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Gaming, Simulations, and Planning: Physical and Digital Technologies for Public Participation in Urban Planning

Editors

Andrew Hudson-Smith and Moozhan Shakeri

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Editorial

The Future's Not What It Used To Be: Urban Wormholes, Simulation, Participation, and Planning in the Metaverse

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Abstract
In this editorial linked to the thematic issue on "Gaming, Simulations, and Planning: Physical and Digital Technologies for Public Participation in Urban Planning," we explore how urban planning has been, arguably, slow on the uptake of modern technologies and the move towards the next media revolution: The Metaverse is now on the horizon. By artfully pushing technological, cultural, and social boundaries in creating virtual environments, games and gaming technologies have presented interesting opportunities and challenges for the planning profession, theory, and education over the years. This thematic issue documents a wide range of innovative practices in planning enabled by games and gaming technologies. It attempts to open discussions about the way we conceptualize and treat new media and technologies in planning. By providing a wide range of examples, from non-digital games to gamified systems, interactive simulations and digital games, the issue shows that the lack of adoption of these practices has less to do with their technical possibilities and more to do with the way we understand tools and their added value in the dominant narratives of planning. As we note at the end, planning should be at the forefront of these technologies, not embracing technologies for technologies sake but because it should, as a profession, be leading the way into these new environments.

Keywords
gaming; Metaverse; public participation; simulation

Issue
This editorial is part of the issue "Gaming, Simulations, and Planning: Physical and Digital Technologies for Public Participation in Urban Planning" edited by Andrew Hudson-Smith (University College London) and Moozhan Shakeri (University of Twente).

"Good afternoon, ladies and gentlemen. It is with great pleasure that I introduce you to the magic of television...." With those words, Leslie Mitchell introduced Britain's first high-definition public television programme from Radiolympia. The date was 26th August 1936, broadcasting to the estimated 100 television sets available in the UK (Marcus, 2015). In nine years (1947–1955), television ownership increased from 80,000 households in London to nearly 15,000,000 all over the UK (Emmett, 1956). Rapid growth in broadcast media leading to mass adoption by the public and the professions is characteristic of successful new formats. Tim Berners-Lee, a British scientist, invented the World Wide Web (WWW) in 1989, while working at CERN. The Web was originally conceived and developed to meet the demand for automated information-sharing between scientists in universities and institutes around the world (CERN, n.d.). This demand by universities and institutes quickly developed into an all-encompassing platform that is arguably, only 40 years later, taken for granted in a comparable way to television. Our understanding of technologies and communication media and how they impact our life has significantly changed since the introduction of TV and even since the introduction of the WWW. Particularly the works of media ecologists and their study of media not only in their environment (in relation to the context in which they are used and their precedent media) but as an environment (capable of introducing new habits of perception, forms of understanding and monopoly of knowledge) have introduced new lines of enquiry into how communication media and technologies impact our social, economic relations as well as our cognitive abilities (Strate, 2004).

Urban planning, as Hudson-Smith (2022) suggests in this thematic issue on "Gaming, Simulations, and Planning: Physical and Digital Technologies for Public Participation in Urban Planning," has been, arguably, slow on the uptake of modern technologies and the move towards the next media revolution on the horizon; what can be described as the Web 3.0, characterised by decentralised technologies (Edelman, 2021), is following a similar path. The Metaverse is, perhaps, for the moment, one step too far for urban planning. However, hand in hand with digital twins and the rise of collaborative online systems, the Metaverse is coming, in the same way as television and the WWW, and it needs a "digital" urban planning system to embrace it. The time is now, we would argue, to be at the forefront of the next revolution in urban planning, powered by, as we explore in this thematic issue, gaming concepts, ideology, and technology, and with these wider participation.

With this in mind, it is important to note that, to date, innovative and critical takes on media in planning have often been pushed aside by the dominant narratives in planning that understand media as entities merely in service of the planning processes than a key player in participation and policy development: From Castells' writings in the late 1980s (Castells, 1989), exploring the web of interactions between the process of technological change, the process of socio-economic restructuring, and the new urban and regional processes, to Batty's seminal work in the late 1990s on the "computable city" (Batty, 1997). Onwards to the works of Sandercock and Attili (2010) on multimedia explorations in planning and beyond there have been efforts to find a place for the conceptualisation of media and technologies beyond their mere instrumental value in the service of planning processes.

Games are in a unique position among other media and technologies in planning. The history of their use in planning is as old as planning profession itself. Their use as support tools for planning process is justified in different planning paradigms; they are used as a simulation and testing technology in the early days and their use has also been explored in the communicative turn in planning. They have been discussed as educational tools, simulation technologies, deliberation support tools, and storytelling tools. At the same time, they are of the most known technologies to the public. In 1997, Batty wrote: "Reportedly, SimCity was the most popular-selling computer game in the UK at Christmas 1995, with many more people being exposed to the game than there are professionals concerned with the study and planning of cities" (Batty, 1997, p. 164).

Gaming technologies have always been at the forefront of technological advances for visualisation and storytelling and they have been at the heart of emerging virtual environments and now the cities which are starting to form in the Metaverse and its iterations, as explored by Delaney (2022) in this issue and his urban planning work in Minecraft. Even in their non-digital format they involve levels of abstraction, symbolizing, and storytelling that is unlike other media. Having story as their core, they always include forms of storytelling involving creation of virtual spaces, societies, and cities.

Adoption of games, gaming technologies, and game thinking introduces interesting challenges for planning as a profession and as a way of thinking about the built environment. There are well-documented records of attempts to adopt games in planning in the early 1960s (Duke & Schmidt, 1965). They reveal not only the opportunities that games were then presenting for simulation and scenario building and testing but also discontinuities that they presented. One of the biggest deployments of gaming in planning programs that was tested in the US was halted as it could not produce data on its direct impact and planners found it "difficult to hold to time schedules because the players became so involved in the game that they wanted to continue interaction phases far longer than ideal schedules allowed" (Light, 2008, p. 367).

In 1997, Batty argued that the future of technologies in planning is about not only examining the ways in which computers are changing the methods for understanding but also the ways they are changing the structure and dynamics of the city itself. Building on this, the thematic issue is an attempt to provide such a comprehensive look at games as medium and technology and their use in and impact on planning, to document the opportunities and discontinuities that games have introduced and continue to introduce to planning as a discipline and profession.

Beyond the future looking and arguably all-encompassing incoming Metaverse, the issue includes reflections on how games can be adapted for use in participatory planning practices. Tewdwr-Jones and Wilson (2022) and Delaney (2022) argue for using games as complementary participatory methods to other mixed-method approaches in social science and discuss how already-available technologies and games can be used as part of collaborative decision-making processes. Tewdwr-Jones and Wilson (2022) discuss the use of LEGOs for the co-creation of innovative projects and Delaney (2022) presents an innovative use of Minecraft as a participatory support tool for urban design and planning projects. Tan (2022) discusses how a network of games can be created by connecting games to other available datasets and games. Raghothama et al. (2022) highlight the impact choice of technology (analogue vs. digital) has on user experience in terms of learning, agency, and exploration. Hügel and Davies (2022) discuss how games can be used to empower young people to understand and engage with the complexities, uncertainties, and processes of climate adaptation planning. Finally, Avendano-Uribe et al. (2022) discuss how the use of games in participatory modelling can promote holistic system understanding among stakeholders and increase ownership of modelling techniques.

The issue also includes publications on how games, gaming technologies, and gaming frame of mind can change the way we think about planning and its processes. Reflecting on more than a decade of designing and testing virtual worlds, as noted, Hudson-Smith (2022) discusses the possibilities of rethinking digital planning considering existing and future Metaverses. Ampatzidou et al. (2022) argue for co-designing processes as a way of sharpening problem understanding in planning processes. Roumpani (2022) presents how procedural modelling techniques can be used to create and communicate informed 3D urban scenarios, and by reviewing the history of interactions between game studies and planning, Shakeri (2022) explores how game studies' concepts are rendered useful in planning and how planning theory has dealt with disagreements and discontinuities presented by games.

The works in this thematic issue document the challenges of designing and adopting games as part of planning practices as well. These challenges partly are technological or related to resource availability and partly are conceptual. The conceptual challenges are what media ecologists call discontinuities presented by a new media into its environment. Fox et al. (2022), Hügel and Davies (2022), Delaney (2022), and Ampatzidou et al. (2022) all discuss the challenges of evaluating the usefulness and outcome of the designed games and gamified system as well as balancing the meaning and the playful elements of the games, challenges that will not be overcome by new advanced technologies.

Although the thematic issue is focused on games, it attempts to open discussions about the way we conceptualize and treat new media and technologies in planning. Innovative practices around the design and use of virtual worlds, gamified systems, and games have been around in planning for over decades. However, they have never managed to find a functional place in planning practice, theory, and education. By providing a wide range of examples, from non-digital games to gamified systems, interactive simulations, and digital games, the issue shows that the lack of adoption of these practices has less to do with their technical possibilities and more to do with the way we understand tools and the dominant narratives of planning. The digital future of planning, we argue, is about addressing and embracing the discontinuities that these technologies present for planning theory and practice rather than dismissing them. Planning should be at the forefront of these technologies, not embracing technologies for technologies sake but because it should, as a profession, be leading the way into these new environments. In twenty years (2042) we will be able to look back through the wormhole between the real and virtual universes and hopefully mark the point at which the planning profession entered and led the way into the Metaverse.

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Thanks go to all the authors in this thematic issue, curated to encompass both the broad scope of gaming, simulations, and urban planning, as well as providing future insights into digital technologies within the urban planning system.

Conflict of Interests

The authors declare no conflict of interests.

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Article

Unstable Wormholes: Communications Between Urban Planning and Game Studies

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Abstract
The past decade has seen a gradual but steady increase in the planning scholars' interest in outlining a functional place for games in planning. A wide range of games for and about urban planning is developed and tested, from data-driven games that rely on extensive modelling techniques and aim to reduce the cost and risk of real-world scenario testing, to those that seek to educate their players about the complex nature of political and social issues. Despite the increasing interest in strengthening communications between planning and game studies, the current state is an amalgam of confusion and optimism about games' role and added value. To shed light on why such confusions emerge, the article reflects on the nature and outcomes of communications between urban planning and games studies and explores games' historical and current conceptions in planning. By adopting concepts from the work of Holbrook on interdisciplinary communications, the article explores how game studies' concepts are rendered useful in planning and how planning theory has dealt with untranslatability and incommensurability of concepts in the processes of establishing and sustaining communications with game studies.

Keywords
game design theory; interdisciplinary studies; participatory planning; planning theory

Issue
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1. Introduction

The critical reflection on the nature and success of interdisciplinary explorations in planning has become increasingly crucial with the recent focus on urban and civic issues across disciplines. In 2008, when Friedmann wrote about planning theory as the work of translation that should aim at "translating concepts and knowledge generated in other fields" to "render them accessible and useful" (Friedmann, 2008, p. 254), the assumption was that through communications with other fields and disciplines a reciprocal comprehension and a set of shared knowledge would be identified or created between planning and other fields. Despite the positive valence of the idea and the planner's current devotion to exploring the possible connections, the critiques of the nature, and success of these practices (Bickenbach & Hendler, 1994; Davoudi & Pendlebury, 2010) remain sufficiently powerful. Limiting the communications to mere juxtaposition, i.e., borrowing tools or concepts from other disciplines and uncritical mix and match of theories from the competing epistemic communities (Davoudi, 2015), have long been the main criticisms of interdisciplinary explorations in planning.

Today, planning scholars face new challenges in defining and establishing interdisciplinary communications. They are now required to communicate with fields that not only have fluid and porous boundaries and concepts (Repko, 2007) but also conflicting insights and theories with planning. The communicative and interpretive turn in planning, particularly, required planners to communicate with fields such as game studies and interactive storytelling that are often seen as scholarly themes emerging from disciplines of computer science, media studies, and cultural studies, rather than fields of studies in their own right. Frameworks, other than traditional approaches to interdisciplinarity, are needed to fully understand the nature of communications between planning and these relatively new fields of study; frameworks that go beyond understanding interdisciplinarity as an integration of two disciplines (Klein, 2013) and do not fall short in accommodating disagreements, untranslatability, and incommensurability that might appear in the communications between planning and other fields of study. By taking the possibility of reaching common ground between any two disciplines as a given, in traditional approaches to interdisciplinarity, the shortcomings of interdisciplinary explorations and communications are often blamed on academia's culture and politics rather than the epistemic nature of the communication itself (Holbrook, 2013).

In this article, by adopting concepts from the work of Holbrook (2013) on interdisciplinary communications, I critically reflect on one of the seemingly successful communications between urban planning and game studies. I aim to understand how planning has instrumentalized games and rendered them useful for its practice and how planning theory has dealt with untranslatability and incommensurability of concepts in establishing and sustaining communications with game studies.

2. Translatability and Interdisciplinary Communications

In understanding the nature and underlying concepts of interdisciplinary studies, scholars have gained insights from philosophy, language, cognitive sciences, and communication studies (Holbrook, 2013; Repko, 2007). Fields are believed to have their own conceptual scheme, their own unique way of organizing facts of the world (Davidson, 1973). If no conceptual schemes can explain a phenomenon, the communication between disciplines and "constructing an integrated framework with a common vocabulary" (Klein, 2005, p. 44) to improve an understanding of a phenomenon becomes crucial. In traditional interdisciplinary theories, such integration is assumed to be possible between any two conceptual schemes (Holbrook, 2013); disciplines modify or reinterpret "components or relationships from different disciplines to bring out their commonalities so that linkages can be identified between sub-systems" (Newell, 2001, p. 20). This understanding, which is the dominant approach to interdisciplinarity, cannot fully explain the cases in which disciplines try but fail to find common grounds.

By reviewing the existing philosophical approaches to translatability and integration, Holbrook (2013) outlines two alternative approaches to interdisciplinarity: the Kuhn-MacIntyre (recognizing incommensurability) and the Bataille-Lyotard (reflective invention). The Kuhn-MacIntyre approach emphasizes the importance of interpretation rather than translation in communications between different fields of study. In this approach, translatability is not about the mere translation of concepts or aiming for integration. Rather, it requires the competence to learn the standpoint of the target system of thought. The differences in the debates between two opposing systems, in this approach, can be resolved when "members of one system of thought resist the urge to translate claims made in the alien system of thought into their own language, but instead learn the language of the alien system as a second first language" (Holbrook, 2013, p. 1872).

In outlining the Bataille-Lyotard approach, Holbrook distinguishes between the strong and weak sense of communication (Holbrook, 2013). Weak communications are mainly used to "convince others to agree with us" and "to establish humble truths which coordinate our attitudes and activity with those of our fellow human beings" (Bataille, 1993, p. 199). As long as these weak communications are stable, i.e., as long as we appear to understand each other, strong communication will not be sought (Holbrook, 2013). In this account, mere interaction between disciplines, such as borrowing and translating concepts or tools from other disciplines and creating common grounds, are all efforts to sustain weak communications (Holbrook, 2013). The strong interdisciplinary communication, then, occurs with what Lyotard (1988) calls "differend," i.e., when disciplines fail to find common grounds: "In the case of a differend, the parties cannot agree on a rule or criterion by which their dispute might be decided" (Lyotard, 1988, p. xi). Strong communication, in this account, inevitably involves "mutual willingness [for disciplines] to risk [their] identities [which] may eventually be manifested in the creation of a new genre of discourse" (Holbrook, 2013, p. 1876).

Holbrook's work questioned the necessity of disciplines' integration in realizing successful interdisciplinary communication. He provided frameworks for understanding the many ways in which disciplines and fields of study communicate with each other, how they fail in communication, and what mechanism they use to deal with disagreements and untranslatability and incommensurability of concepts. Having these frameworks in mind, I will explore how communications between planning and game studies are established and sustained in the following sections.

3. Game Studies: An Overview

When the discipline of game studies—or ludology, as Frasca (2003) dubbed it—was called for in the early 2000s, the aim was to unify the works scholars were doing on games and playful activities. Gaming scholars began to "articulate [the discipline's] exact nature and scope, codify its tools and terminology and organize its findings into a coherent discipline" (Perron & Wolf, 2009, p. 4). This involved clarifying and critically evaluating, and defining the field's basic concepts. Defining what games are and how they are distinguished from other interactive media became the agreed-upon priority for the field (Arjoranta, 2014; Stenros, 2017).

Game scholars adopted two main approaches to defining games (Arjoranta, 2014): definitive, focusing on defining sufficient and necessary conditions for an entity to be a game (see, for example, Abt, 1970; Avedon & Sutton-Smith, 1971; Costikyan, 1994; Juul, 2003; Koster, 2013; Salen & Zimmerman, 2004), and descriptive, categorizing games based on their technology, genre, mechanics, etc. The definitions provided using definitive approaches are essentially a list of sufficient and/or necessary conditions for an entity to be a game (Arjoranta, 2014). For defining these conditions, in their early attempts, gaming scholars took inspiration from the works of anthropologists and psychologists on the concept of play and games (Caillois, 1961; Huizinga, 1944; Suits, 1978). Caillois (1961, pp. 10–11) had defined games as "an activity which is essentially: free (voluntary), separate [in time and space], uncertain, unproductive, governed by rules, make-believe." Huizinga (1944, p. 13) had defined play as:

> A free activity standing quite consciously outside "ordinary" life as being "not serious," but at the same time absorbing the player intensely and utterly. It is an activity connected with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner.

By the late 1980s, a new approach to defining conditions, known as the "common core approach," was developed. The idea was that one looks at previous definitions, finds common elements and gaps, and then provides synthesis to fill those gaps (Arjoranta, 2014). The well-known and commonly referenced works of Juul (2003) and Salen and Zimmerman (2004) followed the same approach. Salen and Zimmerman (2004) suggested new properties for games to better fit their definition within the systems thinking framework, and Juul (2003) aimed to expand the so-called classical game model to cover new types of games to better distinguish them from other interactive and playful systems.

Despite its value in providing a universal set of conditions, the definitive approach to defining games had certain limitations. Setting rigid boundaries between what is and what is not a game, they fall short in explaining certain activities traditionally perceived as games or accommodating for those who would be perceived as games in the future (Calleja, 2007). In response to this limitation and inspired by Wittgensteinian's family resemblance theory, a number of gaming scholars (see, for example, Arjoranta, 2014) made an effort to devise descriptive frameworks for talking about games.

The idea was that rather than focusing on the essence of a phenomenon, one could explain how its use resembles its context (Arjoranta, 2014). The very immediate use of Wittgenstein's ideas in game studies was taking whatever is "commonly known" as a game and putting them into different categories; i.e., defining families of games based on their technology, platform, strategy, storyline, or even the country in which they were produced (Arjoranta, 2014). With the continued popularity of decision sciences and the appeal of system thinking in various fields, descriptive approaches, though used in daily conversations about games, failed to gain traction in fields looking to use games beyond entertainment purposes.

It is important to highlight that the context in which game studies as a field emerged was very influential in shaping the overall narratives around games and their use beyond entertainment purposes. Formal studies of games began in the era characterized by its heightened trust in science and scientific approach and its predisposition to explain everything through the lens of system theory. It is no surprise then that the game's conception, even in definitive approaches, in the early 2000s, shifted from focusing on essential elements of play to describing games as systems, from the player's experience in the magic circle to the system's productivity in the real world, and from understanding the game as a means to entertain and the game as a means for problem-solving Calleja (2007; Table 1). This conception distances itself from considering the primary role of games as "an escape from, an alternative to, or questioning of society" to the use of games "as a perfection of means toward societies' given end" (Walz & Deterding, 2014, p. 15).

Conceptualizing games as a means for problem-solving or driving real-world change was for a long time a point of disagreement and heated discussions between gaming scholars. For those considering games as a means to entertain, the systemic view of games was about understanding how game elements (including storyline, visualization, level design, and goal) can work together

Table 1. Differences between definitive and descriptive approaches to defining games.

	Focus	Definition of Games	Use of Games
Definitive	Productivity and achieving repeatable patterns and ensured outcomes	Rigid boundaries and list of necessary and sufficient conditions	Research, pedagogy, and problem solving
Descriptive	Play and promoting creativity and artistic values	Categories or descriptions	Entertainment and communication

to bring about certain experiences for the player. They argue for games as art forms (Pearce, 2006; Smuts, 2005) and refer to the then-renewed understanding of art's public and private value (McCarthy et al., 2004) in outlining the potential social and economic impacts games could have. For them, the intrinsic benefits of games (i.e., fun experience) were the starting point for all other social and economic benefits games could bring about. Koster (2013), for example, called games "edutainment" and argued for the educational value of games as a by-product of the fun experience players have rather than the game's main goal. For those considering games as a means for problem-solving, the systemic view of games was about how games can produce a certain outcome for the player (learning) or the field in which the game is being used (information collected from players in the game). They mainly highlighted the instrumental value of games and developed frameworks (Harteveld, 2011; Roungas et al., 2019) to address how "elements of paida [free form improvisation] and ludus [highly regulated activity aiming for predefined goals] play" can be combined "by being at once regulated and providing freedom for improvisation" (Iversen, 2009, p. 11).

4. Trends in Game Design: Conflicts and Agreements

With the various conceptions of games and the heated arguments between gaming scholars on games' nature and role, different trends emerged in game design, most notably simulation gaming, serious gaming, and gamification (Table 2). Disciplines reinterpreted the theoretical body of works in game studies, repurposed old terminologies in their own field, and introduced new vocabularies. Oppositions also emerged from game designers in the entertainment industry, with some designers calling gamification and serious game trends bastardization (Bogost, 2014) and colonization (Aarseth, 2001) of games. To them, the new trends were a neo-liberal move that replaced the player's experience and fun with mere productivity (Rey, 2014; Whitson, 2014).

Simulation gaming and serious gaming trends both build on the conception of games as systems and have their root in the works on simulation and gaming in the late 1960s. With the then popularity of simulation models and the technological advances in digital graphics led by the video gaming industry, the use of simulation gaming in settings where real-world training or decision-making was too costly or risky became popular (Pierfy, 1977). In 1970, simulation and gaming emerged as a field, and the *Simulation and Gaming* journal was established. The term "serious game" was coined by Abt (1970) in the same year to refer to games that "have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" (Abt, 1970, p. 9).

While serious gaming banks on the game's educational capacities, the simulation gaming trend seeks ways to integrate gaming with social and urban modelling to enhance the data collection and decision-making processes. At the core of the simulation gaming trend was the idea that "valuable tacit knowledge often results in some observable action when individuals understand and subsequently make use of knowledge" (Dalkir & Liebowitz, 2011, p. 8). In carefully designed immersive simulated environments, the players' actions can be used as a proxy for their mental model of how things work in reality. New gaming technologies have made it possible for simulation game designers to design game environments with high fidelity to the real world; they allow for high-resolution 3D visualisation, provide computational capacity and infrastructure for collaboration and interaction of a large number of players, and allow real-time capturing and analysing of the players' behaviours and their interaction with game environments.

On the other hand, gamification has long struggled to be acknowledged and accepted as part of game studies and remains a contested concept (Deterding et al., 2011). However, with the widespread use of the term and the increased attention it has received in the urban planning field (Harviainen & Hassan, 2019; Hassan, 2017), it is important to include it in this study. Gamification emerged at the intersection of game design and behavioural science (Morford et al., 2014), and it is often defined as the use of game design elements in non-game contexts (Deterding et al., 2011). The core idea behind it was to understand how games successfully create intrinsic motivations and how those qualities of games can be used in the design of services and tools. Gamification for long was interpreted as using badges, leadership boards, and points as a means of persuasion for behaviour change in any designed service. The history of the idea, however, goes back to the early 1980s, when two articles titled "Toward a Theory of Intrinsically Motivating Instruction" and "Heuristics for Designing Enjoyable User Interfaces" were published by Malone (1981, 1982).

Table 2. The conception of "game" in different trends in game design.

Trends in Game Design	Conception of Game	
Gamification	Game-like systems	System
Simulation games	Systems for collecting data, testing scenarios, and pedagogy purposes	
Serious games	System for pedagogy purposes conscious of the importance of user experience	
Games initiated as entertainment	Structured playful experience with educational capacities	Play

5. Game Studies and Planning: The Communication so Far

Marking the beginning of the games and planning communication is not easily possible. In the 1940s and 1950s, particularly after World War II, war gaming was transferred to simulation gaming as a rational and analytical method for dealing with social complexities and public policy-making (Brewer, 1979; Mayer, 2009). The work of von Neumann and Morgenstern (1944) on the theory of games and economic behaviour, the emergence of decision sciences (i.e., operational research), and the wide range of studies done by the RAND corporation (Brewer, 1972; Goldhamer & Speier, 1958) were very influential on the then-emerging discipline of "gaming and simulation" (Fischer et al., 2007).

In the late 1940s, board games, such as Planning Operational Game Experiment designed by Francis Hendricks, METROPOLIS designed by Richard Duke, and CLUG (Figure 1) designed by Allan Feldt were used in planning courses to teach about the complex nature of cities and decision-making processes (Light, 2008). Games were known to be "exercises in the mastery of environment or self, social system, and of the supernatural" (Roberts et al., 1959, p. 604), and their pedagogic value was known to scholars in various fields. Particularly in developing strategies in the military context, games were used for creating simulated interaction environments for exploration, planning, testing, and training of military operations (Brewer, 1979; Klabbers, 2009; Mayer, 2009).

Figure 1. Early version of CLUG, 1966. Source: Feldt (2014, p. 286).

In the late 1950s, cities in the US were dealing with high levels of poverty. Urban renewal plans implemented to tackle the widespread urban poverty were heavily criticized for their impact on the neighbourhoods and communities. Those who favoured system thinking redefined "cities as communication and information systems, city problems as problems of communication and information flow and by extension, city planning as a science of communication information and control" (Light, 2008, p. 351). Around the same time, the added value of urban models was extensively explored in planning. Urban models were not pure architectural representations of cities' physical form anymore. Rather, they were seen as tools for representing cities' processes, testing scenarios, and predicting future outcomes (Batty, 2001). As Klabbers (2009, p. 448) puts it:

> Simulation models enabled expressing complex dynamic systems in tangible ways, and they allowed for performing experiments without interfering with *real-life* reference systems. In addition, linking human players to such models—that is, framing a gaming and learning environment—could enhance the transmission of available knowledge.

In 1970, Richard Duke organized the first International Conference on Simulation and Gaming (Klabbers, 2009). This conference marked the earliest formal interaction between planning and scholarly works that were then being done on games and was a reaction to a series of experiments done with games in policy-making as part of the Model Cities program in the US. With urban projects becoming a core of rebellion in the early 1960s, federal governments sought new ways of dealing with urban issues. As a result, several federally funded programs were introduced. Model Cities, in particular, became the program that highlighted the issues with communication strategies and tools in planning processes (Weber & Wallace, 2012).

While acknowledging the importance of public participation in decision making, much of the program was "focused on advancing participation through the structuring and management of citizen behaviour to match federal and local planning activities, creating Model Citizens eager to work within the *system*" (Light, 2008, p. 363). Several games, including MULBERRY, SIMPOLIS, and GHETTO, were developed by the second half of the 1960s as part of the Model Cities program and were applied to neighbourhoods in 150 cities across the US (Light, 2008; Figure 2). While initially, the plan was for these games to facilitate two-way communication between planners and the public, they soon turned into tools of one-way communication and control (Duke, 2011). By the early 1970s, with the lack of funding and city officials' inability to prove these games' effectiveness, the experiments with games could not be justified any longer (Light, 2008).

Figure 2. A group playing CLUG. Source: Feldt (2014, p. 291).

Having these experiments in mind, the main topic at hand in the First International Conference on Simulation and Gaming was the use of games for research purposes in the urban planning and public health context. The use of games for pedagogic and communication purposes was already tried-and-tested. The use of games for research purposes, however, was not yet explored to that date, and therefore, it raised many arguments at the conference of 1970; as Klabbers (2009) reports, the matter was left unsolved.

As the final decision, members suggested: "labelling the [use of games for] pedagogic objectives as gaming and the [use of games for] research objectives as simulation" (Klabbers, 2009, p. 450). The idea was that contrary to the games solely designed for entertainment purposes, games for the policy-making need to be based on "scientifically valid and policy-relevant theories that could be developed or tested" (Mayer, 2009, p. 831). Building on this conference's findings, Duke (1974, 1980), Meier (1977; Meier & Duke, 1966), and Feldt (1972, 1995) published extensively on the ways simulation games can be used in urban planning contexts.

Duke (2011), in particular, criticized the way games were used as part of the Model Cities program and published a series of books (Duke, 1974; Duke & Geurts, 2004; Duke & Greenblat, 1979) outlining games' potential for deliberation and strategic management. At the same time, literature emerged criticizing the "weak scientific foundations of gaming" (Mayer, 2009, p. 830). Duke (2011, p. 342) argued that games "are not intended to be predictive; rather, their primary objective is to help a group achieve consensus through the multilogue mode of communication."

With the communicative turn in planning (Healey, 1992), community empowerment, communication, and contemplating and sharing knowledge among various stakeholders became explicit themes in planning discussions. The aim was to move away from system thinking and rational approaches to accommodate varied types of knowledge in decision-making processes in planning, expand the language of planning, and extend planners' creative capacities (Sandercock, 2004, 2005). By the late 2000s, the second wave of interest in the use of games in planning processes emerged. The success of the gamification trend in advertising and marketing was also very influential in the renewed interest in games. In the second wave, rather than emphasizing the technical capacities of digital games as in the *Simulation and Gaming* tradition, urban scholars and practitioners focused on the games' participatory qualities (Poplin, 2012).

6. Urban Games and Their Underlying Theories

Given the wide range of games used in urban planning processes and the ubiquitous use of terms playful, gameful, and games in planning literature, categorizing urban games into distinct categories is challenging. However, understanding how the urban game design practices borrow concepts from game studies trends is helpful in better understanding the function and design of the urban games (Table 3).

6.1. Urban Games Initiated as Entertainment

The traces of ideas from the 1970s gaming and simulation trend can be found in many commercially successful games designed in the entertainment industry. Today, the so-called city-building genre is offered on a wide range of platforms (including mobile phones, PCs, and VR headsets). While there are city-building games (e.g., Tropico 5 and Urban Empire) that focus on negotiation and diplomacy in city management as a source of development, most city-building games extensively rely on modelling the physical and social growth of the cities as a form of algorithmic city generation. In building virtual cities and their algorithmic generation, game designers have used a variety of "intelligent virtual environment''

Table 3. Trends in game design and their use in planning.

Trends in Game Design	Use of Game in Planning	
Gamification	Changing behaviours and collecting data on the public's behaviour	System
Simulation games	Urban modelling and testing future scenarios	
Serious games	Capacity building in a participatory planning setting	
Urban games initiated as entertainment	Placemaking and enhancing urban experiences	Play

(Luck & Aylett, 2000) design techniques. These techniques help designers model physical growth using cellular automata urban models (Garza, 2005), and create interactive and adaptive crowd behaviours, using rule-based behaviour control of autonomous and guided crowds (Reynolds, 1999; Ulicny & Thalmann, 2001).

Another group of games known as pervasive games is a subset of mixed reality games (Hinske et al., 2007). "Geo-coaching," also known as a "scavenger hunt," "geogames" (Ahlqvist et al., 2018), or "treasure hunt" games, were long the popular game mechanics in pervasive games. Can You See Me Now? (Benford et al., 2006), for example, was of the first examples of mobile mixed reality games in which online players compete against performers on the streets. Up to 20 online players were chased across the city by three performers running through the streets in this game.

The added value of pervasive games beyond entertainment is often discussed, considering their three main design elements: mobility, sociability, and spatiality (de Souza e Silva & Hjorth, 2009). The spatiality element, along with the physical and mental dimensions of pervasive games, make them great educational tools for increasing the player's spatial literacy (Bartoschek et al., 2018). These games' social and immersive qualities are also emphasized in placemaking exercises. The technological advances in the locative media have lent plausibility to collecting or creating located information as part of pervasive game design (Matyas et al., 2008). For example, Pokémon Go and its earlier successful counterpart, Ingress, collected a large amount of data on the player's locations, movements, and stops, which ignited heated discussions around the potential and downfalls of commodifying location information (Frith, 2017) as part of these practices.

Given the popularity and commercial success of the city-building and pervasive games, their potential uses for facilitating spatial decision-making processes have been extensively explored. Some have praised city-building games as great tools for learning about urban design, planning, and urban modelling (Gaber, 2007; Kim & Shin, 2016; Minnery & Searle, 2014), calling them "crucial bridge[s] between the realms of play and practice" (Bereitschaft, 2016, p. 52).

6.2. Gaming and Simulation (Game-Based Simulations)

Following its traditional form, simulation games are used as a tool for exploring urban models and scenarios. Certain simulation games are used in participatory planning settings to allow the communities to navigate future scenarios. The Participatory Chinatown (Gordon & Schirra, 2011), for example, is a web-based simulation of Boston that allows the player to walk through a potential future neighbourhood and provide comments. The games in this category are used mainly for feedback gathering. The design of these often guided interactions also allows communication between various actors and data collection on the nature and frequency of the interactions between players.

6.3. Serious Games

Serious games are often used for educational purposes and capacity building as part of participatory planning practices. Since the simulation gaming trend is often associated with rational and scientific approaches, most games designed to be used as part of participatory planning practices tend to associate themselves with the serious gaming trend. They often highlight games' pedagogic and capacity-building values and their value in consensus-building and negotiation (Poplin & Vemuri, 2018), rather than their simulated nature and role in data collection. The assumption is that, through playing such games, the players become more interested in planning issues and better understand what would and would not be possible.

Most games in this category that are used as part of participatory practices, though not relying on complete simulation of the physical or social urban spaces, are in one way or another a replica of the real-world processes. Several low-tech table-top or non-digital games were designed in the past decade following the same logic. For example, Play the City (Tan, 2017) has designed a series of games addressing the circular economy and affordable housing issues.

6.4. Gamified Systems

Gamified systems are often used in urban contexts for changing and understanding people's behaviours and habits (see, for example, Chromaroma, which aims to encourage its players to use public transport). In recent years, in response to the critiques of gamification and its strong reliance on external incentives (very often monetized rewards) for changing behaviour, efforts are made to accommodate for enhancing people's experiences in urban spaces—for example, Pieces of Berlin (Alfrink, 2014) and Hello Lamp Post (Stuart, 2013). Gamification principles are also used to create better governmental services and enhance public participation practices (Harviainen & Hassan, 2019; Hassan & Hamari, 2020).

7. Translation: Sustaining the Weak Communication Between Planning and Game Studies

The first instances of communications between planning and game studies and the resultant conception of games as systems happened decades before game studies were consolidated as a field in its own right. The works of Duke, Feldt, and the other early policy game designers were very influential in establishing weak communications between planning and game studies. The then-emerging theoretical discussions on what simulation games are and how they can be used in planning are great examples of communication as translation, as discussed by

Friedmann (2008). They introduced new terminologies and design elements to better fit games into urban planning theory and practice and made future communications between the two fields possible.

Since the early interactions of planning and game studies in the 1970s, game studies have evolved greatly. A wealth of theoretical works has emerged, rethinking the games' nature and function. These works have expanded our understanding of games' functions and added value in dealing with complex social problems. However, the second wave of interest in games in planning did not theoretically engage itself with these new understandings of games. Rather, it conceptually rooted itself in the definitions of games as a system, developed at the height of the systems thinking era. It did not translate new understandings into planning theory nor learned the gaming as its second language. Rather, it sustained the weak communications by conceptualizing games as systems with predictable outcomes. The dominant narrative, therefore, remained similar to the 1970s; those games that are considered of value in planning processes are often an educational or complete simulation of the future development or participation process, at times, at the expense of the player's experience and fun qualities of games.

In 2011, the seeds for strong communication between planning and game studies were sowed in a reflection piece written by Duke (2011). By reflecting on the early and then-recent urban and policy games, he outlined the moments when communication between the two fields became problematic. He also hinted at the fundamental differences between the problem-solving approach in game studies and urban planning. By referring to the work of Armstrong and Hobson (1973), he emphasized that:

> Some policy problems did not lend themselves to traditional scientific techniques….These problems were often intractable—they were difficult to quantify, and we could see no scientific basis for their solution—their complexity demanded an intuitive, yet disciplined approach. (Duke, 2011, p. 353)

New tools, such as games, geared towards communication and encouraging stakeholders' involvement, were needed to address such policy and planning problems (Duke, 2011). Today, while the use of games is justified using similar arguments, the conception of value and use of games remains rooted in the positivistic approaches to problem-solving in planning. The efforts are, therefore, mainly focused on better designing the game itself and balancing the game's elements rather than reflecting on how the game and the gaming frame of mind can enhance planning's problem-solving and decision-making processes. This can also partly be blamed on the struggles of planning as a field in moving away from positivist approaches and accommodating the subjective types of knowledge in its decision-making processes, the struggle that is documented to a great extent in planning theory (see, for example, Osborne & Grant-Smith, 2015; Sandercock, 2005).

Strong communication with game studies or an attempt by planners to learn game design as their second language could enable planners to see games beyond their instrumental value and expand their problem-solving capacities by approaching the problem-solving process from a non-deterministic, intuitive game designer's mindset. Such communication could result in a more value-embedded understanding of media and tools in planning, enabling planning scholars to better understand the cycles of production and reproduction of values through the use and design of tools in planning processes.

8. Conclusion

Communications with other disciplines and fields of study are inevitable and crucial for the planning field. While the planners feel the urge to expand the range of knowledge they work with, the main narrative in communications between planning and fields that have an opposing system of thought to planning is often thought of as abandoning the very idea of planning as a discipline (Davoudi, 2012; Friedmann, 2003, 2008), rendering planning too fragile in its interdisciplinary explorations. This is partly because the existing interdisciplinary frameworks in planning are rooted in the traditional understanding of interdisciplinarity, seeking integration between the two fields. Acknowledging and understanding the untranslatability and incommensurability of concepts in interdisciplinary communications is crucial for the future of planning.

The story of communications between game studies and planning shows how planning has avoided such untranslatability and incommensurability through establishing and sustaining the weak communications. Games are rendered a useful tool for rational planning processes by introducing scientific validity measures and adopting the conception of games as systems. On the surface, games are great collaborative and interactive pedagogic tools. They have the potential to capture and influence the users' perceptions, attitudes, and preferences which makes them great tools for community building and participatory decision-making. On a deeper level, however, there are fundamental unaddressed differences between the approaches to social change in planning and game design as an art form, leading to unstable wormholes between the two disciplines.

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Conflict of Interests

The author declares no conflict of interests.

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Article

Co-Designing Urban Planning Engagement and Innovation: Using LEGO® to Facilitate Collaboration, Participation and Ideas

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Abstract
There is a growing academic interest in the idea of co-designing methods to achieve urban innovation and urban planning. As we see cities as "living laboratories," beyond the control of elected city government, there is a momentum to develop and test shared responses to the social, environmental, and economic challenges present in contemporary urbanism. These living laboratories are a function of open innovation or "quadruple helix" actors, drawn from state, business, higher education, and community sectors. However, translating the often-good intention principles of working together through shared and co-designed arrangements in any major urban area is often a significant challenge and a topic neglected to date. This article addresses this gap through the case study of Newcastle City Futures, a university-anchored platform in the north-east of the UK, that sought to co-design collaborative urban research, public engagement, and innovation. Newcastle City Futures created novel working methods centred on participatory games to facilitate shared understanding and joint ideas for new urban innovation projects across established sectors. This article will examine one method that was successful in generating collaboration and participation: "LEGO® mash-ups." Detailed empirical accounts of the development of the LEGO® mash-up method are used to illustrate attitudes to urban challenges, the fostering of a spirit of open collaboration, and the development of innovative responses through co-design. These are used to support the conceptual argument that the use of the quadruple helix as a form of urban innovation system needs to be accompanied by accessible, workable, and easily interpreted translation methods, such as games, by intermediaries.

Keywords
co-design; engagement; innovation; LEGO®; LEGO® mash-up; Newcastle City Futures; quadruple helix

Issue
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1. Introduction

Designing and delivering innovative solutions for the range of problems that cities now face has become a key focus for researchers, policymakers, and consultants all over the world. Traditional sectoral and policy responses through urban planning and other mechanisms are no longer, arguably, fit for purpose, having been devised in another century when cities were managed and controlled predominantly by city authorities, and governance was less fragmented (Phelps, 2021). As new smarter forms of digitalisation and technological innovation have become more embedded within the life and operation of urban areas, so has the management of change started to occur in increasingly more physically distant ways from citizens (Wilson & Tewdwr-Jones, 2022). Representative democracy and government remain a cornerstone of urban planning approaches across many cities and regions; but they may also be seen to be archaic to the way people—

governments, businesses, citizens—now interact with service providers and access intelligence and live data about aspects of territorial change.

Against this backdrop, there is a need to find new methods that can begin to analyse the complexity, speed, and nature of urban and regional change in places through a range of digital and non-digital devices (Batty, 2018). A concern with the future of cities in the 21st century encompasses a range of issues, from demography, climate change, and socioeconomic differentials, to infrastructure, well-being, and decent affordable housing. These challenges are corollaries of an increasingly urbanising world (Nijkamp & Kourtit, 2013) but are also present in cities in developed nations. Technology may provide some new systems to help us recognise these challenges and begin to find timely solutions. But equally, it could be argued that there are also limitations of more corporate-driven, technology-centred, smart city interventions in and across cities, especially if they are not as transparent and accessible as traditional forms of urban democracy and are more remote from the citizens themselves (Dixon & Tewdwr-Jones, 2021).

One area of academic interest that has developed through the 2010s and 2020s is the question of how universities can contribute knowledge and skills back into the cities in which they are located and support new ways to understand and plan for the challenges of complex cities (Goddard & Vallance, 2013). This work has started to see the city itself as a living laboratory since it is a site or pathway for a range of actors to experiment, learn, and precipitate change in their local areas (Bulkeley et al., 2018; Karvonen & van Heur, 2013). In this context, new scientific knowledge is seen as the product not just of academic experts or government officials, but rather as a mode of practice that is multiple, transdisciplinary, and socially reflexive; it is designed and produced by a range of actors from state, business, community, and education sectors working collaboratively for practical application beyond the academy (Gibbons et al., 2012; Nowotny et al., 2011).

One conceptual framework that has been used to analyse relationships and collaborations between representatives of the four sectors is the quadruple helix model (Carayannis & Campbell, 2009). This framework acknowledges that citizens of cities may be beneficiaries of collaboration and innovation, but may also contribute to those ideas themselves, resonating most strikingly with the idea of a living laboratory (Arnkil et al., 2010). But the question remains: What practical method could be developed that enables the quadruple helix government, business, community, and academic sectors to make sense together and collaborate most effectively to generate co-produced ideas (cf. Healey, 1997)? This has led to the development of experiments and pilots in specific places to test out novel partnership practices and to assess whether new methodologies are required to support and enable sectoral interaction.

This article examines the design and development of one of these new methodological approaches for urban co-produced innovation. The innovative methodological approach, that drew from the literature on new approaches to facilitate discussions on issues related to governance and place, aimed to explore the applicability of more creative approaches to facilitating workshops and discussions amongst city stakeholders. The purpose of the research was to identify, design, and pilot a workable and practicable collaborative method with organisations beyond the research community, to examine the stages of implementation, and to assess its outcomes. This case study draws upon a UK Research and Innovation-funded initiative rolled out in the UK city of Newcastle upon Tyne from 2016, led by the university's Newcastle City Futures (NCF) initiative, but involving representatives from other sectors in the city, aiming to work with each other to develop new projects and ideas. The method used gaming to instil collaboration across different sets of people possessing their own languages and organisational objectives. The example specifically used LEGO® bricks as a device for participants to collaborate, develop shared ideas, and communicate.

The work is structured into a series of parts: Following this introduction, the article looks at the recent use of gaming in urban and built environment change, before going on to consider the use of LEGO® specifically. After that, the article sets out the role of the Newcastle case study, its purpose, and form, prior to a detailed examination of the LEGO® method in design and practice. A final section analyses the case study in relation to a wider conceptual debate about whether gaming and LEGO® may be useful methods to generate participation and interaction.

2. The Use of Gaming for Cities and the Built Environment: Service Design and Innovation

Approaches to facilitating discussion—whether research or practice-focused—have explored the role of non-verbal communication in overcoming barriers to self-expression and communication. These approaches have been necessary to encourage creative, authentic, and legitimate discussions (McCusker, 2019), and reduced some of the barriers associated with more traditional debating approaches—for example, the most powerful or talkative person dominating meetings (Clavering & McLaughlin, 2007). One way this can be overcome is through rethinking how exploratory events can encourage equitable engagement from a broad range of people.

An approach gaining traction within education, business, and government is the use of tangible objects as a tool for structuring, sustaining, and evidencing collaborative events. The qualities of tangible objects lend themselves to becoming items of discussion and critique that can address some of the difficulties of traditional approaches to facilitated discussions and events. The tangible object physically embodies and represents a shared understanding and vision. Objects are better the more abstract they are, otherwise, there is a tendency for people to think about the details, rather than the overall picture (Buur & Mitchell, 2011). One example of a tangible object could be a game.

Games can take many forms, with no single agreed definition. Salen and Zimmerman (2003, p. 83) posit that a game is “a system in which players engage in an artificial conflict, defined by rules, which results in a quantifiable outcome.” The use of games in exploring issues pertinent to urban planning and wider society (rather than just playing a game for enjoyment; see Abt, 1970) has a long lineage. Shakeri (2017) dates games that mirror society back to chess, where chess pieces and their movement replicate the power, place, and authority in society. The roots of gaming are argued to be in ancient war games, where battles and military exercises were planned out, predicted, and explored (Mayer, 2009). Their use later, around World War II, developed into increasingly sophisticated predictions and simulations. As Mayer (2009) argues, games, policy, and decision-making have shared a lineage for centuries, allowing experts to experiment and play through scenarios.

More recently, however, the link between games and serious issues has become more tightly bound. “Serious games” are conceptualised as games that go beyond just providing entertainment, possibly employing strategy or role playing (cf. Abt, 1970). Serious games can also facilitate and encourage debate among the players, but may borrow many useful attributes from elements of more playful games. These may include: sharing ideas and approaches visually; requiring decisions to be made within a set of rules, procedures, or constraints; competition between the participants; and introducing chance and unexpected outcomes (Dresher, 1961). Serious games unite “the seriousness of thought and problems that…combine the analytic and questioning concentration of the scientific viewpoint with the intuitive freedom and rewards of imaginative, artistic acts” (Abt, 1970, pp. 11–12), and “offer us a rich field for a risk-free, active exploration of serious intellectual and social problems” (Abt, 1970, p. 13). These games are increasingly being co-opted into civic contexts where games present alternative formats for discussion that can make formal engagement approaches more open and participatory, and possibly fun (Gordon & Baldwin-Philippi, 2014).

Based upon the lineage and potential of serious games to stimulate discussion, LEGO® began to develop the “LEGO® SERIOUS PLAY® method” (Roos et al., 2004), and later a series of kits, as a method for businesses to encourage “group discussion, knowledge sharing, problem solving and decision making” (The LEGO Group, 2021). Their aim was to develop a “higher energy method” as an alternative to “their two-dimensional visual presentations of texts, graphs, and numbers using flipcharts, overheads, slides, spreadsheets, and the like” (Roos & Victor, 2018, p. 334). The intention was to encourage senior managers to think long-term, rather than on a day-to-day basis. Using the approach, three-dimensional models are made from LEGO® pieces in response to questions asked by a facilitator, which become the topic of further discussion and analysis (The LEGO Group, 2021) and “bring hidden insights to the surface and generate entirely new ideas” (Roos et al., 2004, p. 565).

Zenk et al. (2018, p. 248) note the effectiveness of using LEGO® for engaging thinking around complex problems: “Build[ing] models and metaphors…support[s] a mindset for solving ill-defined problems. In that sense, the bricks are used as a language for collaborative creativity,” that can entice questions about other people’s models and facilitate the sharing of viewpoints and build shared understandings (Gauntlett, 2018; Zenk et al., 2018). Gauntlett (2018, p. 12) notes:

> The idea is that going through the physical, thoughtful process of making something…an individual is given the opportunity to reflect, and to make their thoughts, feelings or experiences manifest and tangible. This unusual experience gets the brain firing in different ways, and can generate insights which would most likely not have emerged through directed conversation.

3. Methodology

As described earlier, Roos and Victor (2018, p. 337), early pioneers of the LEGO® SERIOUS PLAY® methodology, called attention to five characteristics and considerations to stimulate engaging SERIOUS PLAY® opportunities:

> The concept is exciting, but people can be anxious to engage; warming up is vital; material choices matter and there should be neither too much nor too little; the atmosphere must be safe, playful and comfortable, though there is flexibility in this setting; and the process is delicate.

With these considerations in mind and, as the article goes on to discuss, the research team of NCF devoted significant attention towards how they might develop practically a LEGO®-based game that encouraged interaction, critical reflection, and innovation in urban planning ideas with representatives of the four quadruple helix sectors. Recognising—as Roos and Victor (2018) note—that professionals and participants may see a serious game as an indulgence and something they need not attend, the team combined the game approach with more typical participatory workshop practices at the outset so that attendees might feel more comfortable.

This new gaming device was trialled in May 2017 with 40 participants. The following section outlines the way it happened and the experience of running what eventually became eight workshops over 15 months. But it is important to note here that the objective of the trial was to identify whether representatives of different sectors could collaborate and work together in a meaningful way on urban planning issues using a gaming approach. The trials were run by the research team acting as facilitators and took place in a new one-room innovation district building in Newcastle city centre, known as The Key (a neutral centrally located space). Before setting out the way the gaming workshops were designed and operationalised, it is first necessary to reveal more about the urban engagement and innovation platform in Newcastle that enabled the method to be trialled in the first place.

4. Newcastle City Futures: A Quadruple-Helix Urban Platform

Newcastle City Futures (NCF), led by Newcastle University, was an engagement and innovation platform in existence from 2014 to 2019 that attempted to create shared opportunities to shape the future of Newcastle and Gateshead through research, engagement, and innovation. It was designed as an agile initiative that used engagement to broker new research and innovation opportunities for the city, region, and university, while acting as a supporting partner to government, businesses, and communities, and as a project facilitator between Newcastle University and external agencies (Vallance et al., 2019).

The model of NCF was to work as a quadruple-helix intermediary (Vallance et al., 2020), linking together government, businesses, communities, and the academy to generate test-bed demonstrator projects and deliver four objectives (simultaneously, if possible): excellent research, business growth, public expenditure savings, and citizen engagement. NCF linked together existing university initiatives and funded research projects, to new audiences and opportunities in a hub and spoke approach, drawing together blue-chip projects focused on the region with user groups from policy, businesses, and communities.

The work included developing both a trust-building exercise through visual means (Tewdwr-Jones et al., 2019) and a state of the region report (Tewdwr-Jones et al., 2015) that would be used in the later period of NCF's endeavour. This was an attempt to get partners across sectors to work together to think of new shared project ideas. These new project initiatives were not imposed on participating partners by NCF but rather were intended to be identified by the organisations themselves, working together, but facilitated by NCF. The expectations of this approach were ambitious: New project ideas had to address multiple sectors rather than single sectors; had to have multi-partner involvement; and they had to employ some aspect of digital, visualization, or engagement methods. Projects that were developed and matured through this approach would then be submitted to the City Futures Development Group, a special-purpose Newcastle City Council committee, for comment and endorsement. That did not, in itself, imply a direct route to project delivery. It was vital from the outset to remind all participants that no funding was guaranteed for any project; the aim, rather, was to develop good ideas.

