

Article

Virtual Urbanism: A Conceptual Framework for Digital Urban Mediation

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Abstract

Virtual cities in video games have emerged as significant sites for the production and reinterpretation of contemporary urban imaginaries. By translating the complexity of real-world urban life into interactive and emotionally engaging environments, they offer new ways of experiencing and understanding cities. Despite their growing importance, research on virtual urbanism remains fragmented across disciplines and lacks a coherent conceptual foundation. Consequently, there is an urgent need for an integrative conceptual framework that explains how virtual cities mediate the production and transformation of urban knowledge. Drawing on an interdisciplinary synthesis of the literature from urban theory, media studies, and game design, this study identifies three key analytical dimensions (representation, abstraction, and spatial cognition) through which virtual urban experience is mediated, alongside urban rearticulation as a distinct process through which virtual urban experiences may be reinterpreted in relation to real urban thought and practice. These insights are integrated into the Virtual Urbanism Feedback Model (VUFM), a cyclical framework composed of three interconnected domains: Real to Virtual Inputs, Ludic Urban Transformations, and Virtual to Real Outputs. The model conceptualizes virtual cities as dynamic epistemic systems in which real and digital urban processes continuously interact through cycles of translation, reinterpretation, and feedback. The study contributes a unified conceptual framework for understanding digital urban mediation and highlights its implications for urban planning, urban design education, participatory planning, and the study of spatial experience in increasingly hybrid urban environments.

Keywords: virtual urbanism; digital urban mediation; digital cities; video games; urban imaginaries; urban planning



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1. Introduction: Rethinking Urban Experience in the Digital Age

Digital games have become one of the most influential cultural and technological media shaping contemporary urban imaginaries. Across genres, from open-world explorations to city-building simulations, virtual cities operate as arenas where architectural typologies, planning traditions, and infrastructural logics are reinterpreted through ludic and representational practices [1]. As gaming technologies advance and digital urbanization accelerates, scholars increasingly view these environments as mediators of urban knowledge, translating complex spatial and social systems into playable and emotionally engaging forms [2]. City-building games, in particular, have also been used as educational tools in geography and urban planning disciplines [3]. These developments raise a broader

question concerning how cities are represented, transformed, and cognitively experienced within digital environments. In this study, virtual urbanism refers to the interdisciplinary study of how cities are conceptualized, represented, and experienced within digital environments, particularly video games. It encompasses both the cultural meanings of urban form and their translation into interactive environments shaped by design, technological affordances, and player engagement.

This question connects to a long tradition in urban theory in which the city is understood not only as a material environment but also as a socially and imaginatively produced space. Çınar and Bender [4] argue that urban space is constituted through collective imaginaries, everyday practices, and cultural narratives that shape how cities are experienced, interpreted, and continually reproduced. Video games extend this relationship into digital environments by making urban space visible, explorable, and manipulable, while also raising questions of spatial power and inequality associated with Lefebvre's notion of the Right to the City [5]. The relationship between physical and digital urban experience is further evident in location-based and immersive environments: Sengupta et al. [6] show how location-based play in Ingress reshapes urban mobility and social interaction, while Bibri and Allam [7] frame the emerging metaverse as an extension of smart-city logic that raises questions of surveillance and datafication. Urban imaginaries can also operate as tacit governing devices that shape sociotechnical futures [8]. These perspectives position virtual cities within a broader continuum of digital urban mediation through which material space, urban imaginaries, digital technologies, and user experience increasingly intersect.

Building on these theoretical perspectives, scholars have examined how games translate urban complexity into navigable, affective, and interactive experiences. Esser [9] demonstrates how *Assassin's Creed: Syndicate* reimagines Victorian London as a heterotopic reconstruction of urban memory, while García [10] traces archetypal spatial forms, including the center, labyrinth, and threshold, from ancient cities to digital architectures such as *Age of Empires III* and *BioShock Infinite*. These studies illustrate different manifestations of digital urban mediation without constituting separate analytical categories, showing how urban forms and imaginaries are represented and reinterpreted through virtual design and user experience.

Despite increasing scholarly attention, research on virtual urbanism remains fragmented across three analytical strands: representational, procedural, and cognitive. Studies of representation analyze how games reconstruct or stylize real cities [1], whereas studies of abstraction focus on the translation of governance and infrastructure into simplified procedural mechanics [11]. A smaller body of work addresses cognitive and pedagogical dimensions, exploring how games foster spatial reasoning and systems thinking [3]. However, these strands rarely intersect, resulting in conceptual silos that limit theoretical coherence. Few studies link visual or representational design to cognitive interpretation or examine how procedural simplification shapes broader urban imaginaries. These representational, procedural, and cognitive strands are treated here as complementary processes of digital urban mediation and not as separate domains of the proposed model. Their integration provides the conceptual basis for examining how urban knowledge is mediated between real and virtual environments through real-world inputs, ludic transformation, and the interpretation and potential real-world implications of virtual urban experience.

This fragmentation reveals three related gaps in the literature. First, while many studies describe how games depict cities, few relate these depictions to theories of form, memory, or power [9,10]. Second, limited work theorizes how ludic systems translate urban complexity into game logic [5]. Third, little synthesis exists on how engagement with virtual cities influences players' cognitive and affective understandings of real urban life [2]. These gaps reflect a common problem of digital urban mediation: how urban knowledge

enters virtual environments, how it is transformed through game design, and how virtual urban experiences are subsequently interpreted in relation to real urban life.

These limitations extend beyond theoretical fragmentation. As game-based simulations, digital twins, immersive visualization, and virtual participation become increasingly relevant to urban planning and urban design, the absence of an integrated conceptual framework constrains understanding of how virtual environments shape planning knowledge, spatial decision-making, and public engagement. These developments demonstrate the growing practical relevance of digital urban mediation across emerging planning contexts. Addressing this gap is therefore important not only for advancing virtual urbanism as a field of inquiry but also for informing the broader digital transformation of planning research and practice.

