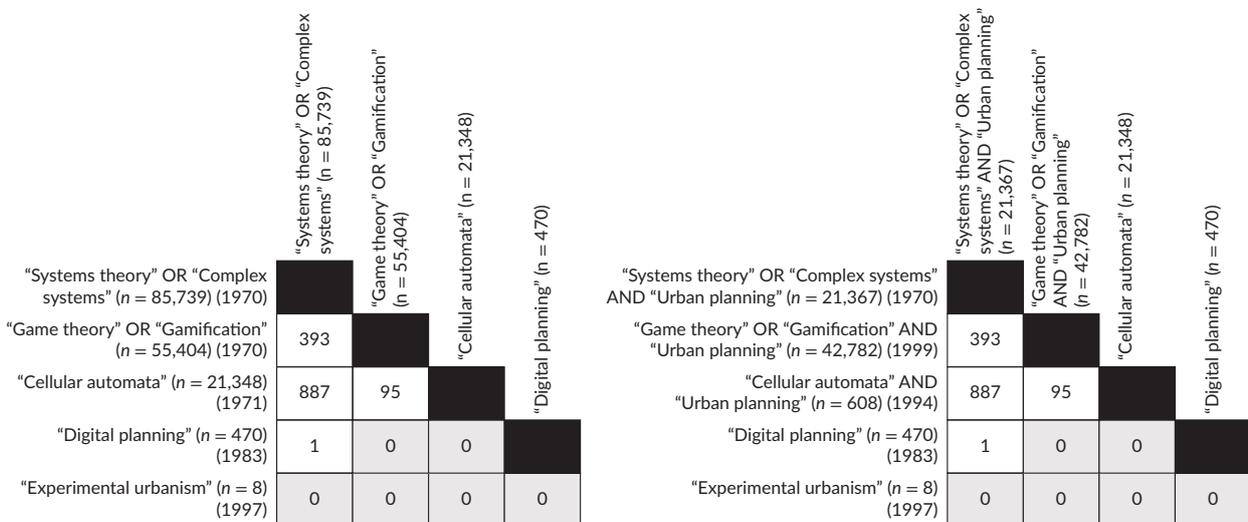


Figure 11. Cross-tabulated number of records found based on structured systematic search by year of publication for each of the linked literatures.

occurrences, we have thus made the decision to ignore specific individual outlier data points where these are clearly non-continuous areas of research or have used the keyword for a different semantic meaning. The expectation is that over time, the islands of research become less isolated as subject areas.

4. Key Current Applications of Gamification in Urban Planning and Main Limitations

There are several significant trends within this interrelated literature that are becoming apparent as the waters around the islands of research recede to expose new areas for experimental academic exploration and enquiry. The following section summarises these principal findings from the analysis of the literature and dominant applications of gamification and urban simulations.

4.1. Participatory Planning and Civic Engagement

Within the collective literature, participatory planning, as one of the current dominant paradigms within planning theory and practice (Healey, 2006; Jenney et al., 2018), is also one of the most prominent areas of applications of gamification in urban planning. This is mostly with an explicit aim to enhance public participation and civic engagement. More traditional public participation processes suffer from apathy, low attendance, limited diversity of participants, and superficial engagement with complex planning issues (Arnstein, 1969; Bishop, 2015; Montgomery, 2015). Gamification, and to a lesser extent, urban simulations, offer potential innovative solutions by making participation more accessible, engaging, and meaningful. Several studies have documented successful applications of game-based participation tools. Gordon and Baldwin-Philippi (2014) analysed community planning games that apply role-playing and scenario-building to engage residents in neighborhood planning processes. Their research found that game-based approaches increased participation rates and improved participants' understanding of planning trade-offs and constraints. The Block by Block initiative, developed by UN-Habitat in partnership with Mojang (creators of Minecraft), represents a notable example of gamification in participatory planning. This uses Minecraft as a platform for community members to visualize and design public spaces, with success in engaging young people who are often excluded from traditional planning processes (Olsson et al., 2020). Evaluation of the Block-by-Block projects has shown increased civic engagement, improved design outcomes, and enhanced community ownership of planning decisions.