This heady mix of expectations reflected the purposeful "in-between" model devised to work across and between existing organisations, their vested interests, and silo policy sectors, to unleash something that might not otherwise have been considered due to the peculiarly fragmented English governance arrangements existing in the region (Pike et al., 2019). And although there was much merit in plugging the governance gap with a joining-up initiative based in higher education, it also meant that NCF continually had to be sensitive to political and governmental pressures, changing economic contexts and social needs, and the politicised position of the university. The phase of work involving facilitating partners' joint innovation ideas would be one of the more challenging requirements of the initiative and eventually led to a completely new approach and method being devised; this was how the gaming LEGO® workshops came about.

5. Developing a Co-Produced Participatory Method: The LEGO® Mash-Up

5.1. Overcoming the Challenges of Fragmentation

NCF had to find constructive and practical ways for all participating partners across the four sectors of the quadruple helix to start collaborating. Such a move was not without its challenges: each of the four sectors had their own legitimate reasons to participate; each partner came with their pre-existing objectives and working practices; most organisations could work independently from each other; and many were sceptical about the merits of participating in what was seen initially as "a talking shop." Additionally, some of the biggest barriers related to an unwillingness to listen to other sectors and a reluctance to share information and ideas. Such barriers to collaboration and co-production have been well documented in the literature and are not easily overcome, at least quickly (Bertosa et al., 2017).

The team had previously run participatory workshops of mixed participants and had been acutely aware of the unevenness of participation; people were divided between those who were happy to talk and those who were passengers, or—more likely—those who regarded themselves as being there only to observe events. Some who attended were senior managers with a decade or more of experience, whereas others were recent appointees. There were also participants who were uncertain whether they could speak out as individuals or whether they were there to represent their employing agency.

What was required, ideally, was a co-production method that would deliver several outcomes in sequence:

1. To be an icebreaker to warm the room up, relax people, and allow everyone to speak in front of each other;

2. To be a level and fair platform where nobody's pre-existing knowledge drowned out the potential of other people's input;
3. To develop a common language to ensure everyone could communicate openly with each other;
4. To serve as a fun participatory activity that would entice people to get involved without worrying about getting things wrong in front of other professionals.

5.2. The LEGO® Mash-Up Workshop

Having weighed up a number of options, the team settled on a three-hour morning co-production participatory workshop. Forty people representing different organisations from all four government, business, community, and education sectors attended each event that was divided into a number of key stages. The early stages were of a more traditional participatory workshop style, whereas the latter stages developed the gaming through a LEGO® approach. Table 1 illustrates how Roos and Victor's (2018) principles of successful SERIOUS PLAY® were adopted within the LEGO® mash-ups. Rather than seeing each activity as standing alone, the purpose was to structure a series of activities that led to sustained discussions on the practicalities and details of a potential project through LEGO®.

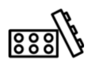
5.2.1. Arrival

Participants were encouraged to sit at any one of the round tables set out in the room. Each round table had six chairs around it. Participants were also encouraged to help themselves to coffee, tea, and pastries or fruit on arrival and engage in small talk with other participants. Once everyone had arrived and chosen a seat, the resultant random seat pattern on a single roundtable meant that the participants were mixed up. There was a chance, for example, that a local government policy officer would be sat next to a schoolteacher, who was sat next to a company director, who sat next to someone representing a mental health charity, who was next to a director of a telecom company, who was next to an academic. This was an intentional objective. The NCF director then introduced the team and the purpose of the event. The details were kept to an absolute minimum, but particular emphasis was placed on developing new and long-term ideas that would benefit the city; that is, participants should not be worried about working within current policy parameters, financial constraints, or employers' practices.

5.2.2. Icebreaker

The director put up a single PowerPoint slide with just one question: "What were you doing in 1992?" The specific year could be amended as necessary, but the point was for each person, in turn, to say what they were doing, what employment they were in, and where they lived. This was a deliberate different set question to asking everyone to state their name, their job title, and affiliation. There was no need for this information at that point as the objective was for everyone to harness their own skills and knowledge for a greater collaborative purpose. The whole exercise took about 20 minutes. In some cases, people had very different jobs or lived overseas; in others, the participants were not yet born. The exercise was intended to make people feel relaxed and leave their professional status and rank at the door, but also to consider, through a backcasting technique, what had changed in their personal circumstances in the interim period as a way of encouraging people to think about what might happen in the following 25 years.

Table 1. Sequential stages of the LEGO® mash-up process.

	 1. Arrival	 2. Icebreaker	 3. Introduction to Place Issues	 4. Idea Development	 5. Building the Model	 6. Sharing the Outcomes
Purpose	Making introductions	Facilitating mutuality	Setting the scene	Understanding challenges and opportunities	Visualising a project	Explaining and listening
Materials	Coffee	Round-the-room question	Image prompts, A1 paper, marker pens, and coloured sticky notes	Hand-drawn bubbles and keywords	LEGO®	LEGO® and video
Gaming Element	Space set-up	Team building	Game rules set-up	Team-working	Shared game task	Team game results

Note: Images retrieved from Flaticon (https://www.flaticon.com; left to right: Good Ware, Uniconlabs, Pixel Perfect, Freepik, Payungkead, Freepik).

5.2.3. Introduction to Place Issues

The team then put up a handful of very selective image-based slides intended to act as prompts to the workshop, shown in Figure 1. These slides represented some of the results of the state of the region report previously undertaken (Tewdwr-Jones et al., 2015), showing a list of the positive features or assets of the region on the left-hand side (such as city heritage and profile, prevalence of nature, community spirit, digitisation) together with a list of the negative socio-economic indices on the right-hand side (such as educational attainment, skills ability, climate impacts, mental well-being). There then followed a quick-fire set of tasks. The first task required each roundtable—following their own agreement—to take one issue from the left of the slide and one issue from the right of the slide and start to list all detailed aspects of each they wished to highlight. This exercise was undertaken using an A1 piece of paper, marker pens, and coloured sticky notes for people to jot down their ideas. That task was limited to just 15 minutes. This was followed by a second 15-minute task, where the roundtable was then asked to consider what the relationships were—if any—between their selective pairs. This comprised a second piece of A1 paper with a series of hand-drawn bubbles around keywords, linked together by a possible rather than identifiable relationship.

5.2.4. Idea Development

The third task, of 25 minutes, required the roundtable participants to choose one paired link of their choice and develop it further. This necessitated going into more detail about the feasibility of the pairing, overcoming potential obstacles to pair them, or considering the possible benefits of pairing and for whom. At this stage, the roundtable participants—having invested deeply in the exercise and the choice of issues over the previous 55 minutes—would embark on a detailed discussion, producing a single agreed outcome or project idea.

5.2.5. Building the Model

After a further quick refreshment break, the NCF team would distribute a bucket of LEGO® Classic bricks to each table with the expectation that the participants would construct their agreed final project or at least a representation of it. This allowed everyone, over the following 25 minutes, a chance to play with LEGO®, and was a necessary fun finale of the morning tasks, but also allowed some people to be more creative with their ideas and forms. This was vital in order to communicate possibly complex ideas publicly in a succinct way (Figure 2).

5.2.6. Sharing the Outcomes

Once the models were constructed, one volunteer from each table would present their project to all the participants, outlining the justification for selection, highlighting the potential benefits, and linking the project idea back to the original themes of the city and region.

5.3. Outcomes and Review

This approach, which lasted no more than two hours, proved to be a popular, inclusive, collaborative, and fun method to generate new urban innovation project ideas. It was so popular that, over the course of a year, NCF ran eight LEGO® workshops of 40 people in each case, and most of the participants had not been involved in anything like this exercise previously.

By inviting the participants to build and physically represent an idea, they were able to discuss the idea piece-by-piece in a structured way, which encouraged group members to scrutinise how the idea might be developed. This included an understanding of the individual steps and links between them that would be necessary to progress the idea further. Through engaging with the tangible objects, literal structures of joint understanding began to develop the practicality of realising ideas. The LEGO® bricks echoed the overall aim of the events that everyone had something to contribute and should be included in discussions to help explore, identify, and potentially work towards a solution of city- or region-wide problems.

The outcome of the eight LEGO® mash-ups was over 50 innovative co-produced project ideas for the city, multi-themed and related to the specific issues facing the place and people. The project ideas generated at each workshop differed enormously, with a noticeable distinction between the ideas of senior managers and those of non-senior managers. The latter group tended to think of projects that could relate to specific sectoral issues, such as digitally-enabled lifestyle housing for older age

Figure 1. Examples of prompt slides used during LEGO® mash-up, from an icebreaker question to introducing place issues.

Figure 2. Participants during LEGO® mash-up and project idea outcomes built as LEGO® models.

groups that could address dementia and assisted living in the city centre, or a community sports facility for young people that was digitised to enable them to learn digital skills as they played football. But the senior manager groups tended to address broader structural and governance issues because they viewed these as critical barriers that needed to be overcome to facilitate new innovations. For example, among the more memorable ideas for Newcastle and its region in 2047 presented by the senior managers to the participants were:

- *A single service regional delivery model for social enterprise and growth* with digital connectivity through the customisation of services.
- *An integrated lifecourse skills plan based on partnership as a new industrial regional strategy* that builds on existing assets rather than trying to land initiatives that have been successful elsewhere.
- *An inclusive growth and equitable societal infrastructure platform* to support a circular economy and fit-for-purpose public transport infrastructure, with less reliance on private car ownership.
- *A new Newcastle Gateshead City State* that encouraged self-sufficient regional food production that would be located across all parts of the city fabric.
- *A city built on ambition and aspiration*, with a fit-for-purpose education system to deliver skilled workforce and an urban area comprising shared spaces of real quality, but also where leadership was distributed between local government and business service providers, and the community played an active role in shaping and deciding the future of their own places.

In the two years following the workshops, many of the project ideas developed further, and the NCF team ensured that the project ideas did not fade away once the mash-ups were over. In some cases, the mixed group of people on individual roundtables asked NCF to facilitate a second meeting to identify whether the ideas could be taken at least one step further. Some of the mash-up projects did eventually morph into real-world projects, including the development of the Future Homes Alliance that is in the process of building 66 digitally-enabled age-friendly housing units on a city-centre site, and NUCASTLE, a £10 million community sports hub that is a digital and technological skills site for young people from deprived backgrounds.

6. Learning From Gaming and Creative Design Methods

The beneficiaries of the approach were many: for the research community, it was to develop inter-disciplinary cross-sectoral thinking in how they look at the city and understand and analyse problems; for participants, it was to identify opportunities to collaborate with individuals and agencies that they would not otherwise have considered working with, and creating a platform of trust for future partnership working; for urban planning specifically, it was to demonstrate how creative gaming methods such as LEGO® could be used proactively for more serious discussion about resolving complex place-based challenges.

Creative methods, more so than traditional social science research methods or planning consultation methods, allow for improvisation and messiness, and open opportunities for researchers to wander outside of their disciplinary fields to both reflect and reconnect with the social life they proport to be concerned with. Unlike discipline-defined social science research methods, creative methods can be shaped by their object of study and suit collaborative and interdisciplinary approaches.

These creative methods are not meant to change existing approaches, replace well-established methods, or usurp formal democratic forums. But they can serve a purpose in collaboration with other research methods and can be used at any stage within the research process and participatory design, from data gathering, analysis, and reporting. New and innovative creative methods are being used increasingly within the social science tradition but their development within urban planning consultation remains largely untested. The creative methods include arts-based formats, especially visual and gaming methods, and technological approaches. They allow participants to focus on issues in a different way that might then lead to more expressive and alternative views.

There are now many more combinations of methods that can be harnessed by the social scientist, a mixed-methods approach that uses a variety of quantitative, qualitative, and creative methods. This can be particularly helpful if the researcher is dealing with really complex research or even place-based questions. Multiple mixed methods could provide richer data and more insight into critical questions.

As a pilot of a game approach, the workshops did prove to be popular with participants, and it did lead to a number of concrete outcomes that were developed further; these manifested themselves into real-world projects, policy, and strategy discussions, and additional forms of engagement. The approach, therefore, testifies to the decision taken to adopt a combined traditional and LEGO® based participatory workshop. There had been a conscious decision to keep the bricks back from participants until the latter half of the workshop, for fear that the roundtables would focus on the LEGO® too early rather than generating joint ideas and shared project agreements first. That decision was borne out when it was discovered, during the course of some workshops, that individuals were going around to other participants roundtables and bartering for certain coloured bricks in exchange for others to represent their project ideas (for example, green to represent environmental issues).

The gaming element was initially viewed to be more of a secondary consideration in the participatory design, compared to the desire to create a collaborative and engaging activity that could generate agreed actions and outcomes about the city's problems. In the event, for some of the participants, they saw the LEGO® element as more of a game than the organisers had anticipated and developed a much more competitive attitude to both constructing their models, presenting them to the rest of the participants, and winning attention. Accordingly, if this method was adopted for similar purposes in future, a more intensive gaming element could be developed further to allow people to compete in the workshop, team against team. Although there might be a danger that this would undermine the collaborative objective of the meeting, it would not be allowed to dominate proceedings, but it would still require careful management on the day.

7. Conclusions

The whole LEGO® experience was intended to pilot workshops that allowed for the co-production of ideas from quadruple helix actors that specifically related to urban and regional problems. Through a careful choreography and structuring of events, cross-sectoral working was placed central to discussions, as this was identified by the research team as critical to respond to the complex problems of places. The choices that were made while designing and developing the workshop events were all intended to achieve this—the venue, the table placement, the number of seats available, the random seat allocation, even the coffee breaks—to create an environment for both opportunistic conversation, as well as more structured (but still open) discussions on a broad range of urban and regional topics.

The entire process was new for all participants. The trial was therefore intended to identify the degree of comfort that participants experienced in a different format to ones they had experienced previously. The unique circumstances of trying to address place-specific problems, across a large urban area, with representatives of so many different organisations, while instilling greater trust and partnership between them, all meant that the choices made by the research team differed from those advocated within more structured LEGO® SERIOUS PLAY® methodologies.

The innovative methodological approach certainly developed the relevance and applicability of using more creative methods to facilitate workshops for and discussions amongst city stakeholders. Identifying, designing, and piloting a workable and practicable collaborative method with organisations beyond the research community from scratch was an uncertainty, but it did generate the trust the facilitators had hoped for. It also allowed for much more reflection and questioning of new solutions for urban problems than traditional planning consultation methods.

Overall, the LEGO® mash-up demonstrated that a playful, fun, and colourful method could be used with a diverse group of people from different professional backgrounds to facilitate, generate, and produce urban planning project ideas that nevertheless addressed serious problems of the city. The novelty of the participatory method was viewed by participants as an innovation but, ultimately, the real test was whether participants were willing to stay for the whole duration of the workshop, were happy to present their achievements to others, and could see how the outcomes of the collaboration could be taken further practicably. Despite the fact that many of the urban issues addressed by participants were some of the most complex and structurally challenging in government and in society, they demonstrated not only a willingness to find innovative solutions in a co-produced way, but also to find common understanding and language across different groups of actors. Set against the more archaic forms of urban planning consultation methods currently employed by governments, more innovative co-production methods, including those using gaming techniques, could unlock not only a much more proactive and focused response among agencies and citizens in places, but also address the nature of multi-faceted urban challenges in a dynamic way.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Gamifying Decision Support Systems to Promote Inclusive and Engaged Urban Resilience Planning

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Abstract

Urban residents are often unevenly vulnerable to extreme weather and climate events due to socio-economic factors and insufficient greenspace. This can be amplified if citizens are not meaningfully consulted in the planning and design decisions, with changes to greenspace having detrimental impacts on local communities, e.g., through green gentrification. These deficiencies can be addressed through inclusive landscape-level collaborative planning and design processes, where residents are fully engaged in the co-creation of urban greenspaces. A promising way to support co-creation efforts is gamifying technology-based interactive decision support systems (DSSs). Gamification, the incorporation of video game elements or play into non-game contexts, has previously been used for DSSs in urban planning and to inform the public about the impacts of climate change. However, this has yet to combine informational goals with design-play functionality in the redesign of urban greenspaces. We conducted a review of state-of-the-art video game DSSs used for urban planning engagement and climate education. Here, we propose that gamified DSSs should incorporate educational elements about climate change alongside the interactive and engaging elements of urban planning games, particularly for real-world scenarios. This cross-disciplinary approach can facilitate improved community engagement in greenspace planning, informing design and management strategies to ensure multiple benefits for people and the environment in climate-vulnerable cities.

Keywords

climate change; decision support system; gamification; urban planning

Issue

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1. Introduction

Urban areas face unique challenges in adapting to climate change, including extreme weather events such as floods, droughts, and heatwaves (Bai et al., 2018). These extreme events can cause damage to the social, ecological, and technical aspects of cities, such as damage to the built infrastructure and harm to human health (Hobbie & Grimm, 2020). Compared to natural or rural landscapes, urban areas can be more vulnerable to these extreme weather events due to the compounding effects of the built environment and modifications to natural features. For example, impermeable surfaces can magnify flooding events, and built infrastructure with low albedo can intensify heatwaves (Hobbie & Grimm, 2020). Furthermore, climate change also poses other direct impacts on cities including the loss of biodiversity, worsening air pollution, and changes to cultural heritage and tourism, as well as the indirect effects on a city's economic productivity and competitiveness (Hunt & Watkiss, 2011).

The goal to strengthen urban resilience in the face of climate change is being addressed in many cities through proposals to increase urban green space and tree cover (Ernstson, Barthel, et al., 2010). However, urban resilience requires more than just arbitrary management plans (e.g., inconsequential planting of trees) and any proposed adaptation measures need to involve key stakeholders, including residents, in a meaningful way (Susskind & Kim, 2021). To date, the management of urban greenspaces has been traditionally driven by top-down approaches, which stress technical expertise or bureaucratic function at the expense of meaningful input from the communities who regularly use and interact with these spaces (Huang et al., 2021). Furthermore, several barriers impede community acceptance of urban planning initiatives, including: (a) distrust in city governments, (b) lack of buy-in for recommendations from planners, (c) green gentrification, and (d) concerns about personal safety and the spillover of crime from adjacent greenspaces (Anguelovski et al., 2019; Soto et al., 2018; Weber et al., 2017). These unintended consequences of excluding community voices in the planning and management of greenspace (Carmichael & McDonough, 2018) are compounded by a lack of acknowledgment and acceptance by planning professionals of cultural and provisioning ecosystem services (McLain et al., 2014; van Berkel & Verburg, 2014). These deficits can be addressed by developing inclusive landscape-level collaborative planning and design processes that can increase multifunctionality by including community-identified values and uses in the design and configuration of urban greenspaces (Campbell-Arvai & Lindquist, 2021).

As there is a high level of complexity involved in urban planning, one way to engage residents more fully is technology-based interactive decision support systems (DSSs). In the urban planning context, DSSs are software or tools developed to help find solutions to potential conflicts or problems with proposed designs whilst educating stakeholders about the proposed solutions, impacts, and benefits in a transparent way (Schindler & Dionisio, 2021; Walling & Vaneeckhaute, 2020). Originally, such decision support relied on static image depiction and photomontage alternatives to elicit feedback and management priorities during public and stakeholder consultations (van Berkel & Verburg, 2014); more recently, promising advances have been made that offer a high level of immersion, such as immersive virtual reality (VR) systems (simulated experience delivered through head-mounted displays), 3D cave environments (immersive rooms created by projectors), and multisensory environments (immersive environments that stimulate multiple senses, e.g., visual and sound; Herbert & Chen, 2015). While systems like these offer a means to interact with simulations by looking around and moving about, they often ask stakeholders to provide opinions on a few externally generated alternatives and lack the ability for users to change or alter a design or plan.

Actively engaging the community in the design of landscapes using immersive environments can empower stakeholders to challenge the status quo and entrenched top-down processes (Lindquist & Danahy, 2006). The growing number of DSSs that include users' input have required upfront consultation, built-in flexibility, and the simplification of complex systems (e.g., using a restricted number of landscape features and functions) to enable the meaningful integration of stakeholder feedback. They often include geographic information (Omidipoor et al., 2019) for investigating spatial distribution and tradeoffs (e.g., Cerreta & De Toro, 2012) and incorporate scenario-based projections for understanding temporal dynamics and plausible outcomes (e.g., Guzman et al., 2020). However, an ever-present challenge in DSSs is gaining sufficient participation and motivation for meaningful and representative public engagement. Gamification, the incorporation of video game elements or play into non-game contexts, may overcome these two challenges by providing an engaging and motivating experience, whilst allowing for users to provide inputs and make changes in real-time (Xu et al., 2017).

Though there is no standard definition for gamification, it is recognized as a process of enriching products, services, and interactive systems with game-design elements to positively influence user motivation and enhance behavioral outcomes (Deterding et al., 2011). The term "game" is used to describe numerous activities depending on the focus of interest (Parlett, 1999). In the context of DSSs, games are generally designed following the standard approach to video game design which includes providing players with goals, constraints, payoffs, and consequences whilst including some aspect of competition, either between players or self-competition (Dempsey, 1996). Games can be further categorized as "casual games" and "serious games." Casual games are typically designed solely for entertainment purposes and are generally not considered educational, while serious games are those designed not only to entertain and engage, but to also provide training and education, or to inform policy and decision making (Poplin, 2012). Both types of games have merits and limitations in educating and engaging different audiences on the topics of sustainability and urban planning, and both can be used as a gamified DSS (Ampatzidou et al., 2018; Prandi et al., 2017). Here, a gamified DSS is any tool used to aid the decision process that includes game elements; from simple features such as rewarding competition amongst participants of a workshop with points or badges, to extensive and interactive video games that represent the real-world environment (Redondo, Zapata, et al., 2020). By incorporating gamification elements, DSSs can attract users, motivate, and sustain engagement throughout a process (Deterding et al., 2011; Kasurinen & Knutas, 2018), and increase productive output (Kim, 2017).

Previous work has used non-gamified DSSs to link climate science to urban planning or management plans, e.g., Sheppard (2005) developed photorealistic landscape visualization of areas in England under both existing conditions and potential low-carbon designs, while Baird et al. (2014) used a participatory decision-making approach to the co-management of climate change adaptation in Canada. However, to date, there is limited application of gamification in a cross-disciplinary manner that addresses climate science in an urban planning context. This article aims to assess the current best practices for gamifying DSSs, with the results of this review informing how gamification can be used to promote inclusive and engaged urban resilience planning.

2. Methods

To assess the state of the literature on gamification, planning, and climate resilience, we carried out a systematic search for recently published articles using games in the context of urban planning and climate change mitigation. To capture the full scope of gamification studies of relevance to our focus we conducted a Scopus scholar search (www.scopus.com) using the search "TITLE-ABS-KEY((gamification OR gamified) AND ((urban PRE/1 planning) OR (climate PRE/1 change))) AND PUBYEAR > 2017." This initial search returned 66 published articles. The authors carefully read these article abstracts to determine the most relevant papers (i.e., those that referred to a named game). We also considered how these articles described audience engagement, the educational opportunities from participation, and whether the game could be used to instigate real-world changes. To ensure that we captured all relevant articles, a snowball sampling approach was used to identify additional examples of games from the reference lists of papers that met our inclusion criteria. This increased the number to 27 games for final review (Figure 1). The analysis was restricted to video game technology applied to the topics of climate change and/or urban planning, eliminating non-video games (e.g., board games) as well as review and conceptual articles, as we were aiming to include only primary references to games that have been developed.

3. Results

From the 27 games identified from our systematic literature review (see Supplementary File), we identified some key best practices for engagement, education, and applications (Table 1). However, there were few examples of gamified DSS that have as their focus inclusive and engaged urban resilience planning. While we found a similar number of games centered on either climate or urban planning (13 and 10, respectively), there were only four examples (14.8%) of gamified DSSs which included *both* urban planning and climate change/urban resilience as a thematic focus. Moreover, there was a lack of DSSs with a community design focus that would allow users to interact with and augment the private and public green spaces in their neighborhoods. The implementation of

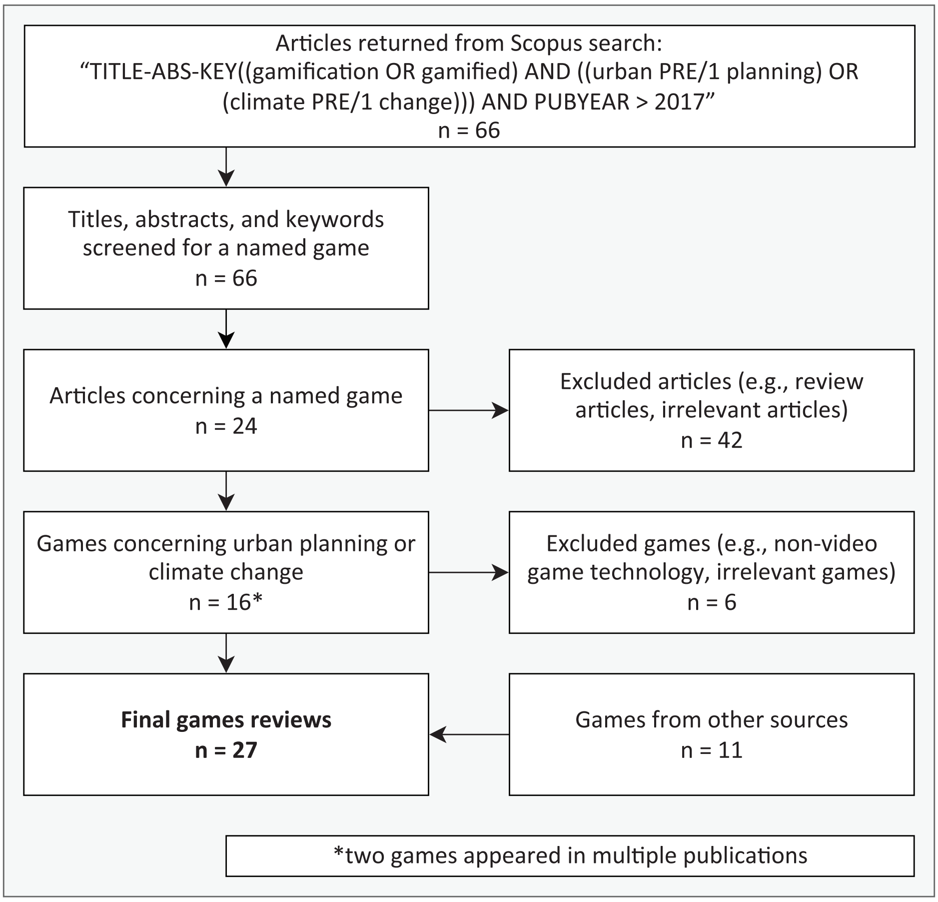

Figure 1. Systematic approach to filtering articles for review.

Table 1. Examples of best practices from reviewed games.

Aspects of Suitable Gamified DSS	Examples of Best Practices	Games
Engagement	Increased game realism	*Parkis* (Baušys et al., 2021) *Cities: Skyline*s (Khan & Zhao, 2021)
	Utilizing technology (VR or augmented reality [AR])	*GAME4CITY* (Redondo, Fonseca, et al., 2020; Redondo, Zapata, et al., 2020) *Ikigailand* (Bhardwaj et al., 2020)
	Facilitating community discussions	*Community Circles* (Thiel et al., 2019)
	Promoting continued engagement	*Land.Info* (Lindquist & Campbell-Arvai, 2021)
	Rewards-based incentives	*Cool Choices* (Ro et al., 2017)
	Diversity of participants	*Global Sustainability Crossroads* (Capellán-Pérez et al., 2019)
Education	Socialized learning	*GAIA Challenge* (Mylonas, Hofstaetter, et al., 2021; Mylonas, Paganelli, et al., 2021)
	Providing players with informed consequences of their actions	*Maladaptation Game* (Asplund et al., 2019)
Application	Designing real-world locations relevant to stakeholders	*Parkis* (Baušys et al., 2021) *Land.Info* (Lindquist & Campbell-Arvai, 2021)
	Encouraging real-world behavior change	*WasteApp* (Aguiar-Castillo et al., 2019)
	Multiple applications or scenarios	*Parkis* (Baušys et al., 2021)

these practices and examples of urban application is further explored in the Section 4. Most games assessed in this review were serious games, with only two casual games evaluated in an experimental setting.

4. Discussion

4.1. Gamification and Sustainability

Much of the gamification research to date has been in the domain of pro-environmental behavior, i.e., energy conservation, water conservation, and recycling. In these games, prizes and badges are accumulated based on "pro-environmental" behavior and goals. For example, Wemyss et al. (2018) noted a significant increase in energy savings amongst households assigned to collaborative and competitive gamified structures (vs. control households) in the *Social Power* game, and Ro et al. (2017) tested the *Cool Choices* approach to energy conservation, where individual households and teams accumulate points and prizes by adopting various pro-environmental behaviors, e.g., commuting to work by bike, replacing or eliminating inefficient household appliances, and switching to "clean energy" sources. Furthermore, Aguiar-Castillo et al. (2019) illustrated the effectiveness of the mobile phone application *WasteApp* in increasing recycling behavior amongst tourists visiting Europe. The success of these and other projects appears to be related to providing extrinsic rewards-based opportunities to learn and try out new behaviors and on the feedback provided about users' performance in comparison to set goals, or other players (Douglas & Brauer, 2021; Morganti et al., 2017).

Whilst less work has been focused on gamification to address the lack of concern and limited action on climate change amongst the public, recent reviews (Douglas & Brauer, 2021; Galeote et al., 2021) suggest that this may also be a fruitful context for application. Gamified systems, in providing opportunities for self-directed learning and skills acquisition, can build capacity and empower individuals to address climate change through their own actions and in cooperation with others (Rajanen & Rajanen, 2019). For example, *Greenify* is an online social media platform that promotes peer-to-peer learning on how lifestyle choices can affect the climate (Lee et al., 2013). Similarly, the *GAIA Challenge* (Mylonas, Hofstaetter, et al., 2021; Mylonas, Paganelli, et al., 2021) was designed for in-school sustainability education by providing a platform for cross-class participation where students compete with different schools and track progress through leaderboards. Socializing gamification, in addition to providing further motivation through interaction with peers, appears to increase climate change knowledge (including mitigation and adaptation efforts), as well as strengthening the affective (emotional) aspects of public engagement, e.g., interest, concern, personal responsibility, cooperation, and empathy (Galeote et al., 2021).

4.2. Gamification and Urban Planning

One approach to community-engaged urban planning is to stimulate community-wide discussions through rewarding participants using video game mechanics, and crowd-sourced reward tokens. Early examples that used this kind of gamification include *Community PlanIt* (Gordon & Baldwin-Philippi, 2014) and *The DuBes Game* (van Bueren et al., 2007). *Community PlanIt* (Gordon & Baldwin-Philippi, 2014) was designed to give stakeholders meaningful input to decision making, whilst providing opportunities for learning about the planning process. The game rewarded participants with points reflecting the degree to which they engaged with these community discussions. Players could then redeem their points to better advocate for the ideas they believe to be important (Gordon & Baldwin-Philippi, 2014). *The DuBes Game* (van Bueren et al., 2007) allowed for collaborative discussions surrounding the urban renewal of a fictional or real-world location. More recent games highlight how technological advancements have continued to facilitate community-engaged discussions. The app *Community Circles* (Thiel et al., 2019) facilitates communication around both bottom-up and top-down approaches to urban planning by allowing citizens to voice their own ideas about plans or issues and by providing city administrators with a platform to gauge feedback on proposals. Communication is made through geolocated posts (text, images, tags, etc.) on a map of the local community. Other users of the app can then comment on or like these posts and are rewarded with in-app points and a leaderboard that measures these contributions. Location-based games such as this can allow users to interact with and learn more about their surroundings with these interactions providing decision-makers with data on public preferences (Bishop, 2011). Single-player games can also aim to create a discussion-based atmosphere through simulated discussions via in-game characters that provide dynamic and realistic feedback on a player's choices. For example, in *MiniLautern* (Polst et al., 2021), players' actions are discussed with a fictional game narrator. Though such single-player games can help increase education and engagement, there is little scope for them to be integrated into the co-creation of climate-resilient landscapes for tackling real-world problems (Vervoort, 2019).

Some DSS games have been designed to improve communication with stakeholders on planning decisions through the simulation of proposed urban developments (Devisch et al., 2016). These games allow players to edit 3D models of urban areas with gamified goals which can be linked to realistic targets, such as tasking a player with designing a building within a fixed budget. Older games, such as *NextCampus* (Poplin, 2012), leveraged simpler 3D models to give players the ability to redesign a virtual 3D university campus within the constraints of a limited budget and in-game goals, such as improved levels of stakeholder satisfaction. More recent games build upon these concepts and provide players with additional realism and engagement through newer technologies. For example, *Parkis* (Baušys et al., 2021) generates realistic 3D models of real-world locations derived from GIS data. *GAME4City* (Fonseca et al., 2021) allows for players to interact with realistic 3D models of urban designs in a VR environment, thus providing an immersive experience in which players can gain an increased understanding of the project whilst facilitating the incorporation of user input into designs. These games can provide real-time information to stakeholders about changes in landscape features and functions throughout the redesign process (Lindquist & Campbell-Arvai, 2021). This method allows participants to view the expected visual impact of plans and allows them to indicate their preferred designs for urban spaces (Gnat et al., 2016), thus providing planners with valuable information on public preferences and improved opportunities to build public support for planning projects.

Finally, casual video games such as *Metropolis*, *Cities: Skylines*, and *SimCity* simulate the planning process putting players in charge of designing urban areas (Devisch et al., 2016; Khan & Zhao, 2021; Pramaputri & Gamal, 2019). Though these casual games can be highly engaging, they often simplify the planning process, making them less effective for educational purposes. For example, in *SimCity*, the player assumes the role of mayor of the city with the executive decision on all aspects of planning, which omits the fact that real-world urban planning requires a complex interaction between multiple stakeholders (Haahtela et al., 2015).

4.3. Challenges of Incorporating Gamification in DSSs

4.3.1. Game Design and Realism

When creating a new gamified DSS, considerations are needed for game development costs and effort, as well as how long the project will take to complete. These limitations mean that projects often face trade-offs between game design and the realism of the final product. Games relying on simple text-based designs or 2D renderings of the environment are the quickest and cheapest to develop and create (Gnat et al., 2016). Simpler 2D games can provide good representations of a city and help to facilitate education in urban planning (Poplin, 2011). However, although 2D models may be easier to create, there are multiple benefits of designing games to have a greater sense of realism. 3D models may provide an improved sense of belonging for a player (Gnat et al., 2016). Furthermore, technology such as VR and AR provides additional aspects of immersion and realism (Cirulis & Brigmanis, 2013). For example, AR games such as *The Urban CoBuilder* (Imottesjo & Kain, 2018) allows users to visualize the differences between an existing urban space and the consequences of proposed in-situ changes; this functionality may help to increase users' immersion in and connectedness to the proposals (Olszewski et al., 2017). While realistic games can be highly representative of real-world locations and increase players' sense of connectedness to the simulated environment (Swetnam & Korenko, 2019), with the potential to increase community support and buy-in, more work is required to better understand and quantify the influence of improved realism and immersive experiences on public engagement.

4.3.2. Inclusive Gamified Systems

Previous work has shown promise that serious games can increase motivation and engagement across a range of demographics (e.g., Capellán-Pérez et al., 2019). For example, games concerning the impacts of flooding have previously appealed to wider audiences, including older adults who are less likely to play video games and teenagers who may be less likely to interact with games on serious topics (Rebolledo-Mendez et al., 2009). There are however differences in the engagement of different demographics based on the game's method of delivery, for example, a digital divide exists in which not all individuals have access to smart devices (Leuzinger et al., 2019), while older people may find VR headsets particularly challenging (Redondo, Zapata, et al., 2020). For some stakeholders, VR headsets can cause motion sickness and some challenges have been encountered in the collection of results from VR experiments (Munafo et al., 2017; Redondo, Zapata, et al., 2020). Some studies have tried to make games accessible to wider audiences; for example, Mueller et al. (2018) made their gamified system *SimUSys* available as a web-based application that requires no additional downloads. Understanding the opportunities and barriers for inclusive design and planning with diverse audiences is needed to support meaningful and sustained community collaboration. Where empirical tests of a game's behavior change and knowledge outcomes have been conducted, they have in some cases omitted diverse audiences. For example, Galeote et al. (2021) found that over half of the climate change games studies reviewed focused on primary- and secondary-aged children and that almost 80% of these studies were focused on Europe or North America. Furthermore, as ethnic, racial, and socioeconomic minorities have heretofore been offered fewer opportunities to participate in collaborative urban-focused projects, their voices are less likely to be represented in outcomes of these programs (Pandya, 2012). While gamified DSSs are highly relevant for co-creation in urban planning, there is scarce evaluation of their efficacy and inclusivity in community-based settings. There is thus a need for additional research into the use of gamified DSS for urban planning and building climate resilience, particularly to ensure that all stakeholders can meaningfully and fully engage with the process.

4.3.3. Issues of Scale

Mismatches between urban policies and environmental and social issues occur over a range of temporal, spatial, and institutional scales (Bai et al., 2018). For instance, research suggests that urban greenspace must be considered at multiple scales: from local greenspaces to city-wide networks and to the surrounding region (Ernstson, Van der Leeuw, et al., 2010). Gamified DSSs should therefore not only focus on localized urban planning decisions but ensure that they support assessment measures over the full range and extent of a decision's influence, such as how scaling-up local designs will influence regional and national environmental targets (Bai et al., 2018). Though gamified urban planning DSSs have often focused on small-scale projects, games can be applied at a variety of scales from site-specific to city-wide (Ampatzidou et al., 2018). Gamified DSSs could therefore represent the nested realities of urban policy interventions by showing scale-appropriate city- and regional-level climate targets (e.g., mitigating flooding), and performance metrics might additionally inform users of the contributions of their local designs toward these broader, landscape-level goals. Providing information about larger-scale outcomes to local users would also contribute to an improved collective awareness of landscape-scale challenges and reveal how positive outcomes can only be realized through the synergistic coordination of many small-scale design projects.

4.3.4. Reporting of Results

Many articles concerning new gamification DSSs primarily focus on describing the software and potential applications (e.g., Tóth & Poplin, 2014). However, the number of studies that present empirical tests and results for these DSSs are more limited. Where results from gamified participatory studies in urban planning have been published, they are generally framed in a positive light, e.g., increased engagement from stakeholders and positive learning outcomes (Fernandes & Aquino Junior, 2016). However, a closer reading of the outcomes of such approaches shows mixed results. For example, a comparison of traditional respondent engagement with and without gamification found no advantage to including gamified elements (Guin et al., 2012). This suggests that a more critical evaluation is necessary to assess the merits of gamification in DSSs (Hassan & Hamari, 2020). Some promising studies have begun to add these vital evaluative steps regarding the effectiveness of gamified DSSs (e.g., Redondo, Zapata, et al., 2020) by including empirical tests of games across a range of populations and end-users. Applying a more critical lens to evaluations of engagement and education potential will contribute to the growth and innovation of gamification as a DSS.

4.4. Gamified DSSs for Urban Planning and Design for Climate Resilience

To date, there has been limited application of gamified DSSs that directly engage citizens with real-world urban planning and design for climate resilience. The game

Ikigailand (Bhardwaj et al., 2020) starts to address this by placing competition between two players who test the other players' city design by subjecting it to a catastrophic event, while the *Mayor's Dilemma* (Müller et al., 2018) touches upon these themes by placing players in the role of growing a simulated city focused on different energy production methods, the choice of which has impacts on their city—e.g., amount of air pollution. However, these two games do not allow players to build realistic worlds capable of guiding real-world planning scenarios; thus, current games that acknowledge both urban planning and climate reliance tend to have limited real-world planning and design opportunities. We argue that such a gamified DSS could be improved by engaging a wider range of audiences on the multiple dimensions of urban climate resilience initiatives, promoting inclusivity, and supporting actionable citizen-engaged decision making. The success of such a tool can draw on previous experience of DSS and gamification in other contexts by leveraging different forms of motivation and social learning (Seaborn & Fels, 2015) and by incorporating design objectives that matter to local communities (Campbell-Arvai & Lindquist, 2021).

Some citizen-engaged design of cities has provided participants with limited feedback on the environmental impact of their decisions, e.g., based on the architectural design of buildings (Birch et al., 2018). However, if the feedback given to participants does not also promote learning and reflect meaningful user-generated outcomes, the utility of engaging the public in a design process may be limited (Devisch et al., 2016). Gamification and the 3D visualization of cities can provide an intuitive method for non-experts to explore spatial designs and can provide real-time multicriteria feedback based on users' design decisions (e.g., costs, rainwater storage; Bishop & Stock, 2010). Games that facilitate community deliberation and collaboration, such as through online or in-person fora (e.g., Gordon & Baldwin-Philippi, 2014), additionally allow for participants to learn from the viewpoints and designs of others, providing them with opportunities to gain a broader and deeper understanding of the topics and design opportunities at hand (Latifi et al., 2020). Furthermore, through an inclusive collaborative planning and design process, the process of co-production can increase multifunctionality by including community-identified values and uses in the design and configuration of urban spaces at multiple scales.

Based on our previous experience with the DSS *Land.Info* (Campbell-Arvai & Lindquist, 2021; Lindquist & Campbell-Arvai, 2021), we believe that such systems can allow for user-generated climate-resilient designs for urban greenspace and green infrastructure by placing users in simulations of their community and casting them in the role of a landscape designer. Whilst designing their landscapes, users can be provided feedback about key performance metrics so that they may evaluate the impact of their designs against scale-appropriate climate resilience targets (e.g., mitigating flooding, reducing urban heat island effects), as well as other objectives of relevance to residents (e.g., aesthetics, personal safety, and recreation opportunities) that have often been ignored in expert-driven top-down design processes. Furthermore, design-scale DSSs like *Land.Info* can build community knowledge and buy-in through engaging participants in workshops and design charrettes, online and in-person. Evaluation of learning outcomes from and user satisfaction with such inclusive design processes is ongoing.

The lessons from our literature review suggest that the success of a gamified DSS for urban planning and climate resilience requires elements that promote engagement, facilitate education, and that the system is applicable to the real-world challenges of users (Figure 2). To be successful, DSSs need to provide an engaging experience for citizens. As traditional forms of civic participation, such as polls and consultations, do not lend themselves to promoting long-term sustainable engagement, interactive games can provide learning opportunities for individuals and communities that foster continuous engagement in urban planning (Devisch et al., 2016; Gordon & Baldwin-Philippi, 2014). Additionally, through providing an alternative educational approach and learning model, DSSs can be uniquely suited to address knowledge deficits, create buy-in, break ingrained habits, and increase long-term engagement (Devisch et al., 2016; Galeote et al., 2021; Petersen et al., 2019; Ro et al., 2017). Finally, games should have real-world applications that can have beneficial impacts on local communities (Baušys et al., 2021; Lindquist & Campbell-Arvai, 2021). A good balance of these qualities is likely to enhance user experiences by improving motivation for participation and offering an understanding of the implications, both positive and negative, of a proposed design.

Adding gamified elements to design-scale DSSs can play a key role in motivating participation and supporting learning, e.g., about the multifunctionality of public greenspace and the climate resiliency benefits that can accrue (Bonney et al., 2009; Silvertown, 2009). Public visibility of gamified outcomes may increase individual-level motivation for participation through the prospect of influencing local outcomes and foster long-term community-level involvement in the achievement of community-identified climate resilience targets (Kasurinen & Knutas, 2018; Newman et al., 2012). Such increased public participation may additionally encourage traditional public and private entities like municipal planning departments to incorporate suggestions from citizen inputs (e.g., crowdsourcing). Moreover, gamification can reduce the common challenges that planners have in attracting broad participation and citizen feedback by removing barriers to citizen involvement. New voices can be heard when time constraints are removed (e.g., public fora are held digitally rather than in-person) and real-world benefits are realized (e.g., community feedback is integrated into the planning process). Social interaction in such systems has the potential to mobilize

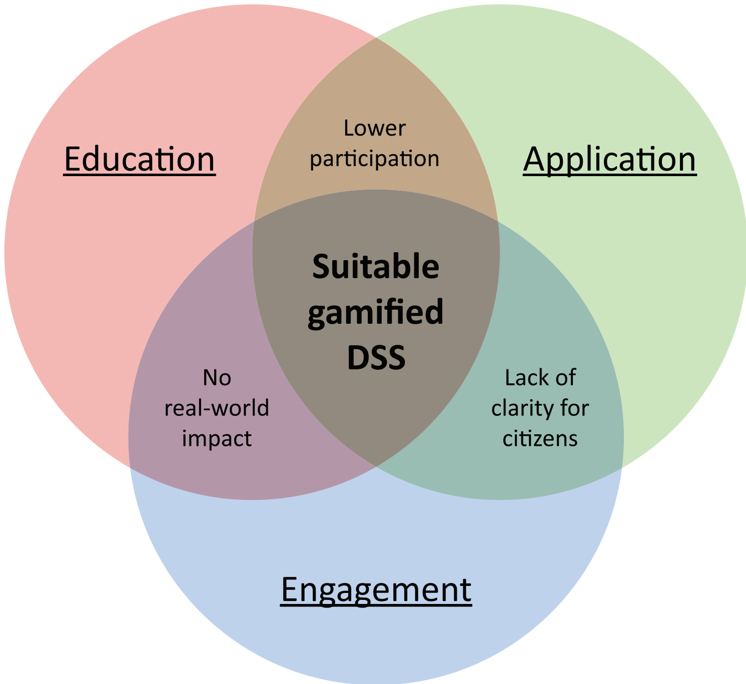

Figure 2. The engagement, education, and application framework for gamified DSSs.

a diversity of citizens in collective action and contribute to the democratization of the planning process in the service of inclusive and resilient cities (Afzalan & Muller, 2018).

4.5. The Future of Gamified DSS Under a Changing Climate

The development of inclusive technologies means that the accessibility of these games will increase. It is now possible to disseminate "high-tech" games, such as those using AR, to people through their mobile devices, allowing play from home or on the move (Mühlhaus et al., 2018). These emerging technologies can not only increase the number of people that can participate in crowdsourcing data, but also open novel and broad-based opportunities for climate resilience planning.

4.5.1. Future Technological Developments

Emerging technologies may help to further refine the public engagement, education, and planning applications of DSSs. For example, deep learning-based image interpretation can be used to infer user landscape preferences from choices made during the DSS design process, e.g., the influence of vegetation types and landscape complexity on aesthetic preferences (Gosal & Ziv, 2020; Havinga et al., 2021). Machine learning technologies, such as the Google Vision Cloud API and the Clarifai AI, have previously been used to assess photographs of landscapes and urban areas in a range of planning contexts (Ghermandi et al., 2022). It is foreseeable that these algorithms can be applied to photorealistic designs generated within video game DSSs to provide a more standardized evaluation of citizen designs to aid in supporting decisions, i.e., the degree to which they meet aesthetic, recreational, or carbon capture goals. The ability to identify favoured landscape features and functions will not only provide insight into landscape preferences but will also bolster our ability to identify landscape designs that optimize public use and multifunctionality, e.g., balancing needs related to human well-being and stormwater management (Rai et al., 2019). Furthermore, AI algorithms can utilize other datasets such as light detection and ranging (LiDAR) for landscape-scale disaster management such as simulating fire in a gamified environment (Yu et al., 2021).

As a result of climate change, game designs and, in particular, the generation of realistic 3D environments, will need to rapidly adapt to emerging challenges and constraints. However, current methods of generating 3D models of cities usually require time-consuming manual methods (Gnat et al., 2016). As urban areas become more prone to natural hazards, such as flooding and extreme weather, these 3D models must have the capacity to autonomously update to rapidly reflect changing landscapes, climate threats, and user needs. To meet these emerging needs, DSSs should leverage automated 3D model generation to quickly update features. For example, 3D point clouds from remotely sensed LiDAR data can be a useful tool for generating 3D models representing changing landscapes (Spielhofer et al., 2017).

4.5.2. Novel Applications

Climatic change is already having considerable impacts on cities and, as such, it is likely that DSSs will be a valuable tool for addressing these shifts. Future systems should be designed to address the rapidity and nonlinearity of climate change with built-in flexibility that can help developers react to new community needs and reflect changes in real-time. Such flexible platforms can strengthen community resilience by structuring discussion about stressors and aid in preparedness, for example, by providing neighborhood-level climate information and serving as a platform to pinpoint locations for intervention prioritization and as fora for reporting on and learning about climate-related disasters (Kankanamge et al., 2020). Games focusing on emergency planning, such as *Ready!* (van den Homberg et al., 2015) tend to focus on the community capacity to respond to disasters; however, these games could be reoriented to increase policymaker emergency planning foresight, as demonstrated by *WeShareIt* (Onencan et al., 2016).

Gamified DSS can contribute to smart cities by leveraging interconnectedness and big data to improve the livelihood of citizens and overcome complex challenges such as climate change. Here, gamification can be used to enable citizens to voice their opinions and concerns about smart city designs and help practitioners better respond to the needs and concerns of residents (Latifi et al., 2020; Zica et al., 2018). Furthermore, gamified apps can enable citizens to contribute to the large datasets that drive smart cities, such as recording and uploading water or soil quality (Bucchiarone et al., 2021). There is also scope for casual games to be a useful tool in the planning of sustainable cities. For example, a recent update to *Cities: Skylines* allows players to focus on sustainable development and could be useful for crowdsourcing experimental smart city designs from citizens (Khan & Zhao, 2021).

5. Conclusion

The goal of this article was to assess the current best practices for gamifying DSSs and to inform how gamification can be used for community-engaged landscape design to tackle climate change adaptation in climate-vulnerable cities. Here, we have identified three core principles that DSSs should follow: engage a larger number and diversity of stakeholders; educate participants about the positive and negative outcomes of design choices and scenarios; and be grounded in real-world applications. Gamified DSSs should therefore present opportunities to not only engage and educate citizens on the serious topics of climate change and urban planning but facilitate actual community-driven changes to urban and landscape plans. As a departure from expert-driven top-down management, a community-based and collaborative approach to landscape design will allow us to learn more about the community members' preferences and help to foster long-term community-engaged and resilient landscape designs in the face of climate change. Here, we have highlighted several research gaps that may limit the effective application of gamified DSSs in influencing decision-making. Combining informational goals with design-play functionality in the redesign of urban greenspaces will add novel urban planning engagement and climate education tools to the burgeoning DSS game space. Moreover, empirical work should be undertaken to assess the effectiveness of different gamification elements to improve the diversity of stakeholder engagement, and to ensure that the results of gamification studies inform the urban planning process. Including the public in such exercises must be part of larger strategies aimed at changing public attitudes, inspiring public action, and democratizing the urban planning and policy development process.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Curating Player Experience Through Simulations in City Games

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Abstract

The use of games as a method for planning and designing cities is often associated with visualisation, from simplistic to immersive environments. They can also include complex and sophisticated models which provide an evidence base. The use of such technology as artefacts, aids, or mechanics curates the player experience in different and very often subtle ways, influencing how we engage with (simulated) urban phenomena, and, therefore, how the games can be used. In this article, we aim to explore how different aspects of technology use in city games influence the player experience and game outcomes. The article describes two games built upon the same city gaming framework, played with professionals in Rome and Haifa, respectively. Using a mixed-method, action research approach, the article examines how the high-tech, free form single-player games elicit the mental models of players (traffic controllers and planners in both cases). Questionnaires and the players' reflections on the gameplay, models used, and outcomes have been transcribed and analysed. Observations and results point to several dimensions that are critical to the outcomes of digital city games. Agency, exploration, openness, complexity, and learning are aspects that are strongly influenced by technology and models, and in turn, determine the outcomes of the game. City games that balance these aspects unlock player expertise to better understand the game dynamics and enable their imagination to better negotiate and resolve conflicts in design and planning.