This study addresses these gaps through an integrative analytical synthesis of the interdisciplinary literature spanning urban theory, game studies, and digital media. It critically examines how virtual cities are represented, abstracted, and cognitively experienced across different genres and historical periods, synthesizing key interdisciplinary scholarship from the past two decades to identify recurring conceptual patterns. Building on these insights, the study develops the Virtual Urbanism Feedback Model (VUFM): a framework that explains how real urban logics inform game design, how they are transformed through representational and procedural mechanisms, and how players' experiences in virtual environments reshape their perceptions of real urban life. The analysis is guided by three central research questions: (1) how cities are represented and symbolically constructed in games; (2) how design abstractions transform urban complexity for playability; and (3) how cognitive and affective engagement in virtual cities influences understandings of real urbanism. These questions examine complementary processes of digital urban mediation—representation, abstraction, and cognitive-affective engagement—whose conceptual integration informs the broader feedback architecture formalized in the VUFM as Real-to-Virtual Inputs, Ludic Urban Transformations, and Virtual-to-Real Outputs.

The study contributes to advancing a more integrated and theoretically grounded understanding of virtual urbanism by synthesizing fragmented scholarship across design, cognition, media, and urban theory and by introducing the VUFM to conceptualize the bidirectional relationship between real and virtual urban environments. The framework integrates representational, ludic, and cognitive processes to explain how real urban logics shape digital design and how virtual experiences, in turn, influence perceptions of real cities. These contributions position virtual cities as socio-technical systems and legitimate objects of urban inquiry with implications for identity, infrastructure, and spatial justice. More broadly, the study provides a conceptual basis for examining the growing role of virtual urban environments in urban planning, urban design, and digital participation research, as well as for understanding how emerging digital technologies may further intensify feedback between real and virtual urban domains.

2. Virtual Urbanism and Digital Urban Mediation

This section establishes the conceptual foundation of the study through three inter-related dimensions. It begins by defining virtual urbanism as an interdisciplinary field linking digital environments and urban theory, and then examines how urban space is perceived and represented through cognitive, user-experience, and cultural frameworks, including the relationship between virtual and physical spatial experience. Finally, it explores how urban complexity and political dynamics are transformed in digital environments, establishing a theoretical basis for the feedback structure later formalized in the VUFM.

Building on research in virtual heritage and digital reconstruction [1], advances in computational power have enabled increasingly complex and data-driven urban simula-

tions, through which digital cities have evolved from static representations into navigable and modifiable environments [2]. Unlike digital twins or high-fidelity simulations, these environments are not constrained by strict realism but are shaped by artistic intent, technological affordances, and gameplay logic [12]. The scope of virtual urbanism also extends to virtual and augmented reality, where the boundaries between digital and physical space become increasingly blurred, transforming the city into a participatory environment for spatial experimentation [6,7].

This perspective builds on earlier urban theory that conceptualizes the city not only as a material entity but also as an imagined and cognitive construct. Çınar and Bender [4] argue that cities are constituted through collective imaginaries and shared urban experience, a perspective that extends to digital environments where spatial meaning is actively constructed through interaction. Video games operationalize this idea by allowing players to inhabit and reshape urban forms, merging representation with participation. Within this context, three complementary processes explain how virtual cities mediate urban knowledge. Simulation models systemic processes such as traffic or zoning through interactive systems. Representation reinterprets historical and cultural forms through narrative and visual design. Abstraction simplifies complexity into procedural rules that support engagement and playability [11,13]. These processes demonstrate how urban logic is translated into playable and meaningful experiences. Play has also been examined as a dimension of urban experience in physical public space. Stevens [14] explores how people engage with urban spaces through playful practices that can extend beyond their prescribed functions. Although this account focuses on material public space and does not directly address virtual environments, it broadens the theoretical discussion of the relationship between play and urban experience.

The convergence between virtual and physical space further broadens the notion of urbanism. Location-based and augmented reality games such as Ingress and Pokémon GO merge real and digital spatiality, reshaping mobility, sociability, and perception [6]. Similarly, the emerging Metaverse has been described as an extension of smart-city logic, embedding data-driven governance into everyday life [7]. These developments suggest that both real and virtual cities function as socio-technical systems that are simultaneously material and imagined, requiring new frameworks to understand how urban experience is produced across hybrid environments.

Related approaches have examined the interconnection between physical and digital urban environments from different perspectives. Research on digitally mediated public space has conceptualized urban environments through interacting physical, digital, and human layers, including projects developed by the MIT Senseable City Lab that use digital technologies to mediate interactions between people and urban space [15]. Similarly, the CyberParks framework conceptualizes public open spaces as hybrid environments in which physical space, digital technologies, and human experience are increasingly intertwined [16]. More directly within game-based urban applications, Wang and Vu [17] integrate digital-twin and serious-game approaches to support virtual urban exploration, social interaction, and planning. These approaches establish a broader context for physical–digital urban mediation. Within this context, the VUFM developed in this study focuses specifically on how urban knowledge and experience circulate between physical and game-based virtual environments through real-world inputs, ludic transformations, and potential virtual-to-real outputs.

Understanding how these environments are experienced requires engagement with theories of spatial perception and cognitive mapping. Kevin Lynch's concept of legibility explains how urban elements such as landmarks, paths, edges, districts, and nodes contribute to the formation of coherent mental images of the city [18]. This perspective

remains relevant to virtual environments, where spatial understanding similarly develops through navigation, recognition, and interaction with environmental cues [13,19]. Video games often selectively amplify landmarks, spatial hierarchies, routes, and other orienting features to support navigation and gameplay, potentially producing environments that are more explicitly legible than their real-world counterparts. Spatial cognition in virtual cities therefore emerges not only from the represented urban form itself but also from the interaction between environmental design and the player's processes of orientation, navigation, and cognitive mapping.

This interaction introduces an important user-experience dimension to virtual urbanism. Research on gaming and virtual environments indicates that engagement with digital environments can involve perceptual, attentional, and learning processes associated with spatial cognition [20]. Studies of virtual navigation further suggest that spatial learning and navigation performance may vary with users' prior gaming experience, with more experienced gamers employing more effective search strategies in virtual environments [21]. More recent studies of game-based navigation further demonstrate differences in how users interpret spatial situations and engage with navigational aids such as maps and mini-maps, with prior gaming experience associated with differences in visual strategies and spatial interpretation [22,23]. These findings shift attention from the virtual city as a designed spatial representation to the player as an active interpreter of that environment. From this perspective, spatial cognition is produced relationally through the interaction of virtual spatial structure, interface, navigational cues, and user experience. This provides a stronger basis for understanding how engagement with virtual cities can contribute to spatial learning and meaning-making without assuming that such effects occur uniformly across users.

