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GAMIFICATION IN URBAN PLANNING - EXPERIENCING THE FUTURE CITY

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Abstract

Virtual Reality (VR) systems have been commonly used in the game and entertainment industries and are also increasingly explored in architecture and urban planning. They assist designers to communicate design ideas to a wider public and can engage them in the design processes. In this paper, we explore gaming environments to allow users to learn about smart city applications, such as innovative mobility approaches, urban farming, drone delivery, etc. The project is part of a real-world project for a future city for 50,000 inhabitants in the European side of Istanbul, Turkey. VR technologies can offer a testing ground for testing ideas, simulating performance, crowdsourcing ideas, before building the actual city physically. Gaming incentivizes citizens to participate in the design process, and the data collected provides a significant feedback loop to shape the city of the future. Citizens can immerse themselves in the VR environment, and experience the design via four circulation modes, e.g., walking, biking, driving, and flying. They allow users to explore novel circulatory approaches within new and innovative city arteries. Indeed, the design of the city accommodates a portfolio of mobility options, and the gamification allows testing pioneering designs, e.g., parallel streets for pedestrians, vehicles, etc. Furthermore, the game allows users to collect points when engaging in smart city topics, such as urban farming, solar energy usage, carbon neutrality, etc. Feedback loop that helps to iterate on the design. The project consists of three phases, a. an immersive VR version of the city experienced on head-mounted-displays, b. edutainment and the gamification of the city, and c. the integration of the digital version of the city into Meta's multi-user space. In the paper, we present early findings of the project, the methods/tools explored, and discuss the utility of VR technologies in the design processes of architecture and urban planning.

Keywords

Gamification, smart city, mobility, VR, carbon neutralization.

GAMIFICATION IN URBAN PLANNING
EXPERIENCING THE FUTURE CITY

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ABSTRACT

Virtual Reality (VR) systems have been commonly used in the game and entertainment industries and are also increasingly explored in architecture and urban planning. They assist designers to communicate design ideas to a wider public and can engage them in the design processes. In this paper, we explore gaming environments to allow users to learn about smart city applications, such as innovative mobility approaches, urban farming, drone delivery, etc. The project is part of a real-world project for a future city for 50,000 inhabitants in the European side of Istanbul, Turkey. VR technologies can offer a testing ground for testing ideas, simulating performance, crowdsourcing ideas, before building the actual city physically. Gaming incentivizes citizens to participate in the design process, and the data collected provides a significant feedback loop to shape the city of the future. Citizens can immerse themselves in the VR environment, and experience the design via four circulation modes, e.g., walking, biking, driving, and flying. They allow users to explore novel circulatory approaches within new and innovative city arteries. Indeed, the design of the city accommodates a portfolio of mobility options, and the gamification allows testing pioneering designs, e.g., parallel streets for pedestrians, vehicles, etc. Furthermore, the game allows users to collect points when engaging in smart city topics, such as urban farming, solar energy usage, carbon neutrality, etc. Feedback loop that helps to iterate on the design. The project consists of three phases, a. an immersive VR version of the city experienced on head-mounted-displays, b. edutainment and the gamification of the city, and c. the integration of the digital version of the city into Meta's multi-user space. In the paper, we present early findings of the project, the methods/tools explored, and discuss the utility of VR technologies in the design processes of architecture and urban planning.