Keywords

city-gaming; experience; Haifa; modelling; Rome; simulation

Issue

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1. Introduction

From Cities Skyline (2018) to IBM's CityOne (2010) to Will Wright's SimCity (1989), and from Richard Duke's Metropolis (1969) to Buckminster Fuller's World Game (1961), many games are predicated on a city environment to design and plan aspects of the physical, social, and institutional dimensions of the urban fabric.

Game terminology in urban planning is not new. Sotarauta and Kautonen (2007) compared regional development to a game, and Innes and Booher (2010) talked about players in the context of collaborative policy. Head and Alford (2015) reminded us of a vicious cycle between gaming behaviour and wicked problems, especially when conflicting interests are involved (Rittel & Webber, 1973), which could be part of the wicked problem itself. Van Bueren et al. (2003) use games as a metaphor to illustrate finding a shared perception of the problem. Games have long been seen as a way to understand or address different kinds of planning problems (Mayer, 2010). Bishop (2011, p. 1) asked if landscape planning should be a game and viewed the concept through the objective of the game: "In collaborative planning, the objective should be for everyone to be a winner, or at least negotiate a mutually acceptable solution."

Games have long had a special place in urban planning as an instrument to enhance participation, generate consensus, educate, and solve problems (Meier & Duke, 1966). Starting with Jay Forrester's work on industrial dynamics, and the CULD and Metropolis games, to forming the basis for SimCity, games and simulations have had a long (and sometimes chequered) history in urban planning (Light, 2008; Wells, 2016). The need for such tools reflected the change in perception of cities as isolated city-states to hypermodern self-organising systems, positioning planners as spectators instead of technocrats (Devisch, 2008). In this regard, Batty (2015), Epstein and Axtell (1996), and others advocate the development of simulation models, not as reproductions of physical systems but as artificial worlds that exhibit similar features to those observed, functioning as experimental designs based on a theory. This, they argue, invites the planners to again shift away from spectatorship and back into a a central role in the planning process, and develop capabilities to steer spatial processes in desired directions (Devisch, 2008).

Games place the planner(s) as participant(s). At the heart of these encounters is a tension between reality and gaming (Tan, 2020). How close and distant are the game world and the real world from each other? How can players relate to each other? While there are many examples of successful games in urban planning, most games are evaluated with their primary aim of creating consensus or enhancing participation. We argue that the key to how games can perform in the real world lies in how games and reality connect (Raghothama & Meijer, 2018). It is therefore essential to understand how the game and its constructs influence gameplay, how players relate between the game and reality, or how the game constructs curate and nudge the player experience in subtle and unforeseen ways.

In this article, we attempt to unpack this relationship. We describe two games, one each in the cities of Rome (Italy) and Haifa (Israel), where traffic controllers and planners played with a realistic simulation of their respective cities. The city-specific simulations were developed using the ProtoWorld framework (Hauge et al., 2016; Raghothama & Meijer, 2015b). Pre- and post-questionnaires, recordings of gameplay, and debriefing sessions were analysed to understand how players perceived the game environment. In Section 2, we situate our games and experiments in the context of modelling, game analysis, and their scientific foundations. In Section 3, we describe the two games and the analysis method. Section 4 describes the dimensions found in our analysis, with reflections and sample comments from the players, wrapping up with our reflections and a discussion.

2. Background

Complexity theories of cities have emerged as a dominant approach to urban dynamics, planning, and design. As Portugali (2021, p. 2) puts it:

> The application of complexity theories to the study of cities entailed two potentials: (1) to reformulate a "new science of cities" based on the plethora of quantitative methods and modelling approaches offered by the theories of complexity—this potential was fully realised; and (2) to bridge the century-old gap between the quantitative and the hermeneutic traditions in the study of cities—this potential has yet to be realised.

In Portugali's two potentials, the first one is addressed by computational approaches to representing and understanding urban phenomena (Batty, 2015). The second one is addressed to a certain extent through co-creation and participatory approaches (Innes & Booher, 2010). We argue that games could be the perfect vehicle to bridge the two potentials. However, as noted by several scholars, there is a triadic relationship between models (which every game contains, quantitative or otherwise) and actors and theory. This hermeneutic relationship is one where players gain insight, through interaction with the model, about the many emergent relationships that form the reference system (Giere, 2004; Knuuttila, 2005). Models perform a mediating role, either in an autonomous or semi-autonomous fashion, between players, the theory which informs the model, and the reference system (Morgan & Morrison, 1999). Players are therefore playing both the strategic and wicked game of urban planning as well as the less serious, more fun game. This triple hermeneutic relationship, where players are strategizing in the game and reflecting about the wicked problem adds radically different source of uncertainty to game analysis (Raghothama & Meijer, 2018), which can only be bridged by understanding "play," within the context of planning (Feldt, 1966).

Games and reality can relate to each other in many ways. Games can narrate their storyline in a real-world setting, using depictions of real cities as backdrops, serving as an effective learning mechanism. Buckminster Fuller's World game famously highlighted the fact that an equitable world is not only visible but possible by altering country borders and pointing out the unfair distribution of resources. The most common form of games in planning is when a real-world challenge is introduced into a game, providing a safe and fun space for failure, learning, and building consensus. While settling on an ontology for games is a quixotic task, serious games and gaming simulations are best positioned to deliver tangible results that can be transferred to the real world.

Simulation games can support knowledge transfer from the game world to the real (Chalmers & Debattista, 2009). The use of simulation games to convey complexity and design within complex systems is large, as are applications to facilitate multilogue communication. The ability of simulation games to foster multilogue communication (Duke, 1974) combined with realistic representations of the social and technical system provide an instrument for going beyond learning and engagement (Lukosch et al., 2018). The scientific foundations of validity for simulation games come from several fields, from modelling to human-computer interaction, design, and so on. This foundation relies to a large extent on Duke's (1974) five Cs—complexity, creativity, communication, consensus, and commitment—but scholars have argued for other dimensions such as agency, fidelity (Feinstein & Cannon, 2002), and exploration to be just as important, if not more so.

The literature on the player experience of serious games is large. Law and Sun (2012) outlined a framework with several dimensions that can describe user experience, for example, gaming experience which concerns the player's one-to-one relationship with the game (Calvillo-Gámez et al., 2015) and includes flow, immersion, affect, challenge, and skills development, all of which appear to be central to gameplay (Huotari & Hamari, 2016). The *game challenge*, which deals with a player's perceptions of difficulty (Cox et al., 2012), contributes to *immersion* (Jennett et al., 2008), and as antecedent of *game flow* (Admiraal et al., 2011), allows learning to occur. Csikszentmihalyi (1997) developed flow theory as a way of explaining the state of mind of people who are *immersed* in a goal-driven activity which can increase motivation, allowing *learning* to occur. *Learning experience* (Cook et al., 2012) and *fidelity* (Lievens & Patterson, 2011) are two other dimensions most associated with serious game effectiveness.

Clearly, game analysis is quickly evolving into an empirical field of study, and user experience and human-computer interaction remain popular frames for analysis. We argue, however, that while such frames are useful and indeed necessary, they do not provide a sufficiently comprehensive picture of how players navigate between the game and the real world. While learning may be a goal, most urban planning games are oriented toward producing realistic plans and outcomes. They often rely on realistic, real-world content delivered by data, computational models, and simulations, and, in all cases, the tacit expertise of the players themselves. Players need to blur the boundaries of, or even break the magic circle to navigate this space and produce realistic plans and outcomes (Klabbers, 2009). This analyses player experience in urban planning games with more complexity and requires more nuance that involves not just the player and the game but the content of the game and the planning context as well. Accomplishing this requires analysing urban planning games from the perspective of the player with sufficient realism and fidelity to the planning context.

3. Methodology

We implemented two games using the ProtoWorld framework, one each for the cities of Rome and Haifa to help develop routines and plans for information provision, management procedures, and services for mobility in these cities. The framework and games were developed for the PETRA project. This project aimed to develop an integrated service platform that connects the providers and controllers of transport in cities with the travellers in a way that information flows are optimised while respecting and supporting the individual freedom, safety, and security of the traveller. Cities get an integrated platform to enable the provision of citizen-centric, demand-adaptive, city-wide transportation services, and travellers will get applications that facilitate them in making travel priorities and choices for route and modality.

The development of a shared understanding of mobility, and requirements for information provision from multiple perspectives and stakeholders, such as citizens, city planners, traffic controllers, and transportation service operators, required an approach that reflected the daily operations, behaviours, and patterns of these stakeholders. To collect requirements from the service providers' perspective, we placed traffic controllers, who would eventually be direct users, in a simulated environment (the games) where they would need to manage the city, either by providing information, by adding or reducing capacity, by changing signalling options, and so on. The games served as instruments to collect requirements for information and data visualisation and to design and test procedures to manage transport through information in the city.

In the following sections, we describe the framework used to develop these games, the steps followed to design and develop them, workshops and experiments where the games were played, and the data collection and analysis.

3.1. ProtoWorld

ProtoWorld is an open-source, distributed, simulation gaming framework, built using the Unity gaming engine. The framework can spatially integrate several urban simulations and visualise them during the run time at different levels of granularity (Raghothama & Meijer, 2015a, 2015b). The visualisations are rendered live within procedurally generated geography, with data sourced from OpenStreetMaps (OSM), which can also have different levels of detail and scale. Depending on the simulations being visualised, the framework can also provide interaction to the simulations, enabling run-time interaction with a dynamic simulation of a real city. ProtoWorld has interfaces to Simulation of Urban MObility (SUMO), Vissim, the General Transit Feed Specification, a crowd simulation built by Thales (no name), and a crowd simulation built within Unity. Depending on the scenario and requirements, these different simulations and technologies can be layered, visualised, and interacted with to provide a run-time interaction with a simulation or data. This run-time interaction provides players immediate feedback on the consequences of their actions and interventions. The framework has been used and tested in many studies, including in applications in the cities of Berlin, Venice, Stockholm, Amsterdam, Driebergen-Zeist, and the foci of this article, Rome and Haifa.

3.2. Scenario Development

For each new game—i.e., for Rome and Haifa—the following steps were carried out (extension of the list in Hauge et al., 2016):

1. Requirement analysis: Process in the real world, needs, the target of simulation, stakeholders, decision making options for each stakeholder group, and the possibility of delivering real-world data (traffic data, travel times, etc.).
2. Mapping of the real-world scenario into the simulation scenarios (including mapping different variables and definition of game mechanics).
3. Prototyping: Transferring into the gamified simulation environment (either using paper prototypes or directly digital prototyping).
4. Definition of game scenario (key performance indicators [KPIs]), polishing, narrative, goal setting/objectives).
5. Implementing the scenario in the prototype gaming simulation environment:

    a. Generate the 3D environment with data from OSM. The framework will procedurally generate the city, including roads, train lines, buildings, etc., by downloading data from OSM.
    b. Create the simulation(s) in their respective software(s). This includes generating the scenario files and calibrating the simulation to the gathered data, such as traffic data, timetables, etc.
    c. Design and implement control interfaces to the simulations. For example, if the player/controller would like to close a link, add vehicles, or tune certain parameters for the simulation (options gathered through the requirement analysis), they must be provided through the gaming interface to the simulation. This step is only necessary if the option has not been previously implemented in the framework, a rare occurrence.
    d. Design and implement data visualisation, to demonstrate the simulation effects in the 3D city. Similar to the previous step, apart from the animation of vehicle and pedestrian movements, the players might require some specific KPIs to be visualised to give them a better understanding of the simulation. These need to be implemented in Unity. Again, this only happens if it has not already been implemented.

6. Verification of the constructed scenario in the simulation gaming environment by the field experts (ensuring that the granularity and realism are according to the specification and needs).
7. Testing data collection: Role, information, game mechanics—Feedback (KPIs), rewards, chronometer, competition elements, actions, data on the number of moving objects (people, bikes, cars, trucks, busses, etc.), events, starting info.
8. Setting up a workshop for experiments.
9. Analysis of game information (data collected during gameplay in the game, analysis of transcript protocols, observations).

Even if the set-up of the experiments for each scenario varied a little in the number of involved participants, the knowledge level of the participants as well as differences in the implemented scenarios both followed the same procedure/protocol. The next section describes in more detail the differences in the experiments.

3.3. Experiments

3.3.1. Rome

Millions of tourists visit Rome every year, and this number was expected to increase exponentially because of the announcement of the Extraordinary Jubilee of Mercy year at the Vatican in 2016. The steps outlined in the previous section were followed by the Mobility Agency, and a game was implemented for Rome in ProtoWorld. The goal of the game was to develop routines for managing traffic, providing relevant information to tourists, enhancing capacity, and so on. Another goal was to collect information from the players about their requirements for a platform to visualise and understand mobility patterns and, subsequently, communicate them to other stakeholders and commuters.

The dynamic behaviour of the city was simulated by integrating SUMO (Krajzewicz et al., 2012) with pedestrian and public transport simulations. SUMO was chosen because it could simulate large transport networks, but more importantly, includes an API that facilitates fine-grained, micro-control of the simulation. The API supports functions that allow external programs (Unity, for example) to control nearly every aspect of the simulation, as well as make changes to the simulation configuration at run-time. For Rome, a transport network that covered roughly 8 km by 8 km was simulated in SUMO, as shown in Figure 1.

In a workshop organised by the Mobility agency in Rome, two groups of controllers played with the simulated city for a couple of hours. In the game, the players had the simple task of managing the traffic in the city, avoiding overcrowding in stations and buses, and helping people get to their destinations. The workshop setup was simple: Players were initially given a demo of the game and could also test and play it until they got comfortable with the interface and gameplay. Once comfortable with the interface and their task in the game, they played the game for approximately two hours. The steps they took to manage the situation in the game were recorded

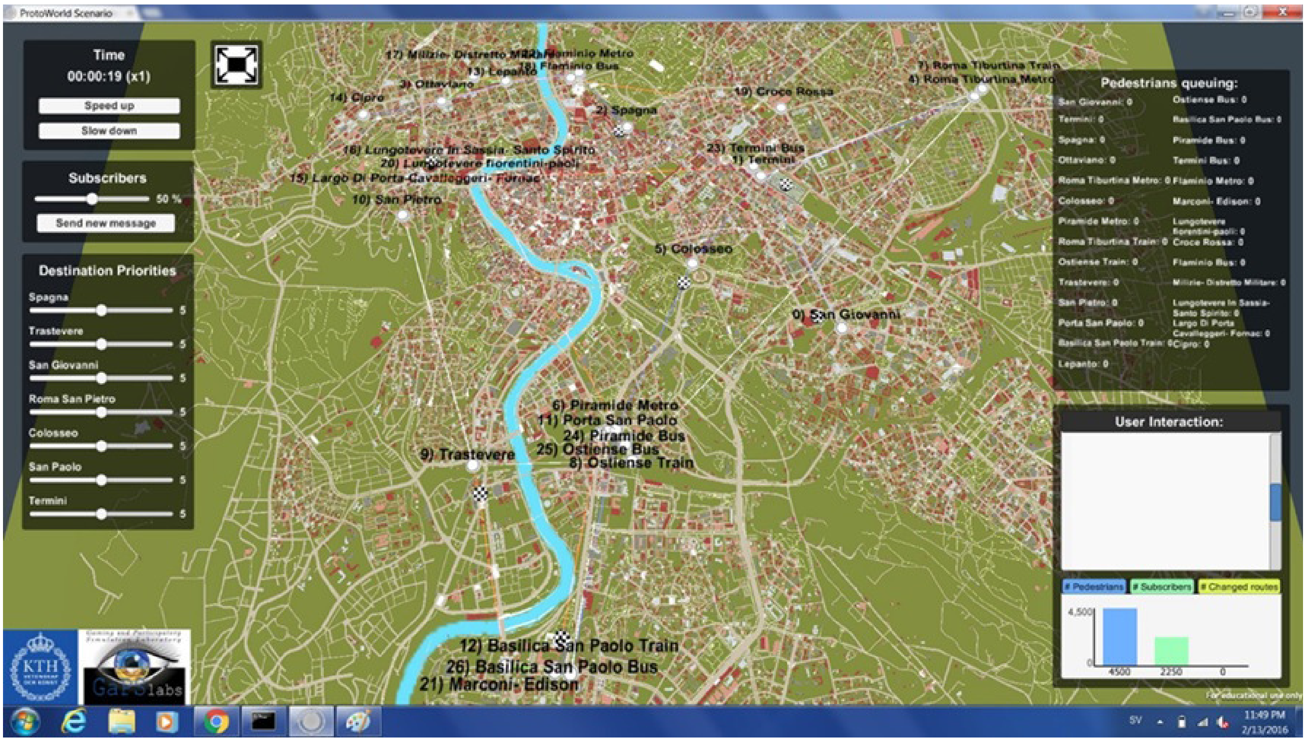

Figure 1. Macro view of the game in Rome.

through game logs to formulate plans. The gameplay was recorded and observed to gather knowledge on how they interpreted the game dynamics, and the discussion during debriefing focused on understanding their requirements and their perception of the gameplay.

3.3.2. Haifa

Another game based on ProtoWorld was built to simulate traffic in Haifa. The dynamics of traffic were simulated by a microscopic traffic simulator called Vissim. Vissim was chosen as the simulator since it was already being used by planners and operators in the city. Six scenarios were simulated in Vissim, each one detailing a different option for management and control of a traffic accident in a narrow corridor, leading to a bottleneck, as shown in Figure 2.

Like Rome, we organised a workshop with the traffic management centre of Haifa, where three groups of players, including a mix of controllers, police, and planners played the game. The structure of the workshop was similar, with the players being given a demo and time to familiarise themselves with the game and play through the scenarios. Data collection was also similar, with observations, video recordings, and questionnaires. Once they finished the game, they were debriefed together.

3.4. Data Collection and Analysis

Players in both games were given questionnaires to answer before and after the game. The first part of the questionnaire focused on validation of the game environment and scenarios presented, the results of which are presented in the Supplementary File. In both experiments, players were sufficiently motivated and found the experiments relevant and the scenarios realistic. Players also found that the experiments helped them with their daily tasks, or that a tool of this nature had the potential to do so. Within each experiment, players had different perceptions of their actions in the game, with respect to making strategic and operational decisions, as well as their influence on the simulation within the game.

Data was also collected through observations, and the extensive debrief was also taped. The videos of gameplay and debriefing and the questionnaires from both experiments were transcribed verbatim and translated into English. The transcripts were inductively coded (Corbin & Strauss, 1990), and the codes were grouped into categories. Over eight hours of video recordings from Rome and 12 hours from Haifa were transcribed and coded. The coding analysis covered many aspects, some specific to the project, some specific to the simulation context and the rest that relate to how simulations and games can elicit the players' mental models and evoke their professional expertise, according to the dimensions outlined previously. Each category contains many comments and is presented with sample comments. The analysis shows that the dynamics were hard to describe from within existing frameworks but found different ones relevant for consideration. In Section 4, these dimensions found in the data are presented and illustrated with sample comments.

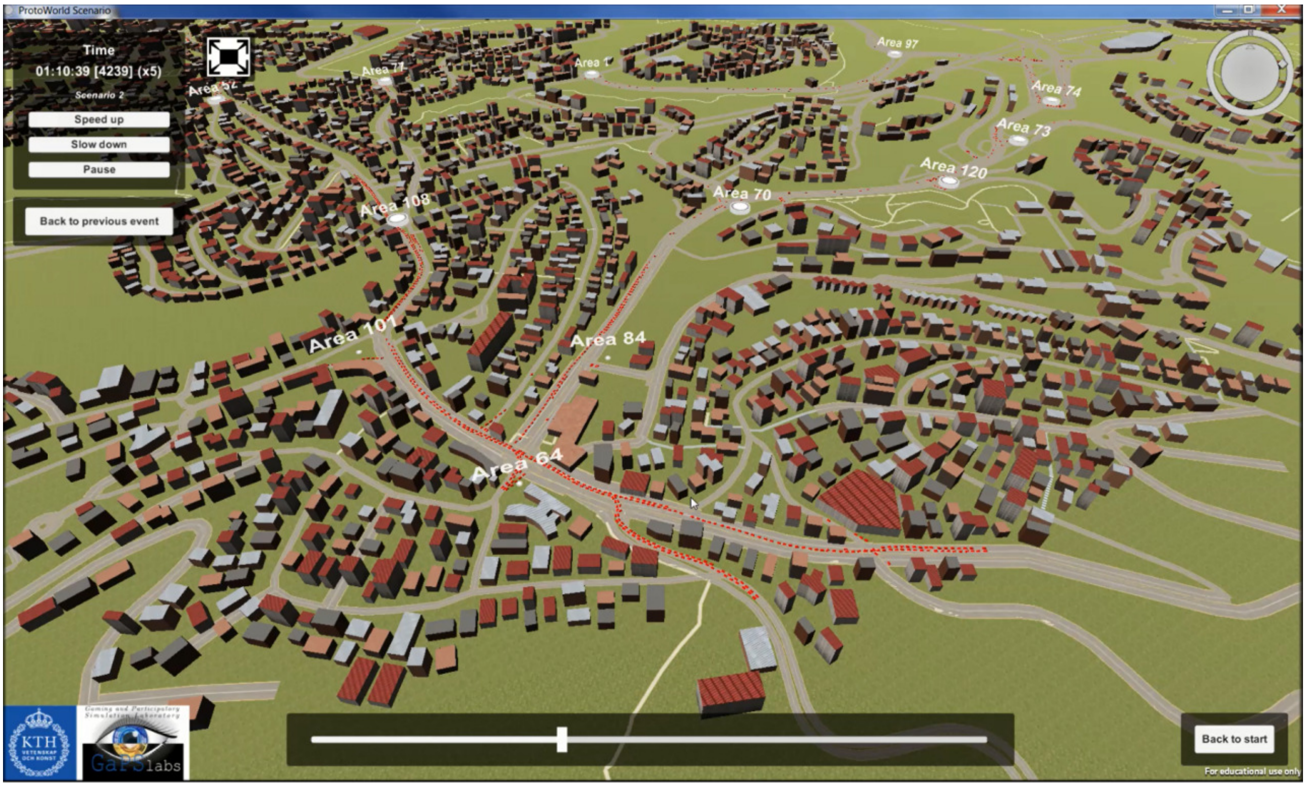

Figure 2. Macro view of the game in Haifa.

4. Findings

The findings from the two experiments show strong overlap with each other concerning how the games were perceived and the learning effects. The games also showed minor differences that can be ascribed to differences in the local context and institutional structure. In both experiments, players were sufficiently motivated and found the games relevant and the scenarios realistic. Players also found that the game helped them with their daily tasks, or that a tool of this nature had the potential to do so. Within each experiment, players had different perceptions of their actions in the game, with respect to making strategic and operational decisions, as well as their influence on the simulation within the game.

In the following subsections, we describe the main themes that emerged from an analysis of the player comments. They illustrate how the mechanics and components of the games influence gameplay. They also illustrate how players adapt to and understand the dynamics within the game, and how they relate those dynamics to their real-world context.

4.1. Learning

In both the experiments, individual learning was difficult to observe and was not mentioned explicitly by the players. This can be explained by the fact that controllers were placed in games referencing their own systems, about which they possess implicit and considerable expertise. Nevertheless, some comments made by the players point to learning about the system or their preferences about information that they would like to have when making decisions:

> It would be useful to know the causes of all the effects seen in the game, for example knowing the cause for queuing at the bus stop.

> Not too many alternatives for exits, so need to know micro-level details.

The controllers' learning points to a reflection on the systems they work with regularly and the shortcomings in information and decision support they currently have. From a methodological perspective, the notion of understanding causal relationships between effects shown in the game was emphasised strongly. This is particularly interesting from a game development perspective. While the game did not demonstrate enough of a learning effect, the reflections do point to the effects they would like to learn more about. For example, controllers pointed out that they would like to understand the decisions users would make when information is pushed out. This indicates interest and requirement in understanding why certain effects occur, pointing to an unmet need in decision support and control. The complexity represented in the simulation highlights their difficulties in managing their systems, provoking a reflection on possible improvements and features for planning support.

Similarly, learning about the perspectives of other stakeholders was observed mainly through a desire to understand the effects of their decisions on the system. Controllers desired to understand how the agents (in the simulation) and people react to the information (that the controllers send out):

> I would be interested in the decisions users would take when they receive information, especially when information is pushed directly into trains and vehicles during accidents in traffic.

4.2. Complexity

Complexity is conveyed in ProtoWorld primarily through a multi-scale representation of the whole system. This means that the game provides a comprehensive view of the whole system and provides the ability to view dynamics at different scales. The ability to observe micro and macro patterns within the same visualisation enabled the players to relate and link patterns across scales. Players could comprehend the emergent patterns across space more easily than across time. The ability to identify causal relationships in the game enables them to question and reflect upon their strategies to manage the scenario, contributing to a learning effect and enabling transfer to the real world.

> Here, it's like all the cameras [are] together. It's wonderful.

> Precise information on queues, on the map they see red for a long line, but it may be shorter.

> It would be useful to know the causes of all the effects seen in the game, for example knowing the cause for queuing at the bus stop.

> If I have at least the trend of the last 30 minutes, one hour then you can see if the situation is improving. I want to understand if things are improving or getting worse. People arriving at the station is increasing or decreasing? I can't remember the numbers. It would be interesting to see, even though we do not have it in the control room, how many people are reaching their destination or if they are in the streets and do not know where to go.

4.3. Exploration

Players can be creative and explore the simulation through interactive features. They can explore the simulation, attempting different choices to understand their effects. ProtoWorld is a high-tech, high-fidelity environment. While there were no technical constraints to do so, the players acted within their agency, and avoided choices they did not have in the real system. Within this space, however, they extensively explored the simulation and designed new steps to manage the situation. While the number of choices for decisions were few, the open environment gave them a large range of values:

> Can we navigate to Cavalleggeri? Station….It is full. Can we also try the bus alternative?

> If there is no coverage from a camera, I will ask a policeman to go take a look.

> We didn't think to write the message to diverge people from the Piramide bus to Piramide station from scratch.

> I should speed up the simulation and see what happens after half an hour to see the effects of what I do. By working in real-time and playing for 10 minutes, you don't get to see the effects. It could be useful to play more with sped up simulation so that you take an action and then the minutes run faster so that you can see the effect that you get half an hour later.

4.4. Openness

Communication is enabled through interactivity, visualisation, and the open dialogue and environment of the experiment. Communication happens at multiple levels: between the controllers and the city as it is represented, between the controllers and other stakeholders they want to include, and between the stakeholders already involved in the game. The socio-political complexity needs to be increased, and the interaction between the simulation of the technical components and the socio-political space needs to be better represented. This can happen through the presence of other stakeholders and roles in the game. The inclusion of autonomous agents in the system should also not be ignored, since they are a big factor in the self-organising emergence of the system as indicated in many comments:

> It would be interesting to see, even though we do not have it in the control room, how many people are reaching their destination or if they are in the streets and do not know where to go.

> Sometimes we hear this first from the people (Twitter…) and only then from the official channels. Once, I was looking at the real-time log of our route planner and I saw that many people excluded the metro B line. After five minutes, the news came out that the line had been closed.

> Communicate with other control rooms to get information about traffic/accidents/special events along the route….That could potentially obstruct or impede the transfer on foot or by bus.

The joint exploration of the simulation model through the visualisation and interface creates consensus. Interactivity with the simulations happens in two phases: by tweaking parameters before the simulation starts to create a scenario and by manipulating the simulation during run-time to manage said scenario. Creating a scenario before the simulation starts ensures that players agree upon limits and assumptions. At run-time, the multi-scale exploration ensures that they agree upon problem formulation, and communicating and exploring together ensures that they devise solutions together:

> In this way, someone could repeat the same simulation taking different choices and which choices are more effective by comparing the number of people that get to the destination.
>
> R: Let's go and see Piramide. Ostiense bus….Piramide metro is ok.
>
> L: Piramide bus instead is at 1,890.
>
> L: To those on the bus we should say to catch the metro then.
>
> J: In 5/10 minutes we will have a discussion on this.
>
> R: Ok, just last message. Here we got to people in the streets. Let's see Termini.
>
> L: 480 people on Termini bus?! The station is full. Are you sure you want to be so extreme?

4.5. Agency

The game should account for and relate to the agency of the players in the real world. Their agency in the reference system thereby constrains their actions in the game, as observed in the comments about not taking certain decisions. In Rome, for instance, the Mobility Agency was constrained in not having proper communication channels with transport operators or the police and would receive information about events in the city after a significant delay. This significantly hampered their ability to communicate information promptly and influence service provision:

> In reality, they close the station and there is no automatic way to inform us. Currently, we get to know it from our press unit because they read the press message that ATAC sent. They are not managing the process.
>
> Sometimes we hear this first from the people (Twitter…) and only then from the official channels. Once, I was looking at the real-time log of our route planner, and I saw that many people excluded the metro B line. After five minutes, the news came out that the line had been closed.

5. Reflections

The motive for the described analysis was that we wanted to understand how players navigate the space between reality and games. While we could have chosen a game that had already been developed, like SimCity, such a game would not have also served as a decision-making tool and would not have represented their reality closely enough to elicit and evoke their mental models. The structure of the session allows for in-depth and elaborate attention to the details of the tasks, as does the case study. While we had a limited number of participants (five in Rome and nine in Haifa), they constituted most of the controllers in the control room and had years of experience in their roles. The findings reveal what the players perceived through the game, and this should be extended further with more tasks and perhaps a longer interval between "before and after" questionnaires to reveal learning effects or a systematised comparison.

Our findings contribute to the literature on games in urban planning in two ways. First, we have generated a more nuanced understanding of what is meant by concepts like "communication" and "collaboration." The various quotes throughout the article give meaning to what the "player perspective" is on the constructs of urban planning games. Second, we have a better understanding of the relative importance of these different constructs of games. Our findings demonstrate the constraints around creativity, particularly the conditions around which operators and planners can co-operate or collaborate concerning hierarchy and the culture around sharing knowledge. Our findings give clear direction on designing simulation-based planning games, for example restricting the agency of players while expanding their options, enabling open environments, and providing multiple scales of abstraction.

It is indisputable that the expertise of the players, and therefore their mental models, played a significant role in our findings. However, this would be true of most experts as well. For instance, the real-world constraints around their agency influenced the actions and decisions they took in the game. The culture and infrastructure (or lack thereof) of sharing information in Rome play a significant role in how the Mobility Agency receives and dispenses information. There was a reluctance to co-operate and communicate with other stakeholders. The high-fidelity nature of the simulator also evokes a realistic attitude and influences how players explore the game.

The games we developed were free-form, high-tech, and realistic. While the interface and visualisation were realistic, the findings described previously relate strongly to the simulation components of the framework. The dynamics to be interpreted, which in turn lead to complexity and learning, are delivered predominantly by the live simulation. It is debatable whether this would be possible without the simulation running and responding to the players' interventions, for example in a dashboard that only visualises data. Caution should therefore be exercised in transferring these findings to other urban planning games, especially ones that do not make use of computational tools. These dimensions should also be studied along a spectrum of planning games, with ProtoWorld at one end and (technologically) simpler paper-based games at the other end. It would be interesting to understand how these dimensions change and influence the player along this spectrum. However, we believe that the relative understanding of game constructs provides insights on how to balance them, on what the trade-offs are, for instance in designing for conveying complexity as opposed to designing for effective communication, enabling game designers to make better choices.

The high-tech, free-form nature of the games reveals interesting relationships between fidelity, creativity, and the ability to explore different options within the games. Expanding the complexity in representation and the open and free-form simulations can enable exploration at low levels of detail and with a wide range of parameter values within a limited set of decision choices. Free-form games with rigorous technical representations of systems restrict the ability of the game designer and facilitator to steer towards outcomes. Again, this is offset to a certain extent by the open and complex nature of the computational simulations, which in turn can deliver operational and tangible plans. This poses a methodological challenge: Enabling them to make radically new decisions could make it unrealistic, and yield unusable outcomes while limiting their agency within the simulation will restrict them to their current roles and hinder them from exploration.

6. Discussion and Conclusion

Planners and researchers playing urban planning games are placed in a strange triple hermeneutic space (Raghothama & Meijer, 2018), and urban planning games should be evaluated and understood as such. Our findings describe, in a nuanced manner, how players navigate this space and how they bridge their realities through the mechanics of these games. The findings outline the mechanisms behind conveying complexity, facilitating communication, and promoting learning. The influence of the technology, particularly the live simulation in mediating these aspects is strong and clearly demonstrated. In this article, we have found and attempted to describe many of these dimensions, some of which are based on Duke's (1974) five Cs—complexity, creativity, communication, consensus, and commitment—and others that were relevant and appear in frameworks in other disciplines. It is apparent, however, that the best mechanism to understand how players relate the real world to the fictional world of gaming lies in the intersection of urban planning, game analysis, and human-computer interaction. Our findings illustrate that several frameworks or intersection(s) thereof might be necessary to comprehensively develop an understanding of player perception.

Games are a fascinating, albeit strange medium. A multilogue is constantly happening, with players sense-making in the game, exploring and experimenting with consequences. In this article, we described a technology-heavy, realistic game, but it remains an individual (or single player) game. As the technologies that support gaming interfaces evolve rapidly, city games can run on data-driven software simulations and provide real-time feedback to players. There is certainly a trade-off between producing digital vs. analogue games: The first is better in terms of the quantity of data that can be processed and the second engenders more trust simply because of interactions amongst players. Our analysis highlights this fact, as consensus is mediated through a technological artefact. Technology heavy games hinder players from changing their perspectives based on others. However, as Tan (2020) eloquently argues, it need not be so black and white and calls for hybrid forms.

Technology can also transform the pervasiveness of urban planning games, allowing players to access and provide feedback on plans and design their own spaces from the comfort of their homes or anywhere in the world. Games can provide a shared language and a very effective medium for enhancing communication and navigating complexity. While the games presented in the article focused on the "expert," many of the lessons from this article can also be applied to "non-expert" audiences, allowing games to relay and elicit knowledge in a tangible and tractable way.

Focusing our analysis on the player has provided a nuanced understanding of the strength of many constructs, as well as their appropriate combinations. This kind of empirical research on applying games in urban planning is sparse. Effective implementation of games can and should extend on such work, with careful and continuous observation of games and analyses of their outcomes, allowing the method to become effective and accurate.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Network of Games: An Ecology of Games Informing Integral and Inclusive City Developments

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Abstract

This article analyzes possibilities for connecting individual city games for building a network of games working together. City gaming works along with the understanding that cities are self-organizing systems, influenced by multiple bottom-up and top-down actors with varying interests and powers. Affordable housing, climate adaptation, or area development are examples of urgent urban challenges city games typically focus on. The assumption is that if these specialized games could be linked, then a large game infrastructure built as a modular system, can offer various game combinations responding to urban challenges in an integral and holistic way. To test a working game network, city games, models, and digital apps have been linked through their shared datasets as well as game interfaces. Two city experiments have been conducted in two Dutch cities—Amsterdam and Breda—which enabled the testing to function as "constructive design research." In Amsterdam (Klimaatspel) two separate city games were connected through their datasets, while in Breda (Play the Koepel) datasets and interfaces merged to create a new game. Used data models are the Energy Transition Model developed by Quintel and the urban plan cost simulator software of Urban Reality. Used game interfaces (digital and analog) include the Typeform, the Network of Games app, the Urban Reality simulator, and the Play the City table-top game format. The testing considered two different approaches for a potential game network. The first option assumes an all-encompassing digital app, reformatting and involving various games and models in a single interface. The second option is an open approach that looks to link custom-made games with existing interfaces. The second option allows both simultaneous and sequential linking. Two experiments utilizing sequential and simultaneous integration of diverse digital tools suggest that a collection of interfaces connecting to each other throughout the entire process from a digital poll to an app, a simulator or a webinar, or analog game sessions is more effective than a single mobile phone app for all potential game interactions. Considering city games as an ecology of city tools that can be linked to one another becomes through this study a concrete goal to reach. Through combining specialized games, addressing complex city challenges becomes possible. This step enables a more effective participation environment for diverse experts and non-experts.

Keywords

city games; climate game; collaborative interfaces; integral planning; network of games; urban area development game

Issue

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1. Introduction

For over half a century, alternatives to single-handed, static city planning have been explored by discussing an integral and adaptive form of shaping cities with multiple stakeholders. The notion of collaboration in the city planning discipline has transformed largely since Team 10 members of the CIAM started questioning the human dimension of modernist city plans (Frampton, 1980). Today the notion of the city as a self-organizing system helps us discuss "participation" beyond the classical dichotomies of the bottom-up and top-down powers (Portugali, 1997). Today we conceive the city as a complex system where various interacting powers coexist.

In the decades following the Second World War, a political movement known as the civil rights movement came to the surface in North America and Western Europe. Students, intellectuals, and workers raised their voices in demand for better labor and education opportunities. Rising values, such as individual freedom, fairer social welfare, and the right to produce one's urban environment instead of solely consuming it, had a reflection in the field of architecture and planning. The modernist movement's focus on the production of the physical plans, ignoring the people inhabiting these cities, neighborhoods, urban blocks, and buildings, received wide criticism. Although the politics of the "populist movement" attracted the most attention, there was a background response through systemic thinking, specifically computational models (Tzonis & Lefaivre, 1975). The beginning of the 21st century has witnessed a comparable popularized civil rights movement. This time technology appears to be in the foreground, enabling the participation of crowds without the necessity of a political statement (Levy, 1990). While classical dichotomies of power between the state, the market, and society do exist, a new perspective offers new possibilities for conceiving cities as complex self-organizing systems as a result of the interplay of various powers. Self-organization in urban planning proposes a more relational interpretation that emphasizes relations of formal and informal planning and of top-down and bottom-up planning and surfaces a different understanding of urban power relations (Eizenberg, 2018). Participation is no more a simple dialectic of governance from above or below; participation becomes various manifestations of self-organization. Viewing cities as complex self-organizing systems requires re-linking planning to the substantive qualitative relations between the various urban elements (Alfasi & Portugali, 2007).

If 21st-century participatory urban planning is indeed grounded in a conception of the "city as a self-organizing system," we will need new city-making methods which are free from the outdated dichotomy of the bottom and the top to be put into practice. The fundamental question is now how diverse ideas become concrete in city-making methods that embrace real constituents, and, in doing so, how they can help a broad range of players to have a greater influence on the urban systems they inhabit.

2. City Gaming for a Collaborative City Planning

Looking beyond traditional and current planning and design methods, this article is based on the idea of city gaming as a method for negotiating and open city-making; games emerge as unique media which can combine multiple agencies, simple rules, and various complex states of orders that evolve through the interactions of agencies. In an era when not one but many makers are in charge, city games become the common language of learning and communication. Building on Alexander et al.'s (1987) urban design experiments with collaborative improvisation and several serious games set up by Portugali (2000) to study cities as self-organizing systems, city gaming is proposed as a method for open city-making (Meyer et al., 2012). Participants gather to strategize ideas and plans in a low-risk environment. In reaching collaborative city development, city games play a critical role: They make abstract data tangible for participating groups of actors. This allows participants to integrate individual and institutional knowledge, from both experts and non-experts. Through the simple and playful language of games, conversations become jargon-free. Informed decisions get supported from across disciplines, through stakeholders ranging from communities to governments. In this way, city games provide a space for top-down and bottom-up planning to meet.

Existing methods of learning and decision-making for cities include "expert workshops" where decision-makers meet experts who provide advice for ongoing challenges and "best practices" where workshops include site visits as well as presentations from project owners. Perhaps most common yet ineffective learning is performed through unearthing policy and project reports published online as "PDF documents." Games, as visualized data environments activated by multiple stakeholders, already offer a real alternative to traditional forms of knowledge exchange.

City gaming as a collaborative city-making method has been investigated over the last decades and has already aided various decision-making processes (Tan, 2014). Games for Cities (www.gamesforcities.com), a research project run through various scientific and practice partners in the Netherlands, monitors how city games worldwide are not only suitable for participatory processes, but they are also containing, visualizing, and communicating large sets of specialized data allowing multiple players to interact with the data and with one another (Figure 1).

One of the conclusions of the Games for Cities research indicates the ongoing tendency toward specialization in games: There are city games focusing on particular urban issues such as migration, circular economy, affordable housing, inclusive public spaces, vacant real estate, smart mobility, and energy transition, to name a few. These games are centered on specific topics and rely on deeply researched and organized sets of data that are important to the chosen topic. While specialized games are successful in focusing discussions amongst players, in reality, parts of a city do not operate in isolation.

3. Network of Games for an Integral Approach to Cities

There appears to be a new opportunity for existing city games to come together to create an interconnected infrastructure. Linking individual games to one another results in an ecology of games which can enrich themselves as well as inform a more integral city development

Figure 1. Map situating the city games worldwide as researched within the Games for Cities research project.

debate. Such an integrated support tool creates a real difference in how cities learn, plan, and decide. When supported by an interconnected infrastructure, we call this "network of games" (NoG) a family of interrelated games that could make a real difference in the integral planning and designing of cities.

NoG builds on the Games for Cities research, a rich collection of city games built to support city development processes. The assumption is that if these specialized games could be linked, then a large game infrastructure built as a modular system can offer various game combinations responding to urban challenges in an integral and holistic way. When translating this theoretical approach to the practice, the question is how to technically enable distinct games to communicate and work together. We tested two conditions where independent games could be connected despite distinct play dynamics and play rules.

3.1. Connecting Datasets

Although played with diverse play mechanics and interfaces, in their essence, most city games run on organized and visualized datasets. So long as the content of given games meaningfully can complement each other, their data will overlap. For example, a game on *affordable housing* that contains data on "land use," "land price," and "planned housing projects" can link to data from an *urban transport* game containing data on "location of transportation hubs," "shared vehicle schemes," or "planned infrastructure projects." With the connection of the distinct datasets, the connected game can inform players about affordable housing schemes in relation to affordable transportation possibilities.

3.2. Connecting Interfaces

As datasets connect games through their content, the question arises about which game interface and rules to use after games connect. There are a handful of hybrid city games hinting at how to link distinct game interfaces to work with or strengthen each other. For example, the gameplay may remain in the physical interface, while digital interfaces enable processing digital data, recording decisions, and reporting to larger audiences. Analog game formats include card games played with four to six people, tabletop games played in a workshop setting with around 20 to 30 people, or conference setting games where multiple tables play simultaneously and reach larger crowds of over 100 players. Digital games run on personal computer software, on mobile apps, or on a website, as well as in virtual and augmented reality environments. They can process data and record user behavior and outcomes. The combination of trust-building advantages of analog formats and data provision end processing, access to thousands of participants, as well as easy recording and reporting makes the connection between the two formats interesting for designers.

Since the development of the theoretical framework for the NoG in 2019, we could implement and test our ideas through two concrete cases taking place in two Dutch cities: Amsterdam and Breda. In both cases, a number of games and simulation models are linked through their data as well as interfaces. In the Amsterdam example (Klimaatspel), two games connect through their datasets, while in the Breda example (Play the Koepel) datasets and interfaces fuse to create a particular new game. After introducing these two cases, we will compare the results and elaborate on achieved and failed targets and will describe further steps to develop the NoG research (Figure 2).

4. Network of Games Linked Through Their Datasets: Klimaatspel, Amsterdam

Klimaatspel is a location-based climate adaptation game developed for the City Technology Office (CTO) of the city of Amsterdam. In 2019, the CTO launched Amsterdam's climate program based on the Paris Climate Agreement. The game enables local residents (homeowners and tenants), housing corporations, energy providers, and civil servants to transition from existing residential neighbourhoods—in this case, the Apollobuurt en Stadionbuurt of the Plan Zuid in Amsterdam—to a climate-neutral city area as they progress through game rounds.

4.1. Datasets of the Klimaatspel

Designers of the Klimaatspel identified four components addressing climate adaptation: clean energy use, sustainable mobility measures, public space use, and management of urban water. Next, to detail these topics, they started building datasets involving strategies and actions for the selected four themes. These data have been collected from the works of organizations and practices with years of open research and experience. Clean energy strategies are based on the technologies involved in the Energy Transition Model (ETM) developed by Quintel Intelligence (https://pro.energytransitionmodel.com). Mobility strategies are selected from the doctoral research conducted at the Integrated Transport Research Lab (https://www.itrl.kth.se) of the Royal Institute of Technology in Stockholm. Green public space strategies are filtered from visions and strategies under the Project for Public Space (https://www.pps.org) research. Water management strategies have been based on the action toolbox of the Rainproof program of the city of Amsterdam (https://www.rainproof.nl; Figure 3).

To become a truly location-based city game, however, Klimaatspel needed to integrate information about the particular local community and location. That meant that, besides four relatively generic climate aspects detailed initially, the game needed to include spatial data and dynamics representing the given neighborhood: existing and/or planned building typology, number of households in city blocks, available public and green spaces, location of available solar panels and situation of rooftops suitable for solar panels, and existing sustainable local energy sources for heat and electricity. To develop and implement a place-based climate game for the city of Amsterdam's CTO team, selected

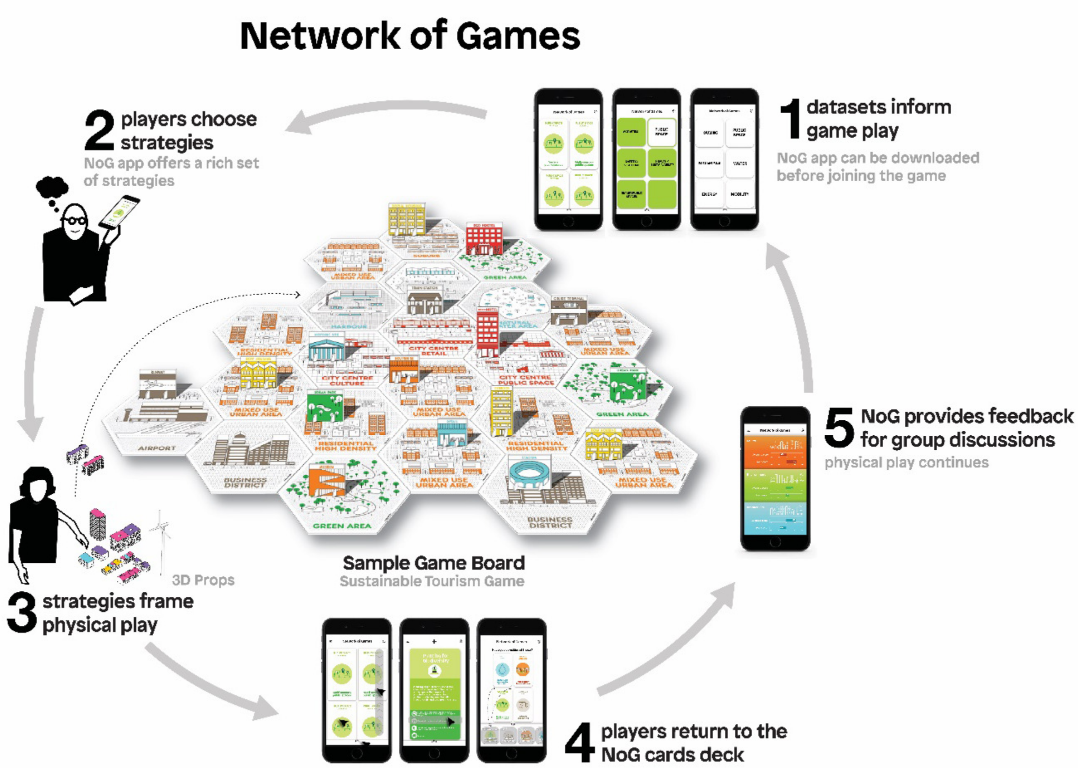

Figure 2. Diagram clarifying the idea behind how city games of various datasets and interfaces can be linked to one another.

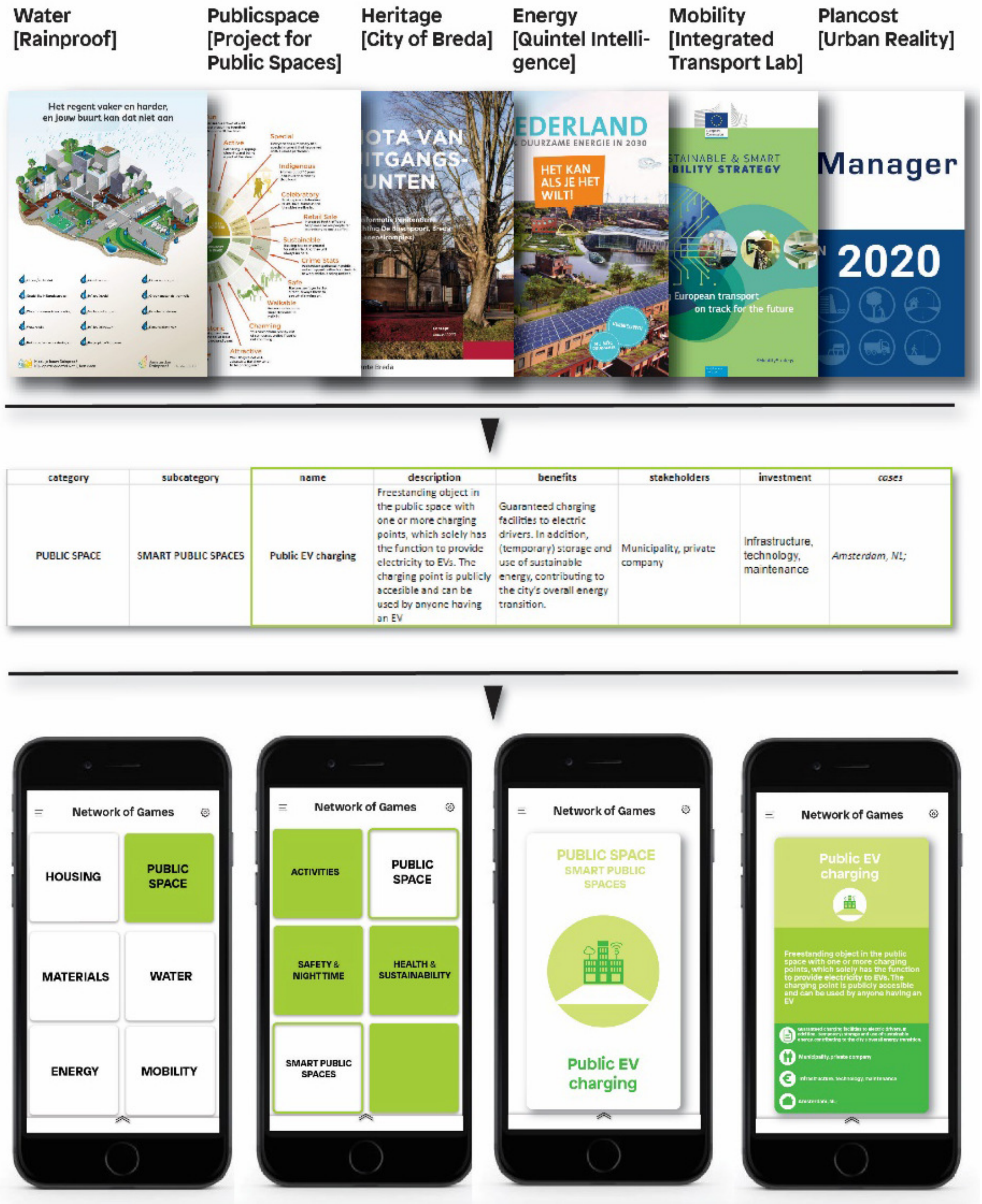

Figure 3. Original data sources, datasets excel sheet documentation, and visual translation of datasets as game cards.

generic climate strategy topics needed to be interlinked with local spatial information about the neighborhood. This could enable an integral urban development approach where spatial and climate experts, developers, and policymakers as well as residents will become empowered to communicate and think in an integrated environment. For example, players could make choices not only about a housing development but also about locating a water-permeable urban square adjacent to this housing development, introducing a shared electric vehicle fleet decreasing parking standards, clean energy generation possibilities, collective heat pumps and neighborhood battery, etc. At this point, a concrete demand was born for connecting the Klimaatspel with the Area Development Game (https://www.playthecity.eu/playprojects/Play-Noord), supporting the conceptual framework of NoG, a system of interdependent games working together to respond to complex urban challenges.