The relationship between user experience and spatial cognition also extends across the boundary between virtual and physical environments. Rather than treating virtual and physical environments as entirely separate domains, theories of virtuality have conceptualized virtual worlds as different but interconnected planes of reality, with digital virtuality understood as an aspect of the real [24]. This relationship is particularly relevant to mixed and augmented environments, where user experience emerges through interaction with both virtual information and physical surroundings. Research comparing spatial perception in 3D geovisualizations and corresponding real-world settings demonstrates that spatial perception and wayfinding can differ between virtual and physical environments and that these differences may also vary according to user characteristics [25]. Mixed-reality research further emphasizes the importance of user-oriented evaluation, combining subjective measures of experience with behavioural measures such as gaze, movement, and task performance, while accounting for the interaction between virtual content and physical reality [26]. These perspectives suggest that the relationship between virtual and physical spatial experience is neither uniform nor purely representational, but is mediated by user characteristics, behaviour, interface conditions, and the degree to which digital and physical environments are integrated. This user-centred perspective is particularly important for understanding how perception and behaviour mediate the experience of spatial relationships across virtual and physical environments.

This cognitive dimension is closely linked to urban representation theory, which interprets virtual cities as cultural artifacts embedded in broader urban imaginaries. These imaginaries shape how identity, history, and power are constructed and communicated through spatial form [4,27]. Open-world games frequently reproduce dominant spatial logics while marginalizing alternative urban narratives, whereas historical reconstruction games negotiate between authenticity and storytelling to produce hybrid representations [1]. As Esser [9] demonstrates, environments such as the reimagined London in Assassin's

Creed: Syndicate simultaneously function as nostalgic reconstructions and critical reinterpretations. In this sense, virtual cities operate as mediating platforms through which collective memory and urban meaning are continuously reconfigured.

In contrast to these representational and cognitive dimensions, urban complexity theory highlights the structural differences between real and virtual cities. Real urban systems are characterized by nonlinearity and emergent behavior that resist complete modeling [28], functioning as dynamic networks shaped by local interactions. Digital environments, however, necessarily simplify these dynamics to ensure playability, translating complex processes into procedural systems that simulate density, mobility, and economic activity [29]. While these systems are designed for gameplay efficiency [13], they also embed implicit assumptions that prioritize order, control, and optimization [5]. Despite this, players actively interpret and engage with these systems. Studies show that gameplay can foster reflection on issues such as congestion and sustainability, suggesting that simplified models can still support systems thinking and critical awareness [2].

These dynamics point to a broader tension between the logics of game design and the principles of urban design. Game environments prioritize clarity, efficiency, and player agency, whereas urban design engages with complexity, uncertainty, and socio-spatial diversity. This divergence reveals the political dimension of virtual urbanism. Digital environments are not neutral representations but are shaped by ideological assumptions embedded in their design. Analyses of open-world games such as Red Dead Redemption 2 describe them as contested spatial systems structured by commodification and exclusion, where players are positioned in relation to broader urban power dynamics [5]. At the same time, participatory simulations offer alternative models by enabling civic engagement and collaborative decision-making through interactive visualization [30]. Virtual cities therefore operate as both instruments of control and spaces for experimentation.

Building on these theoretical perspectives, recent scholarship conceptualizes the relationship between real and virtual cities as a continuous feedback process. In the Real-to-Virtual direction, designers draw on architectural forms, spatial patterns, and cultural narratives to construct immersive environments that balance realism and playability [1,13]. In the Virtual-to-Real direction, player experiences may contribute to how individuals perceive, evaluate, and imagine real urban environments. Research suggests that interactive engagement can support spatial understanding and encourage critical reflection on planning processes and urban systems [2,31]. Increasingly, planners employ game-based tools and digital simulations to support participatory design and civic learning [32,33]. These developments indicate that virtual urbanism is becoming increasingly relevant not only to urban theory but also to urban planning and urban design, where digital environments are emerging as complementary spaces for experimentation, communication, and participatory decision-making.

As a result, virtual cities should not be understood as isolated representations but as integral components of an ongoing exchange between material and digital urbanism. Real-world forms and logics are continuously reinterpreted in digital environments, while virtual experiences reshape collective understandings of urban life. This recursive relationship forms the conceptual foundation for the VUFM, which explains how urban knowledge circulates between physical and virtual domains through digital urban mediation.

3. Analytical Approach

This study adopts a conceptual research design that combines theory synthesis and model development to construct a theoretical framework explaining how virtual cities mediate, transform, and rearticulate urban knowledge. Consistent with Jaakkola's [34] framework for conceptual research, the study emphasizes theory building through the

integration and reinterpretation of interdisciplinary scholarship, without aiming for the comprehensive identification or quantitative synthesis of existing studies. Accordingly, the objective is not to systematically review the literature or evaluate empirical evidence, but to develop a theoretically grounded conceptual explanation by integrating complementary theoretical perspectives from urban studies, media studies, game studies, geography, and digital sociology that are relevant to virtual urbanism. This research design is particularly appropriate for virtual urbanism, an emerging interdisciplinary field in which relevant knowledge remains conceptually dispersed across multiple research traditions.

Within this research design, the different literature streams perform complementary roles. The literature on urban studies, virtual urbanism, and digital urban technologies provides the substantive domain knowledge, whereas perspectives from media studies, game studies, geography, and digital sociology serve as analytical lenses for organizing, interpreting, and integrating the focal phenomenon into a coherent conceptual framework. The selected literature was chosen according to its conceptual relevance and explanatory value for understanding how virtual environments represent, reinterpret, and reshape urban processes across disciplinary boundaries, without aiming for exhaustive coverage, consistent with recommendations for conceptual theory development and integration [34,35].