Gamification has also shown some promise as a means for testing urban policies that require behavioral change. Certain applications draw on behavioral economics (or game theory) insights about how game mechanics can influence human behavior through psychological mechanisms like loss aversion, social comparison, and immediate gratification or feedback (Thaler & Sunstein, 2008). Some of the most effective of these are focused on areas of climate change and energy conservation programmes (for example the OhmConnect in California gamifies energy reduction by awarding points to residents who reduce electricity consumption during peak demand periods), transport or travel behaviour (for example, Streetbank and Cycle Atlanta) through rewarding sustainable transport choices (Kazhamiakin et al., 2015), and waste management (for example, Recyclebank) that reward recycling (Nomura et al., 2011). Reviews of these programs have also shown significant levels of public engagement (Kahma & Matschoss, 2017) in comparison to traditional engagement methods. This area continues to grow through an increasing number of mobile applications; for example, some recent apps like FixMyStreet and SeeClickFix gamify the process of reporting and management of the city by incorporating points, badges, and leaderboards. Research on these platforms suggests there is a potential to increase civic

participation, improve municipal responsiveness, and even influence behavioural change, though questions remain about their effectiveness in addressing complex planning challenges versus basic service requests (Johnson & Robinson, 2014). More significantly, these applications tend to be both specific to single-issue concerns within urban management rather than dealing with complex systems and largely static rather than dynamic forms of gamification.

4.2. Urban Simulation and Scenario Planning

Gamification has proven particularly valuable for urban simulation and scenario planning, allowing stakeholders to explore the consequences of different planning decisions in risk-free virtual environments and in a manner that can sometimes include dynamic scenarios. It is at this point that “serious games” (Dörner et al., 2016; Vaz de Carvalho et al., 2016), games designed for purposes beyond entertainment, have emerged as powerful tools for urban planning education and decision support. Although not explicitly falling within the definition of a serious game, the SimCity franchise has had a particularly significant impact on planning practice and education “parall[eling] and even influenc[ing] the now omnipresent, if not always well-conceived, use of computer simulation in contemporary urban planning...Versions of the game add power-trip possibilities that would give a city planner a God complex” (Lobo, 2004, para. 18). SimCity has been widely used in planning classrooms and professional training programs to illustrate urban systems dynamics and planning principles (Balbin, 2024; Devisch et al., 2016; Robinson et al., 2021). However, critics (such as Bereitschaft, 2021) have noted that SimCity embeds assumptions about urban development that may not align with contemporary planning values, particularly regarding environmental sustainability and social equity. City Skyline is the current leading simulated digital environment for any urban planning enthusiast and experimenter as the inheritor of the urban complexity simulations first explored in SimCity (Jolly & Budke, 2023).

Yet, like the participatory planning applications above (Section 4.1), there are a growing number of thematically focused urban simulation games that have been developed specifically for limited planning applications. For example, the InfraSIM game, developed for infrastructure modelling, allows participants to explore the interdependencies between different infrastructure systems and long-term consequences of investment decisions (Meijer & Perpinya, 2012), finding that participants demonstrated improved understanding of infrastructure complexity. Virtual and augmented reality technologies are also extending the possibilities for urban simulations. Projects like CityScope, developed at MIT Media Lab, are combining physical models with digital parametric overlays to create interactive tools that allow users to manipulate urban designs and immediately see the effects (Larson & Gruen, 2013). Recent work on immersive environments and “digital twins” has increased in sophistication, and these immersive technologies have the potential to provide more realistic and engaging simulation environments. For example, recently, Epic Games has created interactive real-time architectural models to test the new version of their 3D game engine (Dreith, 2023), further blurring the distinctions between architectural visualization and gaming environments. Albeit most simulations still maintain a single thematic focus, be it visual impact or the efficiency of specific urban systems or networks, it is questionable if this leads to more informed planning decisions compared to traditional planning exercises. It is this potential to address complexity in the urban system that will make a more practical connection with the growth in digital planning.

