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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

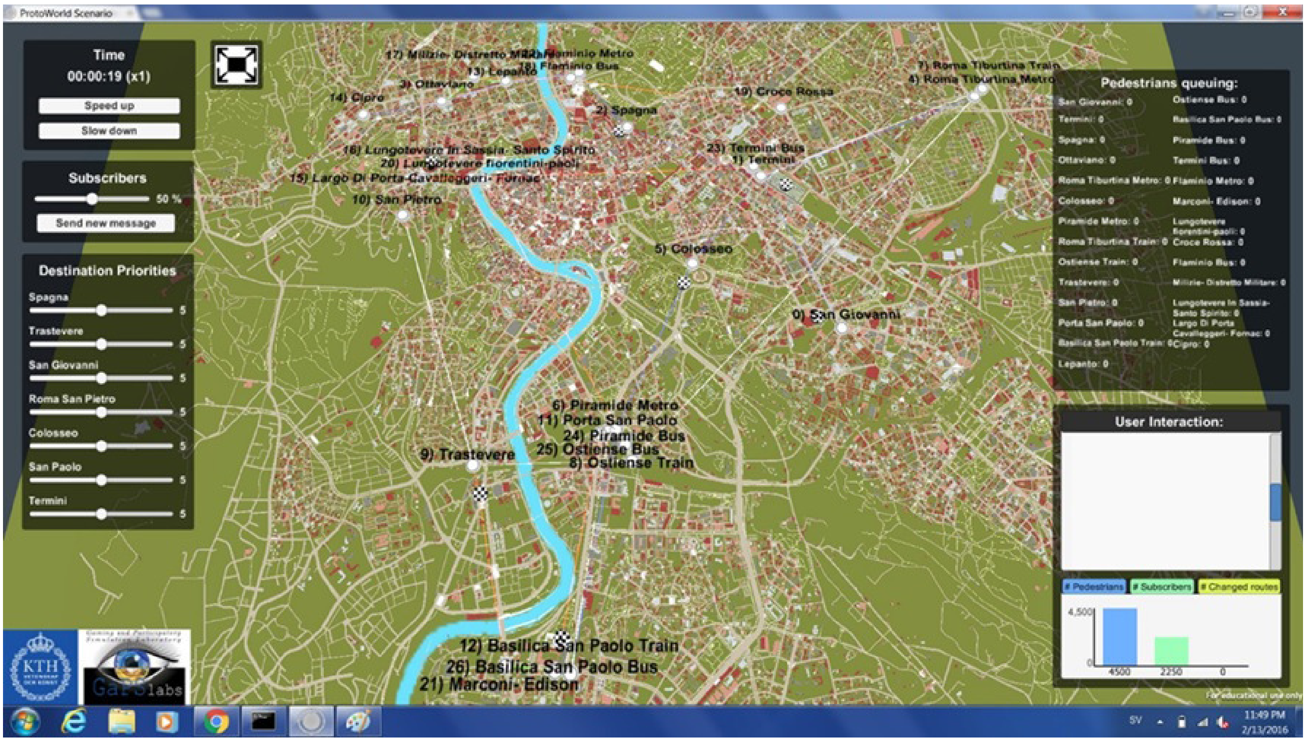


**Figure 1.** Macro view of the game in Rome.

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.

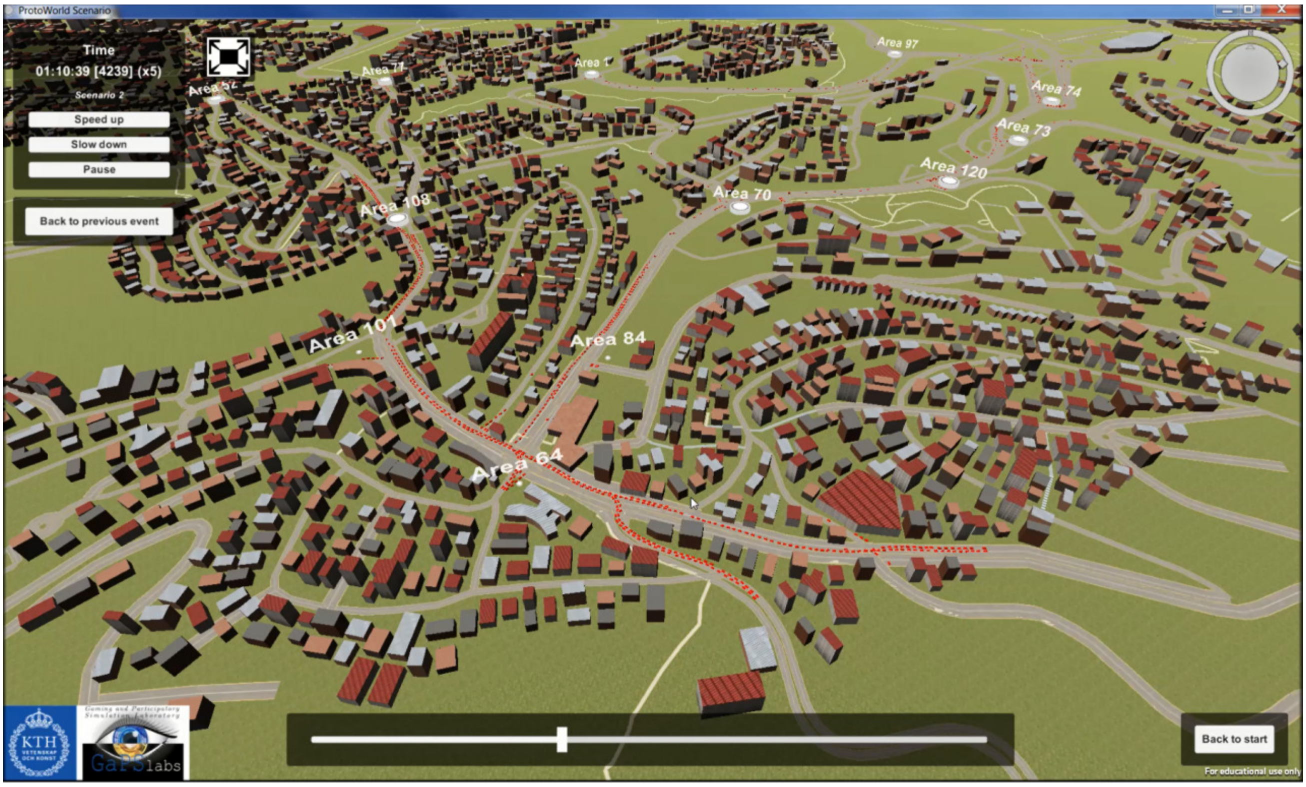


**Figure 2.** Macro view of the game in Haifa.

**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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