The conceptual research design was implemented through three iterative stages: conceptual exploration, conceptual synthesis, and theoretical integration. During the exploration stage, the influential literature was examined to establish the conceptual foundations of virtual urbanism and to identify the principal theoretical perspectives informing the relationships between physical cities, digital environments, and human spatial experience. The second stage involved conceptual synthesis, in which the selected literature was subjected to iterative interpretive analysis to identify recurring conceptual relationships and theoretical convergences. The analysis was guided by the three research questions introduced in Section 1: (1) how cities are represented and symbolically constructed in games; (2) how design abstractions transform urban complexity for playability; and (3) how cognitive and affective engagement in virtual cities influences understandings of real urbanism. Through continuous comparison across theoretical perspectives, three recurring analytical dimensions (representation, abstraction, and spatial cognition) emerged as the principal mechanisms through which virtual urban experience is mediated. Urban rearticulation was subsequently identified as a related but distinct process concerning how virtual urban experiences may be reinterpreted in relation to real urban thought and practice.

These analytical dimensions, together with the distinct process of urban rearticulation, subsequently informed the conceptual development of the model. The final stage focused on theoretical integration. Through iterative conceptual mapping and conceptual integration, these elements were organized into a coherent explanatory structure describing the circulation of urban knowledge between physical and virtual environments. This process resulted in the development of the VUFM, comprising three interconnected domains: Real-to-Virtual Inputs, Ludic Urban Transformations, and Virtual-to-Real Outputs. The VUFM serves as a theoretical architecture that synthesizes existing knowledge into an integrated explanation of digital urban mediation, without functioning as a predictive or empirically derived model.

This conceptual research design is particularly appropriate for the study of virtual urbanism for three reasons. First, the field remains theoretically fragmented, with complementary perspectives on representation, spatial cognition, digital mediation, and urban experience often developing independently. Theory synthesis provides a means of integrating these perspectives into a coherent conceptual understanding. Second, because the study seeks theoretical advancement without undertaking empirical validation, conceptual integration enables the development of new relationships across disciplinary boundaries.

Finally, model development facilitates the organization of these relationships into a coherent theoretical framework capable of explaining the iterative exchange of urban knowledge between physical and virtual environments.

4. Mediating Urban Experience: Analytical Dimensions and Urban Rearticulation

The thematic synthesis identifies three closely related analytical dimensions through which virtual urban experience is mediated: representation, abstraction, and spatial cognition. Representation concerns how urban forms and meanings are reconstructed in digital environments; abstraction addresses how urban complexity is translated into playable systems; and spatial cognition concerns how these environments are interpreted and learned through user interaction. Urban rearticulation is considered subsequently as a related but distinct process through which virtual urban experiences may be reinterpreted in relation to real urban thought and practice. These three dimensions, together with the distinct process of urban rearticulation, provide the analytical synthesis from which the broader VUFM is developed. Feedback is not treated as an additional analytical process, but as an emergent property of the broader cyclical relationship formalized in the VUFM.

4.1. Analytical Dimensions

4.1.1. Representation: How Are Cities Reimagined in Digital Form?

Representation forms the aesthetic and symbolic foundation of virtual urbanism because virtual cities are not neutral reproductions of physical environments but culturally constructed urban imaginaries. Cities are continually represented, interpreted, and reimagined through symbolic, visual, and digital practices, extending beyond their existence as material entities—a process that has become increasingly prominent in the age of digital culture [4,27]. Scholars examine how developers reconstruct, stylize, or invent cityscapes that evoke architectural familiarity while supporting narrative and play. The most typical and intuitive case is the restoration of a historical town as the primary stage of a game. *Assassin's Creed II* and *Assassin's Creed Unity* employ cartographic and architectural data to recreate cities like Florence and Paris, balancing historical authenticity with narrative and mechanical functionality [13]. *Assassin's Creed: Syndicate*, for instance, transforms Victorian London into a heterotopic reconstruction that both romanticizes and critiques industrial modernity [9]. These virtual reconstructions operate as historical urban imaginaries, reinterpreting the past through interactive and playable forms of representation.

Further, speculative or dystopian worlds, from *Deus Ex* to *Cyberpunk 2077*, extend this representational logic by visualizing crises of urbanization, surveillance, and social fragmentation. These digital cities exaggerate real spatial tensions to dramatize the contradictions of contemporary urbanism. Marji et al. [36] describe such environments as “fantastical cities,” translating collective hopes and fears into experiential and navigable form. Across both historical and imagined settings, developers employ techniques of imageability (Lynch, 1960) [18] by amplifying landmarks, spatial hierarchies, and atmospheric cues to ensure coherence and recognition. Even entirely fictional geographies draw upon cultural references; for instance, *Genshin Impact*'s Inazuma reassembles Japanese architectural motifs and elements of the game's main storyline into a stylized yet resonant urban identity, illustrating the design logic discussed by Shi et al. (2024) [13].

Ultimately, representation in virtual urbanism is not imitation but interpretation. It translates architectural and cultural meaning into affective space, turning the digital city into a narrative artifact that encodes memory, identity, and ideology. These reconstructions reveal what societies choose to remember, beautify, or critique, positioning virtual environments as mirrors of cultural consciousness and instruments of urban imagination.

4.1.2. Abstraction: How Is Urban Complexity Simplified for Play?

Abstraction constitutes the procedural core of virtual city-making. To create coherent and playable systems, developers translate complex urban dynamics into simplified, rule-based mechanics. City-building simulations such as SimCity reduce urban governance to quantifiable processes of zoning, transportation, and resource management [11]. These designs cast the player as an omniscient planner, enacting instant change, an idealized inversion of real-world bureaucratic negotiation. Denham and Spokes [5] argue that open-world games reproduce neoliberal ideals of optimization and control, framing urban space primarily as a site of technical management while limiting the role of political negotiation.

More specifically, abstraction first appears through geometric and functional simplification driven by playability and cognitive constraints. Virtual environments selectively reduce and reorganize the full multi-scale complexity of real cities into legible and manageable spatial patterns. Shi et al. [37] demonstrated that virtual cities exhibit spatial distribution heterogeneity, but in a simplified and compressed manner compared to real urban environments, reflecting both designers' cognitive frameworks and technical limitations. This process results in environments that privilege clarity, navigability, and interaction over comprehensive realism, transforming urban complexity into playable spatial systems.

These procedural abstractions also embed epistemological assumptions about what constitutes an orderly or "successful" city. This process can also be understood through the lens of procedural rhetoric [38], which argues that video games communicate meaning through their rules, mechanics, and procedural structures rather than through explicit narratives alone. Accordingly, abstraction is not merely a technical strategy for making cities playable; it also embeds assumptions about how cities function, which planning priorities are privileged, and what constitutes effective urban governance. As a result, virtual cities can reinforce particular urban imaginaries while marginalizing alternative social and political interpretations. Environmental dynamics follow the same logic: pollution, energy use, and sustainability are reduced to linear variables that equate ecological well-being with managerial performance [29]. Consequently, environmental issues become primarily strategic concerns, with their ethical dimensions receiving less emphasis.