4.2. Datasets of the Area Development Game

The Area Development Game (Gebiedsontwikkelingsspel) has been first developed and implemented in Overhoeks, Amsterdam Noord in 2011. Since then, the game has been adapted to various cities in and outside of the Netherlands. The Area Development Game includes a comprehensive dataset category of *urban programs* (urban functions) with subsets such as housing, work, hotels, restaurants and cafe's, retail, public services, culture, infrastructure and public space (squares, streets, parks, parking), energy, green infrastructure, and water. Every subset contains tens of functions with data such as area size, building height, number of households, etc. These data have also been translated to 3D building blocks and pieces enabling players to collectively design and test city areas, streets, and city blocks filled with desired urban functions. To achieve urban development that fulfils a given urban program and density with precision, these components carry quantitative data informing urban density, minimum green and parking requirements, etc. (Figure 4).

4.3. Connecting the Datasets of the Klimaatspel and the Area Development Game

Here, the question rises how to technically connect the dataset categories of the Climate Game (mobility, energy, public space, and water) and the dataset categories of the Area Development Game (urban functions). To provide compatibility and easy access, we started organizing the datasets of the Klimaatspel. Initially, to simplify the access to hundreds of climate adaptation strategies collected under categories such as energy, water, public space, and mobility, we introduced subsets for each category. For example, the clean energy strategies have been classified under subsets such as *save*, *generate*, *store*, and *network*. Similarly, the water category contained subsets such as *collect*, *retain*, *filter*, and *reuse*. Next, every data subset has been provided with spatial information (area size that a given clean technology occupies, the place that it will be situated in, or the number of households/office units/public services a given technology serves) so that overlapping data become possible with the urban program category of the Area Development Game.

Once the excel datasheets were complete, the following challenge was making such excessive amount of data accessible to players. The subsets could provide a certain degree of direct access. Players could be informed about the main purpose of strategies and thus, accordingly, could eliminate a subset of actions they found irrelevant. Even after such a quick selection, as most innovative technologies are new to players, it will take time to read what the meaning and impact of these actions are, understand the size they occupy in urban space, with which technologies can they be combined, and potential downsides. Given that the players are expected to combine their climate strategy choices with spatial choices such as where to locate them and how many households they serve, we needed to develop the Klimaatspel further to make it possible for a player to scan enough strategies, to evaluate their selection with fellow players, and test various locations during the limited amount of play time to finalize their decisions.

One of the techniques we applied for direct and simple communication was visualizing all strategies through comparable scale 3D drawings. We followed the drawing language of the Area Development Game in visualizing and modelling the 3D building units. Further, with

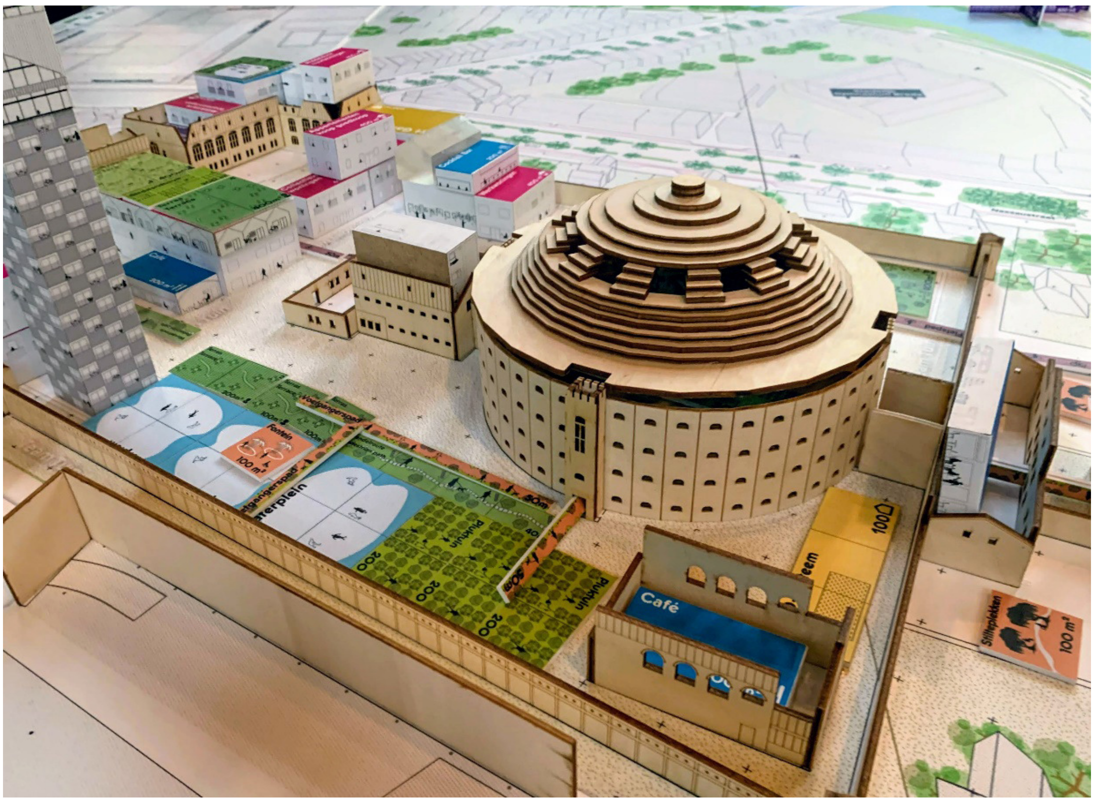

Figure 4. Data as translated to 3D building blocks.

a graphic designer's team, we created dedicated cards for each strategy with respective short verbal information (*simple descriptions*, *combination possibilities*, *application areas*, as well as *known positive and negative side effects of these strategies*). With this last step of containing all visualized *strategy cards*, a game system came to life with thousands of game components from two distinct games fusing into a single game interface. Finally, the Klimaatspel involved three major components: the game board with GIS information (of Stadion and Apollobuurt), 3D game building units, and visualized *strategy cards* based on the datasheets (Figure 5).

4.4. The Making of the Network of Games App (Beta Version)

Synchronization of data categories through an excel sheet, digital visualization of climate adaptation strategies, and building units in the same visual language cleared the way to a digital tool. We aimed at a smartphone app that could communicate all visualized strategies as a cards system where players can select, collect, and combine them into a card deck. Simple and pleasant navigation through various data layers was the major purpose of the NoG app, where urban strategies are present to address complex city questions. The convenience and common use of smartphones could potentially blend data easier with analog play through dedicated game rounds framing the location-based spatial scenarios. In the meantime, after a long search, we settled to work with young and talented developers through a partnership with the Bahcesehir University Game Lab. Several conversations led to an advice brief clarifying the technical background of the NoG written by the developers. Based on this, our team could develop an initial wireframe sketch for the mobile app built using the Unity development tool (https://unity.com; Figure 6).

There are three main parts of the app which is reading and loading the cards from an excel document, designing an algorithm to recommend cards, and the UI/UX arrangements of the digital game. The algorithm is developed in order to recommend players. The algorithm can be trained in time. Every time the user makes a choice, the cards in the deck are remembered to be recommended in the future. Once the NoG app (beta version) was ready to be played, the experts in the advisor team but also other experts in our network played sessions to train the app and eventually build connections between strategies belonging to distinct categories (Figure 7). The app can be viewed at the following link: https://drive.google.com/open?id=1pFGc5UBUGZj0_BIu6nehMqKhgSdFdO9V&authuser=r.ekimtan%40gmail.com&usp=drive_fs

4.5. First Evaluation for Network of Games

First with the production of the physical game components, later with the integration of the NoG app based on the datasets of two games, the Klimaatspel has been the first fusion games within the NoG project. We tested the game in various settings with local residents, experts, and students. In a period of two years (2019–2020), Klimaatspel has been played 10 times. Three of these sessions were implemented with residents (*renters* and

Figure 5. Visualized strategy cards based on the datasheets. Sample category: Energy.

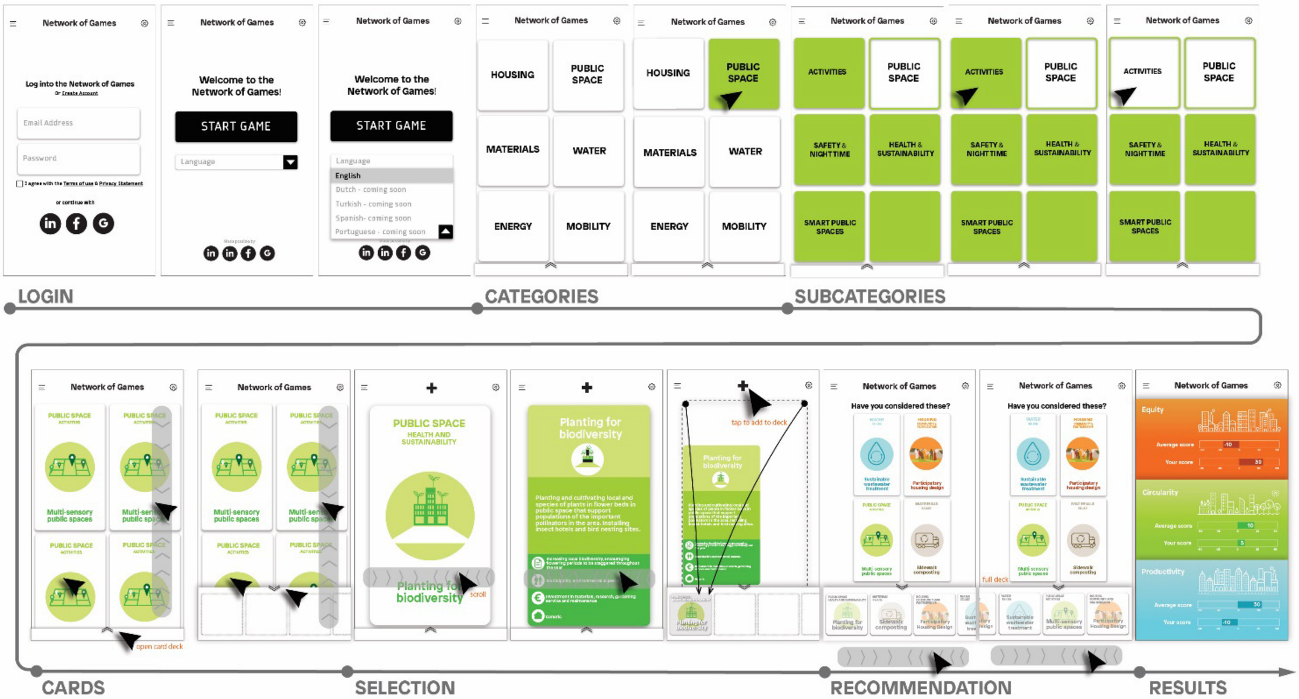

Figure 6. The wireframe.

homeowners) on site. The rest seven meetings took place with various city departments of the city of Amsterdam, expert organizations, and with the generation of the digital app with advisors committee and students (Figure 8).

Fusion of two games bringing spatial and climate questions together in one creates a rather complex field of decision, making it accessible to diverse experts as well as non-experts. Klimaatspel reveals the climate adaptation as an integral transformation question: *smart mobility*, *water balance*, and *inclusive public space*. Participants understand the complexity of transitioning to a climate-adaptive city by exploring multiple stakes necessary for a long-term change. Based on the system analysis, players take concrete steps in the game

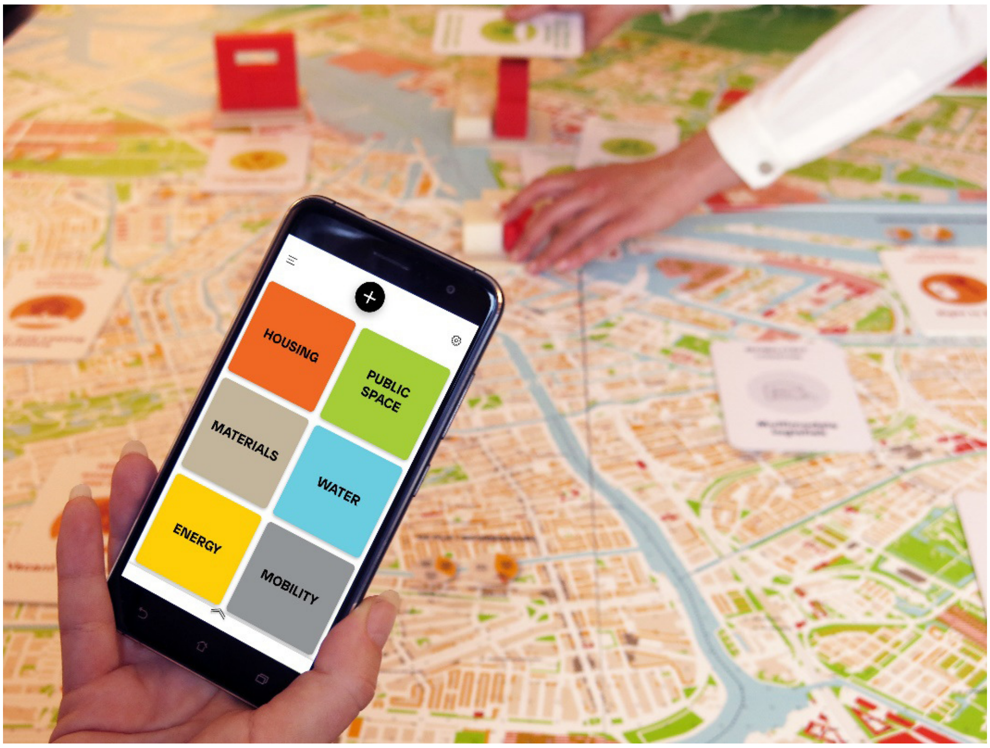

Figure 7. A shot from the NoG app.

Figure 8. Photo taken during a play session of Klimaatspel in Amsterdam.

such as neighborhood batteries, shared heat pumps for a given housing block, renewable energy co-operatives, and smart micro grids for a given neighborhood, and explore the impact of these new infrastructures on public space and individual building blocks. Participants also explore and interlink three scales of action: *home*, *housing block*, and *neighborhood*. This way they build shared narratives based on collectively selected actions such as energy cooperatives and neighborhood batteries.

During the play sessions, we received returning remarks both from residents as well as experts about missing quantified data (such as the approximate CO_2 reductions of strategy cards) to help compare and select the available technical solutions. We concluded this as feedback to improve the game by adding a new dataset comparing CO_2 reductions of various strategies that could positively support in reaching decisions and more coherent narratives.

While the test outcomes of the Klimaatspel were, content-wise, fulfilling, with the integration of the NoG app we could observe serious hiccups caused by the interface integration and play dynamics of the game. The NoG app has been activated in Klimaatspel sessions for two moments. The first moment was one week before the game, when all invited players received the link to download and explore the digital game app. This way, players could find the time to explore and compile their cards even before joining the game. Given the richness of the game content, this early interaction did help in earning time in exploring the game components. The second time the NoG app was used was during the physical game meeting contained within one of the game rounds. The app functionality of recommendations did help the players to surf easier through categories of energy, water, mobility, and public space, and make more holistic choices. Yet, recommendations that the app provided during selection of cards were not obvious for all the players. Furthermore, the switch from the NoG app to the game table was not always easy and flawless and we observed that players still needed the physical cards to hold in their hands or locate on the game board. Accordingly, we re-introduced the physical game cards as part of the game, despite digital scan and selection of cards remaining available before and during the game. Besides the transition between digital and physical interfaces, we observed that the narratives generated around the table among multiple players were much more engaging. The most important handicap of the beta app is that it did not allow choices to be made by players collectively. Accordingly, the emergence of collective debates and narratives during the digital selection round remained rather limited.

When introducing data references of the Klimaatspel, we earlier mentioned the ETM developed by Quintel Intelligence. In ETM, users develop scenarios for CO_2 reduction relating to clean energy and mobility interventions in Dutch cities compared to 1990 levels. Based on the criticism we received in the first game sessions, we took an extra step in extracting quantitative data about CO_2 reductions. As a last iteration of the Klimaatspel, we ran a possible scenario for the current number of households city of Amsterdam in 2020 and generated CO_2 reduction values to clean energy and sustainable mobility strategies involved in the game. The last two game sessions played with students involved the quantitative datasets on CO_2 reductions and helped a more nuanced conversation among players (Figure 9).

We shared earlier that Klimaatspel used the climate adaptation actions based on Quintel's ETM. For calculations of carbon reduction from ETM, a scenario 2020 (existing) for the city of Amsterdam was taken and the value for CO_2 data relative to 1990 (A) was noted (63.6%). The values of each strategy in households, buildings, and transportation were noted according to the existing situation. The percentage for each strategy separately was made 100% using the slider and the CO_2 relative value (B) was noted. The difference between A and B is the calculated carbon reduction/increase for each strategy/technology, considering the impact it has when it is used in isolation. As an example, the current usage of photovoltaic panels is 1.4% of its potential in households. When they are used at 100%, the value for CO_2 relative to 1990 changes to 49.4% (B). This is subtracted from the original value of scenario 2020 (A), and the difference is 14.2%, which is the reduced CO_2 impact for the entire city, considering the rest of the strategies and their quantities remain the same.

5. Network of Games Linked Through Their Interfaces: Play the Koepel in Breda

Klimaatspel is made possible by linking datasets of the Climate Game and the Area Development Game resulting in a detailed and comprehensive excel document containing strategies on five categories. Visualized strategies, relations built among these strategies, and the recommendation algorithm formed the learning NoG app. Positive outcomes were booked by this integral think, debate, and design game. Hiccups in play dynamics were caused by the incompatibility between the digital app and physical storytelling format. This problem inspired our team in thinking further about linking games beyond datasets. It was necessary to develop a deeper understanding of the relation between offline and online (hybrid) interfaces and their synchronization. After studying various game examples in Games for Cities research, we concluded two major forms of reaching a hybrid game interface: *simultaneous* and *sequential* connection of analog and digital formats.

5.1. Analog and Digital Play Take Place Simultaneously

In this form, to achieve real-time feedback, choices made by players during a physical game are simultaneously linked to a digital platform that can store this information and process it through a particular algorithm. Here, various forms of scanning possibilities exist to connect the physical environment with phones, tablets, laptops, and

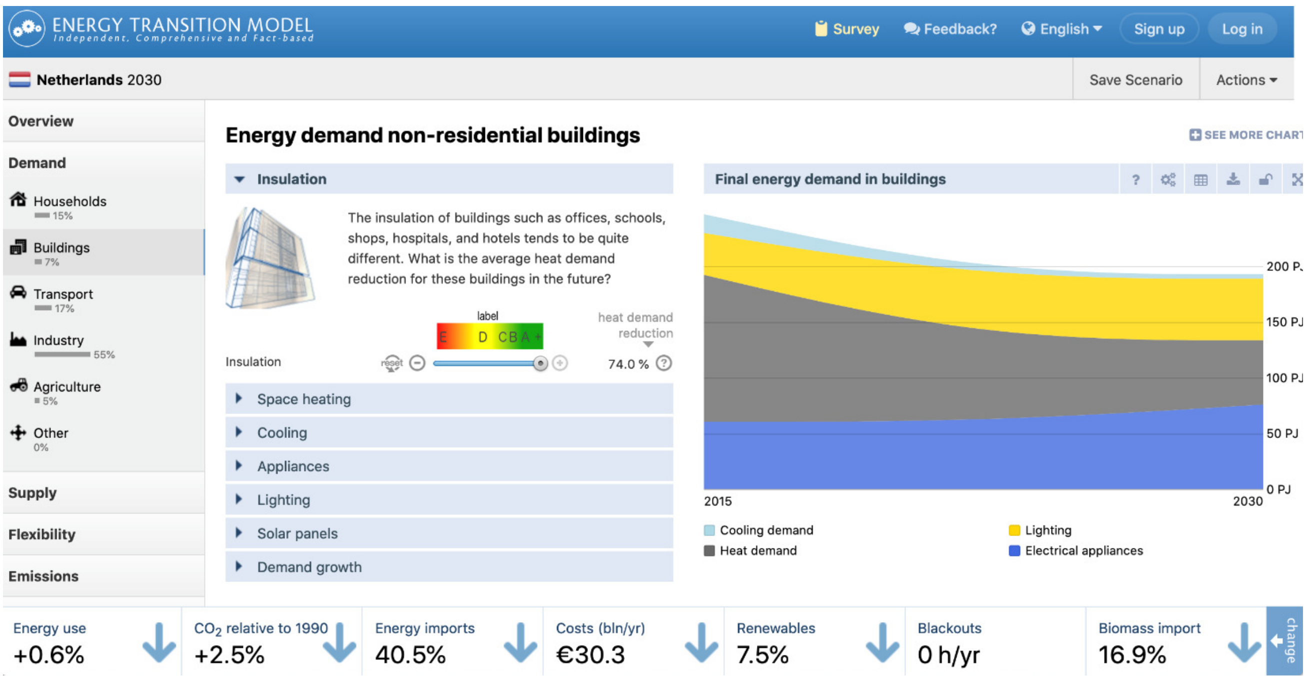

Figure 9. Screenshot from the ETM developed by Quintel Intelligence.

other devices through 3D video scanners, near-field communication, radio frequency identification, QR codes, and more. These technologies come with different sensibility, speed, and price ranges. Through direct communication to a digital environment, they make the analog play process accessible to a large audience. By digitizing choices made in the physical environment, they enable the recording and reporting for the longer term much faster and easier.

5.2. Analog and Digital Play Take Place in a Sequence

Hybrid play is achieved by connecting digital and analog formats in a sequential manner. The key to providing connectivity in this form is making sure outputs of a given format can be converted to the input of a following game interface. Namely without the direct scanning technology, connecting analog and digital formats becomes possible. As soon as the digital play takes place, its stored outcomes will become input for the analog game format and vice versa.

The beta version of the NoG app linked online and offline play formats sequential in the Klimaatspel case; yet, technically the app can be developed in such a way that physical components such as cards and 3D building blocks can be scanned directly during the analog play and real-time recommendations or quantitative feedback (for example number of parking lots based on the volume of urban programs used during the session) can be provided during the play session. During the Klimaatspel sessions, we received comments about how the play round with the app disconnected people from the collective narrative building around the table. This disturbance kept our team looking for alternative hybrid models where a smoother transition between the digital and analog formats was possible.

At this phase, we decided to include the city of Breda's challenge (transformation of the De Koepel prison campus) for a complex urban area development as a second case for the NoG project. A large number of residents needed to be consulted for the future of a former prison campus situated in the core of Breda. As in Klimaatspel, the city of Breda was seeking an integral planning approach that could combine themes such as spatial development and climate adaptation with special attention to the architectural heritage due to the historic prison of the De Koepel in Breda. The game needed to generate future scenarios for this central area. One week after the game brief Play the Koepel was formulated by the urban design team of the city of Breda, the worldwide Covid-19 epidemic reached the Netherlands resulting in a lockdown on 16th March 2020 (Figure 10).

Figure 10. Photo taken during a play session of Play the Koepel in Breda.

The need for an integral approach and the ongoing lockdown imposing digital solutions were precisely the conditions for implementing the NoG app. This NoG app piloted for the Klimaatspel could be redeveloped and tailored for the Play the Koepel process. All interested Bredenaars (with a smartphone running on Android) could download the app through a public invitation. The app was ready for scanning and selecting relevant climate and urban development strategies. As we explored deeper the requirements of the process and the output expectations for the digital tool, a few aspects of the NoG app were running short: Firstly, before sharing hundreds of rather abstract digital strategy cards with the users, we needed to share the background narrative about the Koepel (the conditions and expectations around redeveloping the historic prison, current and potential future owner of the building, the role of the municipality, the importance of innovation for today's Breda in a historically innovative prison building with the implementation of the panopticon, and the social reintegration ideas). Next, we needed not only to share the narrative of the city of Breda but also to let participants react to the storyline, telling their own tales about the transformation of the Koepel campus. Only then selection of strategy cards supporting individual visions made sense. Finally, a technical property we needed in the NoG app was user-based registration. Only then we could save and track the selection outcomes and analyze preferred strategies. The beta version of the app was designed so that future development around individual user login would become possible. Yet, we did not have the time and financial resources to further app development, as the digital participation needed to take place as early as June 2020.

Typeform is an application that offers the opportunity of loading customized visualized game strategy cards. It does not come with some of the properties of the NoG beta app, such as recommendations and relations between strategy cards. Yet, the digital poll app enables developing a clear narrative (what is the history of a given area, what are existing or missing spatial qualities, who are landowners, what are their expectations, which technologies were relevant options, what were the major dilemma's and why) supported with visuals that could inform users. Taking the participant by hand and sharing the background knowledge could enable players to develop their own visions built upon the selected strategy cards. Not only imposing a single-way narrative but by leaving open questions and room for adding new actions, this particular digital poll allows players to develop their own narratives. Given the affordability of the ready-to-use tool, we started installing the NoG datasets along with a narrative introducing the dilemmas and ideas around the redevelopment of the Koepel campus. A significant side note here is we could never achieve a highly visualized digital poll filled with well-researched data if the steps leading to the NoG app (data collection and digital visualization) were not taken in advance. Thus, selecting to move on with the Typeform for the Koepel process instead of the NoG app could only become possible due to the structural work leading to the NoG app.

5.3. Dataset Extension for the Play the Koepel With a New Data Category: Heritage

During the tests ran with the city team, we received concrete feedback from the city of Breda's expert teams that has been translated to the NoG data infrastructure. The heritage experts from the city introduced new knowledge that needed to be taken into account when planning a future scenario for the redevelopment of the historic prison and multiple strategies to support these scenarios. Using the excel datasheets with the dataset structure of various categories, the heritage team was able to translate their input into strategy cards following the same data structure, adding heritage as a new data category, with sub-categories, descriptions, and attention areas.

5.4. Linking to the Urban Reality Simulator

The input from the finance department was about implementing a reality check layer to the game. By introducing a feedback mechanism around the project's costs, the game could provide feasibility feedback to residents who can make more realistic choices. Urban Reality, a team of plan economists developing financial simulation models for large-scale urban development projects, joined the team at this stage. The calculation models Urban Reality develops are prepared with professional precision, taking weeks to calculate various development scenarios. Yet they took on the challenge of real-time feedback on the cost of developing scenarios during the game meetings as the players select strategies and locate 3D building blocks on the game board. This could happen only with the correlating of Urban Reality with that of the NoG. This way, the Urban Reality algorithm could calculate production costs or indicate the amount of parking needed for a given scenario, etc. The purpose of integrating this calculation model was not to provide players with the promise of cost precision but to give feedback about the financial feasibility of development and qualitative comparisons for scenarios generated during various game sessions.

With the collaboration of Urban Reality, we developed the idea of object scanning and registering physical building blocks and strategy cards and linking this information according to the user/team into the Urban Reality simulator. During the Breda session, we registered all these steps manually, thus developing the app so that it automatically registers physical developments digitally, remembers user login and choices, records, visualizes outcomes, and makes it possible to share outcomes during the physical gameplay.

With the integration of the Typeform and the Urban Reality algorithm, Play the Koepel has become a hybrid (online and offline) game where both sequential and simultaneous integration of physical and digital interfaces has been conducted. The game started as a digital poll where most of the urban design narrative and the game content have been introduced to participants through visualized datasets. The poll included questions about the values and principles that will guide the future development of the area, the narrative about the new expected urban program, the combination of functions, principles about the architectural heritage, and climate adaptation measures. In total, 951 Breda residents responded to the digital poll, 250 of which registered to be able to join physical game meetings. Due to Covid-19 measures, 60 people could join three analog sessions with social distancing rules as a result of a lottery selection. Results of the digital polls were shared in real-time on the municipality's website. Before analog sessions began, we could add new game strategies and 3D building units based on the resident response digital poll collected. Analog game sessions helped to connect individual ideas to develop into collective narratives about the future Koepel. During these game sessions, the Urban Reality model ran simultaneously and provided real-time feedback about the financial feasibility of developing plans.

6. Design Recommendations for Building a More Comprehensive Network of Games

NoG is a game system to support a holistic debate and decision forming where experts and non-experts meet to explore urban questions from public space to energy and from heritage to mobility. It focuses on developing an interconnected modular game system through data and interface for an integral planning and design approach. With two concrete game integrations in Amsterdam and Breda, the transition from the theoretical NoG approach into implemented cases has been achieved. These experiments provided practical answers to the initial question of how to build a NoG. We can safely conclude that the hypothesis about linking games through their datasets and interfaces proved to be relevant and, to a large extent, manageable. We consider this a start where new additions of game datasets and interfaces will enrich the data infrastructure of the NoG. In this way, relevant combinations of specialized city games, enable bottom- and top-down actors to engage in holistic discussions and therefore integral decision making. Similarly, an infrastructure of NoG enables stakeholders of diverse backgrounds with a distinct set of knowledge and experiences to interact and reach negotiated shared solutions. This is in line with a new conception of cities as self-organizing systems where a plurality of actors exercise their influences in the making of the city.

6.1. Linking to New Relevant Open-Source Datasets

With datasets on climate adaptation and urban development developed, synchronized integration of data models (Quintel and Urban Reality), and addition of four interfaces (Typeform, NoG app, the Urban Reality simulator, and Play the City table format) linked to one another, a game ecosystem is already under development. In reaching and distilling, most of these datasets we used are publicly invested resources.

6.2. Making Own Datasets and Apps Open Source

Accordingly, we plan to make collected datasets and the beta version of the NoG app publicly accessible, also given that the NoG runs on a study financed by two major public grants (Stimuleringsfonds Creatieve Industries and Nederlands Organisatie voor Wetenschappelijke Onderzoek) and two local governments (city of Amsterdam and city of Breda) financed projects. With this step, we will make the data infrastructure of the NoG known to more urban designers and game developers. This potentially opens up the way to further growth of the game network and partnerships.

6.3. Actively Seeking New City Game Collaborations

In future iterations, we see possibilities for expanding with new datasets on sustainable tourism (a city game developed by Breda University's tourism department), food datasets (a city game in development by Utrecht's art and science institution Casco), and health and well-being datasets (game research conducted at the Australian Urban Design Research Centre).

6.4. Expanding Interface Integrations

Just as the datasets are subject to expansion with new categories, so are the interfaces allowing various forms of engaging with participants for the NoG. In the early phases of this research, our assumption was that an app containing interconnected game datasets would be the best answer for hosting a platform of interconnected games. After developing the beta version of the NoG app and subsequently working with the Typeform and the UR calculation model, we realized that an open approach (as in interconnected datasets) would become necessary also in the interface aspect of the platform so long as the data infrastructure can be integrated into these new interfaces. Two experiments utilizing sequential and simultaneous integration of diverse digital tools suggest that a collection of interfaces connecting to each other throughout the entire process from a digital poll to an app, a simulator, a webinar, or analog game sessions is more effective than a single mobile phone app for all potential game interactions.

Principles such as data sharing, relating, and connecting interfaces behind the NoG approach started spreading among city game developers, planners, urbanists, and architects. We expect that publicly sharing data categories and subsets will enlarge the ecosystem and generate a series of innovative game combinations in the coming decades. We can only look forward to new meaningful collaborations and further maturing of the city gaming practice.

Conflict of Interests

The author declares no conflict of interests.

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About the Author

Ekim Tan (PhD) is an architect and urbanist from Istanbul based in Amsterdam. Before relocating to the Netherlands, she worked and studied in the US, Syria, and Egypt. Being trained as an architect, her growing interest and passion in cities and games led to a doctoral degree at the TU Delft, titled *Negotiation and Design for the Self-organizing City: Gaming as a Method for Urban Design*. In 2008, she founded Play the City, an Amsterdam- and Istanbul-based city consultancy firm that helps governments and market parties effectively collaborate with stakeholders. The city gaming method developed during her doctoral research at the TU Delft has been applied in projects worldwide, among others, in Istanbul, Amsterdam, Dublin, Shenzhen, Tirana, Cape Town, and Brussels. Following the book on her doctoral research (2014), Tan published *Play the City: Games Informing Urban Development* (2017) sharing special knowledge and experiences developed through the Play the City practice.

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Article

Playing With Uncertainty: Facilitating Community-Based Resilience Building

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Abstract
Resilience has become a fundamental paradigm for communities to deal with disaster planning. Formal methods are used to prioritise and decide about investments for resilience. Strategies and behaviour need to be developed that cannot be based on formal modelling only because the human element needs to be incorporated to build community resilience. Participatory modelling and gaming are methodological approaches that are based on realistic data and address human behaviour. These approaches enable stakeholders to develop, adjust, and learn from interactive models and use this experience to inform their decision-making. In our contribution, we explore which physical and digital elements from serious games can be used to design a participatory approach in community engagement and decision-making. Our ongoing research aims to bring multiple stakeholders together to understand, model, and decide on the trade-offs and tensions between social and infrastructure investments toward community resilience building. Initial observations allow us as researchers to systematically document the benefits and pitfalls of a game-based approach. We will continue to develop a participatory modelling exercise for resilience planning with university graduate students and resilience experts within academia in Christchurch, New Zealand.

Keywords
community-based resilience; participatory modelling; resilience planning; role-play games; serious games; socio-technical systems

Issue
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1. Introduction: Participation in Community Resilience Building

Community resilience planning needs public participation to include multiple perspectives for effective decision-making and to advance where robust scientific approaches meet decision-making needs (Barton et al., 2020). Consequently, it is difficult to communicate the concept of resilience to decision-makers along with practical implications. For example, Norris et al. (2008) describe resilience as a process rather than an outcome. This process includes social capital, community competence, information and communication resources, and economic development. However, some of these aspects are measurable, others are not, and thus do not provide clear guidance for policymakers in the field (Norris et al., 2008).

Disasters and crises happen in and beyond social, policy, and infrastructure systems. In growing and interconnected systems, it is challenging for decision-makers to comprehend the impact of their actions on other systems or interdependent infrastructure systems (Ansell et al., 2010; van Laere et al., 2018). Disaster researchers, planning managers, and policymakers along with the community need to understand the profound implications of interconnected social and infrastructure networks that deliver essential services (Thacker et al., 2019). For a better understanding of, and ability to apply, knowledge of the distinct dimensions of resilience, these experts have to make their knowledge explicit.

Approaches that support decision-making processes provide an avenue for improving public participation by encouraging the awareness of multiple conflicting tensions to make choices. Participatory modelling seems to be such a promising approach as a decision-support tool for community resilience because of its ability to represent realistic models and the inclusion of the human element in an interactive way (Miles, 2018; Voinov & Bousquet, 2010). We conceptualise simulation and serious games as instruments of participatory modelling. Simulation and serious games have played an important role in bridging the interface between scientific information and decision-making processes since the 1960s (Ampatzidou et al., 2018; Duke, 1980). In addition, simulation games are widely known as a research method for the transdisciplinary integration of concepts, theories, perceptions, information, and techniques (Lukosch & Comes, 2019).

Flood et al. (2018) present a systematic review of the use of serious games for engagement and decision-making specifically in the climate change and adaptation arena, including the application in recovery, analysing prevention, and disaster management. So far, the focus of serious games has been on emergency training, risk management, and educating audiences about disaster preparedness, with less attention on preparedness for investment and engaging with local actors and engineering (infrastructure) stakeholders (Bathke et al., 2019; Flood et al., 2018). Our work aims to close this gap with the exploration and development of an engaging way for different actors such as communities, infrastructure providers, resilience researchers, and policymakers to understand trade-offs and interdependencies when building community resilience. This contribution is part of ongoing research on participatory modelling in building resilience, and its scope is limited to exploring past work on serious games that could inform which physical and digital elements are useful to design a participatory approach used for community resilience planning.

In the first two sections of this article, we explore how game-based participatory modelling can contribute to an understanding of building resilience as a process of addressing both the technical and the social dimensions. In Sections 3 and 4 of the article, we present related approaches and summarise common game elements to inform our participatory methodology. These sections do not include the implementation with practitioners but focus on design choices and first experiences with university students and academic experts in New Zealand. In the last sections, we conclude by analysing the benefits and pitfalls of some game elements from related work applied to our participatory modelling approach.

2. Background

2.1. Dilemmas Between Social and Infrastructure Resilience

The Sendai Framework for Disaster Risk Reduction 2015–2030, adopted by the United Nations (United Nations Office for International Strategy for Disaster Reduction, 2015), because of its emphasis on multi-dimensional and interrelated resilience, supports a need for approaching resilience through both (a) improving infrastructure assets and (b) improving the social capital needed to respond to a future disaster effectively. Currently, it could be argued that decisions toward disaster risk reduction are made by disaster experts, planning managers, and policymakers, assuming independence between social and infrastructure system investments (Avendano-Uribe et al., 2020).

On the one hand, physical infrastructure is the built environment, structures and facilities that provide essential services to sustain human activities (O’Rourke, 2019). Resilience in the context of infrastructure is considered a mechanism by which an infrastructure system can prepare for and adapt itself against disruptive events to reduce vulnerability and increase adaptive capacity (Fuchs & Thaler, 2018; O’Rourke, 2019; Omer, 2013). In particular, the critical infrastructure that supports communities includes transportation and water, energy, and food supplies. Besides transportation buildings (roads, highways, bridges, airports, and public transit), critical infrastructure includes waste-related facilities (wastewater treatment, solid waste, and hazardous-waste services) and other services that are connected to the network of residencies (Chester, 2019; Cutter, 2020; O’Rourke, 2013). Infrastructure resilience centres on engineered and social systems (e.g., an infrastructure network or community as a whole; Davidson, 2015). However, infrastructure resilience as a conceptual framework approached from the perspective of physical-technical systems alone has limitations and drawbacks. Those institutional arrangements that enable infrastructure resilience to operate are the links between social assets and infrastructure assets.

On the other hand, social capital is defined as the cumulative experience of information, trust, institutions, norms, and expectations about behaviours among a community to plan, prevent, mitigate, and prepare for a disaster and the learning experience to respond and recover from a disaster (Aldrich & Meyer, 2015; Cai, 2017; Yan & Galloway, 2017). Social capital includes actions made before, during, and after a natural disaster: prevention, mitigation, preparedness, response, and recovery.

In resilience planning, the context that affects trade-offs and decision outcomes can change over space and time. That is why it is important to enquire not just about the resilience of what, to what, and for whom, but also why and where (Meerow & Newell, 2019). For example, New Zealand is a country that has an international reputation in terms of resilience practice (Wither et al., 2021). The New Zealand Ministry of Social Development defined what matters in communities as social resilience, referring to building connections between people and communities, access to decision-makers, and policy and research communication (Chen et al., 2021). Access to critical infrastructure and essential services is paramount to community resilience (Logan & Guikema, 2020).

One vital challenge in the field of community resilience, and the main motivation for our study, is that resilience itself is a rather ill-defined operationalised concept, which makes it challenging to communicate the concept along with practical implications to decision-makers (Ottens et al., 2006; Wither et al., 2021). Overall, researchers are liable to focus on either the impacts on infrastructure overlooking the social impacts of resilience or vice versa (Doorn, 2019; Doorn et al., 2019). There is an appreciation that the two types of capital are needed. According to Saja et al. (2019), the trend to consider multiple variables as resilience indicators can be confusing for the practice of community resilience building. They suggest that generalising a framework can improve resilience investment decisions across different contexts. Still, current multi-dimensional frameworks lack an adequate measure of social resilience for effective decision making.

Our study upholds integrative approaches to understand resilience in complex systems and create a common stakeholder arena to make decisions. That is why we adopt the conceptualisation of resilience for socio-technical systems (STSs). A STS refers to the interplay and interlinked social and technical parts of a system (Van der Merwe et al., 2018). Complex STSs involve physical-technical elements and networks of interdependent actors. Problems cannot be understood or solved without the knowledge of the system and its actors (de Bruijn & Herder, 2009). Community resilience integrates both social and infrastructure assets, their interactions, and non-linear complexity, and societies should use that integrated understanding to make informed decisions. Our approach aims to develop an understanding of the interdependencies and role of both the physical-technical systems and the social elements in building resilience.

2.2. Participatory Approaches to Building Socio-Technical Resilience

There is a need to understand the challenge of integrating social and infrastructure assets, their interactions, interdependencies, and non-linear complexity to make informed decisions. Numerical or quantitative analysis for building resilience should therefore be combined with knowledge on actor networks and social elements when building resilience. As a solution, in our work, we aim to develop an engaging way of participation for communities, infrastructure providers, resilience researchers, and policymakers to develop a collective understanding of trade-offs and interdependencies between both social and infrastructure resilience investments to build community resilience.

Engineers use formal models within their decision-making processes to bridge the perceived actual reality and the intended reality. Challenges remain due to misunderstandings related to the limitation of modelling methods and the role models play to support decisions (Elms & Brown, 2012). Computer-based and mathematical models support planning and decision-making processes by providing quantitative information (Basco-Carrera et al., 2017), and spatial tools for collaborative planning (Schindler et al., 2020; White et al., 2010). However, complex systems cannot be analysed just with numbers themselves (Rosling et al., 2018). The combination of data tools and people's participation in understanding these systems could provide a benefit in the sense of evidence-based support systems to enable informed decisions. That is why participation approaches in modelling and simulation—called participatory modelling—are useful to actively engage stakeholders in the decision-making process for resilience planning and management (Perrone et al., 2020). Designing for participation in systems is designing with stakeholders, for human experience in and of systems, and to enable stakeholders to relate to a larger system (Brazier & Nevejan, 2014).

Modelling with stakeholders allows researchers to better represent the system and understand the multiple connections between the model built and the real system itself. For example, decisions are implemented with less conflict and more success when they are driven by stakeholders (Voinov & Bousquet, 2010). Consequently, simulation models are used as boundary objects or negotiating artefacts to facilitate transparent and verifiable discussions and the proliferation of ideas (van Bruggen et al., 2019). In recent years, resilience frameworks have been utilised in science and policy interventions in natural resources and disaster risk management (Sellberg et al., 2018). Researchers suggest that fostering learning, increasing participation, and facilitating awareness among stakeholders about trade-offs, interdependencies, and interactions in complex adaptive systems is a way to strengthen community resilience (Biggs et al., 2015).

The use of participatory modelling could help policymakers, communities, and engineers understand different perspectives around the same problem (Gray et al., 2015), especially when policymakers need to comprehend interdependencies between social systems and infrastructure (Thacker et al., 2019). However, participatory methodologies combined with quantitative data collection and abstract modelling could be a challenge. An innovative way to solve this gap is using simulation games or serious games in risk and disaster planning to both inform audiences and to empower stakeholders (Barreteau et al., 2021; Bathke et al., 2019).

As a form of participatory modelling, serious or simulation games are used in research to understand interactive decisions in complex engineering systems (Grogan & Meijer, 2017). Serious games are defined as activities used for purposes other than entertainment (Bathke et al., 2019). Abt (1987, p. 6) defines games as "an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context." Applied to engineering research, games incorporate data from an underlying model but are not quite as realistic as actual fieldwork (case studies; Figure 1).

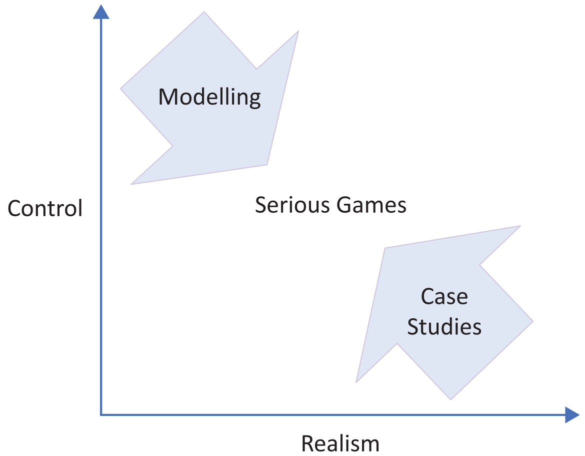

Figure 1. Gaming methods related to other methods in engineering research. Source: Authors' work based on Grogan and Meijer (2017).

Figure 1 illustrates that serious games are in between an abstract representation of reality, controlled by a model and a case study that is close to reality when understood as a case study. Modelling methods help to understand reality by simplifying the complexity using an abstract representation of the real world (Grogan & Meijer, 2017). Simulation games are interactive environments that simultaneously model a technical system through simulation and a social system with role-play participants (Grogan & Meijer, 2017).

Despite existing studies and raising demand for practical guidance on resilience planning and climate adaptation, practical studies on the resilience of STSs are scarce, and more work needs to be done to understand the social domains required to ensure resilience (Preiser et al., 2018; Sellberg et al., 2018; Van der Merwe et al., 2018). The lack of innovative methodologies to encourage systems thinking remains a challenge to tackle wicked problems. We discuss serious games as a participatory method to create a common understanding of the complexity of resilience, especially the concepts of social and infrastructure resilience.

3. Related Work: Serious Games for Community Resilience Building

Our exploration starts with an inquiry into the role of elements from serious games in community resilience building. We analyse common elements of serious games applied to resilience to illustrate what game elements are useful to build our participatory modelling approach. First, we present game settings from general serious games applied in resilience of STS to find which game elements have potential application for our purposes. Secondly, starting from this analysis, we chose three game examples that aim to facilitate resilience-building using participatory approaches and we conduct detailed analysis to inform our findings on game elements useful to apply a research tool for policy making.

The main reason to use serious games for resilience in STSs is to provide an immersive experience crucial for facilitating multi-stakeholder interaction. The work of Solinska-Nowak et al. (2018), which analyses 45 serious games used in disaster risk management, inspires our participatory modelling methodology design. They find that serious and simulation games are powerful tools to assist risk awareness, perspective-taking, and empathy. In addition, they show that in these types of games, players can select between simulated scenarios and observe the consequences of their decisions when the disaster finally develops. For example, two of the games cited by Solinska-Nowak et al. (2018)—Decisions for the Decade and Paying for Predictions—involve investments as the main stakeholder exercise. These games allow participants to increase their awareness about planning investments while choosing scenarios to discuss the implications of each decision. Our lesson is that deliberation processes could foster relevant conversations between multiple agents and perspectives, improving stakeholders' cross-fertilisation of ideas (Ansell et al., 2010). However, there are no games addressing the problem of planning for community resilience based on infrastructure and social assets and related interconnections and trade-offs. We intend to address this problem with our own participatory modelling approach.

Research conducted by van Laere et al. (2018) provides game development combined with role-playing simulations to understand interdependencies in critical infrastructure. They highlight game elements such as learning goals, choice of player roles, degree of realism, the time scale of scenario, and re-play abilities. In their research three challenges remain: (a) Models about infrastructure resilience tend to be too abstract, (b) scenarios are limited to short term disruptions and lack of interactions to explain cascades, and (c) community resilience continues to be difficult to operationalise with simple metrics (van Laere et al., 2018).

Solinska-Nowak et al. (2018) and van Laere et al. (2018) inspired us to search comprehensively for similar work and we found only six simulation games tackling critical infrastructure resilience. In Table 1, we show how different sectors from civil systems engineering related to resilience are covered by serious games.

According to Table 1, common game elements that could provide useful applications in a participatory modelling for analysing STSs in civil systems engineering are

Table 1. Highlights to inform game design from serious games used for community resilience building in civil systems engineering.

Serious Game	Game Elements to Highlight	Sector of Application	Reference
Sustainable Infrastructure Planning Game	Participation of peer graduate students	Lifelines and agriculture	Grogan (2014)
CIPRTrainer	Option to revert a decision: Go back in time	Lifelines	Rome et al. (2016)
Disruption Game	Model: High abstraction level	Port infrastructure	Kurapati et al. (2015)
SimportMV2	Transferability to the policymaking process	Port infrastructure	Bekebrede et al. (2015)
Smart Mature Resilience	User-friendly interface	Lifelines	Iturriza et al. (2017)
SPRITE	What if scenarios: Students play the role of policymakers	Dyke/coastal infrastructure	Taillandier and Adam (2018)

the use of hypothetical scenarios using a model that allows participants to understand the system while interacting in a user-friendly platform. Our lesson from those games is that bringing together stakeholders to discuss a common problem from different social and infrastructure (technical) perspectives can potentially foster systems thinking in the civil system engineering sector. For example, CIPRTrainer is a game to increase the awareness of crisis managers in disasters about interconnected critical infrastructures while understanding possible consequences of a specific scenario evolution (Rome et al., 2016). Revisited serious games aim to provide a tool for decision-makers to train themselves. This is the case of Smart Mature Resilience, where researchers suggest engaging with multiple stakeholders to foster the participation of professionals who will use the gained skills during the game later (Iturriza et al., 2017). In the Sustainable Infrastructure Planning Game, the aim is to build an interactive simulation model with graduate students from the Massachusetts Institute of Technology (Grogan, 2014). A similar approach is chosen for the game SPRITE, which aims to teach risk management to engineering students to raise awareness about the risk of coastal flooding. SPRITE places students in the roles of policymakers and politicians while simulating real situations (Taillandier & Adam, 2018). The Sustainable Infrastructure Planning Game, SimportMV2, and SPRITE show that trials with graduate students that play the role of practitioners are useful for understanding further implementation.

In addition to the games presented previously, we searched for references close to civil systems engineering that use community resilience planning to understand interconnections and trade-offs in STSs. We neglected to choose references on post-disaster analysis, disaster management, or financial aspects of a crisis. We found 11 research-based games and we identified similarities and differences in game elements (Figure 2).

We discovered that elements like role-playing and simulations, scenarios or storytelling, and debriefing are relevant in games associated with STSs. However, systems thinking, negotiation, and discussions are not always present and physical and digital elements vary. Only three games—Kin Dee You Dee, Ready for Drought?, and MoBinn—have common elements from the criteria we analysed in Figure 2. We have chosen these serious games because of the experiences reported with local authorities, the inclusion of decision-making processes enhancing collaboration, and the variety of themes related to resilience covering social/technical systems. Finally, the diversity of locations for these three serious games (Asia, America, and Europe) helps to extract lessons. Here, we compare the three games extracting the purpose of the game, its elements, and the dos and don'ts analysis following Freese et al. (2020; Table 2). We provide a detailed description of the three games described in Table 2 and in the Supplementary File.

The analyses presented in Table 1, Figure 2, and Table 2 serve to extract game elements that could be essential in creating a participatory modelling approach in the context of community resilience in STSs. For example, the use of scenarios, narratives, and storytelling can be useful for facilitating and guiding participants into an immersive experience to easily understand complex concepts and systems thinking. The use of role-playing and physical elements such as tokens, dates, pawns, dices, and boards, can support the game dynamic of the participation using visual cues, adding some physical experience to the game. Finally, negotiation sessions, peer-review feedback, and reflections throughout a debriefing moment can support the communication and interaction between participants (Lukosch et al., 2018). In the following section, we show how game elements from the above analyses are informing our participatory approach for an STS in New Zealand.

Reference	Serious Game	Elements							
		Role-Play	Simulations	Scenarios/Storytelling	Systems Thinking	Tokens, Dates, and Dices	Tabletops/Boards (Physical or Digital)	Negotiation/Decision	Debriefing
Gugerell and Zuidema (2017)	Energy Safari	✓	✓	✓		✓	✓	✓	✓
Klemke et al. (2015)	SALOMO	✓	✓	✓		✓	✓	✓	✓
Kourounioti et al. (2018)	Modal Manager/RCCA/SynchroMania	✓	✓	✓	✓		✓		✓
Kurapati et al. (2018)	Modal Manager	✓	✓	✓	✓		✓		✓
Marome et al. (2021)	Kin Dee You Dee	✓	✓	✓	✓	✓	✓	✓	✓
Poděbradská et al. (2020)	Ready for Drought?	✓	✓	✓	✓	✓	✓	✓	✓
Pollio et al. (2021)	Antarctic Futures	✓	✓	✓		✓	✓		✓
Red Cross Red Crescent Climate Centre (2017)	Paying for Predictions	✓	✓	✓		✓	✓	✓	✓
Roukouni et al. (2020)	MoBinn (Mobilize Innovation)	✓	✓	✓	✓	✓	✓	✓	✓
Rumore et al. (2016)	NECAP	✓	✓	✓	✓				✓
Wesselow and Stoll-Kleemann (2018)	Livelihood Game	✓	✓	✓	✓		✓	✓	

Figure 2. Highlights to inform game design from serious games used for community resilience building in civil systems engineering.