4.3. Data Collection, Citizen Science, and Urban Analytics

Gamification applications increasingly offer innovative approaches to collecting urban data. Traditional data collection methods, such as surveys, focus groups, and observational studies, can be expensive, time-consuming, and limited in scope. Experimental game-based approaches (for example, apps like Foursquare and Swarm) can potentially overcome some of these limitations by gamifying location-sharing features. While not explicitly designed for planning purposes, location data generated by many applications has been used by researchers and planners to understand urban mobility patterns, commercial activity, and neighborhood dynamics (Cranshaw et al., 2012). More explicit planning-oriented data collection games have been developed for specific research purposes. For example, the Place Pulse project at MIT used online games to collect perceptions of neighborhood safety, attractiveness, and other qualitative parameters by asking participants to compare pairs of street view images (Saleses et al., 2013), an approach that would be impractical through traditional survey methods. Similar citizen science applications (for example, projects like iNaturalist and eBird, which gamify biodiversity monitoring) incorporate gamification elements to encourage volunteers in different forms of urban data collection. Urban planners have begun using data from these platforms to inform green infrastructure planning and biodiversity conservation strategies (Bonney et al., 2009).

5. Conclusions, Limitations, and Future Research Directions for Gamification Applications in Urban Planning

Gamification offers a powerful, yet complex and challenging set of tools for urban planning. The literature demonstrates the potential to enhance public participation, improve realistic visualisation of urban environments, and even promote more sustainable behaviours. However, the field is ripe for more rigorous and theoretically grounded research. This section sets out the main directions for future applied research within the current limitations of practice.

5.1. Limitations of Current Practice

The current limitations in the context of simulations and gamification applications in urban planning are that they are largely sector or topic-specific, provide time-limited or static viewpoints, or linear in the consideration of end-state planning. All these concerns highlight the differences between gamification or urban simulations and the complexity of real-world urban planning.

In this set of limitations, the first key critique of current practice is the necessary reductionist approach to the gamification and simulation of complex real-world urban systems. This level of simplification is often due to the sector or professional-specific perspective and interest in urban planning and/or management. In this instance, there is a risk that game-based approaches may obscure important aspects of urban challenges or promote overly simplistic solutions (Bogost, 2007). Urban planning involves navigating complex trade-offs between competing values and interests that may not translate well into simple game formats. Related to such overt reductionist approaches are the associated issues of social justice, environmental sustainability, and economic equity, which require nuanced consideration that may be difficult to capture in gamified formats designed for broad accessibility and engagement. Indeed, one additional significant concern about gamified planning approaches is the bias created by the “digital divide” (Crilly et al., 2023) between different social groups and

the exacerbation of existing inequalities in civic participation. Research on digital divide issues in planning has well documented persistent disparities in technology access and use across demographic groups (Stern et al., 2009; Trevisan, 2022). Gamification typically relies on technologies that may not be accessible to all agents, particularly older adults, low-income residents, and those with limited digital literacy (Hargittai, 2002). If gamified planning tools primarily engage already privileged community members, they may inadvertently marginalise the voices of those most affected by planning decisions and place undue emphasis on the urban issues of the more digitally active agents.

A consequence of any reductionist application, even where this is justified as a specific policy approach, is the dominance of static outputs synonymous with end-state planning. In practice, this simply means that applications have been designed for a particular policy purpose with associated budgets and timescales. Applications are designed to assist time-critical or targeted decision-making and thus remain short-term. A significant gap remains in understanding the long-term effects of gamification on sustained civic engagement and behavioral change.

Finally, there is the limitation regarding scenarios and options around the consideration of possible futures based on decisions made within any urban game or simulation. There are concerns that preset narratives within many geogames will ultimately have limited outcomes, potentially to the point where certain futures are inevitable, or from a “closed” set of options. In this context, critics have raised concerns about the dangers of gamification to manipulate rather than empower participants in planning processes and signpost them towards a preferred policy outcome. The psychological mechanisms that make games engaging—variable reward schedules, social pressure, and achievement systems—could potentially be used to steer participants toward predetermined outcomes rather than facilitating genuine democratic deliberation (Morozov, 2013). The concept of “dark patterns” in game design—techniques that manipulate users in ways that may not serve their best interests—has relevance for gamified planning applications. If planning professionals use gamification primarily to generate support for predetermined plans rather than to facilitate genuine community input, the democratic legitimacy of planning processes could be undermined (Gray et al., 2018).