This selectivity also raises cultural and geographical questions. The processes of selection and subtraction through which real urban complexity is translated into playable environments determine which spatial elements are retained, simplified, or omitted [12]. Such abstraction is not necessarily culturally neutral. Rossi [39], for example, shows how representations of Latin American cities in video games can rely on selective, generalized, and stereotypical spatial imagery, homogenizing culturally specific urban characteristics. These representational concerns intersect with broader asymmetries in game production: research on Chilean developers indicates that peripheral game production can remain strongly influenced by cultural tropes, themes, and conventions associated with core game markets [40]. From the perspective of the VUFM, these patterns suggest that culturally specific or less dominant urban imaginaries may become simplified or less visible as urban environments are translated into playable representations.

Second, social and political abstraction extends beyond geometric and functional simplification to the level of urban imaginaries and governance. Dominant urban visions often give limited attention to conflict, inequality, or displacement, instead reframing cities through technocratic and future-oriented narratives that prioritize efficiency, optimization, and measurable progress. Sepehr and Felt [8] demonstrate how urban imaginaries embedded in smart city policies function as tacit governance devices, shaping urban futures while marginalizing citizen participation and obscuring underlying power relations. Similarly, Soaita and Popescu [41] show that urban imaginaries operate as discursive and affective constructions that can legitimize certain development trajectories while silencing alterna-

tive or marginalized urban experiences. In this sense, abstraction restructures political meaning, transforming contested urban realities into seemingly neutral visions of progress and development. Bibri and Allam [7] further warn that such “algorithmic urbanism” can replicate surveillance-oriented governance models, mirroring ethical tensions in smart city and Metaverse debates.

Abstraction thus serves as both an enabler and a filter: it makes urban complexity playable while revealing the ideological frameworks underlying digital design. It operates as an epistemic mechanism that determines which aspects of the city are rendered visible, manageable, or expendable within the logic of play, extending the function of abstraction beyond simple reduction.

4.1.3. Spatial Cognition: How Do Players Learn and Navigate Urban Systems?

Spatial cognition concerns how players learn, interpret, and navigate virtual urban environments through repeated interaction with spatial structures, navigational cues, and game systems. As established in Section 2, this process is not determined by the designed environment alone; it also varies with user experience and navigational behaviour. Research on virtual navigation indicates that greater gaming experience is associated with differences in spatial learning and navigation performance, with more experienced gamers employing more effective search strategies in virtual environments [21]. Studies of game maps and mini-maps further show that users differ in how they interpret spatial situations and engage with navigational information, with prior gaming experience associated with differences in visual strategies and spatial interpretation [22,23]. Within virtual urban environments, spatial cognition can therefore be understood as an interactive process through which players construct spatial knowledge by interpreting environmental cues, navigating represented spaces, and adapting their behaviour through experience.

Beyond orientation and navigation, virtual urban environments can also support learning about the systemic relationships that structure cities. Virtual simulations and sandbox environments can provide interactive settings in which users explore, modify, and engage with representations of urban space and planning processes [30,42]. Through iterative interaction with variables such as traffic, infrastructure, environmental conditions, and resource allocation, players can encounter simplified representations of urban interdependencies. Research on city-simulation gaming communities further shows that players connect simulated urban issues with real-world planning contexts and their own lived experiences, contributing to how they recognize and interpret planning issues [2]. Spatial cognition within the VUFM therefore extends beyond wayfinding to include the interpretation of relationships between spatial decisions and systemic outcomes. As players iteratively adjust their strategies in response to in-game feedback, they can develop an understanding of the abstract urban principles represented through the game’s mechanics [3].

At the same time, such learning remains conditioned by the abstractions and assumptions embedded in game systems. City-building games can introduce players to urban systems while constraining their understanding through developers’ assumptions about how cities function and should be organized [43]. Optimization-driven mechanics may foreground efficiency, control, and technical problem-solving, while participatory or collaborative forms of play can expose users to alternative ways of engaging with urban space. Spatial cognition in virtual cities should therefore not be understood as a uniform or neutral learning outcome. Rather, it operates across perceptual and systemic levels and is mediated by player experience, navigational practices, and the representational and procedural structures of the game. Within the VUFM, this makes spatial cognition a key process through which abstracted urban systems become interpreted through user interaction, while also recognizing that the resulting understandings may differ across players and virtual environments.

4.2. Urban Rearticulation: How Do Virtual Cities Reshape Real Urban Thought and Practice?

Virtual experiences influence real-world perception, learning, and engagement. Gameplay shapes expectations about urban mobility and spatial experience [31], while simulation platforms promote systems thinking and collaborative understanding of urban processes in both professional and civic contexts [2,32,33]. Discussions among Cities: Skylines players often echo genuine planning concerns, such as traffic and density, illustrating how virtual play contributes to civic imagination.

Municipalities increasingly integrate these platforms into participatory workshops, using games to visualize development alternatives and foster dialogue [44]. However, the use of simplified and model-driven environments also entails limitations. Such platforms may generate overly technocratic or optimistic representations of urban processes, potentially obscuring social conflict and structural inequalities inherent in real cities. Ethical tensions therefore persist: the same participatory tools that enable engagement may also function as infrastructures of surveillance, data extraction, or governance by optimization [7]. This ambivalence, between democratization and control, captures a central paradox of digital urbanism. Through this reciprocal process, virtual cities emerge as both mirrors and engines of urban imagination: they reinterpret architectural knowledge, redistribute planning ideas, and reshape civic perception, demonstrating that the boundary between play and practice is increasingly porous.

The three analytical dimensions, alongside the distinct process of urban rearticulation, present virtual urbanism as a hybrid epistemology that connects representation and abstraction with cognition and the subsequent reinterpretation of virtual urban experience in relation to real-world discourse and practice. Virtual cities encode cultural memory, transform spatial logic into procedural knowledge, and enable these understandings to circulate across digital and physical urban contexts. This synthesis underpins the VUFM developed in the following section and prepares the ground for the final discussion, which considers the broader theoretical and practical implications of virtual urban mediation in shaping the future of urban thought.