4. Our Prototype: Playing With Uncertainty to Facilitate Community Resilience Building in New Zealand

A unique and internationally recognised community resilience process can be identified in New Zealand, which has emerged over a decade from the Canterbury earthquakes that caused huge urban and suburban damage (Thornley et al., 2015). In addition, New Zealand has seen recent efforts for engaging communities in decision-making processes using digital and physical tools (Cradock-Henry et al., 2020; Lawrence et al., 2021; Schindler et al., 2020), in post-disaster community-led interventions (Dionisio et al., 2016; Dionisio & Pawson, 2016), and infrastructure resilience decision-making processes (Davies, 2019; Davies et al., 2021). A common consensus is that there is a need to engage stakeholders to make risk-informed decisions and use contextual factors to enhance community resilience planning (O'Rourke, 2019). The challenge is to build engagement for a decision tool without losing expertise from the competence and proficiency of experts and at the same time include stakeholders' ideas as a genuine participation exercise and not only as a pre-requisite for engaging with actors.

To address these challenges, we are developing Playing With Uncertainty, a serious game as a participatory modelling approach to facilitate community-based resilience building. We are designing role-playing negotiations as a simulated decision-making process in an STS. The intention behind the game is that participants must trade-off between investing in social and infrastructure resilience. The game recreates tensions in STS and conflicting decisions between multiple stakeholders. Participants play roles as community leaders, infrastructure providers, and policymakers. They need to communicate to negotiate and decide whether to invest and arrange priorities from a list of factors and variables of social and infrastructure (technical) assets that secure resilience building in the long term under potential flooding scenarios due to sea-level rise. The mechanics of the game are constructed so that over-investment in one type of resilience is unfavourable, though the participants are only able to probe the mechanics through trial investments. The context of the exercise is to decide how to use a 10-year budget (2020–2030) from the Coastal Hazards Adaptation Program at the Christchurch City Council in the Canterbury region, New Zealand (Christchurch City Council, 2021).

Community resilience remains to be a concept that is difficult to operationalise (Wither et al., 2021). For that reason, Playing With Uncertainty is using social and infrastructure factors derived from the literature on community resilience building in New Zealand (Cutter et al., 2014; Kwok et al., 2016; Langridge et al., 2016; The Treasury, 2020; Thornley et al., 2015). In our prototype, social factors include (a) increasing community connectedness and opportunities to

Table 2. Derived dos and don'ts analysis based on serious games as research instruments in STSs.

Serious Game	Purpose	Physical/Digital Elements	Dos	Don'ts
Kin Dee You Dee (Thailand)	Facilitate discussion of resilience pathways for flood-impacted communities in Bangkok	Dice, tokens, maps, role cards, and scenarios	• Combine different disasters in different scenarios, multi-hazard perspective • Design user-friendly materials and game testing and revisions with underrepresented communities • Invite local municipal authorities, community members, and government agencies	• Long hours in engagement workshops to avoid withdrawal of participants
Ready for Drought? (USA)	Learn about trade-offs involved in a decision-making process on water banking in the Missouri River Basin region under difficult resource-sharing scenarios	Role-playing, pictograms, cards, and graphical representation of scenarios	• Present what-if scenarios with disaster impacts and consequences • Use fewer roles from different sectors • Implement trials with students • Use low technological requirements • Create simulations based on real data	• Discuss decisions for each of the four phases of events • Allow participants to decide factors in the model • Limit the number of variables involved
MoBinn—Mobilize Innovation (the Netherlands)	Collaborate to design solutions to alleviate the pressure on the road network in the Netherlands, while analysing the consequences of certain decisions and policies	Game board, role cards, roles, action cards per role, event cards, tokens, pawns debriefing, scenarios, rules and decisions, and ex-ante evaluation	• Implement ex-ante evaluation of policies to raise awareness while discussing short- and long-term consequences of decisions made • Collaborative decision-making creates a risk-free environment • Include a minimum of five roles • Include positive events or negative disruptions to the flow of the game	• Overcharge decision options with hypothetical scenarios of different policies and actions • The use of coloured indicators can confuse colour-blind participants

get together, (b) resourcing community-based organisations, and (c) improving community infrastructure (Thornley et al., 2015). Infrastructure factors include (a) building buffer zones and storm barriers, (b) building pontoons/amphibious houses, and (c) property acquisitions removing infrastructure.

According to Geurts et al. (2007), a game is a tool to structure communication in complex systems and, as a research method, can facilitate the analysis of STSs. Games have multiple elements, symbols, and components to support communication between participants (or players; Geurts et al., 2007). Gaming as a research method helps to master complexity. Analysis of multiple components of an STS could help to create game elements (Lukosch et al., 2018).

Playing With Uncertainty collects elements from the related STSs of coastal protection in Christchurch and transforms them into game elements. Every serious game element extracted has a match with the element highlighted from the related STS analysed (Table 3).

Table 3 is the result of our analysis and shows how our design will include the following game elements: graphic displays (dashboard), simulations, scenarios, storytelling, systems thinking, tabletops, decision negotiation, and debriefing. Our design will also include physical game elements: tokens, coins, and a table board. In our effort to create a hybrid game, digital and physical technologies are combined (Kankainen et al., 2017). We can shape our design elements for role-playing negotiation and scenario analysis based on lessons from the analysis of serious games presented in Section 3. This hybridisation seems particularly promising for disaster-related research for being able to process (realistic) data that players can use and the physical elements that support the social aspect of the gameplay, facilitate discussion, and enable the "play" feeling that might be relevant to remove some realistic context. The physical elements will be evaluated on their ability to foster communication between participants, while the digital elements will be evaluated for data visualisation. The intention is to use the design described here first with university graduate students, many of whom are conducting doctoral research into community resilience.

Figure 3 shows physical game material that we intend to use to support scenario thinking and role-taking. Investments in physical (infrastructure) and social resilience are visualised on the game board. 3D printed dice show what scenario is simulated. The board design, role cards, and tokens help to visualise the dynamics for the participants.

Figure 4 shows how an early trial of the game that has been played with graduate students in resilience at the University of Canterbury, New Zealand. A combination of physical elements and digital support is evident. We conducted a trial to test the usability of the elements created. During one hour of the game session, the facilitator introduces the aim of the game, rules, instructions, and usability of the game elements. Every participant (six in total) has a role assigned to play. They also have a budget assigned to invest in every round. If they do not spend it, they cannot save it and lose their score as decision-makers. Participants need to wisely discuss their budget both individually and collectively to make sure all factors for community resilience are included in the investment plan.

Participants play six rounds. Each round has a scenario, and a different adaptation plan defines it. Planning for future events requires modelling scenarios with different factors and test parameters to understand potential consequences to make effective decisions. The scenario is defined by chance using the disaster dice. Once every scenario is shown in the sheet, the facilitator discusses potential interdependencies and trade-offs derived from decisions made with participants. Each participant has a say according to their role, and discussions are encouraged by the facilitator, adding tension and conflict to the conversation while investment negotiations happen. Each participant makes a decision and the facilitator, with the help of a modeller, collects data from multiple investment rounds with the digital dashboard, visualising the consequences of each decision immediately.

5. Summary and Discussion

In our work, we assume that using game elements to facilitate a participatory modelling approach will improve engagement with multiple stakeholders while simulating a decision-making process. This argument is supported by past evidence suggesting that games benefit participatory modelling (Bakhanova et al., 2020). We captured design elements from related serious games to support a game-based participatory modelling approach in building community resilience. We conceptualise resilience as a complex STS and distinguish between physical and social resilience. We have analysed past work on serious games that inform the design of our participatory approach related to a complex STS. Our study is located in the context of resilience in New Zealand and translates the social and technical-physical elements of it into game elements. An early trial with our game prototype suggests the potential of the game elements to foster an understanding of resilience concepts. Implementation and analysis of the game's application are beyond the scope of this article.

Playing With Uncertainty aids investment decision-making while participants discuss resilience interventions using the role-playing negotiations approach. Science-based role-play exercises are a type of serious game that involves face-to-face mock decision-making (Rumore et al., 2016). Contrasting with literature, we could observe that the role-play negotiation elements could inspire collaborative learning, cooperation, and body and oral expression to work collaboratively on solving a challenge in the community (Boal, 2013; Tolomelli, 2016). We built Playing With Uncertainty on this idea

Table 3. Elements from the STS Coastal Protection Plan in Christchurch transformed into game elements in the participatory modelling methodology.

	Element From the STS	Game Element	Comparative Description
System scope	Investment adaptation plan for resilient communities at the Christchurch City Council (New Zealand).	Briefing	Facilitators and researchers introduce aims, define scope, and explain instructions and rules of the game. They are using storytelling to contextualise participants.
Decision-makers	Decision-makers: Six participants in charge of the investment resilience plan. Two engineers or technical experts in infrastructure resilience, two community leaders, and two policymakers.	Role-play cards and tokens	Participants with a role to play are represented in a card/token.
Disasters	Descriptive sheets with statistical information and data-driven statements based on literature review and national standards for each potential natural hazard in the location.	Scenarios	Simulated visualisation of consequences of a natural hazard on the geographical area.
Uncertainty	Hazards are prone to happen in the context. 3D printed dice. Each face shows a different risk: earthquake, flood, tsunami, fire, storm, and volcano eruption.	Disaster dice	Randomisation of events occurring. It gives the game unexpected situations and tension due to uncertain pressures.
Social and technical assets	List conflicting variables or social and infrastructure (technical) factors related to each scenario.	Conflicting variables	The weighting of factors changes with each scenario.
Investment plans	Turns of the decision-making process with a specific time for discussion between participants.	Negotiation rounds	Drivers of the conversation for investment.
Budget	Poker coins are equivalent to the weight of investment for each conflicting variable: social and infrastructure assets.	Coins/money tokens	Amount of money available for each investment round.
Data visualisation	A dashboard engine to visualise the consequences of the investment rounds and results from the negotiated decisions. It contains a model of the STS visualising it in terms of investment weights per round and scenario.	Physical and digital board: Dashboards	Decision visualisation tool representing inputs, outputs, and interaction of system´s elements. Dashboard as a digital element, and table board, dice, coins, and tokens as physical elements. (Figure 3 and Figure 4).
Final decisions	Outcomes from the negotiation.	Debriefing	Participants and researchers reflect on decisions made and the game as a tool to facilitate it.

Figure 3. Prototype of table board printed containing all physical elements from the game interacting: Rounds, scenarios, coins, variables, dice, and role-play cards.

Figure 4. Playing With Uncertainty: Trial exercise with graduate students at the University of Canterbury, New Zealand.

as a tool to involve stakeholders in resolving a problem in uncovered tensions between social and physical-technical resilience. Role-playing and negotiation of conflicting values foster discussions and facilitate the decision-making process within the context of realistic scenarios. This game-based participatory modelling exercise could alleviate tensions between participants as it represents a safe, experiential environment without the risk of real-world consequences.

We have learned that designing game elements that connect the game back to the STSs, such as briefing and debriefing, is crucial. Participants require processes and spaces that allow them to meaningfully contribute their ideas, needs, knowledge, and perspectives toward decision-making processes (Hore et al., 2020). Related to resilience, Playing With Uncertainty offers an immersive experience to highlight that participation is crucial to reducing vulnerability, enhancing local capacities to face disasters, and effectively reducing the impacts of hazard events. Integration of complex systems modelling using participatory approaches is a solution for engaging stakeholders in building resilience. Our approach makes use of planning activities for resilience investments. This helps participants to improve their understanding of the system, reduce conflicts between different points of view, and facilitate community engagement in the process (Carmona et al., 2013; Ganapati & Ganapati, 2008; Henly-Shepard et al., 2015). The advantages are that participants make sense of the complexity of policy issues and reflect on system inter-linkages and stakeholder plurality (Beaven et al., 2016).

The use of dos and don'ts analysis shown in Table 2 helped us to reiterate best practices and avoid mistakes from others. For example, the serious game MoBinn shows how physical elements (board) can be used to enable a better understanding of the complexity of the interests of the stakeholders involved, and the need for collaboration. It also shows that the use of dice can foster a sense of uncertainty. It helps stakeholders to understand the variability of the consequences and level of unpredictability that they might need to confront while stakeholders are deciding on resilient alternatives of investments under potential disasters. That inspired the creation of our disaster dice.

The serious game Ready for Drought? presents disaster scenarios as the core element of the game. Researchers included contextualised problem definitions to enable participants to understand the complexity of the problem tackled. The use of coins and tokens accompanies the element of role-playing and adds context to the problem to be addressed. The serious game Kin Dee You Dee considers trialling role-play games with tertiary education students. This inspired our role-play negotiations and encouraged us to think about implementing qualitative tools such as questionnaires and debriefing sessions. This could foster awareness among participants while discussing short- and long-term consequences of decisions made.

In our game, a digital element of the data dashboard together with a physical game board aims to support data-driven decision making. The hybrid nature supports the social and behavioural aspects while understanding tensions in social and infrastructure resilience investments. The translation of elements of the STS of resilience into digital and physical game elements as shown in Table 3 allows us to learn, adjust, and develop our game design based on player feedback and observation.

Finally, our participatory modelling approach is based on a simulation game that represents a real STS at a certain level of abstraction, and participants who work together to complete the aim of the game (Kourounioti et al., 2018). The idea behind engaging with stakeholders this way is to promote:

1. A holistic system understanding: Participants understand while participating on a system level, so the system includes stakeholders' perspectives;
2. Ownership of modelling techniques: Participants could learn modelling techniques along with researchers to simulate decision making and use the model built;
3. Legitimacy of decision-making processes: Participants could express their genuine ideas and bring their insights to the negotiation process leaving room for transparent discussions for deciding.

Further research is required in these three aspects, considering the cross-fertilisation of ideas drawn to STSs from similar work in the field of environmental sciences and disaster risk reduction through participatory modelling (Gray et al., 2016; Lane & Videira, 2019; Smetschka & Gaube, 2020; Vieira Pak & Castillo Brieva, 2010; Voinov & Gaddis, 2008; Voinov et al., 2018; Wesselow & Stoll-Kleemann, 2018).

6. Concluding Thoughts

6.1. Key Considerations

Public engagement with multiple stakeholders for decision-making and planning is paramount for building community resilience. We propose modelling with stakeholders as an engaging way of participation for communities to understand complex systems and support their decisions under uncertainty. Our participatory modelling approach is aimed to allow multiple stakeholders to understand trade-offs and interdependencies between social and technical dilemmas, framed by the concept of STS.

The use of a dos and don'ts analysis helps to systematise a participatory modelling design process that requires theoretical and methodological frameworks for serious games. It allows us to understand how our methodological approach for conducting research on the resilience of STSs can be improved. Game elements such as role-playing negotiations, digital game elements to visualise decisions and scenarios, and physical elements that represent tensions and conflicts in STSs foster a safe and game-based approach that turns difficult conversations into a simulation of decision-making negotiations.

Our ongoing research in Playing With Uncertainty combines physical and digital elements from serious games to foster community engagement to understand tensions in STSs' investments when planning for a potential disaster. It is intended to increase participants' awareness of multiple perspectives on social and infrastructure tensions. The end goal of our ongoing research is a tested and developed methodology that can be used for resilience challenges in local governance, informing both theory-building and practical application in New Zealand or contexts with similar resilience challenges overseas.

6.2. Limitations of the Study

Scientific literature reporting on serious games for resilience in STSs is still rare. The challenges of using game-based approaches remain. This prototype design relies on the possibility to conduct in-person meetings. We acknowledge that the number of people participating, the interaction between participants, and the usability of a game to facilitate engagement between stakeholders are vital aspects in exploring the usefulness of our approach. We have not explored an online version as an alternative. Further systematic implementation and evaluation of the prototype design are needed.

6.3. Future Work

The next steps of our research will involve the refinement of our prototype design through further iterations of the game design by experts and practitioners. We will then encourage the participation of stakeholders from local governments, industry members, and community leaders to validate the usability of the methodology as a tool to raise resilience planning awareness. Systematic work for data collection during game sessions needs to be improved. The use of artificial intelligence and automatised tools to highlight, organise, and categorise ideas from the debriefings and participants' conversations could improve qualitative data collection. The methodology has potential practical use as a decision visualisation environment, as John et al. (2020) propose. Future research is also needed on methods to assess the effectiveness of this and similar methodologies.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

New Insights, New Rules: What Shapes the Iterative Design of an Urban Planning Game?

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Abstract
Games have become established tools within participatory urban planning practice that provide safe spaces for collective actions such as deliberation, negotiation of conflicting agendas, scenario testing, and collaborative worldbuilding. While a body of literature on the effectiveness of games to address complex urban planning issues is emerging, significantly less literature addresses the design and development process of serious games with a possible space in its own right within urban planning practice. Our study investigates long term iterative processes of designing a game for visioning urban futures, specifically, how design iterations connect to the application of games in practice by accommodating or responding to emerging needs, goals, and relationships. We approach this topic through the case study of the Sustainability Futures Game, a game designed by the Helsinki-based creative agency Hellon to support business leaders, sustainability specialists, and city officials to imagine desirable alternative urban futures. Through storytelling and collective worldbuilding, players first imagine what sustainable urban living means for a specific city, frame their vision using the UN's sustainable development goals, and finally create concrete pathways towards reaching these goals. This article uses a genealogical approach to systematically analyse the five design iterations of the Sustainability Futures Game. It aims to elucidate the contextual and relational influences on the application of serious games in urban planning practice to understand how these influences might encourage or inhibit their potential to foster transformation towards sustainable futures.

Keywords
design genealogies; futures methods; serious games; sustainability transitions

Issue
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1. Introduction

In the face of increasingly urgent and large-scale global challenges, there is a pressing need for new approaches and transformative actions to stabilise and restore social and ecological systems (Leach et al., 2013). Cities have a critical role to play in fostering sustainability transformations: The majority of the global population currently lives in urban environments, and cities contribute disproportionately more to climate change. However, they are also places where the necessary changes in lifestyles, productive means, governance practices, and political systems can be initiated. While cities are increasingly concerned with creating more sustainable and desirable futures, creating consensus and shared visions through participatory governance processes remains a challenge (McPhearson et al., 2016). Serious games have become established tools within participatory urban planning practice that facilitate the understanding of complex and wicked problems (Rumore et al., 2016). Serious games provide safe spaces for collective actions such as deliberation, negotiation of conflicting agendas, scenario testing, and collaborative worldbuilding (e.g., Gordon & Baldwin-Philippi, 2014; Medema et al., 2016). There is a growing body of literature on the effectiveness of games to address complex urban planning issues (see Mayer, 2009; Vervoort, 2019) but significantly less on addressing the design and development process of serious games within urban planning practice in its own right.

Our study investigates iterative processes of designing a game for visioning urban futures, specifically, how design iterations accommodate or respond to emerging needs, goals, and relationships, eventually translating contextual and relational conditions into a finished product that can be applied in urban planning practice. We explore this question through the case study of the Sustainability Futures Game, a facilitated, gamified activity. The Sustainability Futures Game uses storytelling and collective worldbuilding to enable players to imagine sustainable futures for a specific city, frame their vision using the UN's sustainable development goals (SDGs), and finally create pathways towards reaching these goals. The development process of the Sustainability Futures Game was defined by its research-driven, exploratory attitude, and it was developed by the Finnish design consultancy Hellon, in the framework of the European research project CreaTures (Creative Practices for Transformational Futures; https://creatures-eu.org), which explores the role of creative practice in sustainability transformations. In addition, it embraced two other levels of openness: a broad attitude towards sustainability and the lack of a predefined client or target group. These conditions have been decisive for the development of the game and allow us to reflect on how contextual and relational influences on the application of serious games in urban planning practice might encourage or inhibit their potential to foster transformation towards sustainable futures.

In the following section, we introduce the academic debate on the use of games as a future method for urban planning and governance, and outline aspects related to iterative game design in this field. In Section 3, we describe the Sustainability Futures Game case study and layout of the framework of the transformative future by Mangnus (2022), a framework we have used to analyse the iterative development process as a futures-focused participatory activity. In Section 4, we discuss how changes in futures perspectives, the institutional context, participation culture, process design, participants, and methodology have related to one another throughout the six iterations of the Sustainability Futures Game. In the last two sections, we provide insights into game development processes for urban transformations. We discuss the proposed extension of the framework of the transformative future to include a genealogical dimension, paying particular attention to processes unfolding over time, the positionality of those managing these processes, and the purpose of future activities.

2. Games for Urban Governance and Sustainability

Understanding and responding to large-scale sustainability challenges increasingly requires interdisciplinary forms of knowledge production (Cairns et al., 2020; Khoo, 2017). To address large-scale urban sustainability transformations, there is an urgent need for participatory creation of shared futures visions (McPhearson et al., 2016), a move away from "solutionist" approaches (Strengers et al., 2019), and a turn towards experimental (Sengers et al., 2016) and values-based (Dulic et al., 2016) futures methods. Art and design bring an experiential quality to sustainability projects (Maggs & Robinson, 2020), and are potent in provoking situations that bring together stakeholders in imaginative, reflective exchange (e.g., Hesselgren et al., 2018; Irwin, 2015). Moore and Milkoreit (2020) suggest that such imaginative exchange is important for both individuals and groups in understanding our current degraded socio-ecological conditions and the systems that brought these about and envisioning both likely and desirable futures. Popular city-building games have often provided the first formative experience with urban planning and governance for generations of gamers (Bereitschaft, 2016). Serious games have a long history of application and evolution in urban governance and policymaking (Mayer, 2009). Compared to other media or forms of learning used in participatory urban planning, games, in particular, have been reported to offer a more effective and holistic understanding of complex systems and to encourage generating ideas for change (Kriz, 2003). Games are unique because they allow for experimentation with new roles (through player characters), new rules that may represent alternative governance structures, and new future worlds to inhabit and play in (Vervoort, 2019). They also contribute to the "fun aspect" of learning (Gajadhar et al., 2008) by combining learning with entertainment (Boyle et al., 2012; Jabbar & Felicia, 2015), and improving interpersonal relations among players (Fang et al., 2016). However, despite their reported benefits, serious games are often disconnected from anticipatory governance processes and urban planning practices (Vervoort et al., 2022). The limited application of serious games and gamified activities in these fields can be attributed to a lack of resources, planners' inexperience with participatory methods, and sceptical audiences (Ampatzidou et al., 2018). Even when used in relevant contexts, the focus tends to stay on the direct learning effects among the players of serious games, and less on their affordances to impact governance beyond such learning (Vervoort, 2019). However, transformative change often depends on recognising individuals as active agents in socio-ecological systems, whose interactions can shape institutions (Bai et al., 2016; Strengers et al., 2019).

Translating complex phenomena, such as urban sustainability transformations into the context of serious games is a challenging task. Iterative design methods are commonly used in game design but are rarely participatory. While conventional game design mainly involves game designers alone, inter- and transdisciplinary and participatory design approaches are used more widely, particularly in the field of serious game design (e.g., Abeele et al., 2012; Khaled & Vasalou, 2014). Adopting a participatory game prototyping process can lead to a balanced game in terms of domain content and playability, particularly when addressing potential players as distinct subgroups with differing and sometimes diverging interests (Ampatzidou & Gugerell, 2019). Stakeholders and game designers may bring different perceptions, ambitions, and interests to the game design process (de Caluwé et al., 2012), so a key benefit of involving different stakeholders in processes of ideation, exploration, and learning is enhanced communication and lowering biases of the game designers (see Magnusson, 2009; Muller, 2002).

3. Case and Methods: The Sustainability Futures Game

The Sustainability Futures Game is a facilitated, gamified activity developed by the Helsinki-based design consultancy Hellon (https://www.hellon.com) to support business leaders and city officials to imagine desirable alternative urban futures. The Sustainability Futures Game builds upon the Nordic Urban Mobility 2050 game, previously developed by Hellon as a tool for collective mobility scenario-making for the Nordic Smart Mobility and Connectivity programme of Nordic Innovation between October 2018 and February 2019. The Sustainability Futures Game exists both as a physical board game and as an online gamified workshop facilitated in the virtual collaborative environment Miro (https://miro.com).

Each gameplay session, designed for five to eight participants, starts with a short introduction by the facilitator followed by a round of introductions by the players and focuses on a real city, which is chosen ahead of the game by the participating players. Through storytelling and collective worldbuilding, players need to imagine a "desirable future" (Bai et al., 2016) for this city in 2030. To build this vision, they first imagine what sustainable urban living means for the specific city and the people living there, through a series of short exercises using visual prompts, additive storytelling, and probing questions. This first part of the process is concluded by using the SDGs to frame the generated vision (Figure 1). The second part of the gameplay focuses on creating concrete pathways towards reaching these goals, by identifying critical issues and solutions. The session is concluded with a short presentation and evaluation, and a debriefing conversation where participants share personal and organisational reflections, and feedback on the game's outcomes, and methodology.

The participatory design process was structured around a series of seven sessions testing five prototypes that iteratively built upon each other. The sessions lasted approximately three hours with a break and included two to three facilitators and five to 12 players. In the session with 12 players, four facilitators guided two subgroups playing in parallel. Members of the Hellon team guided the players through the different steps of the process, moderated the discussions, and kept track of the time. The first four sessions were primarily intended to develop the key mechanics and narrative of the game, while the final three sessions were focused on testing and refining the Sustainable Futures Game with key audiences: The first of these sessions was played within a corporate responsibility network event, the second included representatives of different public sector organisations from Finland and Sweden, and the last one was with master's students at Laurea University of Applied Sciences in the Service Innovation and Design program. Sessions were documented through video recordings when participants consented, participant observation, semi-structured post-gameplay interviews with volunteer players, and regular interviews with members of the design team held between June 2020 and November 2021. No demographic data were collected from the players, as the game is intended for professional audiences, and thus the only relevant information was judged to be their professional background.

In the following section, we present a detailed account of the design process focusing on the underlying interrelations between the different game iterations. We use the transformative futures framework, an analytical framework developed by Mangnus (2022), for understanding how futures-focused participatory practices, including gaming, relate to action and decision-making. This framework extends earlier work by Hebinck et al. (2018), which used four different policy-focused foresight cases through the lens of three elements: (a) the governance context, (b) social dynamics, and (c) methodological factors. While Hebinck et al. (2018) primarily focus on the framing conditions (such as the institutional context) that allow future processes to be impactful, Mangnus (2022) argues that the relationship of influence can work the other way around as well—from methods up to governance contexts. New methods and innovative process design can attract new institutional support and the right mix of participants can re-frame fundamental ideas about how the future is to be understood or provide an example to start transforming participation cultures and so on. Mangnus et al. (2021) also add two new dimensions: participation culture and the basic future perspective dominant in the process. In summary, they distinguish several factors that impact and compensate one another:

1. Future perspective: This refers to fundamental ideas among those involved in a future process on what the future is, how it should be engaged with, and how it relates to action in the present.

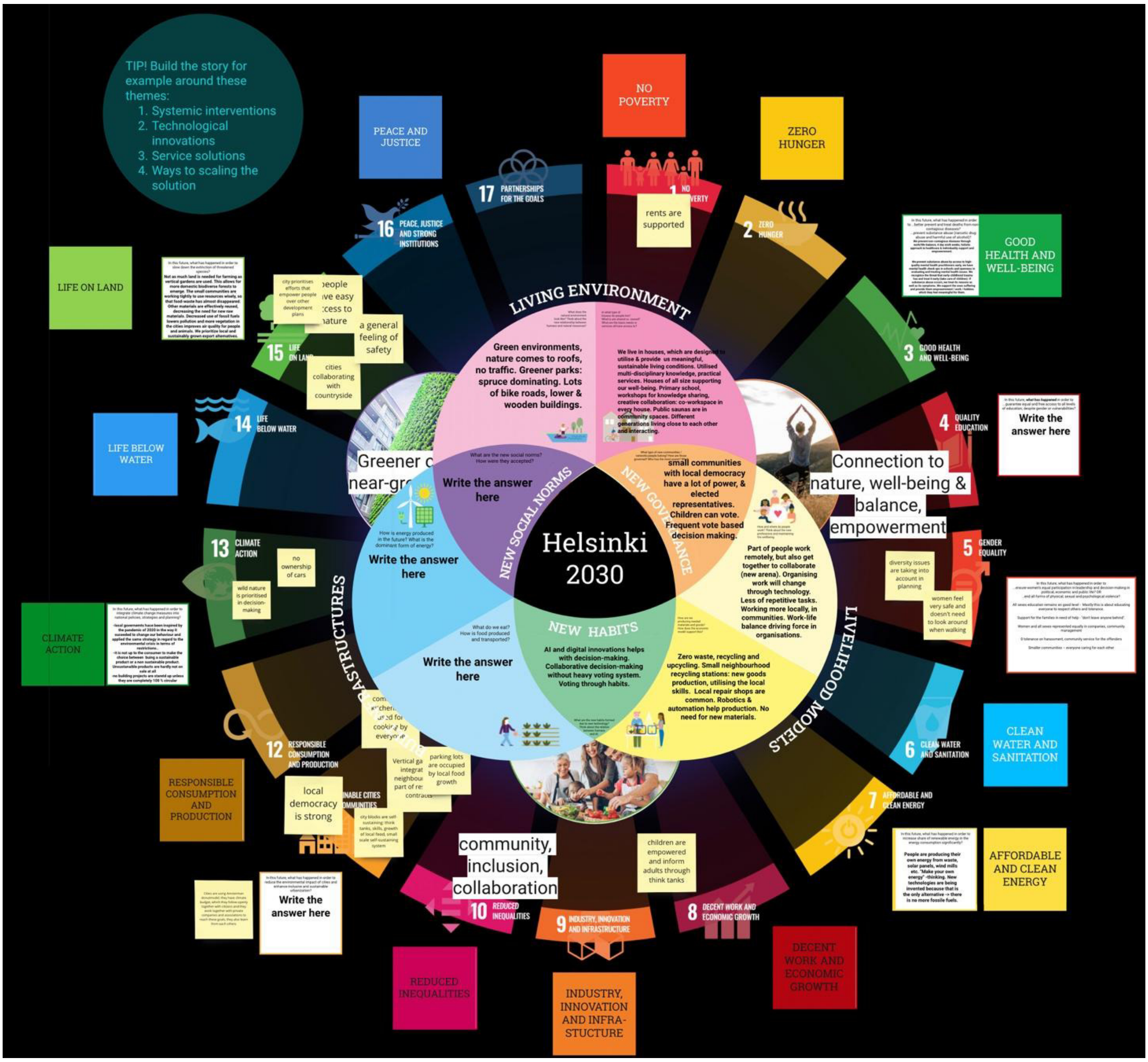

Figure 1. Part of the game board, including the contributions by players during one of the sessions testing the final iteration with an external audience.

Muiderman et al. (2020) identify different common future perspectives in the literature. Some focus on prediction while others see the future as fundamentally unpredictable and focus on navigating uncertainties. Yet, others see the political nature of future visions and actively try to mobilise new groups of actors toward desirable futures. Finally, critical theorists are engaged with recognising deeper power dynamics underpinning societal futures and imaginaries.

2. Institutional context: Institutional conditions and contexts shape what is possible with future processes and practices. They determine what scope there is for taking action and what mandate and support those involved in organising the futures process have from those in power.
3. Participation culture: How familiar with participation are the people involved in a future process? Is open exchange easy or hard in any given national, regional, organisational, or inter-organisational context? How does this change over time?
4. Process design: How is the overall process structured? What is the timing of the process in terms of its wider context? How many meetings are being organised? The performative nature of future work plays a big role in its impacts (Oomen et al., 2021).
5. Participants: It is crucial to consider who takes part in futures processes, since the right or wrong combination of individuals can make or break such a process. This includes those organising the process and any individuals directly involved in funding it.

6. Methodology: Which specific futures methods (such as the game discussed in this article) are being used? What are their intended results and features?

4. A Design Genealogy of the Sustainability Futures Game

4.1. Background: The Nordic Urban Mobility 2050 Game

The precursor of the Sustainability Futures Game, Nordic Urban Mobility 2050 is a scenario-making game for urban mobility. Players create a potential future state of the world in the year 2050, which they elaborate through stories of everyday life. They then imagine emerging and possible mobility solutions and systems for this world. The co-created scenario can be used to reflect on new projects and/or the future relevance of existing project ideas, and to facilitate relevant discussions about strategies and policies related to businesses, municipalities, and the population. The objective of the game is to encourage deliberation on future mobility scenarios for the Nordic countries, to initiate discussions on plausible mobility modalities, and their impacts and desired features, and the game's outcomes should serve as a basis for developing concrete ideas for future Nordic innovation projects.

Player feedback from the Nordic Urban Mobility 2050 game showed that the gaming format appealed for being engaging and offering a holistic view of the future, instead of focusing exclusively on limited, pragmatic aspects of mobility planning. This feedback aligned with Helllon's previous experiences working with game-like methods in service design and customer experience transformation projects and motivated them to continue exploring methodologies that enable this type of integrative futures thinking, and to develop this format further. The framework of the CreaTures research project provided a context where Hellon had the choice to either improve the game design of the Nordic Urban Mobility game, narrowing even more the scope within the well-defined expert domain of mobility, or to explore games as a future methodology at a more abstract level. Eventually, negotiations over the use of the game with the commissioning client and the excitement of developing something new led Hellon to the decision to broaden the scope of the game, with the intention to create a game format that could be easily adapted to the specific needs of different clients.

4.2. The Sustainability Futures Game

Figure 2 summarises Hellon's approach to framing the futures perspective of the Sustainability Futures Game, describing the institutional context and participation culture, the process design, methodologies, and participants connected to the Sustainability Futures Game development. During the iterative design process, intricate interrelations between the different elements developed. Untangling these interrelations offers the possibility to identify how iterative design processes accommodate or respond to emerging needs, relationships, and changing contexts.

4.2.1. Future Perspectives

While the Nordic Urban Mobility Game focused on creating desirable future scenarios around mobility, the Sustainability Futures Game assumes that during the play people learn to navigate complexity related to the future. This change of future perspectives marked a significant design change between the first and second iterations: The focus on supporting politically desirable futures inherited from the Nordic Urban Mobility game is clearly replaced with a focus on navigating the complexities and uncertainties of sustainability transitions. While most of the basic mechanics remained the same in principle, the storytelling layer of the game was redesigned to use the SDGs as a background, on which players create a future vision and think about possible barriers and what needs to happen to get there. This framing of the future as navigating the complexities of sustainability transitions remained constant throughout the following iterations. The main goal of the activity is to help people create visions and pathways to change, and not to provide concrete tools to realise them. Hellon purposely avoided the use of critical elements to encourage a constructive and positive creation of a common vision, where design fiction is centred and feasibility stays in the back row.

4.2.2. Institutional Context

The European research project CreaTures defined the institutional context in which the Sustainability Futures Game was developed and played, because it provided Hellon with the opportunity to work with an open brief, instead of a client-driven process. This marked a major departure from the Nordic Urban Mobility game and has remained consistent throughout the whole design process. Only while working on the last iterations of the game did the Hellon team start to think about the possible applications of their game in a business context and the possible clients that may be interested in employing the Sustainability Futures Game within their organisations, thus shifting the institutional context of the game. More specifically, in the fourth iteration, Hellon's desire to start engaging with new institutional contexts drove changes in the process design and in the future perspective. There was a clear shift toward a future perspective that would support players to navigate the complexity of sustainability transitions and to practice imagining desirable near-future scenarios, instead of working within an institutional framework focused on generating politically desirable futures. In terms of the process design, it led to the change in the time horizon of the future scenario, the introduction of the SDGs and other minor adjustments

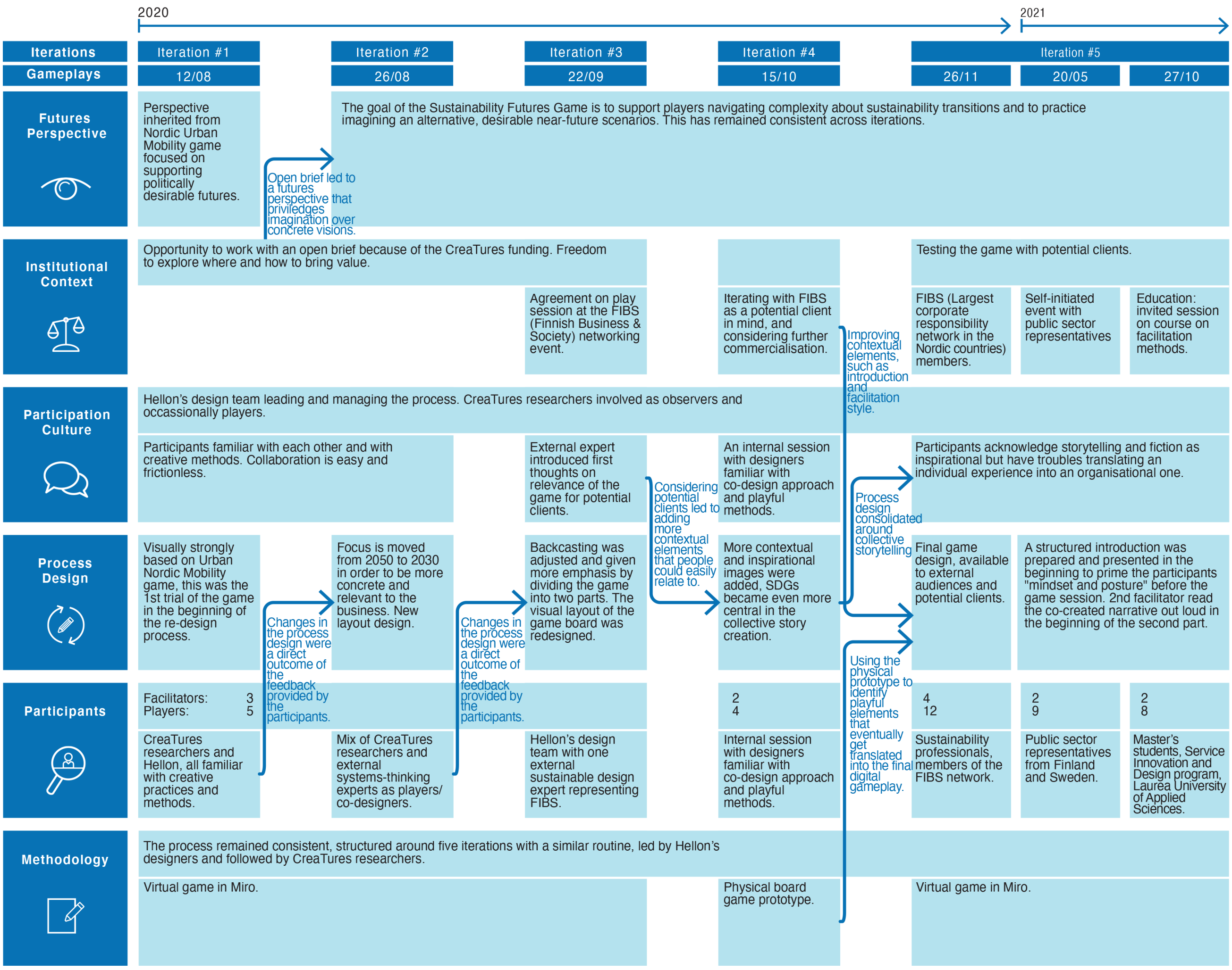

Figure 2. Development process of the Sustainability Futures Game following the framework by Mangnus (2022).

such as simplifying some of the tasks to better fit story creation purposes and adding two new tasks to cater to potential new business clients.

4.2.3. Participation Culture

Games have been a core part of the Hellon professional toolbox. In a field dominated by marketing professionals, many people in the Hellon design team have a background in service design, pedagogical, empathic, and participatory design. Because of this background, Hellon recognises that games provide safe spaces, make people relaxed and comfortable, and provide frameworks to share sensitive information. Having been developed as a commercially unsolicited project with a strong research focus, the design process of the Sustainability Futures Game was strongly managed by the Hellon team. The facilitator role was split between two members of the Hellon team, one responsible for guiding the players and one taking care of the more technical aspects of using the online collaborative workspace. During the first iterations, participants mostly knew each other, as, despite their different backgrounds, they were involved in the same research project. They were all familiar with creative methods, human-centric approaches, and moving between the different scales that the game utilised (personal, community, society). Collaboration was thus easy and frictionless. Only from the third iteration and later, when an involved sustainability expert with a strong business perspective and mindset was involved, discussions emerged on how to create room for negotiation in the game and how probable or interesting the scenario would be for potential participants. During the last sessions, while participants acknowledged the use of storytelling and fiction as inspirational and empowering, going beyond the individual experience of the player and into an organisational process of sustainability transition has been challenging. Organisations tend to operate with short- and medium-term goals and specific projects. A more open-ended approach would only be interesting as part of a larger project.

4.2.4. Process Design

Gameplay sessions followed the routine detailed in Section 3; they started with an introduction to the game by a member of the Hellon team, followed by a round of introductions of all players, and then the gameplay started. Each session closed with a short debriefing conversation and gathering player feedback. The consistency in the session routine allowed a focus on the development of the narrative and exercises. In the initial prototype, most of the basic mechanics were directly inherited from the Nordic Urban Mobility game but the mobility elements were removed, and the game was translated into a digital format that could be played in Miro. Testing this version with a group of CreaTures researchers, the design team concluded that more specific sustainability-related content should be created to enhance the focus of the game. The storytelling layer of the game was thus redesigned to use the SDGs as a framework. The first game scenario implied that in 2050 the SDGs have been met and players had to imagine how the focus city looks. In the second iteration, there was a narrative switch from a 2050 to a 2030 timeframe to accommodate short term business perspectives and make the case more concrete and relatable. Over the following iterations, the use of the SDGs gradually became stronger. A significant change occurred in the third iteration when the game was divided into two phases: (a) building the 2030 scenario, and (b) backcasting and identifying barriers and solutions. Splitting the game into two parts improved the flow of the gameplay, even though the first part was clearly more game-like, whereas the second part came closer to a traditional workshop format.

4.2.5. Participants

People with diverse backgrounds were involved at different stages of the iterative design process. Each session had a different player composition: Two sessions were played with researchers from the CreaTures project, one session had a mixed audience of game designers and researchers, one session was internally played by Hellon designers alone including persons who had not contributed to the game design earlier, and one session was played in the framework of a business event with the aimed core audience. In the months following the design phase, the final iteration of the game was played in three sessions with target audiences. The first session included players mainly from a business background, the second primarily public servants, and the third session was carried out with students in the framework of a course on facilitation methods.

There were notable differences in how participants from different backgrounds reacted to the Sustainability Futures Game sessions. People with an academic or research background insisted on fact-based scenarios that were considered plausible, as well as on introducing conflicts and negotiations that would lead to more realistic scenarios, while notably, people with a business background were the least familiar with gaming as a method, while both researchers and students appeared more at ease with the method. Particularly in the first session, which was conducted in the framework of a business networking event, participants represented their organisations, which all are members of the same sustainability-related association. Getting into the game and unleashing the creative flow was most difficult in this group. Students tended to be more open and less concerned with connecting the story to any reality. Due to the particular focus on facilitation, the students were more interested in the format of the session providing the most feedback on the visual and storytelling aspects of the experience.

4.2.6. Methodology

The development of the Sustainability Futures Game followed an iterative participatory design process comprising five design iterations tested in seven playing sessions. With the exception of the fourth iteration, which was tested using a physical prototype, all other sessions were played online. The choice for an online format was imposed by the then-ongoing Covid-19 pandemic. Instead of developing a fully digital experience, Hellon designers chose to use Miro as a prototyping platform, filling the gaps in interaction manually thus simulating a potential digital experience. Hellon did not make the decision to productise the game, thus it has not been developed to a full, stand-alone digital version. The focus of the game sessions stayed on understanding the narrative, value, and context of the players, with easy to edit elements and not finalising the design. The design team used the physical prototype to identify playful elements quickly and easily in the experience. The eye contact between players gave the feeling of co-creation and many of the mechanics introduced in the physical prototyping were taken over to the digital version and became tasks of the facilitator.

5. Discussion: Lessons From the Sustainability Futures Game Design Process

In this article, we examined the iterative development of a game used for the participatory exploration of different futures around the SDGs as a framing device. The iterative development process of this game serves as an example of how many different factors interact with each other to influence and frame the development of game-based explorations of urban sustainability. We have used a framework developed by Mangnus (2022) which expands on work by Hebinck et al. (2018) to identify the different elements and conditions that influence and frame future processes. This framework has been developed in response to a relative lack of inclusive analyses of future processes, including games, in terms of how they are shaped by and interact with different contexts and assumptions.

Our key contribution has been to expand the functionality of this framework by adding the time dimension explicitly—to turn it into a framework for design genealogies, following the different iterations of the Sustainability Futures Game development process. This has led to insights into the benefits and challenges of the game as it progressed over time. These case-based insights offer practical recommendations for game development and iteration. These practical recommendations in turn offer insights into the strengths and weaknesses of the future practice framework by Mangnus et al. (2021) when it is structured over different time steps (elaborated in Section 5.2).

5.1. Insights for Game Development for Urban Transformations

Following the interactions between the different elements of the framework, a multidimensional story of iteration and change emerges. A key feature of the game, which has proved to be challenging, has been its openness and relative lack of focus. Being an adaptation of a more bounded, concrete version of a game on urban mobility, Hellon's original goal was to create a tool that would allow audiences from very diverse fields to come together and address fundamental, systemic issues related to sustainable urban futures. The development process of the Sustainability Futures Game was defined by three levels of openness: (a) the exploratory character of the whole endeavour afforded by the research funding, (b) the openness in thematic scope with regards to sustainability, and (c) the lack of a predefined client or audience. This openness functioned both as an opportunity and a challenge for Hellon. While striving to create a tool with multiple possible applications and potentially many different clients, Hellon also decided to refine the design internally before testing it with a series of notably diverse audiences. As a result, perhaps, feedback from players consistently indicated that the game acted as a good boundary object (Star, 2010; Star & Griesemer, 1989) but that players struggled to see how its outputs could be operationalised in their professional contexts. It has been clear that the boundary object function has been of great value to Hellon as a way to connect to other actors. However, through the different iterations, the game developers struggled to balance openness and clarity of purpose. Across the different framework elements, this included trying to find more concreteness in targeted players, the process and method design, and institutional and organisational contexts in different steps. Overall, however, the lack of constraints due to the research funding for the project meant that there was a relative lack of urgency to focus on concrete uses for the game, and Hellon's interest in open exploration—driven by what Muiderman et al. (2020) describe as the "navigating uncertainty" approach to futures—remained dominant in the game's development iterations. This openness can certainly be valuable but becomes more difficult to translate into action when no other constraining conditions are in place. Hellon's interest in shifting the Sustainability Futures Game into a tool that can be used by specific organisations for explorative "futuring" might help create this constraint in the future.

The process characterised by the multi-conditional framework over time offers a number of lessons for those involved in futures methods within urban planning practice and gaming in particular:

- Maintain clarity of future perspective and institutional context: Initiating an iterative development process requires a firm positioning with regards to the goal of the intended process. Exploratory research can be particularly useful in understanding complex phenomena such as urban sustainability transitions and identifying potential aspects to explore further. Research-driven, exploratory work should be separated from consultancy and client-driven work which respond to predefined briefs.
- Balance inspirational and business value: Creating a participation culture where potential audiences and stakeholders feel comfortable engaging in an honest exchange. Processes that are not profit-driven can generate other types of value and knowledge.
- Establish design constraints: Creating rules to guide the process design and choosing suitable methodologies can help to keep the design process focused, and eventually enable it to transition into an applied tool more easily. While openness can be appealing, it is important to consider specific audiences, needs, goals, and languages.

Vervoort et al. (2014) offer a potential solution to the openness versus concreteness question: Their scenario approach focuses on creating more open, explorative overarching scenario sets that then form the basis for more specific policy investigations. Games, such as the Sustainability Futures Game, could use a similar approach of open exploration and more concrete adaptation of the game results—and Hellon has already been exploring this direction in the final phases of its project.

5.2. Reflections on Methodological Development of the Framework

Repurposing the transformative futures framework developed by Mangnus et al. (2021), with an approach to developing a design genealogy, has provided several important insights that can help to develop the framework.

First of all, introducing the aspect of time and not treating the futures process as an isolated event but as part of a larger, iterative process has enabled us to observe the evolution of the framework elements, pointing to the need to consider time explicitly in the framework. The different perspectives on futures and how these relate to the present have been shown to be crucial in understanding the fundamental logic of the game approach over different iterations and showing how prediction, open exploration, and normative visioning acted in tension with each other over the game's development. However, a dimension that was arguably missing from the explicit framing was a description of the intentional focus or scope inherent in this future perspective. Is the intended use of the game open or concrete and focused? With any future approach, this tension between the openness of the approach and the imagined futures has benefits and drawbacks in comparison to more focused, concrete approaches (Vervoort et al., 2014). For the framework, we would suggest adding open versus concrete or focused to the "future perspectives" category.

Furthermore, we would like to argue for an explicit description of the positionality of those organising and leading the process, especially in iterative processes where this factor might be the main source of continuity and discontinuity. Hebinck's et al. (2018) framework does not cover all dimensions of the Transformative Futures Framework that was adapted from their work—but it has a more specific focus on the role of what is labelled the "researcher" as a category of interest. We would like to argue for a category such as "process leaders and designers" to the framework to explicitly address the positionality of such actors in the process and what they would like to achieve, especially over multiple iterations in a design genealogy. This is also in line with recommendations by Stirling (2014) to forefront the positionality of participatory process organisers.

6. Conclusion

The aim of this study was to elucidate how contextual and relational influences might encourage or inhibit the potential of games and gamified formats to foster transformation towards sustainable urban futures. We explored this goal by examining the iterative development process of the Sustainable Futures Game, a facilitated, gamified activity for collective visioning of desirable, sustainable urban futures, using a framework developed by Mangnus (2022) which expands on work by Hebinck et al. (2018). The results of this research enabled us to formulate practical suggestions for process leaders and designers aiming to develop participatory, iterative, and game-based activities to explore urban sustainability transformations. Our suggestions point to the need for clarity in the adopted future perspective, the cultivation of an open participation culture, and setting design constraints to the process design and methodology. Reflecting on the Transformative Futures Framework, we suggest expanding it to accommodate dimensionality in the futures perspective category and to highlight the positionality of process leaders and designers.

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Conflict of Interests

The CreaTures project has been developed in the form of action research, where researchers and creative practitioners work together as co-researchers. In this context, we disclose that Zeynep Falay von Flittner has been an employee of Hellon and that Kirsikka Vaajakallio is currently employed by Hellon.