5.2. Future Research Directions

In response to the core limitations of the practical applications of geogames and urban simulations, we argue that the response must address real-world complexity as far as practical, increase the dynamic capabilities, and provide the ability to consider multiple options and alternatives for future development.

The concern around addressing complexity in urban simulations is that even a complex game, model, or simulation will ultimately remain reductionist, although we suggest that more complexity is always going to be more informative and more practical. This challenge is set within the developing complex systems literature and the benefits of “breadth over depth” in the scope of applications or simulations with the use of urban data and information modelling. Implicit within this expectation of complexity are concerns about displacement or unexpected consequences or outcomes arising from any decision or intervention. Linked to the challenges of understanding urban complexity is the sub-challenge to rationality and agent decision-making in addressing real-world wicked problems. Once you include the unpredictability and irrational behaviour of human agents into any planning context, you depart from the underlying structures

and rules implicit in the design of any urban game or simulation. This complexity challenge also relates to the development of robust evaluation frameworks that go beyond easily quantifiable metrics like participation rates and user satisfaction. Broader, more sophisticated, or comprehensive frameworks are needed to assess impacts on planning outcomes, democratic legitimacy, and urban conditions. If effective, it becomes harder to dismiss any data or evidence gathered through gamified or simulated methods as limited in scope.

The challenge of dynamic simulation is in part about thinking long-term and adding the time-dimension to gamified applications. While questions remain about the long-term effectiveness of gamification approaches in maintaining civic engagement and behavior change. The novelty effect that often drives initial participation in gamified systems may fade over time, leading to declining engagement and effectiveness (Hamari et al., 2014). Yet, positive research on gamification in other contexts has documented the challenge of maintaining user engagement beyond initial adoption periods. This raises important questions about the sustainability of gamified planning initiatives and the need for ongoing innovation and adaptation to maintain effectiveness. We collectively need to assess time effects, comparing gamification versus traditional planning methods, and ensure longitudinal research and approaches that consider dynamic parameters such as initial starting positions and externalities to the urban systems being considered.

The challenge of “open” outcomes of multiple options is a consideration related to impact in the real-world. To be fully effective as a practical tool for urban planning, future research should explore how gamified and simulated approaches to urban planning can be effectively integrated with statutory planning systems as part of the growth in digital planning. Application of these novel approaches may require integration with the current and largely normative methods used in planning or provide a more effective replacement for certain tasks. We anticipate a growth in testing, investigating optimal combinations of gamified and conventional participation tools, and understanding how to sequence different engagement approaches for maximum effectiveness. Studies should also explore how to successfully embed gamification into urban digital twins for participatory modeling and scenario testing.

Finally, we suggest the need for a stronger theoretical framework underpinning urban planning applications that begins to integrate the underlying theory alongside the methods of gamification and urban simulation. While some studies do touch on the relationship between underlying theory, particularly with concepts like systems or game theory, there remains a lack of holistic integration. Unified frameworks that connect systems theory, game theory, and gamified methodologies in urban planning are sparse, and there is significant scope for more action-research that embraces experimental processes in this area. Thus, future research should move beyond the simple application of game elements and explore how the theoretical underpinnings of game design can be more fully leveraged to address complex urban challenges.

As cities and urban contexts across the globe become more interconnected and complex, gamification presents an appealing tool, but only if implemented thoughtfully. Systems thinking ensures design depth, game theory offers structure and fairness, and experimental urbanism injects critical creativity. Integrating these dimensions within digital urban planning systems could enable scalable, inclusive, and transparent public engagement; support strategic collaboration across stakeholders; and foster adaptation and experimentation in our rapidly changing urban environments.

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Conflict of Interests

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