5. Conceptual Framework: The Virtual Urbanism Feedback Model (VUFM)

The synthesis of the reviewed literature revealed that virtual cities operate not as static digital artifacts but as dynamic epistemic systems in which urban meaning circulates continuously between material and virtual domains. The VUFM conceptualizes this process through three interdependent domains, Real-to-Virtual Inputs, Ludic Urban Transformations, and Virtual-to-Real Outputs, which together form a feedback loop linking material urban form, digital mediation, and human cognition (see Figure 1). The model functions as an interpretive scaffold for understanding how virtual and real cities co-evolve through representational, procedural, and cognitive exchanges, without seeking to predict outcomes.

Figure 1 illustrates the VUFM as a three-domain circular framework representing the cyclical exchange of meaning between real and virtual urban contexts. Together, the three domains integrate the three analytical dimensions identified in the preceding synthesis, representation, abstraction, and spatial cognition, while incorporating urban rearticulation as a distinct process through which virtual urban experiences are related back to real urban thought and practice. The inner loop presents a directional flow of influence, progressing from Real-to-Virtual Inputs through Ludic Urban Transformations to Virtual-to-Real Outputs. The outer loop, in turn, elaborates this process by illustrating the continuous circulation of urban ideas as they are imagined, played, and reimagined. Each domain is color-coded to highlight its distinct yet interconnected function: the yellow

section represents Real-to-Virtual Inputs; the pink section corresponds to Ludic Urban Transformations; and the blue section denotes Virtual-to-Real Outputs.

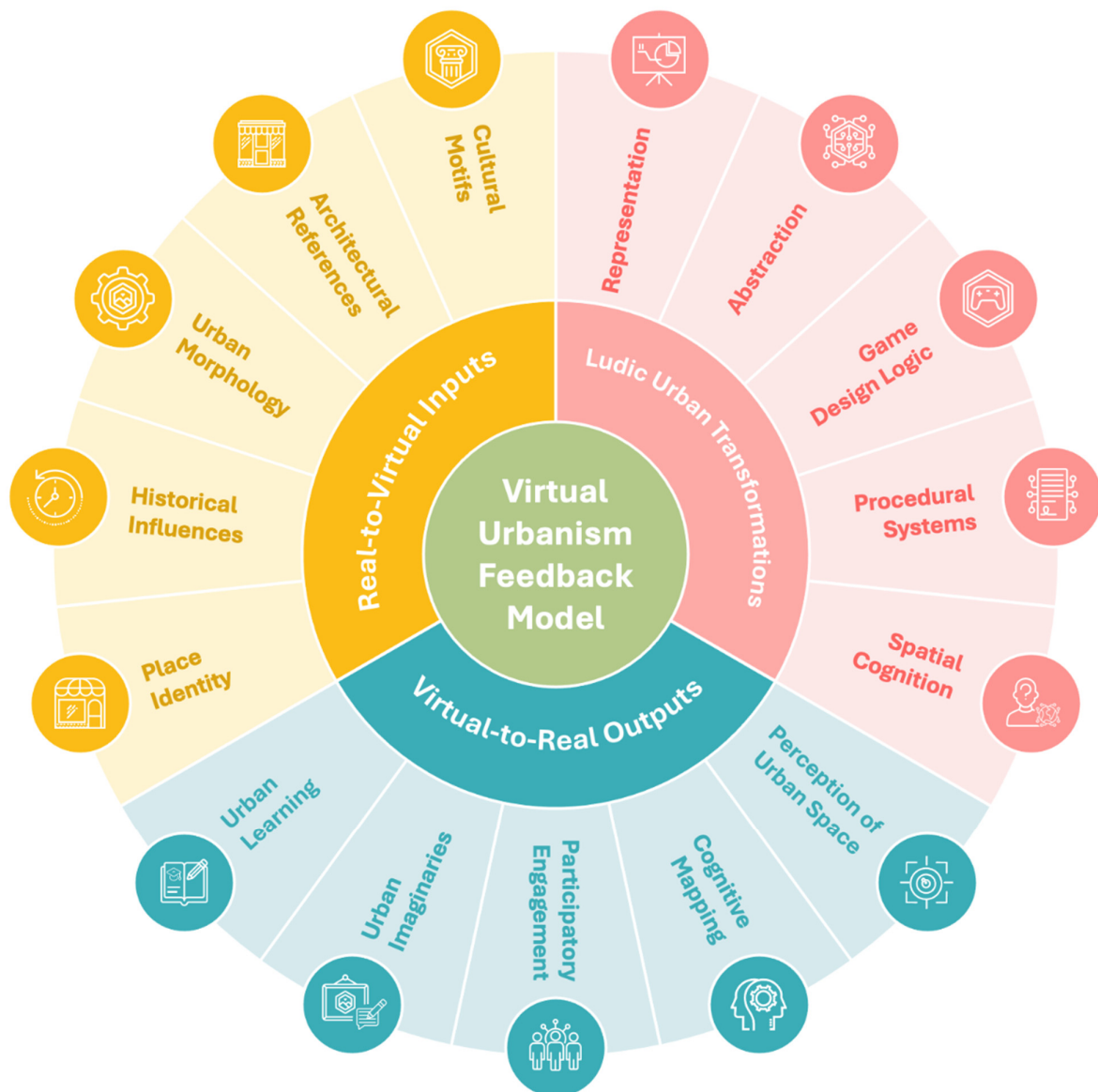


Figure 1. The Virtual Urbanism Feedback Model (VUFM).