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Article

Playing for Keeps: Designing Serious Games for Climate Adaptation Planning Education With Young People

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Abstract

Citizen engagement around climate change remains a wicked problem. It is particularly challenging in relation to climate change adaptation at the local level. In response, this article presents the design steps taken to create a serious game for young people (aged 15–17) as a means to increase engagement in planning for climate change adaptation in Dublin. The iAdapt game acts as the capstone component of the audio and visual teaching and learning resources for adaptation education on the Climate Smart platform and uses open data, interactive in-browser 2.5D mapping and spatial analysis, and exemplar socio-technical adaptation interventions. Its primary aim is to empower young people to understand and engage with the complexities, uncertainties, and processes of climate adaptation planning by using scientifically validated flood data predictions, grounded in a place-based setting and with diverse examples of diverse adaptation interventions. Participants experience the difficulties of decision-making under conditions of democratic governance and uncertainty in order to educate, increase awareness, and stimulate discussions around the multiple possible pathways to planning for climate adaptation. Initial testing results with a cohort of young people in Dublin are presented. We conclude by reflecting upon the challenges of creating a game that has broad appeal yet remains enjoyable to play and the value of integrating real-world flood data with gamified elements. We also discuss the "value question" regarding the impact of games on expanding public engagement. Finally, the article sets out a plan for further development and dissemination of the platform and game.

Keywords

climate change adaptation; Dublin; education; flooding; iAdapt; serious games; youth

Issue

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1. Introduction

Both climate change and citizen engagement can be categorised as "wicked problems" (Rittel & Webber, 1973). That is, they are both arenas of action which are complex and lack a clear and fixed delineation of both aims and solutions. More than this, they are subject to real-world constraints that prevent multiple and risk-free attempts at their resolution. As dynamic, ongoing processes (e.g., in terms of climate changes and the nature of citizens' constituencies), it is unlikely that either will be permanently solved by a single response, with interventions needing to be relevant to the context in which they are applied. As contexts change so too will interventions need to evolve. In many cases, the way a wicked problem is described determines the range of potential solutions considered, flagging the importance of framing and bounding in shaping responses. Indeed, the wicked problems related to climate change and weak citizen engagement are themselves the symptoms of other challenges, from dominant and unsustainable production and consumption patterns to the structures of governance which dictate norms and practices of participation.

Attempting to engage people in climate change adaptation is then undoubtedly fraught with challenges. As already identified in the literature (McKinley et al., 2021), technology-led initiatives seeking to approach this issue often under-estimate the difficulties inherent in engaging people and communities. In the face of an ever-increasing likelihood of extreme climate events, these difficulties increase risks for already-vulnerable publics, particularly those who are marginalised or disenfranchised from policymaking. This is particularly challenging with regard to local level climate-change adaptation, where engagement is most needed and likely to be most effective (Hügel & Davies, 2020).

Despite the challenges and complexities, in this article, we face head-on the coincidence of these two arenas of wicked problems—climate change adaptation and citizen engagement—and present a novel approach to increasing engagement in strategic planning for climate change adaptation, based on the concept of "serious games" (Abt, 1970). Serious games aim to provide an entertaining mechanism for educating young people about climate change challenges whilst also engaging them in discussions about planning for climate change adaptation and the roles and responsibilities they might adopt to play a role in climate adaptation processes. In this endeavour, we built on the development of face-to-face, in-class workshops for young people located in an economically disadvantaged location of inner-city Dublin that is susceptible to flooding and predicted to experience increased numbers of, and more severe, flood events with climate change (see Davies & Hügel, 2021). We describe the process of converting these materials into online formats and outline the development of a serious game, iAdapt, which uses open data, interactive in-browser 2.5D mapping, and scientifically validated socio-technical interventions, to create a fictionalised future Dublin that the game players can shape through the selection of varied adaptation elements across multiple rounds (set as calendar years in the game) towards 2050. We explain the development of the testing protocol and reflect on early testing results, before outlining a suite of actions needed before wider dissemination of the approach in other locations.

2. Serious Games for Wicked Problems: A Review

As outlined above, issues related to climate change can readily be classified as wicked problems since, as Scannell and Gifford (2013) note, the global and long-term nature of climate change defies easy or immediate comprehension in our everyday lives. Indeed, the absence of a central authority to explore and implement solutions consistently and coherently within governments at all scales, while presenting policies that continue to discount future risks in the face of strong scientific evidence to do otherwise, and in spite of the increasing urgency to take action, have led to climate change being dubbed "super-wicked" by some (Levin et al., 2012). Allied to these factors is a lack of motivation to participate in climate change actions within communities that currently feel dislocated from climate change effects. As Spence et al. (2011, p. 46) point out in relation to climate change mitigation, "one of the reasons that people may not take action to mitigate climate change is that they lack first-hand experience of its potential consequences." Similarly, willingness to take adaptive action in relation to climate change is far more prevalent among people who have already experienced climate impacts such as flooding (Cone et al., 2013). However, despite this the need for public participation in responding to the problem of climate change is now well-established, having been included in Principle 10 of the Rio Declaration at the United Nations Conference on Environment and Development in 1992 and reiterated in the IPCC Special Report in 2018 (Masson-Delmotte et al., 2018). It is similarly well-established that mainstream methods of citizen engagement are not effective in driving inclusive participation in climate adaptation planning (Lane, 2005), especially in relation to marginalised and vulnerable populations and young people in particular. There are pragmatic and ethical justifications for enhancing participation and it is certainly a key requirement for any climate governance mechanism which intends to be perceived as legitimate (Alexander et al., 2018).

A recent literature review of public participation, engagement, and climate change adaptation (Hügel & Davies, 2020) identified three major themes that should be addressed to improve the status of citizen engagement in climate change adaptation: (a) the paradox of participation, (b) the challenge of governance transformation, and (c) the need to incorporate psycho-social and behavioural adaptation to climate change in policy processes. Specifically, it identified a need to enhance public participation in place-based, local adaptation policies and community practices that resonate with those whose engagement is sought. This area is a promising site for novel interventions such as educational games for young people where lessons learned in the classroom may serve as a "way in" to more comprehensive engagement efforts; that is, providing they are seen as relevant to and resonate with participants' lived experiences.

In this article, we focus on the concept of serious games as a potential motivator for engaging young people in climate change adaptation. Serious games, a term first proposed by Abt (1970), are games that are intended to inform, educate, and train players (Michael & Chen, 2005), though it should be noted that this does not mean that serious games cannot also be fun, merely that entertainment is not their sole or primary focus. The determining quality of a serious game is, instead, a "utility of purpose" (Girard et al., 2013, p. 4), and it must be designed with this in mind. Early examples such as *The New Alexandria Simulation: A Serious Game of State and Local*

Politics (Jansiewicz, 1973) were analogue in formation, taking their inspiration and mechanics from board games. Most current definitions are based on Sawyer's (2002) landmark research, which makes explicit reference to electronic games, although it should be noted that this definition has itself undergone considerable change over time (Djaouti et al., 2011). Serious games conceptually overlap with game-based learning (GBL), defined as the process of learning by using games (Becker, 2021), usually by re-using existing games that can be repurposed to achieve learning objectives. GBL is an instructor-led, supervised activity, which takes place in a learning environment such as a classroom (Dörner et al., 2016, p. vii). The key difference between serious games and GBL is that serious games are created expressly in order to fulfil the learning objective, and are thus custom-created, constituting the "core" of the activity, allowing them to be played in non-learning environments, without mediation by an instructor (though both are possible).

The increased sophistication and wide availability of electronic media and games in particular, which are now a large and growing feature of our cultural landscape, has further driven interest in online games for uses other than entertainment (Young et al., 2012). These uses fall into a number of overlapping categories: (a) persuasive games, designed as "rhetorical tools through which a designer can make arguments or influence players"; (b) games for change, designed as "critical tools in humanitarian and educational efforts"; and (c) serious games, whose primary aim is to "train or educate the player" (Coulton et al., 2014, p. 193).

Environmental education and policy have embraced the use of serious games, with Madani et al. (2017) identifying 25 examples in the area of environmental management alone. The majority of these (84%) are aimed at a combination of students, professionals, and stakeholders (Madani et al., 2017), with students often being the primary audience, with no distinction made between those in primary, secondary, or tertiary education. Management and role-playing games are the most common format in this category (Reckien & Eisenack, 2013). Climate change education, too, has embraced the use of serious games in a number of areas including water management (Valkering et al., 2013; Villamor & Badmos, 2016), climate negotiations (Sterman et al., 2015), and in terms of understanding risk (Parker et al., 2016).

In their review of online and analogue (e.g., boardgame) climate change games from 1983 to 2013, Reckien and Eisenack (2013) found an even split between a focus on global and local sites of action, with a smaller focus on Europe compared to the rest of the world, noting that most games used English as the game language, with a primary focus on mitigation (86%) as opposed to adaptation (40%). Wu and Lee (2015) have observed several emerging trends in games as tools for climate education and management in their more recent review, including a trend towards mobile games, a move from "virtual'' or computer-based spaces to augmented or real-world physical spaces, and the incorporation of real-world interactions.

More recent work indicates a shift towards a more even split between mitigation- and adaptation-focused games. In their analysis of two role-playing simulation games for adaptation, Rumore et al. (2016, p. 2) found that these were effective in "cultivating climate change adaptation literacy, and enhancing collaborative capacity." A more wide-ranging review (Flood et al., 2018) confirms this increasing attention to adaptation as well as a shift towards the local scale and approaches such as social learning to address the adaptation deficit which arises as a result of insufficient knowledge (Edwards et al., 2019). Their review of the effectiveness of the interventions found that high levels of trust are required between researchers and participants, coupled with robust evaluation methodologies. Finally, a review that used a 15-attribute climate change engagement framework to analyse the content of serious games found that while most of the surveyed serious games (n = 109) were feedback-oriented—attempting to strike a balance between challenge and skill and incorporating elements of experiential learning—social play was a rare feature of the game corpus (Galeote & Hamari, 2021).

It is clear from the more recent reviews that serious games continue to be a popular tool for education and engagement, but, despite a long period of growing research interest, some areas remain under-explored. While there is some evidence of a shift, as described above, most climate change games still predominantly focus on mitigation. This may be because mitigation actions are more easily explained and lend themselves more readily to the mechanics of gameplay, whereas adaptation actions are multi-faceted, often include a policy focus that can be less tangible, and are carried out under conditions of uncertainty. While understandable, it is important that games do not oversimplify or otherwise disguise the complexity of the "real" world (Parker et al., 2016) given this is a central feature of adapting to climate change. Nonetheless, it is acknowledged that integrating validated physical science, socio-economic and policy impacts of climate change, and adaptation actions, in ways that are plausible and readily understood by non-expert audiences and young people in particular, while also ensuring that a game is fun to play represents a considerable design challenge.

Recognising the challenge between realism and entertainment in the context of climate change adaptation leads to another acknowledged difficulty of serious games: definition and assessment of success criteria. There is a need to measure the impact of the game on broader learning activity, which includes how the game impacts the players' knowledge, their interest in the subject, and capacity to act, as well as their willingness to engage in activities beyond the game itself. However, it is always difficult to identify a direct cause-effect relationship between playing a game and impacting a sense of efficacy, which is undoubtedly affected by many other variables outside the serious game engagement itself.

Wider socio-technical issues also remain underexplored; given that most definitions of serious games assume an electronic medium and publications often describe the technical components of the game in considerable detail (e.g., Neset et al., 2020), none of the surveyed literature reflects upon the impact of the technical choices (such as the chosen platform, medium, or use of particular visualisation technologies) on the games' audiences, the ability to scale the game, the availability of their components for re-use, remixing or other forms of adaptation, and their longevity.

In the remainder of this article, we address these limitations in the existing literature, setting out the design approach for a serious game element (iAdapt) of an integrated learning platform, Climate Smart.

3. Climate Smart Design Approach

The iAdapt serious game is the capstone element of an educational module designed for transition-year students (aged 15–17) in Ireland. The original intent was for the module to be taught in person in the classroom, and a pilot was developed and operationalised (Davies & Hügel, 2021). However, the impact of Covid-19 in 2020 made further testing and development impossible, and the decision was taken to design an online platform—called Climate Smart—to deliver the workshop content, with the game being "unlocked" upon completion of the module components. To this end, a custom web platform was developed to host and distribute the content. The platform allows users to register as individuals, students, or teachers and is designed to capture and retain the minimum amount of data about the user's activity on the site while capturing as much anonymised gameplay data as possible. A name and email address are required to register, but neither is verified. If a user is registering as a pupil, they must enter a pre-supplied enrolment code which allows their teacher to view their workshop progress, but no other site activity data such as times or dates of interaction.

The educational module is divided into five workshops (Table 1). Each workshop is broken up into sections of approximately five minutes, consisting of video and animation, followed by a multiple-choice quiz which must be completed in order to move on. Progress through the workshop sections is recorded, with the most recent uncompleted section automatically being shown to the participant upon login, and an overview of completed and uncompleted sections being available. The game becomes available once all the workshops have been completed. The platform also hosts the geospatial data—modelled pluvial and fluvial flood extents and the location and outlines of the interventions—required for the iAdapt game, which is played in a web browser.

A design approach was adopted based on an informant design framework that involves stakeholders at different stages of the design process depending on their expertise in order to maximise the value of their contributions (see Figure 1).

Table 1. Breakdown of workshop content.

Workshop Name	Workshop Content
1. Introduction to climate change	1. Introduction to climate change as a concept 2. Defining adaptation and mitigation 3. Introduction to climate science 4. Global climate policy context 5. Irish climate policy context
2. Flooding in Ringsend	1. Introduction to flooding 2. History of flooding in Ringsend 3. Defending against flooding 4. Defending against coastal flooding 5. Planning and building flood defences
3. Future floods	1. Introduction to flood monitoring 2. Using flood data 3. Flood modelling and uncertainty
4. Sensing floods	1. Visualising flood impacts 2. Flood impacts in Ireland 3. Floods and feelings 4. Taking flood action 5. Irish flood management practice
5. Adapting to our changing climate	1. Grey infrastructure interventions 2. Nature-based interventions 3. Policy and behavioural adaptation

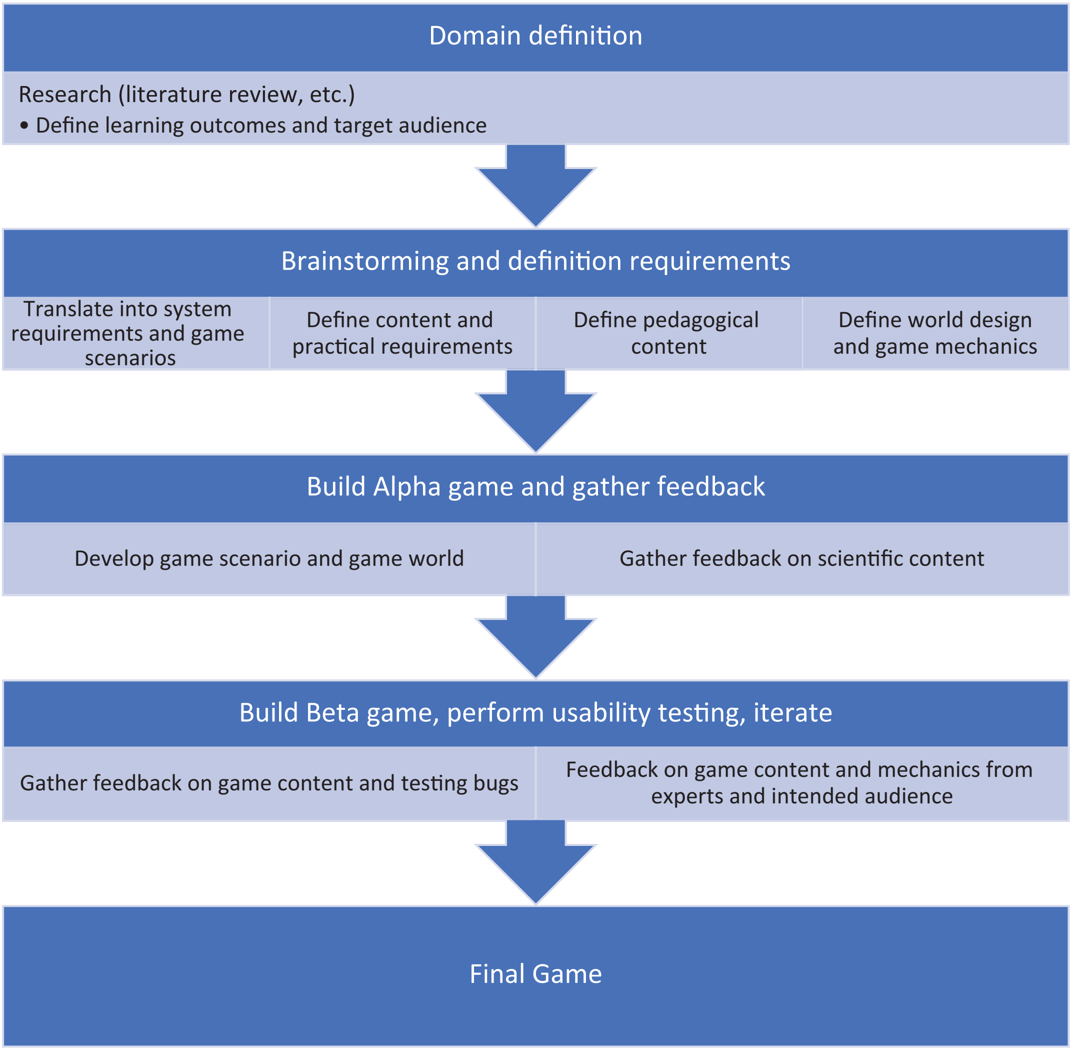

Figure 1. Design methodology framework. Source: Authors' work adapted from De Jans et al. (2017).

Learning outcomes were identified as: increasing knowledge about predicted climate change impacts in Dublin and the complex processes of planning for climate change adaptation; increasing understanding of the pros and cons of different options for climate change adaptation; improving players' confidence about participating in climate change adaptation planning processes; and increasing understanding amongst players that there is not a single perfect solution to the problem of climate adaptation—measures must be evaluated and balanced against their respective advantages and disadvantages. Initial world design and mechanics were sketched out and discussed using an interactive storyboarding tool (Arnold et al., 2013) before alpha and beta versions of the game were produced by researchers (the authors of this article) with skills in digital development, citizen engagement, environmental planning, and climate change. Virtual workshops on the beta version were held with climate scientists, policymakers, serious game designers, and teachers to provide expert feedback on the game design and its components. The game is a turn-based role-playing game that is intended to simulate the process of decision-making under conditions of uncertainty in the context of climate adaptation planning. While it is intended to be played following the completion of the workshops, complementing these, and drawing together their themes and materials in an exercise that is intended to be both fun and instructive, the game design also provides help functions with explanations of key terms for any player who has not completed the associated modules.

The player's character is the newly elected mayor of Dublin, in the year 2045. Players choose an avatar from a variety of ethnicities and genders intended to reflect a broad range of the Irish population. While the role of the mayor of Dublin is currently not invested with any powers to direct flood defence in the city, this decision was made in order to strengthen the narrative cohesion of the game; it is simpler to play as a powerful figurehead than a committee of planners, scientists, and civil engineers.

The game is round-based, with each round representing a year. Each round is broken down into four phases, reflecting core dimensions of commonplace "real world" planning processes: planning, consulting, revising, and adoption.

3.1. Planning

During the "plan" phase in each round, interventions can be bought and sold according to a fixed and limited budget (see Figure 2). These interventions fall into one of the following categories: Grey, Mixed, Green and Blue, and Policy. These interventions are drawn from a variety of sources: interviews with experts in flood adaptation, public participation, and climate science; a review of the scientific literature on flood defence infrastructure and civic society approaches to increasing participation in climate adaptation planning; and data from Ireland's Office of Public Works.

Interventions are priced according to their scale and complexity, not according to present-day costs, with some large physical and societal interventions taking multiple rounds ("years" in the game) to complete and begin to provide benefits. Interventions display a brief description, advantages and disadvantages, and the type of flood event they protect against. Each intervention is also assigned a hidden measure of popularity with each of four political affiliations allocated to Dublin's population at the beginning of each new game: right, centre, left, and green voters. An intervention can defend against a certain amount and type of flooding or increase societal resilience by some amount. As interventions are purchased, they are displayed on an interactive 2.5D map of Dublin, coloured according to their flood protection type. The player is automatically "flown" to the site of the intervention when it is selected, and it fades into view when it is purchased.

The interactive map is the main feature of the game. Previous research (Davies & Hügel, 2021) has shown that the intended audience found the use of such interactive maps enjoyable, useful, and compelling, and this finding was used as the basis for the map's design, which allows smooth zooming, panning, and tilting to present either bird's-eye views of the city or highly detailed views of a far smaller area. The map also features environmental and atmospheric effects such as fog and changing sky colour according to the time of day: A game played early in the morning will be differently illuminated than one played after sunset.

3.2. Consulting

During the consultation phase, the public reacts to the player's plan. The reaction can be positive or negative, according to the total score of each purchased intervention multiplied by the proportion of each political affiliation that was allocated to the population for the game. For example, the construction of a sea wall might be popular with centre- and right-wing voters as it protects property in an affluent area, but it might be unpopular with left and green voters as it is an expensive

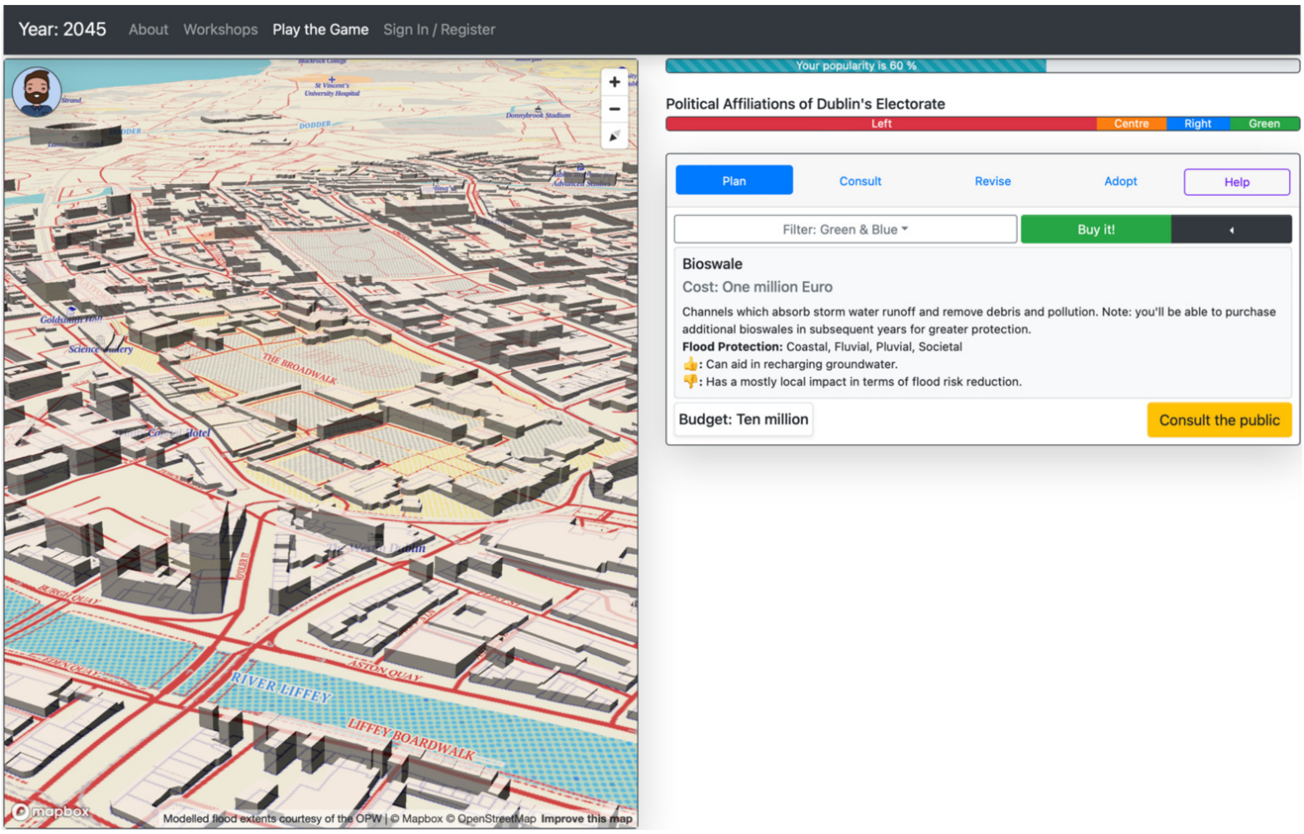

Figure 2. Gameplay showing information about the selected intervention.

carbon-intensive project which benefits a relatively small proportion of the city's population. Thus, in a game with a large proportion of green and left-wing voters, deciding to purchase this intervention is politically costly and can lead to the game ending early if the player's popularity drops below a certain level. This possibility is foreshadowed by the triggering of a protest action if public opinion on a proposed plan is below a certain threshold: A large protest crowd is simulated in one of several central areas of the city (see Figure 3), coupled with audio samples of actual protests.

Players also receive "expert feedback" on each proposed intervention during the consultation phase from one of three experts: the country's chief economist, the government's chief scientific officer, and a prominent social think-tank CEO. This feature has two purposes: first, to add additional factual context drawn from the literature concerning each intervention, and, secondly, to allow the player to decide whether the intervention "fits" with their chosen style of play.

3.3. Revision

The third phase—"revision"—is the same as the planning phase in terms of functionality; interventions bought in the planning phase may be sold and others bought based on feedback from public and experts. If the plan *is* revised during this phase, it will be re-evaluated by the electorate, which can lead to a rise or drop in popularity.

3.4. Adoption

During the final phase—"adopt"—the plan is activated and a flood event occurs (see Figure 4), and its impact on Dublin is measured and represented on the interactive map. During this phase, sounds of crashing waves are played, and the player is slowly "flown" around the extent of the flooded areas. These effects are intended to convey the scale and impact of modelled future flood events. In order to visually convey the distribution of flood adaptation actions, the centroids—the centre of mass of a built intervention or the building in which it takes place—of all purchased interventions are calculated and used to form a triangulated irregular network, which is overlaid on the flood extents which are displayed on the map. These extents are based on scientifically modelled fluvial and coastal flood extents for the city of Dublin in the year 2050 (Environmental Protection Agency, 2019). Flood events can occur in one of three randomly chosen magnitudes—low, medium, and severe—and one of three types—fluvial, pluvial, and coastal. A low-magnitude event involves one flood type, a medium-magnitude event involves two (randomly chosen), and a severe flood event involves all three types.

The player is shown the amount of damage incurred and defended against, as well as the level of societal resilience they have built up. Before advancing to the next round, the player is given advice about how effective (if at all) their defences are against the various flood

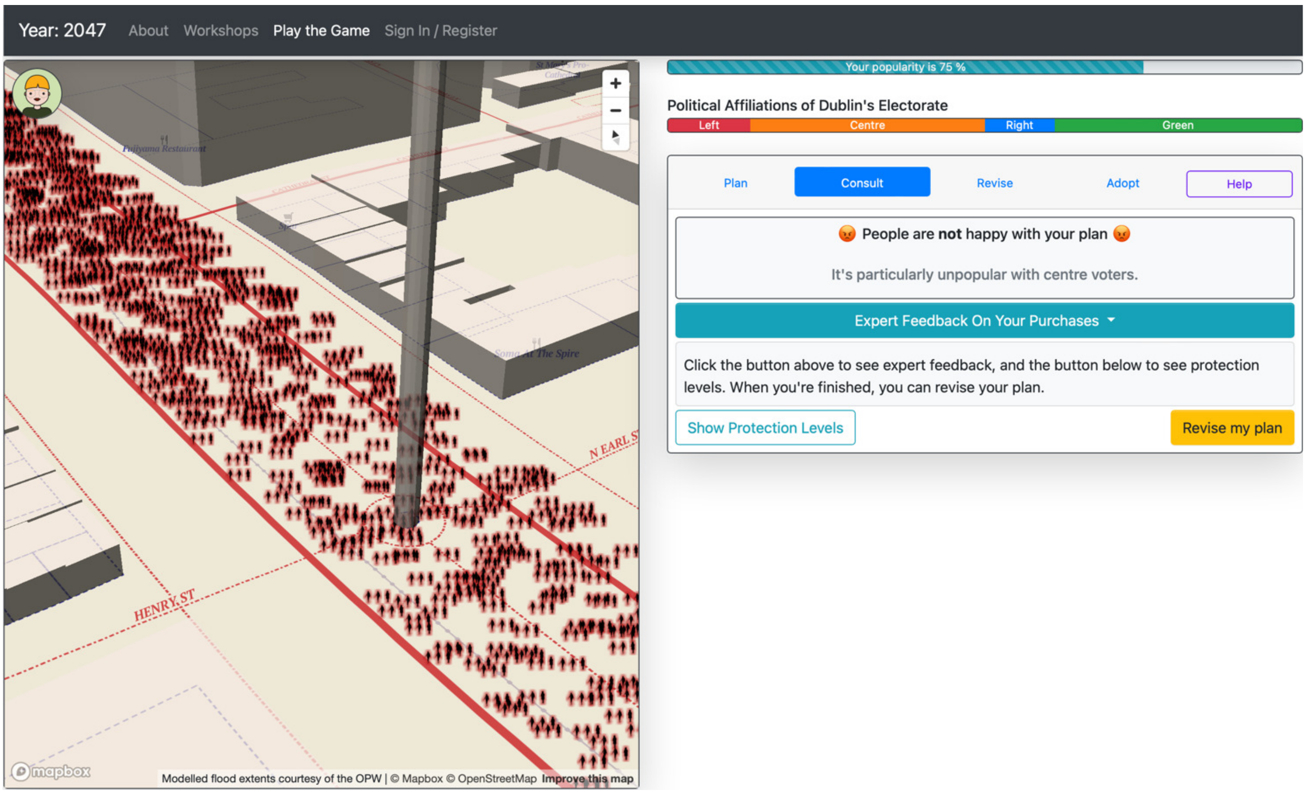

Figure 3. A protest action.

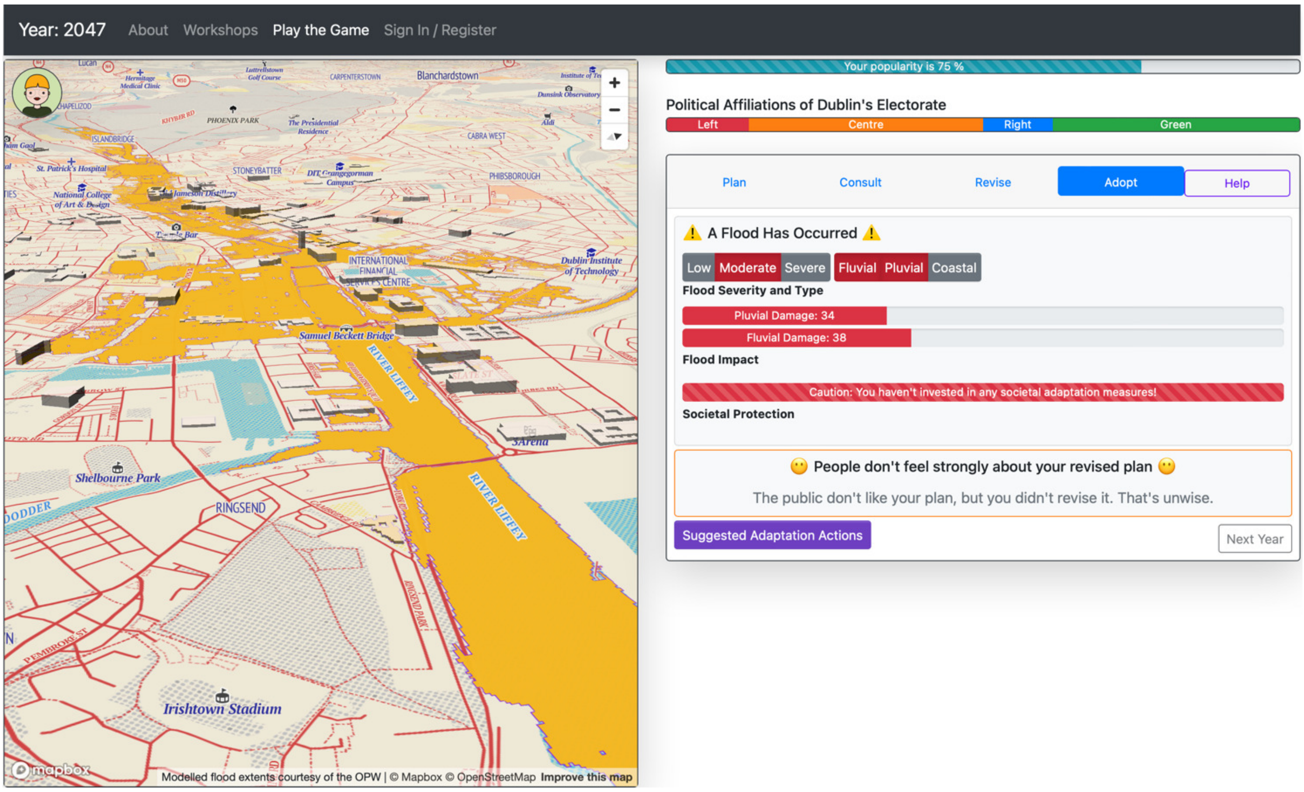

Figure 4. A moderate flood event, showing modelled fluvial flood extents (in orange) for the river Liffey.

types and magnitudes. In addition, the protection levels of all green and blue infrastructures are increased by 10% in order to "nudge" players towards their use. The plan, consult, revise, and adopt cycle is then repeated five times towards the end year of 2050.

3.5. End Game

The game ends in one of two ways: the year 2050 is reached, or the player's popularity drops below 20%. The player is then taken to an "endgame" screen, where their score is shown. The score is calculated by combining three factors: the total percentage of flooding defended against by purchasing physical interventions, an additional bonus set at 100% of the proportion of the total budget that was spent on green and blue interventions, and 50% of the proportion of the total budget that was spent on mixed interventions. The latter two bonuses are applied as green and blue (and some mixed) interventions are considered to have co-benefits such as "water savings…air quality improvement and carbon sequestration" (Alves et al., 2019, p. 244). This score is ranked against all previous game scores and the player's position is displayed relative to the scores of other players.

The end screen also shows a variety of graphs relating to the game:

1. The magnitude of flood defences the player has built up during the game, broken down by type;
2. The player's popularity amongst the public across the game;
3. The type and severity of the flood event that occurred each year;
4. The amount of flood damage that occurred following the annual flood event, broken down by type;
5. The breakdown of spending on each defence type across the game.

This detailed breakdown (see Figure 5) is designed to facilitate in-class discussion of the results by the teacher by showing the links between flood defence levels, severity, and damage, as well as indicating public opinion.

Once the prototype game was operational, testing could begin.

3.6. Testing Methodology

A usability testing protocol for the game was developed based on the frameworks proposed by Lowry et al. (2013) and Olsen et al. (2011). Olsen et al's framework stipulates three focus areas: usability, playability, and learnability/educational merit. Usability focuses on the independent functionalities within individual components of a system. Playability, on the other hand, focuses on a broader sense of overall functionality associated with the integration of several usable tools, allowing for successful, satisfying, and, importantly, enjoyable interaction with a game (Olsen et al., 2011). As a holistic experience, playability is a key trait of serious games. However, there are no agreed-upon and widely used measures for it. There are however associated measures that share similar components to those that are of

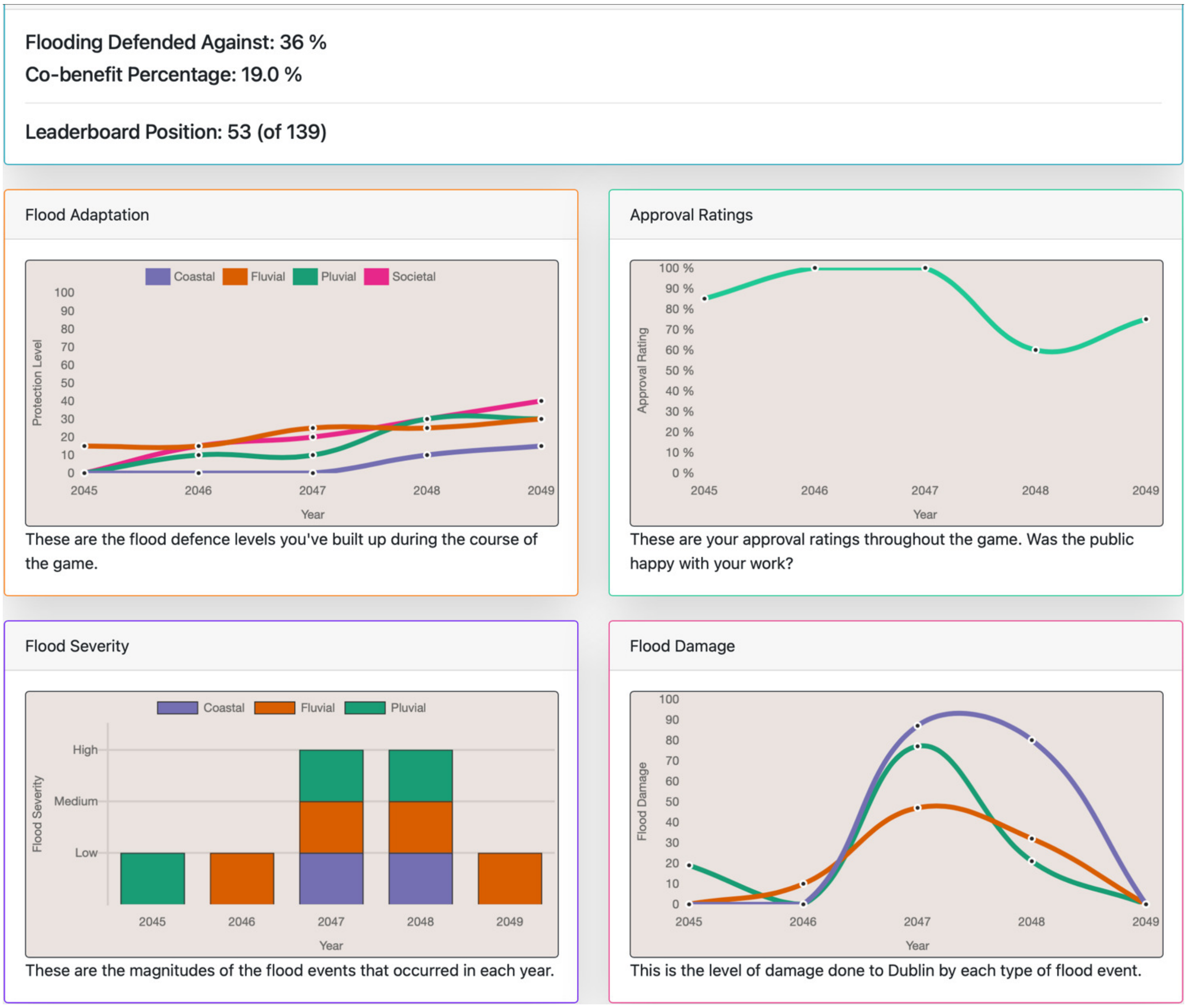

Figure 5. End game screen with gameplay statistics.

interest in serious game usability testing; these include scales of immersion and presence (Witmer & Singer, 1998) and engagement (Brockmyer et al., 2009). By contrast, Lowry et al.'s hedonic-motivation system adoption model (HMSAM) is designed to improve the understanding of hedonic motivation systems (such as games) by attempting to understand flow-based cognitive absorption (Jackson & Eklund, 2004). In addition, it was essential that progress towards the desired learning outcomes was captured during the testing phases of the game to ensure that the game achieves its primary objectives. Focusing too much attention on the "fun" aspects of a game can result in the sacrifice of learning effectiveness. Poor usability can also impair learning by taxing cognitive resources and decreasing motivation to play the game. Therefore, assessing learning outcomes at various stages during development can help determine possible causes of increases and decreases in learning. A suite of questions (Table 2) was developed in order to measure each of these dimensions.

4. Testing Results and Discussion

Testing took place with a cohort of 20 transition year students studying at an inner-city Dublin school which is designated as a DEIS (delivering equality of opportunity in schools) school. Transition year students from this school had participated in the face-to-face version of the workshop (Davies & Hügel, 2021) although the game testing group was a different cohort. Testing was conducted face-to-face within the classroom over a period of two classes (approximately 1h20m) with students as individual players engaging in a period of free play, before facilitators played through the game with the students, phase by phase, with detailed pre-set questions related to each phase being asked. Students were able to raise their own issues throughout the process.

Key results of testing are discussed in this section around (a) supports and understanding, and (b) motivations for actions in their gameplay. This is done for ease of comprehension in the article, although these

Table 2. Usability questions asked during playtesting.

Game Section	Question	Usability Component	HMSAM Component
Start Page/ Mayor Selection	Who read the instructions?	Learnability	Perceived ease of use
	If you read them, did you understand them?	Learnability	Perceived ease of use
	What was *unclear* about the instructions?	Learnability	Perceived ease of use
	Why did you choose the mayor you used to play the game?	Playability	Game-specific self-efficacy
	Is there anyone else you would want to see represented as a mayoral candidate?	Satisfaction	Behavioural intention to use
Gameplay	Did you know where the help button was, and did you think anything was missing from the help text?	Learnability	Perceived ease of use
	Did you find it easy to find and select things to buy using the dropdown menus?	Memorability	Perceived ease of use
	There are four categories for the things you can buy: policy, mixed, green-blue, and grey. Do they make sense to you?	Memorability	Perceived usefulness
	Did you know you can click something you bought to sell it again?	Playability	Perceived ease of use
	Did you understand that the things you buy affect your popularity?	Playability	Perceived usefulness
	Did you understand what the "consult" phase was for?	Learnability	Perceived ease of use
	Did you understand what the "protection levels" button does?	Learnability	Perceived usefulness
	How many people used the revision phase to change their minds about what they'd bought?	Playability	Perceived usefulness
	Did you understand the different flood levels?	Learnability	Game-specific self-efficacy
	Did you understand that the things you bought reduced the flood impact?	Learnability	Game-specific self-efficacy
	Was the suggested advice useful? Did it help you plan what to do in the next round?	Playability	Game-specific self-efficacy
	You don't have to spend the entire budget per round, but the remainder doesn't carry over from one round to the next—What do you think of this feature?	Efficiency	Perceived usefulness
	Was it easy to follow the game as you followed through the phases and rounds?	Playability	Perceived ease of use
Results Screen	Who looked at the results graphs at the end of the game? Did you understand what they represented?	Playability	Perceived usefulness
	Did the end-game screen give you a good sense of how well you did in the game and motivate you to play again in order to improve your score?	Satisfaction	Perceived usefulness

two categories clearly influence each other: For example, supports can motivate players to engage with the game across its duration, and motivated players are likely to make the most use of the supports provided.

4.1. Supports and Understanding

Most students (70%) read the introductory instructions; however, some felt that these were too long, with some confusing elements. No students watched the introductory video that is embedded on the landing page of the game. This is problematic as while it is possible to play the game intuitively, with participants finding their way through the game by trial and error, it is important that the mechanics of the game are clear and the goals transparent if learning outcomes are to be optimised, as "explicit learning tasks, instructions, and support" (Iten & Petko, 2016, p. 1) may be more decisive factors in the achievement of learning goals than the experience of fun.

The next set of questions focused on the help system. Students reported that they either did not realise that there was a help function available or did not make use of it if they did. This was an interesting finding, as the ability to know how to achieve the game's objective is a core concern, however, it is evident that the present help system needs revision; some level of assistance is useful and motivating, but it is clear that players cannot be expected to seek out help if it is not immediately obvious to them. Instead, it may be more effective to provide unprompted contextual "scaffolding" (Obikwelu et al., 2012) as part of the gameplay, based on heuristics such as player popularity, balance of purchases between categories, and total amount of flooding defended against, perhaps at the halfway point in a game.

The difference in flooding levels experienced during the adoption phase was understood by most students, as was the need to purchase a variety of interventions to defend against flooding. This was an encouraging finding, as this is the core mechanic of the game: If players do not understand the objectives and how to achieve them, they cannot effectively play the game, and the learning outcomes cannot be met. Only one student admitted to finding the game confusing, and it was clear from students' answers that they understood the mechanics and objectives. However, as with the help button, most students did not read the advice given to them concerning protection levels at the end of each round, and responses to questions about contextual audio cues such as crashing waves were mixed. Some students reported that they would prefer no sound, however, others requested optional soothing music, as the game required concentration. While personal preference is clearly a factor this feedback suggests more attention to the use and impact of sensory cues, such as sound, is required as existing literature has not taken this issue to task.

Regarding the end game section, most students found the prominent display of their leaderboard position motivating, and said it would encourage them to play again, and some wanted to see their scores in relation to their classmates' scores. This supports Lee et al.'s (2019) research which demonstrates the value of competition in achieving learning goals. There was a range of opinions concerning the graphs: some found them confusing, while others understood the relationship between the graphs and their in-game actions and choices. Approximately 50% of participants understood that there were different types of flooding and that these had to be separately defended against. Of the 20 participants, 19 said they would want to engage in another gameplay session, which is a positive outcome of testing.

4.2. Game Play

Reported motivations for the students' choice of mayor varied: Some chose a character that matched their gender, others chose based on the stated mayoral attitudes towards Dublin ("I chose him because he said 'Dublin is a modern city.'"), and students were broadly happy with the variety of choices that were available to them, though some requested that locally known community figures could be incorporated. A surprising finding at odds with the literature (see, e.g., Lakhmani & Bowers, 2011; Oksanen et al., 2013) was the negative reaction towards a proposed feature which would allow players to design their own mayor: During the brainstorming phase, several student respondents (see Figure 1) noted that this functionality is common and may contribute to players being more invested in doing well, but during testing, participants noted that this would distract players from focusing on the game objectives.

Discussions about choosing interventions revealed a range of responses from the students: Some chose interventions completely at random yet managed to score quite highly; others chose the interventions they thought sounded "the best" in terms of adaptation benefits. However further testing is required in order to ascertain precisely how students ranked interventions. Some students were puzzled by the terminology describing the interventions, some did not realise that items could be bought and sold again during the planning phase, and there was a degree of confusion about the differences between some of the categories: While the difference between the "grey" category and others was clear, some students felt that the "green and blue" and "mixed" categories were essentially the same despite guidance differentiating between these categories.

The relatively high threshold for triggering protests against plans meant that students did not generally consider the popularity of interventions amongst Dublin's population when purchasing. Further engagement with popularity and with the details of interventions could have emerged during further gameplay (Ravyse et al., 2017); however, due to time constraints, the testing did not allow for further autonomous play. Additional testing with this cohort and others is required to verify whether repeated play has an impact on engagement with these elements of the game to maximise learning outcomes.

Approximately 50% of students did not spend their entire budget every year, and most did not use the revision phase to change their plans. This was likely related to the fact that the threshold for receiving negative feedback in the form of protest actions is set too high. However, it might be a reflection of a lack of engagement with the advice given on the nature of interventions and their impacts, including their costs (financial and otherwise) and benefits. It could also be a result of a desire to progress through the game quickly, rather than spend time identifying an intervention that they could afford with their remaining budget, which requires time to go through the drop-down menus and identify interventions that were available to them. While the literature is relatively silent on optimum length of play, this needs to be explored with more testing to ensure optimum engagement whether during free individual play or playing as part of a classroom exercise.

4.3. Next Steps

This article focuses on initial testing with the target audience of transition year students in a DEIS school. An important next step involves wider testing and validation of the game approach, repeating the workshop with the same cohort for more in-depth feedback as well as testing with other student cohorts and with educators. The place-based nature of the game—currently in the Dublin city region—is key to activating engagement (Scannell & Gifford, 2013). The level of effort required to translate the game to other settings also needs to be explored. Providing suitable maps and flood data are available for other settings in Ireland and internationally it could be relatively straightforward to replicate the game process in other settings. Further work is required in order to modify the platform to allow the modular substitution of interventions and flood data, and specific pre-game workshop materials would also need to be adapted to local settings.

5. Conclusion

The process of creating a serious game for increasing engagement with climate change adaptation was complex; there are multiple drivers for the game, and these may not always point in complementary directions. For example, the game has to be appealing to the target audience (and ideally beyond that grouping) in all its diversity (e.g., employing an intersectional reading of societal groups) to encourage engagement, but it must also have some "real world" complexity that underpins the challenge of planning for climate change adaptation if learning outcomes are to be achieved. Predictions are dynamic and will need to be updated as science moves forward with increasing specificity and, one hopes, accuracy around mapping out potential flood futures for the region. Additionally, the so-called "value" question remains, that is, ascertaining the efficacy of serious games for (a) supporting increased awareness of processes, policies, and potential responses; (b) supporting increased understanding of the nature and complexity of "wicked problems" such as climate change; and (c) supporting players to actively engage with processes of adaptation planning post-game play. Test results to date suggest that Climate Smart has positively supported increased awareness (a) and, linked to that, some signs indicate a greater understanding of the process (b), although this needs to be tested with and without the online workshops to ascertain relative impacts of both approaches. However, it is hard to follow the participants to see whether engaging with the game stimulated the active engagement with adaptation planning in the absence of longitudinal studies. Distilling direct cause-effect relations in the messy world of lived realities does however make drawing definitive conclusions hard to ascertain. Nevertheless, at this preliminary stage, lessons learnt from testing suggest that the use of place-based interventions, situated in an area with which players are familiar does seem to increase players' enjoyment of the game, and thus willingness to play. The degree to which this is the case—and whether this would decrease if an unfamiliar or even fictional city were used as the basis for the game—demands further exploration, as does the resource input required to modify the Dublin-focused iAdapt game to focus on other contexts.

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Conflict of Interests

The authors declare no conflict of interests.

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Article

Procedural Cities as Active Simulators for Planning

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Abstract

Modelling a 3D city poses an interesting challenge. To create a virtual city, a road pattern has to be designed and a large number of buildings need to be generated. Every urban place has a road network, often a superimposed pattern plan that serves a population density and buildings which follow statutory rules. This patterned behaviour of the city is why it is possible to develop rules or "computational instructions," to generate city models. In this article, we are going to discuss how to use procedural modelling and CityEngine, a rule-based application commonly used in the movie industry and gaming to produce vast realistic cityscapes, for regional and urban planning via an urban analytics approach. Unlike cinema's imaginary worlds, cities have real-life population dependencies that need to be modelled for the development of planning scenarios. The goal is then to use the generative properties of the procedural modelling approach, along with population prediction models, to create informed 3D city scenarios. Instead of designing solutions, the user can use interactive parameters to affect the 3D model globally, thus enabling virtual cities to become active simulators for planning. Using urban analytics and generative environments, procedural cities may be able to create a "teaser" of different versions of how the city would look like in the future.

Keywords

3D cities; digital twins; procedural modelling; urban generators; urban modelling; urban planning

Issue

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1. Introduction: From 3D Cities to Urban Generators

Remarkably detailed descriptions of cities can be found in the works of architects, cinematographers, writers, and artists, long before the era of 3D digital visualization. As a research topic, the same issue reflects concerns mentioned in megacities and their problems, the metapolis instead of the metropolis, fractal cities, and many others. The explosion in 3D graphics and computer simulations since the 1980s has allowed these notions to become virtualised, with the development of 3D worlds and related tools to be used not only for the better analysis and understanding of our living environment but for the visualisation of the city of the future.

Alternative realities of cities in today's digital media culture are used extensively and even become protagonists in blockbuster films such as the *Blade Runner 2049* (2017), *Total Recall* (2012), *The Witcher* (2021), and games such as GTA V (2013), CitiesSkylines (2015), and many more. But the challenge in these systems is that even small cities comprise several thousands of buildings, streets, streetlights, and several urban furniture, which can easily become a costly and time-consuming production task. With vast amounts of buildings comes a vast amount of geometry. For example, the accumulated area for the development of a realistic city, such as in the movie *Independent Day: Resurgence*, can be as much as 30 sq mi, with 150,000 unique buildings, states VFX lead M. Buhler (Gnomon, 2017). Manually modelling the buildings one by one, controlling the materials, and having to render them properly for a single scene would practically be an impossible task.