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ملخص

تم استخدام أنظمة الواقع الافتراضي بشكل شائع في صناعات الألعاب والترفيه، كما يتم استكشافها بشكل متزايد في مجال العمارة والتخطيط الحضري. فهذه الأنظمة تساعد المصممين على إيصال أفكار التصميم إلى جمهور أوسع وإشراكهم في عمليات التصميم. نستكشف في هذه الورقة البحثية بيئات الألعاب للسماح للمستخدمين بالتعرف على تطبيقات المدن الذكية مثل أساليب التنقل المبتكرة والزراعة الحضرية والتسليم عن طريق طائرات بدون طيار، وما إلى ذلك. هذا المشروع هو جزء من مشروع واقعى لمدينة مستقبلية تسع ٥٠٠٠٠ نسمة في الجانب الأوروبي من اسطنبول بتركيا. ويمكن لتقنيات الواقع الافتراضي أن تقدم فرصة لاختبار الأفكار ومحاكاة الأداء وأفكار التعهيد الجماعي قبل بناء المدينة فعليًا. فالألعاب تعمل على تحفيز المواطنين على المشاركة في عملية التصميم، وتوفر البيانات التي يتم جمعها حلقة ملاحظات وتغذية مرتجعة هامة لتشكيل مدينة المستقبل. يمكن للمواطنين الانغماس في بيئة الواقع الافتراضي وتجربة التصميم من خلال أربعة أشكال للحركة، مثل المشي وركوب الدراجات والقيادة والطيران. فهى تتيح للمستخدمين استكشاف طرق جديدة للحركة داخل شرايين المدينة الجديدة والمبتكرة. وفي الواقع، فإن تصميم المدينة يستوعب مجموعة من خيارات التنقل ويسمح نظام الألعاب باختبار التصميمات الرائدة، على سبيل المثال، الشوارع الموازية للمشاة والمركبات وما إلى ذلك. علاوة على ذلك، تتيح اللعبة للمستخدمين جمع النقاط عند الانخراط في مواضيع المدينة الذكية، مثل الزراعة الحضرية واستخدام الطاقة الشمسية وتحييد الكربون، وما إلى ذلك. يتكون المشروع من ثلاث مراحل: ١. نسخة واقع افتراضى غامرة للمدينة تختبر بواسطة شاشات عرض مثبتة على الرأس، ٢. التعليم الترفيهي و"تلعيب" المدينة، و٣. دمج النسخة الرقمية للمدينة في مساحة *Meta* متعددة المستخدمين. يقدم البحث النتائج المبدئية للمشروع والطرق والأدوات التي تم استكشافها ومناقشة فائدة تقنيات الواقع الافتراضي في عمليات تصميم العمارة والتخطيط الحضري.

الكلمات المفتاحية: التلعيب، المدن الذكية، التنقل، الواقع الافتراضى، تحييد الكربون.

1. INTRODUCTION

Smart Cities and Virtual Reality (VR) are two important research topics that have come to the fore in recent years. There are many start-ups in this field apart from academic studies working on the subject matter (Rebelo, 2021).

Especially in the last decade, studies on user participation and teaching urban design through gamification have intensified. The studies, which focus on VR with the collaboration of architecture students and engineers of computer sciences, support the importance of VR and city experience, and the 'participation' as a topic seen in previous studies, supported by experiments and results of the studies (Redondo, et al. 2020a, 2020b).

Nowadays, the current sources, the predictions, and scenarios of the books, and especially reviews articles, written on the subject show that the topic of 'VR and Smart Cities' will contribute to a wide range of fields and scales, from city life to design process. The results encourage researchers to think and to aim production about this subject because even the sub-titles in the content of the topic are open to very important developments and the potential of this subject is very high, not only in the academic environment but also in commercial game companies.

Behaviors and movements of users in the VR game environment can be a serious research and analysis input. The use of real-world data creates a virtual experience and urban mobility simulation in the game environment, in this way, it can enable the development of data-based systems, which will be close to the reality models (Johannessena, et al. 2016).

Especially, while working on mobility with IoT data, the simulation environment can be created with gamification and the data that close to the real transportation data can be observed (Poslad, et al. 2015). As case study topics, mobility within the city, commuting, and home-school mobility can be important components of the mobility studies (Kazhamiakin, et al. 2021).

Additionally, The VR Smart City research will be beneficial for governments, other industries, and the sustainability of finance and ecology. The VR Smart City games will simulate future cities with real geo-data, population, transportation, and energy data. The results of the simulations-VR will provide high quality in urban areas and protection to ecologic values (Rebelo and Soares, 2020; Nijholt, 2020).

In this paper, we examine gaming environments to allow users to learn about smart city applications, such as innovative mobility approaches, urban farming, drone delivery, etc. Knock et al., analysed 691 case studies, and used 40 of them to redefine the gaps and needs in gamification in terms of psychological and social behaviours of mostly public transportation-focused studies (Klock, et al. 2021). Our study focuses on the idea of game development to educate users and increase the awareness on smart city applications. Choreographing users through the city is an important part of our study in terms of game development. In this study, the issue of 'gamification' is very important in terms of energy consumption and environmental sustainability of the city.

2. BACKGROUND

A smart city is an urban development vision to integrate information and communication technology (ICT) and Internet of things (IoT) in a secure fashion to manage the city's assets. Nevertheless, a smart city needs to be built to meet the needs and requirements of its citizens. A smart city is, beyond technology, populated by people and can be raised by its citizens' contribution and gamification is the means to motivate them (Tandon, 2022).