The Real-to-Virtual Inputs domain (in yellow) represents how the material, cultural, and symbolic dimensions of real cities inspire the design of their virtual counterparts. Virtual cities never emerge in isolation; they reinterpret urban references drawn from tangible sources such as architecture, morphology, and topography, as well as intangible elements like collective memory and cultural identity. Developers and environmental artists synthesize these dimensions to create environments that are simultaneously recognizable and imaginative [1]. Historical titles such as *Assassin's Creed II* and *Assassin's Creed Unity* demonstrate how real urban forms are reconfigured into playable environments that balance historical reference with narrative coherence and gameplay demands. As Shi et al. [13] argues, this process involves compressing and reorganizing urban complexity into legible spatial systems shaped by aesthetic intention and procedural logic, producing environments that feel authentic without reproducing cities in a documentary sense. Cultural motifs further reinforce this translation between the real and the virtual, embedding architectural symbolism and local identity into digital form. As Shi et al. [13] demonstrate, *Genshin*

Impact's virtual cities synthesize real-world architectural and cultural logics, blending traditions, symbolism, and historical aesthetics to create stylized yet emotionally resonant urban settings. These examples suggest that authenticity in virtual city-making arises less from literal replication than from cultural and affective coherence. The Real-to-Virtual domain therefore bridges the material and the imagined, illustrating how accumulated urban knowledge, through architecture, planning, and collective memory, flows into the digital sphere and is recomposed as a new form of cultural and spatial expression.

The Ludic Urban Transformations domain (in pink) represents the procedural and cognitive core of the model. It explains how real urban references are reconfigured through representation, abstraction, game design logic, and procedural systems into playable and meaningful environments. At this stage, the city becomes both a narrative space and a rule-based system, where the complexity of urban life is translated into interactive and procedural form. Representation concerns how visual design and atmosphere reconstruct recognizable spatial cues and identities [27], while abstraction simplifies social and infrastructural processes into coherent gameplay mechanics [11]. Game design logic mediates the balance between realism and playability, determining how players engage with and interpret the city. Through this interplay, game systems generate a playable epistemology, a way of knowing the city through procedural engagement and experimentation. Spatial cognition emerges as players navigate, memorize, and internalize virtual forms, echoing more recent research on spatial learning in virtual environments [19]. Procedural systems further govern how urban dynamics such as density, mobility, and environmental change unfold algorithmically within these worlds. These mechanisms reflect what Shi et al. [13] describe as an emerging form of playable cities, in which urban knowledge becomes interactive, procedural, and experientially accessible through game-based environments. Ultimately, this domain positions the virtual city as a cognitive and experimental laboratory for testing urban ideas and exploring spatial possibility. Within the VUFM, feedback is conceptualized as an emergent property of the complete cycle and not as an isolated internal component. Feedback arises from the continuous interaction among Real-to-Virtual Inputs, Ludic Urban Transformations, and Virtual-to-Real Outputs and does not constitute a separate stage within the model.

The Virtual-to-Real Outputs domain (in blue) completes the feedback loop by illustrating how experiences in virtual environments shape real-world urban perception, learning, and participation. These outputs encompass five interrelated dimensions: cognitive mapping, perception of urban space, urban learning, urban imaginaries, and participatory engagement. Through gameplay, players construct mental models of urban systems, developing intuitive understanding of land use, mobility, and environmental interdependence. City-building and open-world games cultivate systems thinking, fostering a form of planning literacy that helps even non-specialists grasp the consequences of spatial and policy decisions. Affective immersion further amplifies this process: through visual storytelling and spatial exploration, players form emotional attachments to density, diversity, and urban life. Studies such as Chisik et al. [31] show that playful engagement with urban environments enhances people's awareness of spatial and social dynamics, encouraging them to reimagine how cities could be experienced and designed. These affective encounters feed into evolving urban imaginaries, extending the influence of gameplay beyond the screen.

At the collective level, virtual environments increasingly serve as participatory and educational tools. Municipalities and planning institutions employ simulation games such as Cities: Skylines to facilitate collaborative design and scenario exploration [2], building on earlier research demonstrating the value of gamified participatory tools for co-design and collective urban learning [32,33,44]. Such applications bridge expert and public perspectives, transforming entertainment platforms into instruments of civic engagement and

shared urban learning. Through these cognitive, affective, and participatory mechanisms, the Virtual-to-Real Outputs domain demonstrates that virtual cities are not passive reflections but active agents in shaping urban knowledge and imagination. By completing the feedback loop, this domain underscores the reciprocal nature of virtual urbanism: the city imagined in code becomes a lens through which the city of concrete and steel is newly perceived and understood.

These three domains form a continuous and relational cycle of urban mediation. Real cities supply the symbolic and material resources that inform virtual construction; digital design transforms these inputs into procedural and experiential form; and virtual engagement feeds back into real-world perception, discourse, and policy. The VUFM thus positions virtual urbanism as a co-evolutionary system where material form, digital abstraction, and human imagination continuously interact. By reframing abstraction not as reduction but as translation, the model reveals how digital mediation both simplifies and illuminates the cultural and epistemic assumptions embedded in urban thought. Ultimately, the VUFM offers a theoretical architecture for interpreting the cyclical production of urban knowledge across physical and virtual domains. By integrating the insights synthesized throughout this study into a unified conceptual framework, the model explains how urban knowledge is produced, transformed, and recirculated between real and virtual environments. The VUFM conceptualizes virtual cities as active epistemic environments, extending their role beyond secondary representations of urban reality, through which digital experiences continuously inform and reshape urban thought, perception, and practice.

6. Discussion and Conclusions: Future Urbanism in the Age of Simulation

The synthesis presented through the VUFM demonstrates that virtual cities in video games operate as complex epistemic and cultural systems that mediate how societies imagine, represent, and engage with urban life. The model organizes this mediation through three interdependent domains: Real-to-Virtual Inputs, Ludic Urban Transformations, and Virtual-to-Real Outputs. These domains explain how material, cultural, and symbolic dimensions of real cities inform virtual environments, how these inputs are transformed through ludic, procedural, and cognitive mechanisms, and how virtual experiences subsequently shape urban perception, learning, imaginaries, and participation. This cyclical structure reframes virtual environments as dynamic mediators of urban knowledge, moving beyond their conception as passive simulations, and provides the basis for discussing the theoretical implications of each domain.

Within the broader literature on physical–digital urban relations, the VUFM complements approaches concerned with digitally mediated public space and physical–digital integration [15,16], as well as applied frameworks combining digital twins and serious games for urban exploration and planning [17]. While these approaches address different forms of interaction between physical and digital urban environments, the VUFM focuses specifically on the mediation of urban knowledge and experience through game-based virtual cities. Its contribution lies in organizing this process as a conceptual feedback structure in which real urban inputs undergo ludic transformation and virtual urban experiences may subsequently inform perceptions and understandings of real urban space.