The demand in production for these environments led to the use of urban generators, computer-based interfaces which allow the construction of a virtual 3D city, with an incredible amount of detail, all with a "click of a mouse." These systems operate using procedural modelling, a technique in which all geometries and textures are a result of pre-configured rules and algorithms. Procedural control over the urban fabric and not just the individual buildings, enables the generation of digital sets far more quickly, at a larger scale, and with much more level of detail than ever before.

These environments allowed the development of dynamic 3D city models, with the ability to evolve in time and space. As such, they have the ability to inherit simulating capabilities within the generation process. We will call these "active urban simulations of cities," that is 3D city models capable of testing scenarios of population, employment, and land uses, and simulating charge or growth over time. By changing the procedural rules, it is possible to introduce variations or optimality into the process, developing the logic to enable certain goals to be pursued. We can then assume that 3D city models can be either dynamic or static in how they are produced. That is, the idea of hand-made environments or procedural generation to build a single environment, versus a dynamic procedural environment that is responsive.

The question arises, as to whether these environments are useful for urban planning. In the next paragraphs, we will discuss the difference between static and active city simulations and how procedural engines, capable of generating complete urban environments, can become useful planning tools.

2. Static 3D City Simulators

Static models have a predefined structure and study a specific time in space. While dynamically generated models can evolve or change over time and have the ability to create scenarios or variations.

Static 3D city model simulations have been popular since the early 1990s, as an evolution of the traditional "maquette," the physical scaled-down models that architects and planners built to present their conceptual ideas. Tools for planning such as the interactive tables, by Mitchell and McCullough since the early 1990s and others, later on, have had a significant impact on urban design and planning processes, using multi-layered manipulative platforms that integrate digital and physical representations to present such simulations (Mitchell & McCullough, 1995). These 3D digital models of cities have presented new ways of introducing participation, urban analytics, or simulations within the built environment (Hudson-Smith et al., 2007) and that is their primary purpose until today.

We are going to refer to these applications as "static 3D urban simulations." The reason is that even though they are primarily used for displaying dynamic information, the 3D city models themselves are inherently static. There are currently numerous applications and examples of 3D models which serve as integrating simulations for planning purposes, such as traffic management and flow analysis (DCPLION Single Line Street Base Map, Midtown Manhattan Model), the analyses for the maintenance and expansion of the tube transportation system (e.g., New York City Subway Resources), or even the study conducted for the examination of the conditions which caused the collapse of the twin towers of the World Trade Centre (Lower Manhattan Development Corporation). Perhaps more than anything, the use of static 3D city models focuses on tasks related to environmental simulations like noise mapping, disaster management, sustainable architecture, airflow simulations, and city planning (Chronis et al., 2017; Döllner et al., 2006; Shiode, 2000).

Today's challenges on these systems remain the quest for finding a simple way of using urban analytics, as a way to inform designed scenarios of these urban environments. In the next sections, we begin to establish the progression from the foundations of graphics to computer-generated environments, to present the beginnings of the use of procedural simulations for planning with the integration of urban analytics.

3. Procedural Modelling

Procedural techniques are code segments or algorithms that specify some characteristic of a computer-generated model or effect. The adjective procedural is used in computer science to distinguish entities that are described by program code rather than by data structures (Erbert et al., 1994).

With the introduction of three-dimensional texturing (solid texturing) by Perlin (1985), procedural techniques are almost exclusively used to produce realistic images of marble, wood, stone, and clouds (Figure 1). These tools rely on the crucial idea of pseudo-randomness. That is, for example, to seed parameters, which allows the stochasticity in the generation of an image. Pixar's RenderMan is an application that has applied this technique in the generation of procedural 3D primitives (procprims, for short). User-provided subroutines can be called upon to generate geometry (RenderMan, 2013). The advantage of procpripms is that they can generate an incredible geometric complexity from a small number of inputs, requiring much less processing power to handle geometry. The downside however is that the produced variations can be repetitive and stale if the complexity of the rules is low. For example, a cube can be generated in a scene by defining its coordinates in space and the parameters width and height of the cube. By adding pseudorandomness to the cube's dimensions and coordinates, we can begin to generate an *x* number of varying cubes in a scene. Now imagine if this would apply to generating buildings, using a more complex set of rules. A vast variety of scenes would be possible to generate than with a non-procedural representation.

In a procedural approach, rather than explicitly specifying and storing all the complex details of an object, the storing is a set of instructions, or simply a recipe, that can be reproduced or modified at will using simple controls.

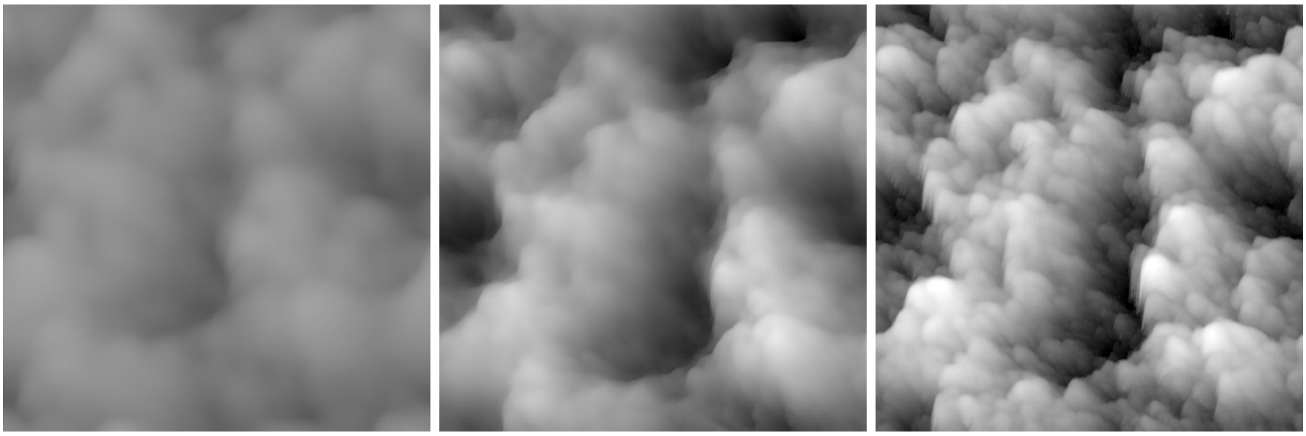

Figure 1. These images of clouds are created exclusively using Perlin noise. It simulates the texture of clouds by modifying parameters. These are three variations out of hundreds of textures generated from the filter "NoiseLab: perlin smudged" by mitaywalle, using the Filter Forge application (https://www.filterforge.com). An application which among others, allow users to create their own procedural textures (see Ashbrook, 2018).

4. Active Urban Simulations

We consider "active urban simulators" as dynamically generated 3D city models, which are computationally able to evolve. These could be procedurally generated, but not necessarily. To understand how active urban simulations are implemented in an urban gaming environment it would be useful to have a closer look into a few distinguished examples from the gaming history (Figure 2). Wright's (1989) original SimCity, as shown in the first figure, is a game and an active urban simulation. The original game simulates the growth of a city and places the user in the role of the mayor. The implementation of this model in a gaming environment was the first example of a model that was communicated to a wider audience using simple controls. Wright, in his original version, implemented Forrester's theories for urban dynamics (Birch, 1970) to calculate values such as the city's education, unemployment, and growth rates, and these figures, in turn, determine whether the city's population will blossom or plunge. SimCity is one of the first urban planning games, which introduced the idea of a user-friendly interface for testing scenarios in a city. Despite that it is a game, based on simplified models and game mechanics, it is an original example of a generated city integrating urban science.

Train Fever (2015) integrates a land-use transportation model, to calculate population and employment flows from rail networks and used this to predict demand in housing and thus growing cities. It's a unique way of engaging people in planning processes and understanding the dynamics of the city by showing how urban developments are influenced by the design of transportation. Other city simulation games, such as Cities: Skylines Urban Road, are also using procedural content generation and asset packaging and provide a fully modular road asset framework for Cities. These games, provide insights into the technology used that could potentially be useful for planning. Batty in a recent conversation on RTPI, strongly emphasised the need for data and software engineering literacy in planning education and practice (Batty, 2021) and some of these tools have been the focus of researchers in computational urban planning field for many years now.

Figure 2. City simulator games that use population dynamics and procedural techniques to simulate the growth of cities. From left to right: Sim City (1989), Train Fever (2015), and CitiesSkylines (2020).

5. Procedural Modelling in Planning

The key idea behind the procedural development of city models is the development of rules for the generation of the "physical" 3D urban environment, that will produce all the viable variations when creating scenarios. That is the reason why both in gaming and in planning, the developers depend on theories of urban morphology and specifically "urban grammars" to write the recipes that will generate the forms. All the way from the pattern language of Alexander (1977) to Salingaros (2000), and the principles of urban structure, these theories provided the mathematical principles of urban structures. A significant leap to translating theories of urban morphology to computing language is the works of Stiny and Gips (1972), which gave the leverage to translate rules to computational instructions for shapes and created a syntax for buildings. Many of today's "city generators" depend on these theories to develop their procedural strategy (see Kelly & McCabe, 2006).

There are a few examples of procedural city modelling and buildings in planning. Mayall and Hall (2007) present a complete software application to generate procedural streets in the programming language LISP. Steadman's (2006) work on geometry and architecture and Spacemate, is also an example where different layouts of buildings are generated using data on floor space index, lighting, and open areas all the way back to 1978 as a study on the geometry of buildings to generate layouts for energy optimisation simulations (Steadman, 2006). Nowadays, research is focusing on the use of machine learning and AI, to create alternative variations of 3D cityscapes using large, collected datasets from captured static 3D models. Characteristic is the example of NVIDIA's generation of 3D approximate landscapes from images (NVIDIA Corporation, 2022).

Most of these examples focus on the generation of city models for the optimization of city configurations (Duering et al., 2020) and a few of them present platforms for facilitating tailored simulations such as UrbanSim (Waddell, 2002). In this case, these virtual environments provide the ideal approach for supporting planning in understanding the possibilities, the problems, and the impacts of the practices of urban modelling, analytics, and planning policies, as it enables the simulation of the consequences directly on the future form of the cities, interactively using simple controls.

At the moment there are some open-source and commercial applications allowing the procedural generation of cityscapes, with only a very few number of those being widely distributed. CityEngine is one of these applications originally by ETH in Zurich (Parish & Müller, 2001). CityEngine has embedded rules to generate street networks and a large number of buildings from open geolocated data, using shape grammars that can be custom tailored. It focuses on streamlining the production of approximate realistic cityscapes using the procedural approach, but at the moment does not provide support for developing urban analytics simulations, such as the forester theories or land-use models, in order to support planning simulations. These need to be developed separately using the built-in Python module. Moreover, it is a stand-alone software which limits the distributing capabilities of the interactive procedural content.

6. Urban Modelling Using Procedural Platforms

To understand how to develop active city simulators in procedural content, perhaps it is useful to look into "toy model" examples. CityEngine, using the procedural approach, can be useful to quickly develop interactive "sketches" of urban models that can be explored using simple controls such as sliders or switches. Such sketches can be extremely useful to help in explaining the underline math of how dynamic models work. In this case, they can provide powerful educational tools, such as in the case of the visualization of theoretically inspired location models, published in the University College London Centre for Advanced Spatial Analysis (CASA) working paper series as found on the CASA website (Roumpani, 2013), which is a demonstration of the process, the advantages, challenges, and limitations of integrating urban modelling simulations within CityEngine or procedural GIS systems and the real-time generation of cities. More specifically, the three studies describe the development of the original von Thünen's (1826) land-bid rent model, secondly a version of the von Thünen generalization by Wilson and Birkin (1987), and finally the retail locational model by Wilson (2010). The extended von Thünen model (Figure 3) attempts to explain how land uses evolve in relation to product demand and supply in a city including multiple centre markets while demonstrating a more complex dynamic by introducing time within the simulation process and allowing to predict how land uses will evolve in one, two, or 10 years based on calculating equilibrium (Wilson, 2012). These applications, as developed in CityEngine using Python, are a demonstration of the generative characteristics and how they can be used to simulate the real-time evolution of land uses.

The produced outcomes can be both visual and analytical with the option of providing 3D statistics and reports. For example, let us assume that a planning task requires the allocation of a new retail centre. This task would require the integration of a retail model (Harris & Wilson, 1978) to measure the revenue of a shop by calculating the flows of money from the residences to the shopping centres. By defining sets of blocks that represent the already existing shopping centres and ones that represent the residences, the application offers the option of acting as a locational model allowing the user to experiment with different locations for shopping centres which will generate the highest profits based on travelling distance and competition. This is achieved using functions that are applied globally to the generated 3D urban environment and can be used to define spatial relationships.

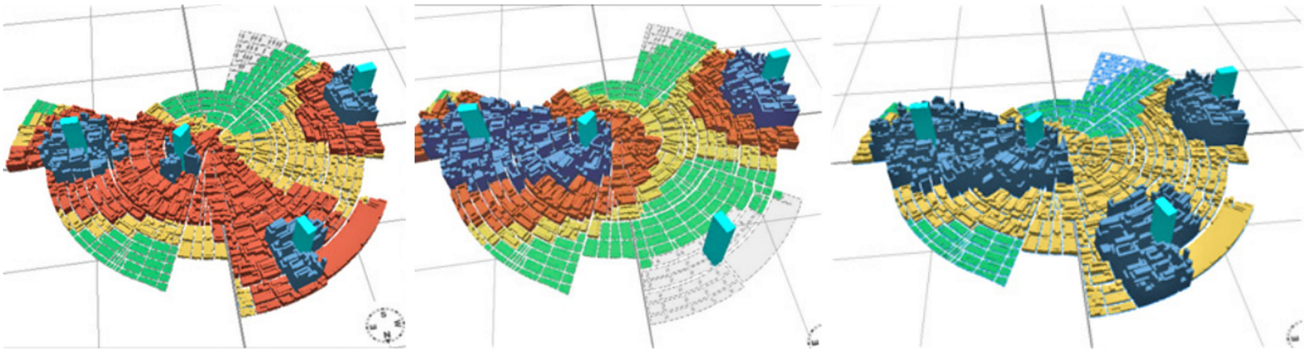

Figure 3. Von Thünen's (1826) generalization land-bid rent model from the three studies in developing theories of location in CityEngine. Three city centre variations are produced by changing the values of simple sliders that are linked to the parameters of the model and display how land uses form in the hypothetical city by calculating the optimal land use for each lot.

It provides the opportunity to create a "gamified" connection between design, urban analytics, and 3D visualisations, as they can provide a unique method for communicating this information to professionals or the broader public. Instead of designing solutions, the user can use interactive parameters to affect the 3D model globally and produce varied scenarios, thus enabling virtual cities to become active simulators for planning.

7. Urban Analytics in CityEngine

The following question can be asked: Can the integration of analytics in 3D visualisations help answer meaningful questions in planning? Picon and Ratti (2019), in a conversation on digital media in architecture and planning, discuss in depth the need for such systems to be developed as a response to the increasing amount of produced urban data for the built environment. The need for parametric/procedural control becomes evident when the complexity of city data, becomes big enough, to require a means to explore a multitude of dependent parameters. With the emergence of digital twins in the smart cities' context and the production of an increasing number of datasets that describe the environment, the challenge is on the development of methods to collect, manage, and analyse the streams of data and, at the same time, cope with the complexity of the algorithms that produce meaningful analytics (Hudson-Smith et al., 2020).

In the following example, we are using a pre-defined external model, calibrated using real data, to define the amount of new future developments required for an area. In this case study, we use the outputs of QUANT (Batty & Milton, 2021) an advanced urban prediction model developed in CASA. QUANT, among others, produces scenarios of population and employment for the UK using a type of spatial interaction (a type belonging to the family of gravity models). We use QUANT as an external model, to provide the population scenarios on a regional scale which define the future housing need of a local area and we will use CityEngine to drive the procedural 3D generation based on these population predictions. The idea is to enable the user to utilise the procedural controls and building syntax supplied by CityEngine as an interface, control the parameters of the urban model as inputs, and produce generated 3D visualisations of the QUANT scenarios as outputs.

The workflow is as follows. The generated or designed building volumes from CityEngine are used to make an estimation of the proposed housing capacity, which in turn is provided to the QUANT model as inputs for the population and employment matrix. QUANT then predicts population fluctuations in the area based on regional flows, which CityEnigne redistributes to the generated zones, thus showing demand for housing and consequently retail or schools (education). An increase in demand is indicated in the 3D model which prompts the planner or user to add additional infrastructure, which in turn triggers a new QUANT iteration. This loop will ensure the stability of the planning scenarios and will allow the communication between the two platforms: QUANT and the planning model built in CityEngine. To develop a fully responsive system, machine learning for accelerating urban modelling can be employed as described in Milton and Roumpani (2019).

Let us now assume that, in this scenario, QUANT indicates that there is going to be additional demand for hosting population in the regional zones where the Queen's Elisabeth Olympic Park is located, for instance, due to a planned increase in employment in one of the zones in the Olympic Park. To estimate the demand for housing within the Olympic Park, we would need to run a new instance of QUANT and re-distribute the population flows within our area of interest. This essentially means that it will be possible to test different urban design solutions inside the park and use QUANT to evaluate population scenarios on a regional scale by including flows that extend the study area (Figure 4).

The result of this work is a composite active simulation of the Olympic Park, with all the planning variables, such as proposed building heights, maximum building heights, roads eaves, etc., redeveloped procedurally, using real development data and outputting analytics from the simulated outputs.

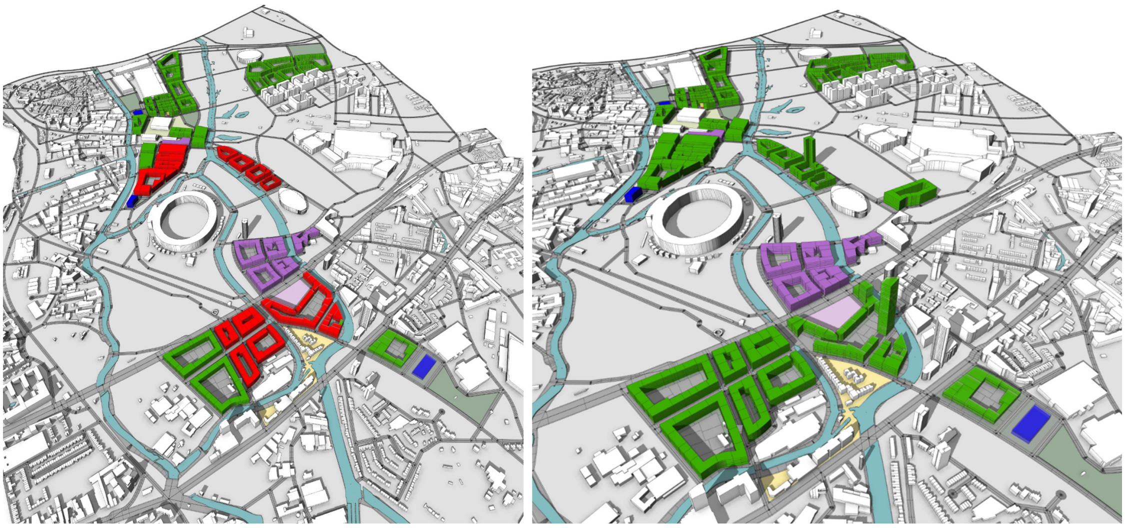

Figure 4. Let's assume that the employment of a nearby university zone is tripled. The demand in the residential area calculated by QUANT shows that it exceeds the building's capacity and is indicated using red volumes (weighted distribution considers proximity to the university). On the left side, we created two skyrises based on permitted development zones in the planning applications. New scenario capabilities allow the user to experiment with multiple solutions/variations that satisfy the population projections, e.g., experiment with building density scenarios.

8. Opportunities for Gamification

Using simple controls to trigger the evolution of a 3D city model creates opportunities for the gamification of urban planning in the context of planning participation. The concept of collaborative planning using a table augmented with digital city layouts and with physical objects that can be moved around to create planning scenarios is a vision that has been developed and exhibited widely with procedural technology used to generate urban layouts.

The "Expanding Lima" model is a study set within the context of the ReMap Lima project, which attempts to utilise public engagement and modelling methodologies to address issues such as the unofficial growth in the outskirts of Lima, Peru. In this example, data collected from mapping drones (Figure 5) are integrated with collected information from the communities and

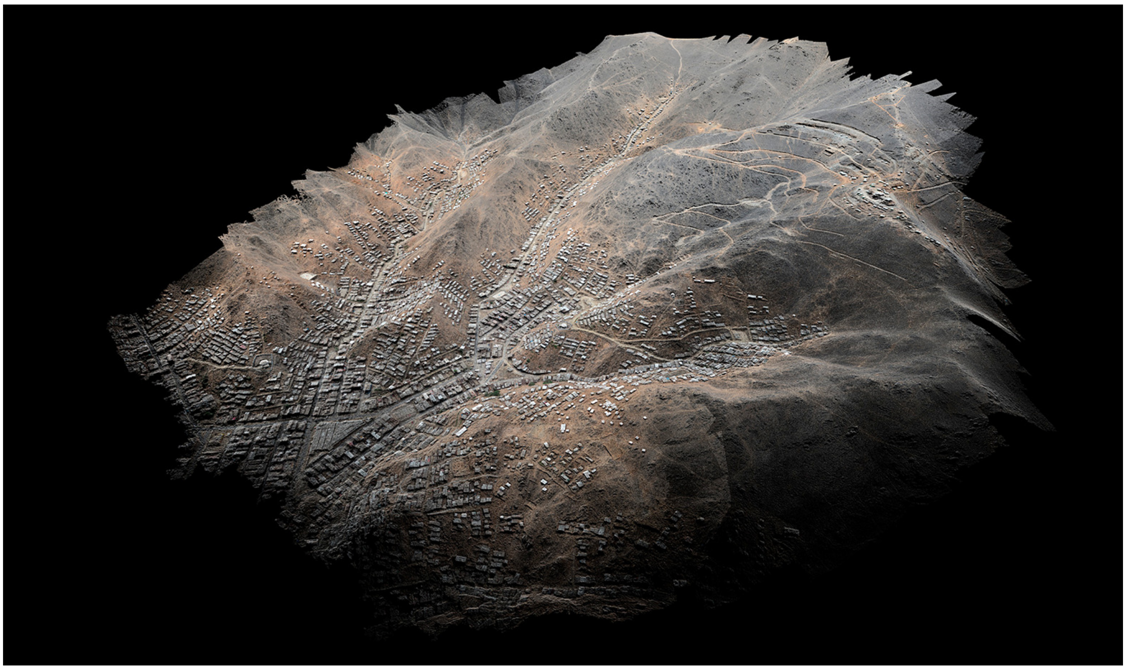

Figure 5. Point cloud of Lima from the 2014 ReMap Lima project, captured by a Sensefly eBee drone. The point cloud reconstruction and the digitization process allowed for the data collected in the Lima expedition to be visualized and analysed. Source: ReMap Lima (n.d.).

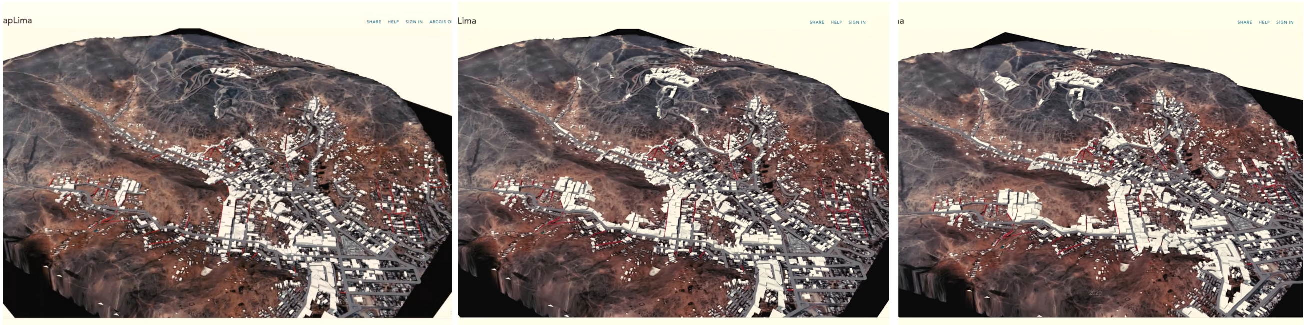

Figure 6. Scenarios of urban growth using a gravity type model in CityEngine. From left to right, predictions of organic growth for 2016, 2017, and 2018.

public participation, in order to provide inputs for a dynamic 3D city simulation. The model uses measures of accessibility through the mapped road networks and house density indicators from footprints extracted from the captured 3D model, in order to create a predicting simulation of the rapidly growing urban environment. All indicators can be controlled externally by the user using the CityEngine sliders to produce the different scenarios (Figure 6).

To demonstrate and test the possibilities for an online scenario, a toy "gravity type" model as described above is employed to identify the optimal locations for possible new developments, based on flows from mapped residences and externally driven population growth. New virtual lots were designed with zero population and began populating the newly developed zones by assuming an increase in population using a growth rate defined by surveys. Despite the lack of sufficient datasets, this work produced an early interactive application which schematically illustrates the growth of the favelas over time and the possibilities for such platforms.

The use of 3D interactive urban environments for public participation can improve the role that planning can play in the socio-environmental processes and open space for the communication between different decision-making parties such as citizens, planners, and policymakers.

9. Conclusions

Tools which include procedural modelling and city scenario methods can improve our understanding of the urban environment. Urban modelling methods and simulations can support planning and communicating the parameters which are critical to balancing urban life. This would help shape decision making either by testing a large number of different options or seeking for the optimum option from a finite number of proposals. Current procedural modelling software such as CityEngine is primarily used for visualization. However, with few additional components, the same tools can be adapted to include urban analytics for the evaluation of early designs. If we assume, that the planning problem is not finite, then there must be numerous variations of produced "optimal" solutions. In this case, this framework may question the authoritarian role of the master plan to produce dynamic online systems that can change over time, either with the inputs from users, with applications for the public, or by the evolution of new proposed developments over the years. Within this context, the procedural approach can provide the means for an online scenario-making methodology that allows the planner to think in terms of properties, capacities, and recipes, rather than traditional design. This is certainly a different way of implementing urban planning in practice which is closer to policymaking. The purpose of the developed tools is then to allow a quick understanding of the implications of applying land use and population metrics within a defined geo-referenced boundary whilst acknowledging existing site constraints and communicating interactive scenarios to the wider audience, allowing to create a "teaser" of different versions of how the city would look like in the future.

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Conflict of Interests

The "Expanding Lima" model was developed by me and supervised by Professor Andrew Hudson-Smith while being employed by CASA as a research assistant within the ReMap Lima project led by the Development Planning Unit and CASA in UCL and funded by the Bartlett Research Materialization Grant, specifically the Bartlett Development Planning Unit with Adriana Allen, Rita Lambert, and Monica Bernal, the Centre for Advanced

Spatial Analysis with Andrew Hudson-Smith and Flora Roumpani, and the Bartlett School of Architecture/UCL Urban Laboratory with Ben Campkin. It was undertaken in close collaboration with Carlos Escalante from CENCA, Silvia de Los Rios from CIDAP, and Liliana Miranda from Foro Ciudades Para la Vida, a network of 57 organisations from 20 Peruvian cities, ranging from local government, academics, and civil society groups, as well as local communities from two contested settlements in Lima, Peru. Drone Adventures will be joining in a mission using mapping drones with Alexandre Habersaat and Emanuele Lubrano.

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Flora Roumpani is a lecturer at the University of Liverpool. Previously she was a research associate in REG in the Alan Turing Institute, working on urban analytics. She is also a visiting lecturer at the Royal College of Art in the Environmental Architecture MSc. She holds a PhD and an MRes from the Centre for Advanced Spatial Analysis in Bartlett UCL and has a diploma in architecture engineering from the Department of Architecture at the University of Patras. She has worked as an urban planner in Doxiadis Associates, for the design and analysis of cities in Greece and abroad, and she is a registered architect in the UK. Her areas of expertise include urban analytics and simulations in 3D environments, spatial analysis and visualization, and urban-regional planning and design. Areas of interest also include projects involving creative technology, public engagement, and exhibitions.

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Article

Minecraft and Playful Public Participation in Urban Design

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Abstract
Digital networks are transforming the way in which our built environment is planned, designed, and developed. Whilst many have heralded this technology as a solution to the problems of citizen engagement and participation in planning and design processes, the state of public participation in this field still arguably leaves much to be desired. In the last decade, academics and practitioners have explored the possibilities of 3D, multi-user, digital environments in planning and urban design contexts. These "inhabited virtual spaces," where stakeholders are represented through digital avatars, hold the possibility of engaging a much wider audience in participatory processes, creating a more democratic and bottom-up process, and improving the outcome of community consultations. These multi-user environments can take many forms—and among the most promising are game environments. The benefits of using play and games in creative tasks and decision-making have been widely recorded, leading to the developing field of "serious games," games which have been designed to accomplish a serious task. Despite this, there has been a reluctance to entertain the idea of appropriating more commercial and widely played games for serious tasks, rather than designing ones from scratch. One game in particular, Minecraft, has shown promising results as part of a participatory design methodology pioneered by UN-Habitat and the Block by Block Foundation. Through an analysis of this program, I will explore how the videogame Minecraft might be used as an innovative tool to improve public participation in urban design, whilst offering a virtual alternative to traditional models of consultation.

Keywords
city-making; co-design; games; geogames; participatory approaches; playful city; public participation; urban planning

Issue
This article is part of the issue "Gaming, Simulations, and Planning: Physical and Digital Technologies for Public Participation in Urban Planning" edited by Andrew Hudson-Smith (University College London) and Moozhan Shakeri (University of Twente).

1. Introduction

It is widely accepted that public participation in urban planning and design is a good thing (Abbot, 1996). Not only does it help to create inclusive, accessible cities and public spaces, but it is a democratic right of citizens to be involved in how their cities are planned and designed (Sewell & Coppock, 1977). "Consultation, communication, and participation" have been at the forefront of planning discourse for over 60 years, and yet the level and quality of public participation still leave much to be desired (Hudson-Smith, 2003, p. 109). Balancing the needs of multiple stakeholders, communicating effectively between professionals and laypersons, and engaging with all social groups in any community are just some of the problems facing public participation in urban design.

In recent decades, the leading response to the challenges of community consultation has come from information communication technology, or ICT. Digital solutions to these challenges come in many different forms, ranging from computer-aided design (CAD) visualisations and flythroughs to online discussion forums and digital questionnaires. This article will focus on virtual interactive environments, which can offer valuable solutions to the issues of visualisation, engagement, and participation in design consultations. Whilst existing research has focused on the possibilities of "serious games"—games designed for a purpose other than entertainment—little attention has been paid to the opportunities of using existing commercial games. This article focuses on one videogame in particular, Minecraft, which is uniquely equipped for use in participatory design processes. Although Minecraft has been central to a long-running and highly successful program of public participatory design called Block by Block, there has been little critical analysis or academic enquiry of Minecraft's usefulness in relation to the wider intellectual traditions of urban design and game studies. I believe that bridging this research gap can help to realise the game's full potential in the field of urban design.

The aim of this article is to understand the potential of Minecraft as a valid and useful platform for delivering public participatory processes in urban design by answering the following research questions:

- Can Minecraft be used to communicate with and engage new audiences in urban design processes?
- What does Minecraft offer over existing digital tools? What are its advantages and disadvantages?
- Why is Minecraft useful? What characteristics and features of the game lend themselves to this particular use?
- What can Minecraft offer to participatory processes in a Covid-19 and post-Covid-19 world?

To answer these questions, I will start with a brief analysis of the existing use of Minecraft in public participation in urban design, and how this relates to the wider intellectual traditions of play and game studies. From here, I developed my own methodology for public participation with Minecraft, before demonstrating and evaluating this methodology via a digital workshop inside the game.

2. Public Participation in Urban Design

The idea of citizen participation originated in the 1960s with the advocacy planning movement in the US (Kurzman, 2000). Two key approaches to participatory design derived from this movement; the first, developed in the US, can be categorised as a "bottom-up'' movement with the aim of empowering citizens and democratising the design process, as developed by Arnstein (1969) in her article "Ladder of Citizen Participation." In Scandinavia in the 1970s, a "top-down" approach to participatory design took hold, striving towards a quality of design that better served its users (Spinuzzi, 2005). The publication of Arnstein's seminal article "Ladder of Citizen Participation" in 1969 coincided with the release of the *Skeffington Report* in the UK (Ministry of Housing and Local Government, 1969). This was the first attempt to set out a systematic approach to community involvement in UK planning, influencing an entire generation of activists, planners, and designers. The report divided the public into two categories: joiners (those interested in local issues and likely to participate in societal matters) and non-joiners (those who, although affected by planning decisions, are unwilling or unable to register their opinions). Fifty years later, the challenge of engaging society's "non-joiners" is still at the forefront of citizen participation discourse.

Though revolutionary at the time, citizen participation is now commonly accepted as a key part of the urban design and management process by governments and local authorities. It is also widely agreed that the continuing growth and increasing density of cities demand the provision of high-quality public spaces which are "safe, accessible, healthy and sustainable" (Gehl, 2010, p. 68). To create such spaces, urban planners and designers must consider the needs and interests of different stakeholders, in particular the "end-user" of those spaces (Amado et al., 2009).

A less-discussed challenge of public participation in urban design is that of youth involvement. Young people are under-represented in consultations of all kinds, and their exclusion from decision-making processes often leaves this demographic socially and politically marginalised (Chawla et al., 2005). Despite more recent efforts from practitioners to include children in public participation (Bornat & Shaw, 2019; Tan, 2019; Wood et al., 2019), this remains a significant challenge to all stakeholders in participatory processes. The cities we design and build now will be inherited by today's youth, and so there is a certain irony that this group is so often excluded from decision-making processes in urban design.

The ICT revolution has transformed the way in which both individuals and communities communicate, interact, and engage. This shift in methods of communication has generated both a need and opportunity to change the way in which we engage and invite the participation of the people that the built environment serves (Kohn, 2015). Having evolved from the early days of CAD visualisations and e-government, contemporary discourse on digital tools for participatory design and planning can be separated into two main categories: 2D platforms, such as online discussion forums, and 3D platforms, for instance, virtual reality environments.

3. Play the City

> We are only human when at play. (Schiller, 1794, Letter XV)

The history of using games and play for serious tasks is rich, as is the literature that this idea stands on. Our philosophical understanding of games and play has been elaborated on by many thinkers—Schiller's sentiment is echoed by Huizinga's (1938) *Homo Ludens*, in which he presents play not as an aspect of culture, but culture itself as a manifestation of play. Caillois' (1958) *Man, Play and Games* and Piaget's (1962) *Play, Dreams and Imitation in Childhood* also offer a perspective on games and play in relation to philosophy, sociology, and psychology, opening up a wide range of possible uses for games in real-life tasks.

The importance of play in creative processes was deeply appreciated by the Bauhaus, Weimar Germany's iconic modernist school. One of the school's professors, László Moholy-Nagy played a crucial role in understanding the relationship between play and creativity—and the importance of maintaining the spirit of play that is lost in adulthood. The work of Moholy-Nagy (1947), among others, identifies play as one of the most important companions of creativity, and an essential element of the creative problem-solving process.

Given the value of play and games in creative processes and decision-making, it is unsurprising that practitioners have sought to incorporate play into urban design processes. Design thinkers and theorists have looked at the relationship between games and spaces, conceptualising a form of "ludic architecture" (Walz, 2010), whilst practitioners have published handbooks and guides to the incorporation of games into architecture and planning processes (Dodig & Groat, 2019). Tan's (2019) Amsterdam-based practice, "play the city," leads the field in developing game-based solutions to urban design and planning consultations. Whilst her team has experimented with a range of game types, most projects are analogue games such as board games and card games, rather than digital games (Tan, 2019). Digital games for public participatory processes are usually in the form of "serious games," games designed for purposes other than pure entertainment. These have proven popular with researchers who develop their own serious games in response to the challenges of public participation in urban design (Ahlqvist & Schlieder, 2018; Scholten et al., 2017). Whilst serious games enable researchers to directly address the problems they are attempting to solve, their success is often limited by the logistical and financial difficulty of developing a good quality, enjoyable videogame. The use of commercially developed videogames has not been seriously considered as an alternative to serious games, though the use of games such as Minecraft to research a wide range of issues has started to change this trend (Delaney, 2019; Pearson, 2019; Tan, 2019).

4. Minecraft

> Notch hasn't just built a game, he's tricked 40 million people into learning to use a CAD program. (Sumter in Cheshire, 2012)

The easiest way to describe Minecraft is as a form of "digital Lego." It is a sandbox game, an open world without a pre-determined course for players to follow. The player makes up their own rules and can play the game in any way they wish. It is also a voxel world. Voxels are 3D pixels—The entire Minecraft universe is set on a 3D grid and made up of blocks that can be placed or destroyed by the player. Crucially, players can animate these blocks, and add characters and objects, all of which the player can interact with. The versatility of Minecraft allows new games and fully interactive experiences to be created within the game, which challenges us to consider Minecraft as a game design tool rather than a game itself—or, as Sumter (Sumter in Cheshire, 2012) of the MIT Media Lab describes, a CAD program.

Having been released in 2009, Minecraft is now the most successful videogame in history, with over 480 million players worldwide and 112 million monthly active players (Bailey, 2019). Minecraft's consistent growth since its release in 2009 demonstrates a long-lasting appeal which is retaining the game's loyal fanbase, whilst also attracting a growing young audience. Thanks to its versatility, Minecraft has been used as part of an innovative global public space program called Block by Block, a non-profit organisation and partnership between Mojang, the creators of Minecraft, Microsoft, and UN-Habitat. Block by Block uses Minecraft as a community participation tool in urban design, with a focus on poor urban communities in developing countries. Block by Block's Minecraft methodology sees the game as central to a community engagement process, whereby workshop participants design and build their ideal public space inside the game. A consolidated Minecraft model containing the most popular design ideas is then presented to local government and planners who translate the Minecraft model into a final plan. The Block by Block Foundation then funds the building of the public space according to this plan, making it the only project in the world where Minecraft-designed projects are built in reality. Since the first trial in 2012, over 100 projects have been completed in 30 locations around the globe. This program is also the subject of the only literature which discusses Minecraft as a public participation tool in urban design (Delaney, 2019; von Heland & Westerberg, 2015), which, despite the success of the program, remains limited.

In recent years, the role of architecture and architects in the design of video games has been given much attention; game developers have sought the advice and assistance of trained architects and architectural historians to create increasingly more convincing and engaging virtual environments (Saga, 2015). On the other hand, little attention has been paid to how video games and game developers might benefit the field of architecture. The Bartlett School of Architecture's "Videogame Urbanism" unit is a rare example of this. Led by architectural design studio You+Pea, this research unit promotes the use of videogames in architectural education and is concerned with how the production and play of games can provoke and assist conversations about urban issues in the real world (You+Pea, 2019).

Minecraft is often cited when the intersection of videogames and architecture is discussed; as a game primarily about "building," it has an obvious connection to the field. However, when discussed, the game's mechanics and technical properties are rarely mentioned. From my own experience using Minecraft, I hypothesise that there are several characteristics of the game which make it a valid and successful tool for urban design in the context of citizen participation.

Firstly, Minecraft is an adept, accessible, and effective tool for visual communication. It is quick to learn, easy to use, and, most importantly, can be used by professionals and non-professionals alike. Unlike many existing design and visualisation tools, Minecraft does not discriminate between those with architectural training and those without—an essential factor in the making of any open and democratic design consultation. Not only does Minecraft allow participants to easily see and engage with the content created by professionals, but it provides them with the agency to adapt that content and submit their own ideas and proposals in a 3D form. The flexible and adaptive nature of the game makes it easy to test and change proposals: Nothing is permanent in Minecraft and the speed with which such changes can be made contributes to its strength as a visualisation and design tool. Even those who are entirely unfamiliar with the game can easily be taught during a short teaching session, as proven by the methodology employed by the Block by Block program, which I will discuss later.

Another benefit to Minecraft's use in architectural design is that it offers a new way of designing and constructing within a digital workspace. When a user builds in Minecraft, they do so from the perspective of their avatar, a virtual character that represents the player inside of the game. All interactions within a Minecraft world must be done so through this avatar; to build a wall, you need to walk up to where you want the wall and place the blocks in front of you. Although this first-person view is a common interface for players to use in video games, it is rarely used in design software and professional digital tools. On the other hand, architects using CAD have a "birds-eye" view. As a result, it is extremely easy to lose a sense of scale or human perspective with traditional design software, whereas Minecraft users are entirely immersed in the environment they are designing, moving through their designs as they create them.

The "multiplayer" feature of the game allows users to access the same virtual environment remotely, from anywhere in the world, and interact with the environment in real-time. For instance, a change made by one user will be seen by all other users in the same environment without delay. This kind of responsive technology does exist in the professional field, with software such as BIM (building information modelling), however, Minecraft also allows users to view the avatars of other users as they adapt the environment. This makes collaborative design in Minecraft highly effective, as evidenced by projects like BuildTheEarth, with more than 210,000 people worldwide participating in one Minecraft megaproject (BuildTheEarth, 2020).

Minecraft is also unique in its offer of a playful approach to design. Whilst most digital design tools have been designed specifically to create technical drawings, there is little consideration for conceptualization or experimentation of design ideas in a playful manner. The links between design and play are well documented; play is a natural mechanism for humans to solve problems—albeit whilst enjoying the activity at the same time. The similarity of the nature of play with real-life situations has generated a whole field of study, led by thinkers such as Johan Huizinga and Jean Piaget, which looks at how game and play can complement our real-life tasks. The concept of "playful design" is something that all Minecraft users are familiar with; Minecraft is a sandbox game without instructions, and when left without instruction the player is forced to come up with creative solutions to the design problems that face them in their own game world.

Finally, Minecraft allows users to create a narrative in and around the environments they build. Existing digital tools require users to create their designs on a blank digital canvas; prior to the user's interaction with the program, there is no existing context or environment. Conversely, Minecraft users design and build within a universe which has existing environmental features and assets; for instance, a day/night cycle allows players to experience their designs in changing lighting and weather conditions which roughly match real-life environments. Players can also add characters, animals, written books, and other content into their environments which they can adapt and interact with. When used in this way, Minecraft becomes a narrative-based design tool that facilitates the creation of inhabited, living digital spaces rather than the inoperative and unresponsive 3D models which are the product of traditional design software.

Inevitably, there are limitations to using Minecraft in a consultation process. Minecraft was not designed to be used in this way and the game's low resolution makes it ineffective for producing technical models or detailed proposals. There is also the possibility of distraction; younger children may struggle to focus on a set task inside a gameplay environment. The use of Minecraft also risks the potential segregation of different age groups; rather than mediating between older and younger participants, older participants may be limited by their technical competence, whilst younger participants who are more familiar with Minecraft, or game environments, in general, would dominate the process.

5. UCLCraft

To test these assumptions, I designed my own Minecraft participatory design workshop. Due to the Covid-19 situation, it was not possible for me to design a workshop that was directly comparable with Block by Block's in-person workshops—Mine would have to be a virtual workshop rather than a physical one. My workshop was of an experimental type, with a purely speculative design brief. My primary interest was how participants engaged with the Minecraft tool, more so than what they ended up building with it.

For my workshop, University College London's (UCL) Main Quad was used as the context for a speculative design brief, to create an outdoor learning space inside the quad itself. This site was chosen to allow comparison between the responses of participants who were totally unfamiliar with the Quad with those who were familiar with it, such as UCL members. From this, I could investigate the nature of a form of "crowd-sourced" participatory design, including participants from anywhere in the world instead of exclusively local participants. It is also a well-documented space that participants who were unfamiliar with it could easily research and find online references. Thirdly, the Quad itself is currently home to the Main Quad Temporary Pop-Up (Figure 1), a five-year facility providing additional learning space in the heart of the UCL campus, giving some real-life relevance to the speculative brief. Finally, when built at a 1:1 scale (where one Minecraft block is equal to one metre), the Quad is an ideal size—big enough to accommodate interesting and detailed proposals, but small enough so that it would not take participants too long to build their designs.

Having selected my site, the first step was to build the existing Main Quad in Minecraft. This was done by importing a scaled satellite image of the Quad as a flat layer and then building upwards using photographic references. The use of community-made building tools such as "WorldEdit" greatly sped up the process, allowing for sections of the build to be copied and pasted, and for one side of the build to be mirrored due to its symmetrical design. The build (Figure 2) was complete after a few hours, after which point I could set up the workshop environment itself—a Minecraft server.

A Minecraft server is a multi-player virtual environment which can accommodate multiple users in the same digital space, each of whom can access the server entirely remotely. In the process of setting up a Minecraft server, the server operator can determine how the environment is laid out, how users can interact with that environment, and the rules which those users are bound to. Assuming that most of the workshop participants would be strangers (to myself and each other), it was important that each participant would have their own model to work on, which would be protected from others to avoid any "griefing" (destruction of Minecraft environments by another player). Despite this, I still wanted participants to be able to see each other's designs and have the option to work in groups on a single model if they chose to. To achieve this, I created a "plots" system, dividing the Minecraft world into a grid of plots (Figure 3). Each participant would be automatically assigned their own plot upon logging in, which would then be populated by the pre-built model of the UCL Main Quad. Participants were not able to build on other people's plots unless consent had been given by that person in order to collaborate.

The workshop was open for five days and the server was live 24/7. All of the information required for users to take part was included in the server itself so that participants could drop in at any time to initiate their design—and could also leave at any time (with the server automatically saving their progress). By advertising on a number of platforms, I hoped to attract a range of participants—who may or may not be familiar with the Main Quad, who may or may not have a background in architecture and urban design, and who may or may not be at all familiar with Minecraft.

Figure 1. UCL's Main Quad Temporary Pop-Up. Source: UCL (2018).

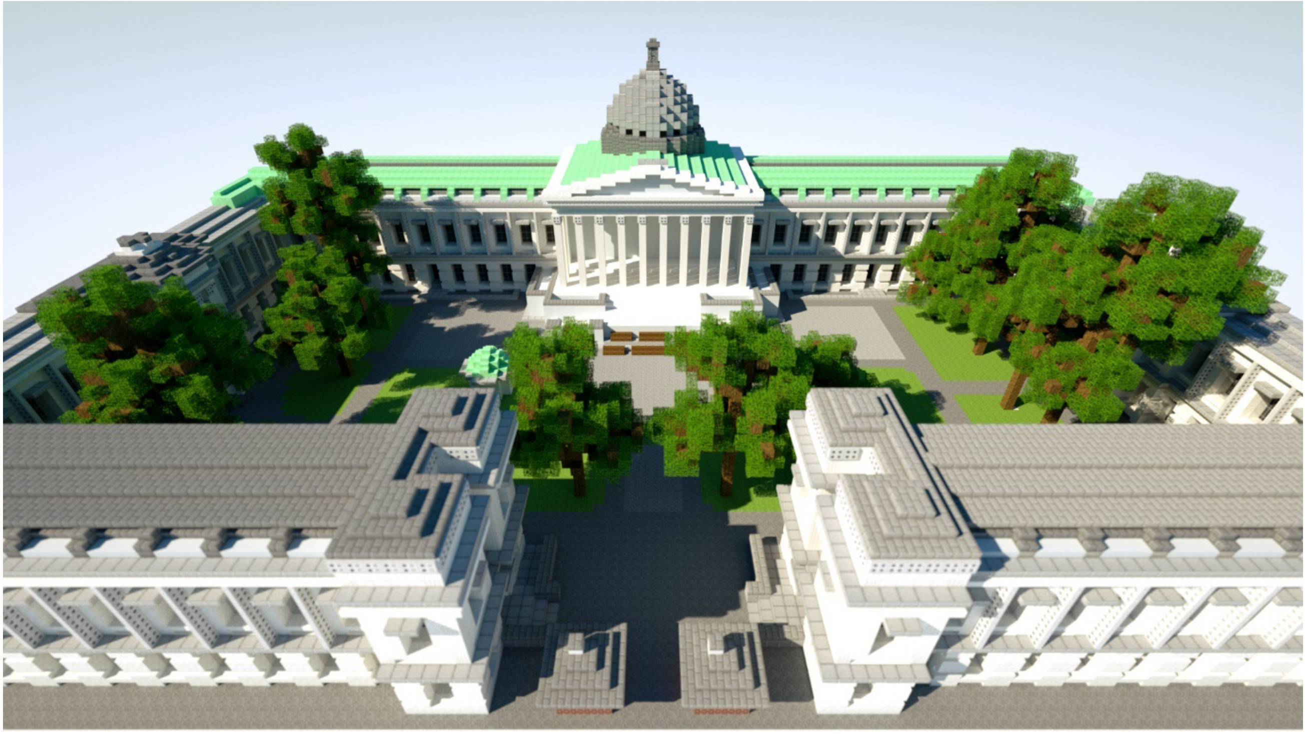

Figure 2. UCL's Main Quad: Minecraft model.

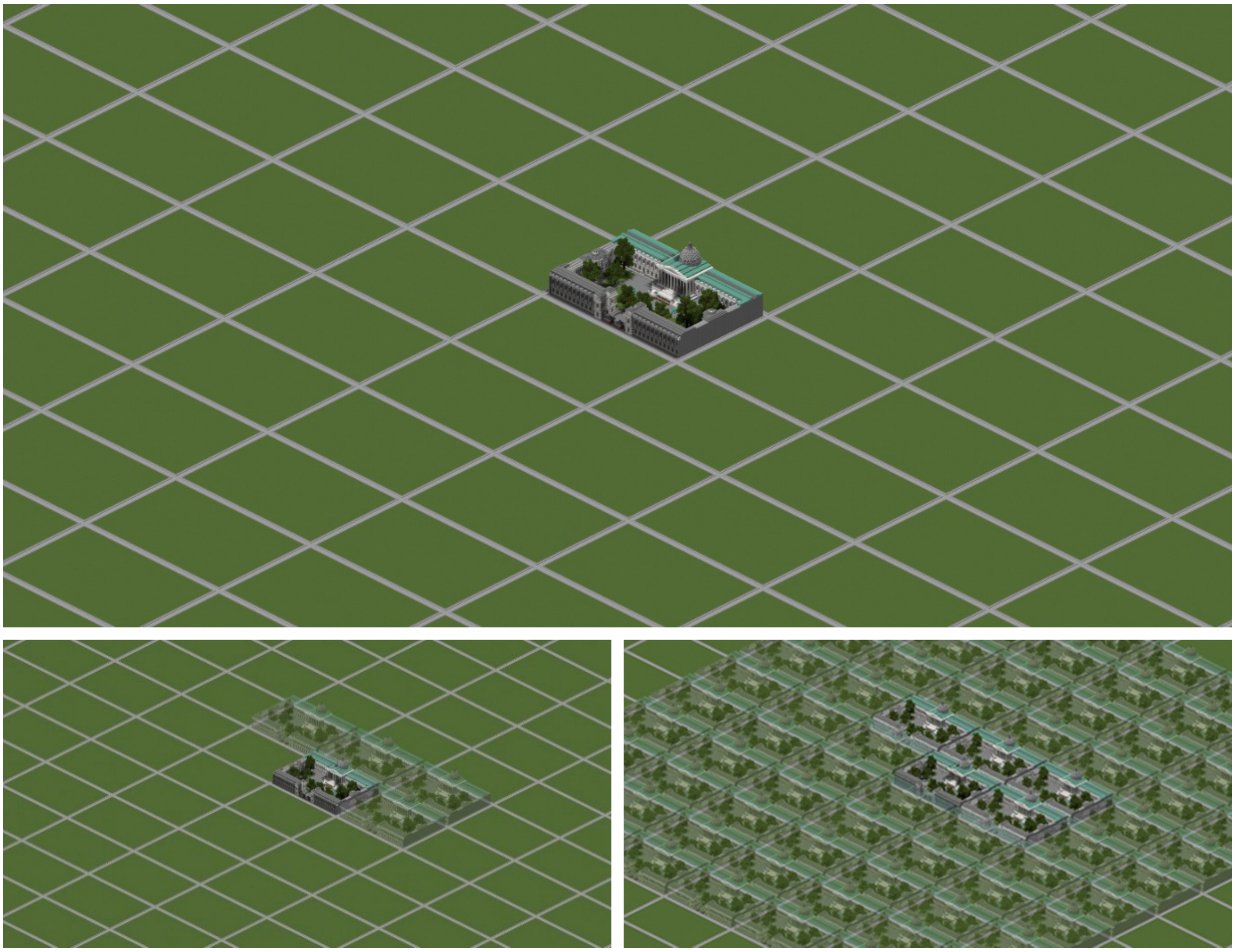

Figure 3. Workshop server, plots system.