The Real-to-Virtual Inputs domain highlights that virtual cities are grounded in existing material, cultural, and symbolic understandings of urban space. Architectural references, urban morphology, historical influences, cultural motifs, and place identity provide source materials through which recognizable urban meanings enter digital environments. Their translation into virtual form, however, does not depend on literal replication. Instead, these references are selectively recomposed to balance cultural and spatial coherence with

the demands of digital design [1,13]. This positions virtual city-making as a process through which accumulated urban knowledge is translated into the digital sphere before being further transformed through ludic mechanisms.

Within Ludic Urban Transformations, representation operates as an interpretive, non-mimetic process. Game-based digital environments selectively visualize and symbolically reconstruct cities instead of reproducing them as neutral or comprehensive models, thereby shaping how urban space is imagined and perceived. From the perspective of urban imaginary theory, digital culture contributes to the fragmentation, layering, and circulation of collective representations of the city, transforming urban space into a mediated and imaginative construct [27]. In this sense, virtuality itself functions as a legitimate mode of urban mediation, reconfiguring how urban form, spatial meaning, and lived experience are understood beyond material authenticity. At an experiential level, symbolic design and narrative framing enable virtual cities to function as sites where collective memory and identity are actively reworked. Through play, historical and speculative urban forms become laboratories of cultural imagination, allowing urban experience to be translated across temporal and spatial scales and expanding the conceptual boundaries of what constitutes “the city.”

Abstraction constitutes another key mechanism within Ludic Urban Transformations. Long viewed with skepticism in planning theory because of its tendency to reduce social and political complexity, abstraction operates within the ludic context as a generative and epistemic mechanism. Simulation systems such as SimCity or Cities: Skylines condense governance, infrastructure, and environmental processes into quantifiable mechanics that invite experimentation [11]. These simplifications make urban systems intelligible while also revealing the ideological assumptions embedded in design, particularly technocratic ideals of efficiency and control. By reframing abstraction as a process of translation instead of distortion, the VUFM highlights how game-based simplification reveals underlying cultural logics of urbanism, turning play itself into a form of spatial reasoning.

The Virtual-to-Real Outputs domain completes the cycle by addressing how engagement with virtual environments can shape urban perception, learning, imaginaries, and participation. Through these cognitive, affective, and participatory processes, virtual urban experience can feed back into how real cities are understood and evaluated. This exchange is cyclical: real cities inspire digital representations that, in turn, reshape public perception, discourse, and even professional practice. Virtual environments influence how individuals value urban density, mobility, and sustainability [2], while simulation platforms are increasingly employed in participatory planning and civic education [32,33,44]. Yet this reciprocal influence also introduces normative risks. When simplified virtual models are mistaken for holistic urban visions, they may propagate homogenized or exclusionary ideals of urban life. Hence, critical mediation is essential. Urban practitioners must frame digital participation within ethical, political, and cultural contexts and avoid treating it as a neutral virtual design tool.

Beyond theoretical reflection, the VUFM offers practical implications for urban learning and education. Simulation and sandbox games provide experiential platforms for developing systems thinking, spatial reasoning, and civic imagination. Through interaction with simplified urban systems, users can explore relationships among spatial decisions, infrastructure, and urban processes in an accessible and experiential form. Within education, such platforms can cultivate spatial literacy and critical reflection, providing opportunities to engage with urban complexity beyond conventional forms of instruction. When understood through the VUFM’s cyclical logic, these applications illustrate how play can serve as an iterative dialogue between digital experimentation and real-world urban understanding.

The VUFM also has broader implications for urban planning and urban design. By conceptualizing virtual environments as spaces where urban imaginaries are produced, negotiated, and reinterpreted, the framework suggests that game-based platforms can support scenario exploration, participatory planning, and design communication. Virtual environments complement conventional planning methods by providing spaces where planners, designers, policymakers, and citizens can collaboratively visualize alternative urban futures, evaluate spatial ideas, and strengthen public engagement throughout the planning process.

The model also foregrounds ethical and political dimensions that have become increasingly salient with the rise in smart cities, digital twins, and the Metaverse. As urban governance grows more data-driven, the same platforms that support participation may reinforce surveillance, algorithmic bias, and technocratic control [7]. The VUFM calls for reflexivity in design and scholarship alike, interrogating whose imaginaries are encoded in virtual systems and how feedback mechanisms might amplify or resist social inequity. In this regard, virtual urbanism becomes both a creative and moral frontier, demanding inclusive and transparent frameworks for digital spatial production.

Despite these advances, several gaps remain in the literature. Research on virtual urbanism continues to overrepresent Western-developed games, overlooking non-Western urban imaginaries and culturally distinct modes of spatial cognition. Comparative, cross-cultural, longitudinal, and mixed-method research integrating ethnography, spatial analytics, and discourse analysis could also test the VUFM empirically, clarifying how virtual experiences translate into real-world learning and civic behavior. Addressing these gaps would deepen understanding of how digital mediation shapes the global circulation of urban knowledge. Future research could also extend the VUFM by examining how different governance logics, political ideologies, and procedural structures are embedded in virtual urban environments and how these shape competing urban imaginaries, while operationalizing and empirically applying the framework across individual virtual city environments to examine the complete feedback cycle and evaluate its explanatory utility in different urban simulation contexts. Such case-specific operationalization and application represent a subsequent stage of research beyond the scope of the present study, which is concerned with conceptual synthesis and framework development.

Overall, the synthesis underscores that virtual cities are not detached fictions but co-evolutionary systems that continuously rearticulate the relationship between material and digital urbanism. The VUFM consolidates this recursive relationship across Real-to-Virtual Inputs, Ludic Urban Transformations, and Virtual-to-Real Outputs, capturing the dynamic interplay between code and concrete, imagination and governance. On this basis, future urbanism in the age of simulation will be defined by the permeability between real and virtual space. As technologies such as VR, AR, and AI-driven procedural generation expand, virtual environments will increasingly inform how societies envision and construct urban futures. The challenge for scholars and practitioners lies in harnessing these digital worlds as instruments of critical reflection and inclusive imagination. The VUFM provides both a conceptual foundation and a call to action, inviting urbanists to recognize that the cities of tomorrow will be co-authored not only by planners and architects but also by players, designers, and the digital worlds through which we learn to think the city anew.

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