Once participants joined the server, they would "spawn" in a plot at the centre of the Minecraft world. As well as the Main Quad recreation, this area contained information on how to navigate the server, the design brief, and information about the original Quad itself. Whilst the workshop brief was designed to be open-ended, I introduced some basic rules restricting participants' building choices within their plot. Any changes to the existing Main Quad build were disabled, on the grounds of the Quad being Grade I and II listed. This forced participants to build inside of the Quad grounds, rather than editing any of the buildings.

The Minecraft server had been programmed to track a number of data points from each participant, such as the number of participants who joined, the times at which they joined, how long they spent on the server, and how many times they returned. In order for users to be assigned a plot and start building, they were required to complete an automated questionnaire first, which was designed to establish their experience with Minecraft, their familiarity with the Main Quad, and whether they had any formal training in architecture, urban design, or a related field. Of the 105 users who joined the server, 72 completed the initial questionnaire, and can therefore be considered participants.

The data from the questionnaire (Figure 4) shows that the vast majority of participants had no architectural or urban design training, were not familiar with the UCL Main Quad, and were already familiar with Minecraft. Only three of the participants were Minecraft novices, 10 were familiar with the Quad, and 10 had an architectural or urban design background. The questionnaire also showed an age range of 12 to 49 across participants, with an average age of 18. The majority of participants said they were from the US (14.4%), followed by the UK (9%), with the rest from 21 other countries.

Throughout the workshop, screenshots were taken of participants' designs as they were being built (Figure 5). There was an impressive variety and quality of the Minecraft builds, with most participants making a clear effort to engage with the brief and design serious proposals.

Once participants were finished with their design, they were prompted to fill out another automated questionnaire, recording their experience of using Minecraft. Of the 72 participants who filled out the initial questionnaire, 40 submitted responses to the final questionnaire having completed their designs. Responses to most questions were almost unanimous, with all participants saying "yes" (with a small number of "maybe") to the following questions:

- Did you enjoy the workshop?
- Was Minecraft useful to visualize different ideas?
- Were you able to express your design ideas?
- Was Minecraft easy to use?
- Would you join future workshops with Minecraft?

5.1. Results of the Workshop

In describing the most and least successful aspects of the workshops there was a wide range of responses. In describing the most successful aspects, the most common responses were on the themes of:

- Easy to visualise different design ideas and an immersive view of the environment;
- Introducing urban design to a new audience;
- Creating a comfortable environment and collaborating with others.

Regarding the least successful element of the workshop, half of the participants commented on the difficulty of adding realistic details due to Minecraft's "blockiness." A number of participants also expressed that they would have preferred to have more advanced building tools made available to them in order to speed up their design process. Twenty-nine out of 40 participants suggested Minecraft could be a valid alternative to more traditional consultation methods, with the remainder arguing that it should be used in addition to (not in place of). Both the initial and final questionnaires suggest a highly positive response to most aspects of the workshop and are a strong endorsement of Minecraft's value as

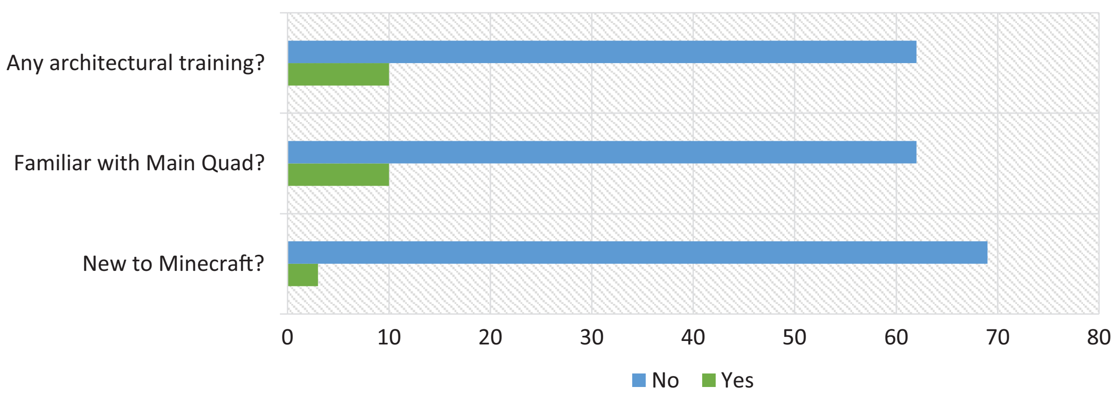

Figure 4. Initial questionnaire.

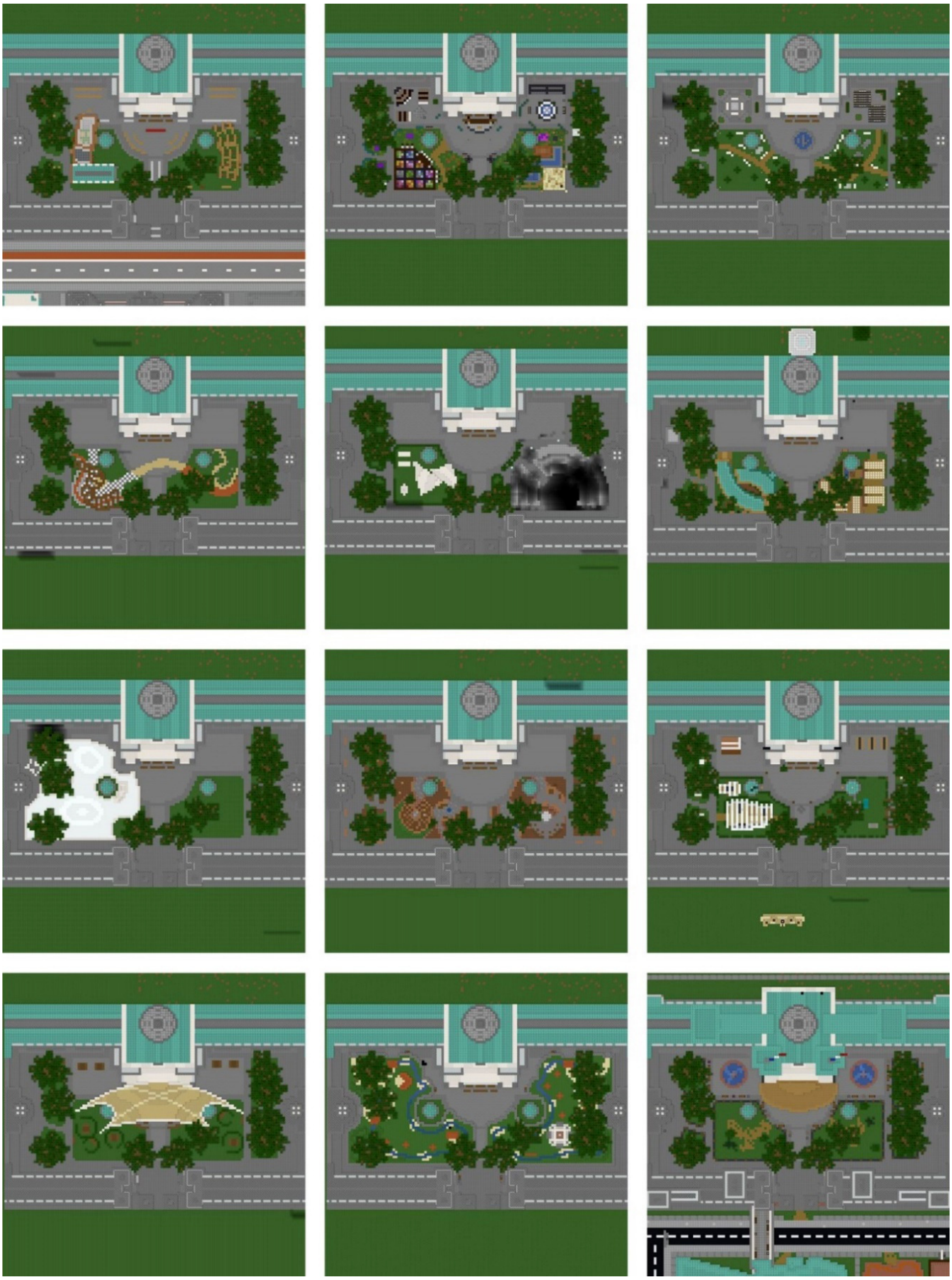

Figure 5. Sample of Minecraft plots: Plan view.

an accessible, fun, and effective visualisation and design tool. The background of participants must be taken into account, however, with the vast majority having had previous experience using Minecraft.

In both the questionnaires and plot builds themselves, there was evidence that participants had conducted at least some additional research on the Main Quad. There was no suggestion to do this, and it was encouraging to see participants explore the wider context of the brief unprompted. In some cases, participants went beyond the brief by building some of the Main Quad's surrounding context.

Some participants took this a step further and used features such as the game's weather patterns to invoke a digital environment that represented Central London. As a light-hearted comment on the UK's notoriously rainy weather, one participant permanently changed the weather cycle to "rain" on their plot, meaning that both themselves and any visitors could only experience their design amidst a digital downpour in Minecraft (Figure 6).

Whilst some participants displayed a clear interest in the history, heritage, and context of the chosen site, there were some who chose to recontextualize and relocate the UCL Main Quad by building a fictional setting surrounding it. One participant filled the entire available plot by adding a newly imagined road to replace Gower Street and designing new buildings opposite the Quad's entrance. Furthermore, they made significant changes to the historic structure of the Quad itself. Whilst the server rules prevented participants from editing existing blocks, this participant was able to re-design the building by adding a façade around the existing build. This kind of inventive defying of the rules represented some level of frustration amongst a small number of participants regarding what they could or could not do. This is perhaps unsurprising for more experienced players, as for many Minecraft is a game defined by its lack of rules and total, unrestricted creative freedom.

A measure of success can be found in the age range of the participants, with an average age of 18. The youngest participant was 12, and there were 16 participants under the age of 16. This demonstrates a high level of engagement with a young audience, largely thanks to Minecraft's popularity with this age demographic. In answering the final questionnaire, 85% of participants said they would join a future urban design workshop if Minecraft was used, with the remaining 15% saying maybe. This makes a strong case that the tool is highly effective at engaging young people, who are notoriously difficult to attract, in participatory design processes.

A challenge of attracting such a young audience can be the difficulty of maintaining the maturity required to engage in a process such as this. Although a design brief had been set, I was fully expecting many participants to ignore this entirely and enjoy creating their own designs irrelevant to the site and brief. Although some designs were far more playful than practical, all the participants bar one engaged with the brief in some way by adding spaces for outdoor learning or teacher. The participant who did not (also a UCL student), built a giant trampoline and airborne assault course inside the Quad (Figure 7). Whilst this may seem incongruous to its surroundings and unhelpful to the brief, this playful approach should not be instantly dismissed. Minecraft provides a "safe space" for participants to experiment and test ideas without fear of criticism or failure.

When asked what the least successful element of the workshop was, by far the most frequent answer was that Minecraft was too blocky to add detail or create realistic designs. As the Quad was built at a 1:1 scale, the smallest module/block that participants could place would be 1 m^3 in reality. As the user SH0RKS put it: "It's pretty challenging to express intent for small details in Minecraft at least for me. That makes it hard to really flesh out an idea and consider how it could be made in reality."

Yet, when considering that on average participants spent three hours and 17 minutes on their designs, I would argue that this was one of Minecraft's greatest strengths as a design tool. The lack of possible detail meant that participants were not bogged down

Figure 6. Minecraft plot by PixelatedSun: UCL Quad in the rain.

Figure 7. Minecraft plot by kennc05: Trampoline and assault course.

in creating accurate and realistic representations of their concept. Instead, Minecraft was used as a three-dimensional sketching tool and proved useful for quickly depicting an idea or concept in the virtual space. In some cases, participants would supplement their designs with a written explanation (using a Minecraft sign) to remove any doubt (Figure 8).

Although the plot layout of the Minecraft world allowed each participant to work on their individual design, participants were able to work as groups if they wished. A plot owner could "approve" other users, thus giving them access to their own plot. In several cases, participants chose to work together to produce one design. Most teams consisted of two participants, the largest consisting of four. Given the remote nature of the workshop, it was surprising to see participants who had never met before deciding to collaborate in this manner.

Many participants commented on the positive social aspects of the tool; for instance, being able to visit other participants' plots, talking, and, in some cases,

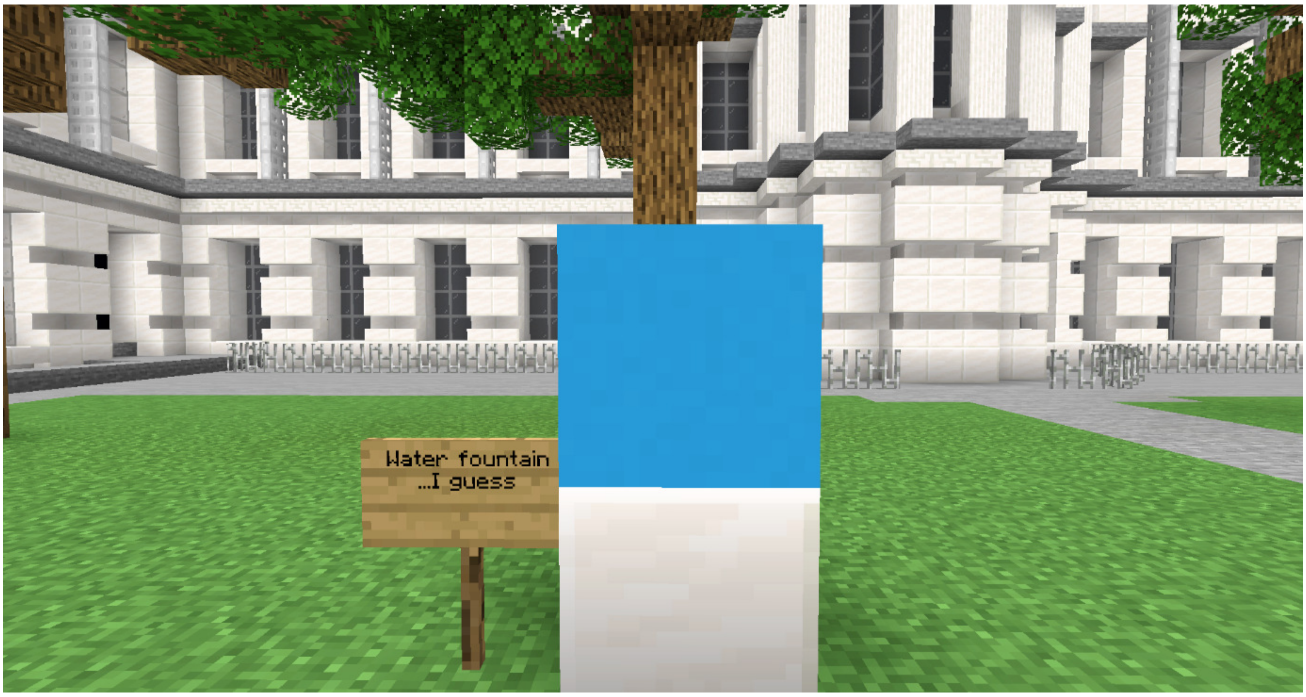

Figure 8. Minecraft plot by BWEvents1: "Water fountain… I guess."

co-creating with them. Eighty-five per cent of participants talked with each other and the 3,800 messages sent suggest a high degree of social activity. In answering whether they enjoyed using Minecraft, 18% of participants specifically mentioned that interacting with other players was an enjoyable feature, with some requesting that they would have preferred a system that made visiting other plots easier. As inhabited virtual spaces, Minecraft servers are highly sociable in their nature, and this was clearly a great benefit to the workshop. In hindsight, this could have been improved by running the workshop for a shorter term, or perhaps only specific hours on each day. This would have led to a higher concentration of concurrent users, fostering a livelier and more collaborative environment. One participant suggested the following: "I would suggest implementing a hub in-game for people to meet and chat in order to exchange ideas and discuss issues and constraints."

Whilst the discussions in the workshop were largely spontaneous between participants, it would have certainly helped to have a dedicated space for discussion and meet in-game. Allocating a specific time for users to present their ideas to each other could have also helped with the cross-pollination of design ideas.

Yet another element of the workshop results worth discussing was the creative use of narrative and storytelling within participants' plots. Participants were able to use Minecraft not simply as a design tool, but as an immersive, interactive environment through which other ideas could be expressed beyond a design schematic. Participants' abilities to place characters and animals, readable books, and change environmental factors such as time of day and weather opened up a much wider range of creative possibilities than most other 3D tools afford. Furthermore, it helped to create environments that were enjoyable to explore and interact with.

6. Conclusions

This study confirms that Minecraft has a great deal to offer as a public participation tool in urban design and planning. The outputs of the UCLCraft workshop demonstrate that the use of Minecraft can help engage a wide audience (youth in particular) with consultation processes. Furthermore, the tool itself provides a useful visualization of existing sites and is an accessible platform for participants to present their own opinions as 3D virtual designs.

Minecraft improves upon the existing uses of 3D multi-user environments in several ways. Firstly, it is a well-established and highly popular platform, especially with a younger age demographic. The act of including Minecraft in a design consultation helps enormously in attracting the "non-joiners" (Ministry of Housing and Local Government, 1969) to the process. The importance of a user-friendly interface cannot be underestimated in the use of technology in democratic processes, and, in this regard, Minecraft is well-suited to the task. The total amount of time spent by users in my workshop (14 days and nine hours), confirms that Minecraft is not only effective at attracting participants, but also maintaining their attention and interest.

Secondly, when used in the right way, Minecraft offers a unique opportunity for a truly collaborative and inclusive co-design process, especially when there are multiple users in the same virtual space at the same time.

The results of my workshop confirm that a number of Minecraft's features and core characteristics enhance its value as a participatory design tool. Some of these features were highlighted by the participants in their questionnaire responses, the benefit of Minecraft's first-person point of view for instance. The low-resolution, "blocky" nature of the game was also valued by participants as it allowed them to quickly sketch ideas without "wasting time in details" (as described by user italosena).

Other useful features of the game became apparent through my observations of participant activity throughout the workshop. The ability to add narrative and storytelling elements to their designs helped many participants create more immersive experiences within their Minecraft models. The benefits of Minecraft's playful nature can also be seen in the creativity of participants' proposals. In a number of more fantastical proposals, participants were not limited by regulations or practical considerations, even finding ways to circumvent the boundaries that had been put in place.

Urban and societal change is typically a slow process. In this respect, Minecraft can be used as a catalyst to improve the efficiency and quality of decision-making in planning and urban design. There is still a long way to go before Minecraft would be considered a mainstream participatory process; advocates of it, such as the Block by Block Foundation, need to engage more with universities, NGOs, and policy-makers to raise awareness of the tool and its benefits.

Despite its benefits, Minecraft is not a panacea for the inherent difficulties of community consultation. In its implementation, it must be used in combination with other tools and methods, some of which can be integrated into the game, and some of which are best carried out in the physical rather than virtual realms.

One major shortcoming of this research was the lack of variety in my own workshop's participants. Participants were overwhelmingly experienced Minecraft players who were unfamiliar with the site in question. This is in direct contrast to the participants of the Block by Block workshop, who were completely new to Minecraft and local to the site. This makes it difficult to draw comparisons between the two, as the positionality of both groups of participants was so different. To remedy this, I should have ensured participation from groups outside the Minecraft gaming community—for instance, targeting student groups.

Furthermore, the term of the workshop was too long. With participants spending an average of just over three hours on their designs, the availability of the server for 120 hours was not needed and only served to lower the average population of the server at any one time, reducing the opportunity for collaboration and interaction between participants. The workshop could also have contained more information about the site and the context of the brief. Although many participants successfully researched the site online, by integrating images, video, and text into the "spawn" area of the Minecraft world, I could have helped participants better understand the environment they were being asked to re-design.

Finally, my workshop has shown that Minecraft is suitable for hosting an entirely remote participatory process, an advantage that has particular relevance in the current Covid-19 climate. This is not to say that a remote Minecraft workshop is an improvement on a physical one; had circumstances allowed, I would have still preferred to carry out my research at a face-to-face Minecraft workshop. Nonetheless, it is a useful tool when this is not an option. Furthermore, it presents a unique opportunity to engage with citizens from anywhere in the world. Inevitably, this means that not all participants will have local knowledge of the site being discussed; however, it does allow for a much greater number of participants who are able to bring in a wide variety of cultural and societal influences into the discourse.

Acknowledgments

This work is the result of my master's research project at University College London's Development Planning Unit. I thank my supervisor Professor Andrew Hudson-Smith for his support, as well as colleagues at the Block by Block Foundation and UN-Habitat for their continued work in this field.

Conflict of Interests

This article discusses the work of the non-profit Block by Block Foundation, which I am a serving board member of. As a voluntary position, this does not present a conflict of interests; rather, I have been able to use my knowledge and experience from within Block by Block to further my research.

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Article

Incoming Metaverses: Digital Mirrors for Urban Planning

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Abstract
The planning process has been, arguably, slow to adapt and adopt new technologies: It is perhaps only now that it is starting to move into a more digitally focused era. Yet, it is not the current thinking around the digital that is going to change planning; it is the emerging metaverse. It is a change on the near horizon that is there but is currently largely unseen in the urban planning profession. The metaverse is, at first sight, a mirror to the current world, a digital twin, but it is more than this: It is an inhabited mirror world where the physical dimensions and rules of time and space do not necessarily apply. Operating across scales, from the change of use of a building up to a local plan and onwards to the scale of future cities, these emerging metaverses will exist either directly within computational space or emerge into our physical space via augmented reality. With economic systems operating via blockchain technology and the ability to instigate aspects of planning law, interspaced with design fiction type scenarios, they represent a new tool kit for the urban planner, spatial, economic, and social. We explore these emerging spaces, taking a look at their origins and how the use of game engines have allowed participation and design to become part of the workflow of these 3D spaces. Via a series of examples, we look at the current state of the art, explore the short term future, and speculate on digital planning using these incoming metaverses 10 years from now.

Keywords
digital mirrors; Meta; metaverse; planning; virtual

Issue
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1. Introduction

The digital toolkit available to the planning professional is vast. In this article, we explore, through examples, many personally developed, that multi-user 3D worlds and emerging collaborative spaces have the potential to change how the planning system operates. Yet, the reality of day to day practice for those involved in the planning system, from the professional through to the public at large is a predominance of the use of architectural drawings, 2D plans, and planning applications published in PDF. In short, it is as far from the vision of an emerging metaverse which we explore and suggest is the future of the digital planning system. Yet, these tools are out there, ready to be used, being developed by teams building digital worlds for virtual reality headsets such as the Oculus Quest from Meta, the company formerly known as Facebook. These tools, currently on the edge of the planning system, have the potential to fundamentally change how the planning process works, but they require a step-change in thinking by the profession. In April 1997, an article in *The Planner*, the monthly publication of the Royal Town Planning Institute in the UK, was written to introduce the planning to the then-emerging World Wide Web. Entitled "The World Wide Web: A Guide for the Urban Planner," the publication contained a look at visualisation online, including an early emerging 3D virtual environment. The article was published but it was retitled by the then editor as "The World Wide Web: Not Just for Nerds"; while a mildly assuming title change, it could be seen, at the time, as reflecting the mood of the planning community and their view of this new emerging technology. Almost 25 years on and the planning profession has arguably failed to grasp the concept of digital; only now is the system coming online with documents often provided in non-machine readable formats such as PDF and the system, arguably, still operating in a similar way to back in 1997, albeit with the ability to submit applications online.

In this article we explore the rise of digital planning, with a focus on 3D, collaborative worlds, known as the metaverse, a term which has perhaps only recently become notable due to Facebook rebranding itself as Meta (Bosworth, 2021) and making a notable move towards developing an occupied metaverse. These metaverses have been developing since the early 1990s and we explore examples we have developed for urban planning. However, before exploring the concepts of the metaverse, it is worth noting the current trends not only in digital planning but in the wider built environment profession. Digital twins and the Internet of Things are arguably the current driving force in the field of the built environment; these represent two different but overlapping concepts relating to our representation and understanding of place and space. Firstly, the concept of the digital twin was initially linked to product manufacturing by Grieves (2015) in 2002 with the concept of linking digital versions of manufactured products to their physical counterparts throughout their life cycle via a digital twin concept model. The model, according to Grieves (2015), consists of three main parts: (a) physical products in the real space, (b) virtual products in virtual space, and (c) the connections of data and information that tie the virtual and real products together. The concept of digital twins can additionally be traced back to the "mirror world" first promoted by Gelernter (1991) in his seminal book *Mirror Worlds: Or: The Day Software Puts the Universe in a Shoebox*. Gelernter (1991) defines "mirror worlds" as software models of some chunk of reality, some piece of the real world going on "outside your window" which can be represented digitally and then rescaled again and again into a form that you can enter and manipulate. A mirror world is grounded in some real space and its power comes from the way we manipulate reality, linking it away from not only a physical product but into wider places and spaces. Ultimately Gelernter (1991) predicted that a:

> Software model of your city, once set up, will be available (like a public park) to however many people are interested…it will sustain a million different views…each visitor will zoom in and pan around and roam through the model as he chooses. (Roush, 2007)

This in essence is the basis of the concept of the digital twin, a mirror on the world, but in software and occupied by people as they log into the system—a collaborative, multi-user digital space, which in turn, once connected to economic and social factors creates the concept of the metaverse.

Central to this concept is the definition of "space." Bell (1996) identifies three different kinds of space: visual, informational, and perceptual. Visual space is our view of physical real space, the space in which urban planning exists, from the colour and reflection of materials up to the construction of reality in which we live. In essence, as Mitchell (1995) noted, a series of primitives is made up of points, lines, and polygons, forming a 2D or 3D arrangement, and it is convenient to think of visual space as being populated by these tokens. This is central to the emerging digital twin, mirror worlds, as the machine—the mirror—needs to recreate these points lines and polygons in digital form. This is a notable task and one that is often overlooked in what is perhaps the current hyperbole on digital twins, that the construction of digital space is complex, computing-intensive, and ultimately expensive. We explore the construction of the digital mirror in the following sections, firstly exploring an increasingly important aspect of the digital twin, one of informational space. In Bell's (1996) definition, informational space is an overlay of the visual space where we receive information—everything from written signage through to sound—adding to the vision. As Borgmann (1999) states, information can illuminate, transform, or displace reality. In digital space it is the overlay and addition of data—data ranging from real-time feeds on, for example, environmental conditions or transport information through to the submission of a new planning application tied to a building, it is this informational space that is arguably the key aspect of the digital mirror. This is a crucial aspect as once the informational space is linked to the visual space it opens up multiple versions of the digital twin, depending on the space observed by the human eye from the digital screen—i.e., levels of reality. These levels of reality and with them the ability to plan are central to the development of digital planning. To illustrate where we currently are in the ability to plan digitally, Figure 1 provides an overview of the current state of play in the creation of this digital space.

The timeline in Figure 1 moves from traditional planning with paper and physical models through to the use of the internet and online documents and onwards to the creation of 3D spaces, its link to data, occupying the space, and then moving towards planning in the metaverse via digital twins. We suggest that the current state of the art is at the start of the creation of the digital twin, with the ability to augment space and overlay data technically possible; we provide examples of such developments in the following sections. The reality in relation to the planning system is however further back on the development line, arguably in the networked space with some more forward planning authorities moving into 3D data. It is between the networked space and the digital twins that can be seen as the current level of innovation. In relation to Bell (1996) and his perceptions of space, the information space is further augmented by social space, our social embedment in the digital environment. This ranges from the use of social media to

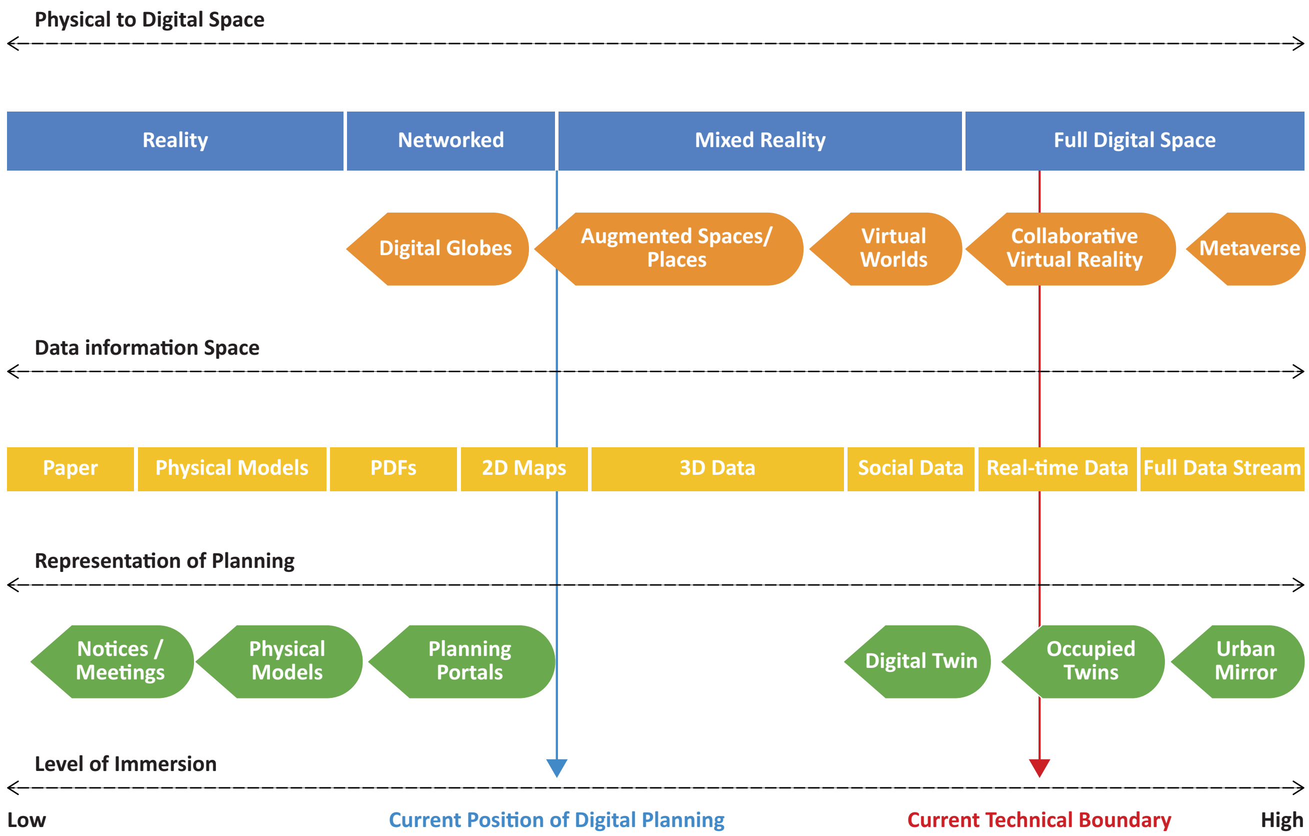

Figure 1. A timeline and current position of digital planning and its move towards the metaverse.

a 3D representation of ourselves in digital space, our own digital twin. It is the overlapping of these three types of space—visual, and informational with the addition of social—that creates perceptual space. This space, once created, allows us to perceive place and space and thus use it for the application of urban planning but with the benefits of digital. As Benedikt (1996) argues that because virtual worlds are not real in the material sense, many of the axioms of topology and geometry so compellingly observed to be an integral part of nature can therefore be violated or reinvented as can many of the laws of physics—creating almost a digital sandpit for urban planning.

At the time of writing (December 2021) there are over 160 companies building the metaverse (XR Today, 2021), a term which arguably implies one singular space, but, in reality, there are many, coexisting metaverses under development. The term metaverse is relatively new, emerging from Stephenson's (1992, p. 35) vision in his novel *Snow Crash* where he first describes the metaverse:

> As Hiro approaches the Street, he sees two young couples, probably using their parents' computer for a double date in the Metaverse, climbing down out of Port Zero, which is the local port of entry and monorail stop. He is not seeing real people of course. This is all part of the moving illustration drawn by his computer according to the specification coming down the fiber-optic cable. The people are pieces of software called avatars.

Although this is the first use of the term, taking a step back from the concept of the Street and Port Zero the metaverse can perhaps be defined as a digital space with an economic structure, occupied by avatars, sometimes mirroring the real world but with multiple representations of the physical world and the ability to change time, physics, and space. Radoff (2021) suggests that the metaverse relies on seven distinct layers:

1. Infrastructure: Connectivity technologies like 5G, Wi-Fi, cloud, and hi-tech materials like GPUs;
2. Human interface: Virtual reality headsets, augmented reality glasses, haptics, and other technologies users will leverage to join the metaverse;
3. Decentralisation: Blockchain, artificial intelligence, edge computing, and other tools of democratisation;
4. Spatial computing: 3D visualisation and modelling frameworks;
5. Creator economy: An assortment of design tools, digital assets, and e-commerce establishments;
6. Discovery: The content engine driving engagement, including ads, social media, ratings, reviews, etc.;
7. Experiences: Virtual reality equivalents of digital apps for gaming, events, work, shopping, etc.

It is these concepts and layers that make the metaverse perhaps the ultimate sandpit for urban planning, the ability to shape a world, plan, design, and open it up for consultation across the professions and the public at large, regardless of physical location. With the early concept of collaborative virtual spaces known then as the collaborative virtual design studio (CVDS), Batty et al. (1999) noted that, although digital worlds may form an entirely automated form of design and planning, through computation, there are five key aspects of the process where digital tools will develop. These involve:

1. Representing the geometric and geographic form of the system in question in terms of buildings, streets, land uses, etc., at different geographic and geometric scales, using different types of media;
2. Modelling movements and relationships between the various components of the built environment;
3. Enabling the designer to sketch different alternative designs which address the problem in question;
4. Visualizing the 2D map geometry or geography in 3D at different scales;
5. Tying together all this various software in a networked participatory digital environment—a CVDS—where various users might participate and collaborate in the process of design.

Perhaps the most popular recent reference point for the metaverse is *Ready Player One*, the novel by Cline (2011), adapted, in 2018, into a film directed by Steven Spielberg. In Cline's metaverse, the environment is known as "Oasis," a utopian virtual environment the population log into in order to escape the current dystopian real environment. Ball (2021) defines the metaverse as an expansive network of persistent, real-time rendered 3D worlds, simulations that support continuity of identity, objects, history, payments, and entitlements, and which can be experienced synchronously by an effectively unlimited number of users, each with an individual sense of presence. Robertson and Peters (2021) note that the metaverse is an aspirational term for a future digital world that is more tangibly connected to our real lives and bodies. They also note the following attributes:

- Feature sets that overlap with older web services or real-world activities;
- Real-time 3D computer graphics and personalized avatars;
- A variety of person-to-person social interactions that are less competitive and goal-oriented than stereotypical games;
- Support for users creating their own virtual items and environments;
- Links with outside economic systems so people can profit from virtual goods;
- Designs that seem well-suited to virtual and augmented reality headsets, even if they usually support other hardware as well.

Despite being in development since the late 1990s, as we will explore, the term is perhaps at the peak of the hype cycle. In September 2021, Facebook announced a $50 million investment in a global research programme to build the metaverse and, in October 2021, changed its name to Meta. Andrew Bosworth, the Vice President of the then Facebook Reality Labs noted in 2021 that it would take 10 to 15 years to build their vision of the Metaverse, additionally defining the metaverse as a set of virtual space where you can create and explore with other people who are not in the same physical space as you (Bosworth, 2021).

Before looking at the current state of the art, it is worth taking a step back to look at past developments in collaborative 3D spaces for urban planning. These examples are from ones we have developed and represent an ongoing timeline into the development of digital representation in what can be termed "early metaverses." Our first example used one of the first popular multi-user world systems in the late 1990s and arguably provided a first take on developing a metaverse in a system known as ActiveWorlds (https://www.activeworlds.com).

ActiveWorlds was, and indeed still is, a multiuser "chat and build" system where objects in the world can be either imported from external 3D software or by building "block by block" using cubes and derived shapes, similar to the now popular Minecraft, which we explore later in this article. Figure 2 details 30 days in ActiveWorlds (see Hudson-Smith, 2002), where an initial short term experiment into "online planning" in a 3D space led to the building of a community, full public participation in the planning process, and a dense network of streets, houses, and social environments being built over a year. ActiveWorlds, while still online, maintains the virtual spaces, but is greatly reduced in its number of users with unoccupied spaces as users have moved onto the next system. Digital spaces need to be able to transfer into the next metaverse and while ActiveWorlds was used for our first urban planning experiments, the concept moved on to a system known as Second Life. Second Life, as Jamison (2017) noted, was supposed to be the future of the internet, a 3D inhabited collaborative space with millions of people spending many hours building and shaping a new, occupied world. Set up in 2003 by Linden Labs, Second Life created an online digital space covering over 700 square miles in space with 36 million user accounts. Land and objects in the world were traded using Linden Dollars, an early example of a digital currency. Jamison's (2017) article was entitled "The Digital Ruins of a Forgotten Future" as Second Life followed ActiveWorlds in being more uninhabited than habited digital space. In more current developed examples, which we explore later, the digital currency is now crypto, with land being traded and sold above the equivalent physical cost.

In 2007, the University College London's Barlett Centre for Advanced Spatial Analysis (CASA) partnered with Nature Publishing and their Second Nature Island to

Figure 2. Fashioning the CVDS in which users appear as avatars and are able to manipulate the elements of their environment, c. 1999.

provide early examples of placing urban planning examples via its then Virtual London project in a collaborative virtual environment. Figure 3 details two avatars in Second Life within a block model of a part of London. The model could be queried for data, such as land use, and manipulated to show possible development options. Beyond the block model are step inside globes, to provide immersive photographic urban landscapes, captured in a similar way to the now familiar Google Street View. Land in Second Life was built block by block and, as Batty et al. (2009) state, although Linden Labs developed the program, it is the population of avatars that is creating the hamlets and towns that form its 750 square kilometres and its economy. Millions of Linden Dollars

Figure 3. Building virtual London in Second Life.

change hands every month for the goods and services residents create and provide. This unit-of-trade may then be bought and sold on LindeX (Second Life's official Linden Dollar exchange), or other unaffiliated third party sites where real currency changes hands (Linden Labs, 2007). Currency in the new emerging worlds has become all-important, as can be seen, for example, in Decentraland (see Ordano et al., 2017). As Goldberg et al. (2021) note, it was created as the first large-scale virtual world, built on a public blockchain and smart contract infrastructure. This is beyond the scope of this article but of note is the price of land in these emerging metaverses. While in Second Life whole islands could be purchased for a minimal amount for urban planning experimentations, the price of land could become a restricting factor in the creation of digital twins. Indeed, in Decentraland, a 96-square meter plot had a market value of $13,000 with the most expensive real estate selling for $4.3 million (Dailey, 2022).

In these new worlds, the population is in flux as users can "jack in" and "jack out," to adopt the now remerging terminology of the metaverse and *Snow Crash*. In August 2007, 23 million man-hours were spent in Second Life; the time was spent by over 974,000 users, with an average of 23.6 hours per user. Hof (2006) stated that as the residents spend:

> A total of nearly 23,000 hours a day creating things, it would take a paid 4,100-person software team to do all that. Think of it: The company charges customers anywhere from $6 to thousands of dollars a month for the privilege of doing most of the work….In other words, your next cubicle could well be inside a virtual world.

ActiveWorlds, Second Life, and many others laid the foundation for the current state of play and the reemergence of the term "metaverse." The concept is the same: a collaborative, occupied virtual space where users can build anything, own land, edit, and inhabit the environment. Arguably, it is the future of digital urban planning; the hard part is building it, which we explore next.

2. Building the Mirror

The construction of digital space for the use of urban planning is a specialised topic. From a UK point of view, the current curriculum to become a member of the Royal Town Planning Institute, and thus a qualified urban planner, is notably lacking in digital skills and incorporates almost no reference to 3D modelling. This will of course change, but, at the present time, the skillset is multi-faceted. The first requirement for any true digital representation for use in urban planning, we would argue, is a 3D model of the environment—just past the current state of play in our timeline of digital planning (Figure 1). These environments form the basis of either recreating the space via photogrammetry methods or more standard computer-aided design. Both methods are time-consuming and expensive when looking at the urban planning system and thus have developed as a "service" mode by companies providing access to digital models. One typical example is VU.CITY, providing access to 3D models for both architects and urban planners. Figure 4 illustrates a subset of their London model, for which they also use the term "digital twin."

From the ability to import designs, see protected views, overlay data from GIS through to height and massing assessments, and the ability to annotate and

Create or import designs securely and analyse them in situ

Add, search and explore and proposed developments

Provide AVR scope to determine which views to assess

Real time transport overlays

LVMF protected views

Overlay historic buildings, borough boundary and GIS data

Figure 4. VU.CITY 3D London model with example applications and data overlays. Note: AVR—Acurate visual representation; LVMF—Landscape visual impact assesment.

collaborate on projects with notes and images, the system provides access to urban planners to a full 3D model. As noted by VU.CITY (2021), one such example is its work in the London Borough of Southwark, where it is helping the borough design and test ideas for the development and growth in the area over the next 20 years by providing locations for 20,000 new homes; revitalising the high street with shopping and town centre facilities; assessing the design and heights of buildings and spaces; creating improvements for pedestrians and cyclists, including new links and making existing routes safer; and improving public transport, which includes an extension to the Bakerloo Line and two new underground stations. These are core planning functions, being carried out, digitally with access to the 3D dimensional model.

The service level model is perhaps inevitable due to the ongoing debate on the cost vs. the use of a 3D model. The Ordnance Survey, the UK's national mapping agency, has perhaps lost the edge it had in providing data for use by urban planners, with 3D not being seen as a priority. While this is understandable with the inevitable resource constraints, in terms of the incoming metaverse and the newly emerging digital environments and marketplaces for trusted data providers, the focus on still representing our environment in 2D is, in our view, concerning. At the same time, it indirectly constrains the urban planning system as the Ordnance Survey remains the main provider of location-based data with the gap being filled by third-party providers and thus without the quality assurance and standards that come as part of data being provided by a national mapping agency.

At the other end of the spectrum from national mapping agencies and service providers are the smaller development teams. One such example is our own ongoing development of the Virtual London model at CASA, which is taking it to the next step, while still using the same concepts as we noted in the CVDS in ActiveWorlds. The model, known as ViLo, builds it on earlier research at CASA into the creation of a comprehensive 3D model of London's built environment (Batty & Hudson-Smith, 2005). The current model supplements static spatial data about the cities' built environment and infrastructure with dynamic elements representing different kinds of events as they occur in real-time. Buses, tubes, and trains can be seen moving across the city while more abstract visualisations show the locations and availability of different services like bikes at local bike-share stations. Sensors transmitting data about environmental factors can also be accessed to show changes in natural phenomena ranging from variations in local microclimate to the patterns in behaviour of particular wildlife species (Dawkins, 2017). Figure 5 illustrates the ViLo model with the inclusion of real-time transport data. The model was developed as an early proof of the concept of a digital twin, in 2017, in association with the Future Cities Catapult, a government-funded organisation with a focus on exploring cities in the UK. The model was arguably ahead of its time with the inclusion of above ground and underground data allowing not only urban planning type scenarios but also operational use in an urban context. The system was focused on the Queen Elizabeth Olympic Park, in East London, a region of new development with a mix of uses.

Figure 5. The ViLo digital twin model with real-time data.

Developed in cooperation with the Mayor of London's Smart London Board it operated across a number of platforms, covering desktop usage, virtual reality, and augmented reality. This is possible due to the development infrastructure being focused on Unity, a cross-platform game engine designed to support and develop 2D and 3D video games, simulations for computers virtual reality, consoles, and mobile devices platforms (Unity, 2017). The availability of game engine technologies is beginning to bring together the multiple professions involved in creating the built environment, from architects to surveyors, urban designers, and back to the urban planner. The main players at the current time are both Unity and Unreal (another game engine), offering access to the ability to import and visualise data relating to the built environment. It is still in its infancy but the game engine provides the catalyst for an integrated visualisation system. This is required due to the current arguably similar but diverse worlds from building information systems through to GIS, working at different scales but with location and data at the centre of both systems. In the geographic information arena, one should note that, in late 2020, ESRI released an open beta release of their ArcGIS maps software development kit for both Unity and Unreal Engine. As the vice president of Unity, Julien Faure, states:

> As gaming technology is increasingly adopted in many industrial sectors including AEC, government, energy, and transportation, we are excited to partner with ESRI to bridge the world of GIS and real-time 3D. The addition of ESRI's best-in-class real-world geospatial data into Unity's real-time 3D development platform will help create real-time digital twins of an unprecedented scale, to better operate and manage massive infrastructure and entire cities in immersive environments. (Hansen, 2020)

We illustrate an early example of this in Figure 6.

The examples thus far have concentrated on using 3D systems to import more traditional digital urban data, in the form of building footprints, height data, etc., to create the urban mirror. This is a development in the timeline of computer-aided design software and the natural integration of GIS along with the merging of building information systems. Using similar technologies but in a directly opposite manner (which could be argued as its own mirror) is the development of urban space directly within computer games, to which we briefly turn.

Minecraft is an open-ended "sandbox" game designed by Markus Persson and published by Mojang, where players build constructions of textured cubes in a world with its own laws of physics (Overby & Jones, 2015). It is perhaps the best example of urban space created in a gaming environment by the players. Currently owned by Microsoft and available across multiple gaming platforms, as of April 2021 there were up to 139 million monthly active players with 238 copies of the game sold worldwide (Microsoft, 2021). The system has been compared to digital LEGO (Olmedo, 2013). The LEGO comparison is not just due to the block-based nature of Minecraft, but also a reference to its open-endedness (Hervé & Salge, 2021). Operating in a virtual space, the dimensions of Minecraft consist of over 3.6 billion square kilometres, or seven times the size of planet Earth (Milakovic, 2021).

These online virtual environments, or metaverses, operate in their own space, limited only by the physical

Figure 6. New York GIS data in the Unreal game engine via ArcGIS.

characteristics of the physical hardware they run on. Minecraft additionally crosses over into physical space via its Minecraft Earth iteration. Working via augmented reality, it links a real-world location to digital space to overlay information. Such overlaps fall into the genre defined by Ahlqvist et al. (2018) as GIS–multiplayer online games (GIS-MOG). These in addition fall within the remit of geogames—games with a spatial aspect. de Andrade et al. (2020) summarising the work of Yamu et al. (2019) define the characteristics of geogames as: (a) anchorage in a certain place, in which the game environment and spatial components can be represented and visualized; (b) focus on solving a spatial problem relevant to the citizens of the selected place; (c) inclusion of rules and elements of enjoyment to attract citizens to play and continue to return to the game; and (d) enabling the engagement and participation of citizens in an urban planning process.

Underlining the potential of Minecraft to build the urban mirror is the BuildTheEarth project, where over 210,000 people participated in one Minecraft mega-project (BuildTheEarth, 2020). Figure 7 illustrates New York City in Minecraft, illustrating the output of BuildTheEarth.

Minecraft is arguably the most used metaverse for urban planning, especially in developing countries, thanks to the work of the United Nations habitat programme Block by Block. The first workshop by Block by Block was held in 2021 in Nairobi after technical models and architectural drawings proved to be assessable and unengaging in local forums (Arnarsdóttir, 2020). Von Puttkamer (2020) notes that the rationale for using Minecraft is twofold: It is very appealing for younger generations, who can be included in urban topics and participatory processes via the game, and it is a very easy tool to use. The audience of Block by Block projects is very mixed and often consists of all age groups and different religions. Within 20 minutes, it is possible to teach even illiterate people to move blocks around in the game. It arguably allows the urban form to become accessible and proposed changes understandable and—perhaps more importantly—editable. Bjarke Ingels, a Danish architect, notes in Winston (2015) that these fictional worlds empower people with the tools to transform their own environments and that this is what architecture ought to be. As the side by side view of the community housing in Figure 8 and the work by Block by Block illustrates, Minecraft can be used successfully to create a twin of the physical world and allow it to be used for future planning. Compared to more traditional architectural models the worlds built in Minecraft are rough and blocky, giving an approximation of space and place. It is perhaps this approximation that makes it so successful: It focuses on the overall impression of the urban environment rather than the fine details. Block by block, Minecraft is building a digital mirror of the real world but in an abstract form; it is this form, along with its playful aspect, that has made it the most successful 3D platform for the built environment.

Location is the key factor across the multiple genres: As Ahlqvist et al. (2018) noted, in terms of GIS-MOG, location in the game is important in the same way that location is important in geography. Location in building the digital mirror is important, not only in terms of knowing where the "player," "avatar," or "user" are but equally in terms of representing the place and space in terms of points, lines, and pixels. It is this representation that is central to the building of the digital mirror.

Figure 7. BuildTheEarth New York City. Source: BuildTheEarth (2020).

Figure 8. Block by block mirroring community housing.

3. Multiple Mirrors

Digital twins, and with them the emerging metaverses, are being built piecemeal, in multiple pieces of software, visualised in multiple ways, and often replicated by multiple people at the same time. Each city around the world has multiple 3D models, developed either by municipalities, multinational companies, architects, local companies, academics, or simply interested individuals. Combined with these multiple representations are the multiple emerging platforms. The metaverse will potentially follow the growth of the World Wide Web, which grew rapidly by linking together individual hosted pages, which in terms of the metaverse will be the introduction of a "platform" linking together representations of place and space. Facebook (Meta) arguably have the view of a single platform, while games such as Minecraft exist in their own microcosm and individual examples exist in the current flow of open standards.

These environments are becoming graphically intensive; the technology is in place now whereas in 2002, with our early examples, it was niche. Worlds, metaverses, came, were occupied and then abandoned with early urban planning examples still existing somewhere in digital space, on a long-unused server. Yet, some of the largest global companies are now behind the next move into the metaverse, digital twins are being built, and the edge of the technical boundary in Figure 1 is arguably a decade away from a true, occupied digital mirror world. The blip on the horizon for urban planning may be simple economics, with the system cost out of representation or experimentation in these emerging spaces which are now increasingly driven by cryptocurrencies. However, with more than 160 incoming metaverses under development and digital planning finally gaining momentum, the use of game engines, avatars, collaborative design studios, and others may finally have reached its time and the current state of play we illustrated in Figure 1 will start to move towards the metaverse. What is needed to ensure this happens is a realisation from the practice of urban planning that digital technologies, game engines, and even background infrastructures such as cryptocurrencies need to become part of the planning curriculum. With this, the next generation of urban planners can lead the way into these emerging metaverses; without it, it will forever be playing catch up to technology and risks long term being a profession lost to the Digital Mirror rather than embracing it, in a similar point to where we started, back in 1997 and it turned out the World Wide Web was not just for nerds.

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Conflict of Interests

The author declares no conflict of interests.

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