Gamification is a term introduced in 2002 by Nick Pelling but became popular only in 2010. Gamification can be defined as a set of activities and processes to solve problems by using or applying characteristics of game elements (Tandon, 2022). Gamification techniques are intended to leverage people's natural desires for socializing, learning, mastery, competition, achievement, or closure, or simply their response to the framing of a situation as a game or play. Action, motivation, and reward are the basic principles in the gamification of smart cities for better engagement with the city. Gamification commonly employs game design elements to improve engagement, organizational productivity, flow, learning, crowdsourcing, employee

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recruitment and evaluation, ease of use, the usefulness of systems, physical exercise, traffic violations, voter apathy, and more (Zica, et al. 2018).

Gamification has been applied to almost every aspect of life. Examples in the business context include the U.S. Army, which uses a military simulator America's Army as a recruitment tool (Kumar, et al. 2020). In the UK and Australia gamified programs were implemented to encourage citizens to walk and cycle. In Australia, the result was that 35% of the car trips to schools were replaced with healthy transportation means. Another program for public transportation was introduced in Singapore. The goal was to motivate citizens to use public transportation in other intervals than rush hours. They were included in a raffle and received rewards. After 6 months of testing in 2012, the result of the program was an estimated 8% shift from rush hour to normal hours (Desouza, et al. 2020).

Gamification can be a real solution for involving citizens in building a smart city and in its customization so that it responds to everyone's needs. Smart city applications are often top-to-down developments introduced by the tech industry. Therefore, using gamification may help the development of IT abilities for all citizens, bottom-up. Creating an application that gives the citizen an opportunity to create their own customized city, would represent real feedback for the authorities on what they can do for the city and its community.

A few examples of urban gamification in its broadest sense of fostering engagement are as follows: Second Life, an online environment created by Linden Lab, a company based in San Francisco. Second Life is an online world in which users -called residents- create virtual representations of themselves, called avatars, and interact with other avatars, places, or objects. In Second Life, residents can go to social gatherings, live concerts, press conferences, and even college classes. They can do a lot of things people can do in real life: buy land, shop for clothes and gadgets. They can also do things that are impossible in the real world, avatars can fly or teleport to almost any location (Lindenlab, 2022). Another example is SimCity, an urban-planning game that is now being used for education in the form of SimCity Edu (Simcityedu, 2022). The game can teach anything from economics, urban planning, and even environmental studies. The goal of SimCity Edu is to make the game a common part of the classroom experience; students can learn a wide variety of subjects while working together, and teachers can create detailed curricula that adhere to learning standards (Electronic Arts, 2022). With these gamification applications, it can be seen that people have considerable trust in this method.

There are also other studies that claim that it is possible to use augmented reality and virtual reality in urban design, and that digital transformation can be used as a decision-making mechanism. The game called "Virtual Smart City Hero" is remarkable with its theoretical background, approach to the problem, method, and data and a very good example to understand the importance of the research subject, as well as the importance of VR experience of smart cities in the future (West, et. al. 2019).

3. METHOD AND TOOLS

The game is basically designed to be mobility-centred and convey crucial information around the smart city topic to the users. A roadmap can be drawn by defining the hardware, software, data, method, and users one by one and clearly identifying their relationships. Hence, for this project, the Unreal Engine game environment, and VR headset hardware are identified as hardware and software components of this Smart City VR Game Project.

The Unreal Engine has the 3D model of the city, i.e., the landscape and architectural model, thus the game offers a unique experience with highly detailed architectural models. We produced a rough 3D model of the future city site (Figure 1.).

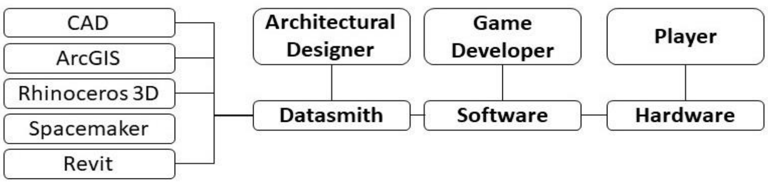

Fig.1: Datasmith and Data Workflow to VR Headset Hardware.

The components within the scope of the game designed in the study consist of 3 different groups, these are the architectural design group, the game development group, and the users. The game development group, deals with the maintenance of the game, updates all requests derived from the architectural design group and produces the game for use to the players (Figure 1.).

VR can provide valuable information and future predictions because the system we are working on consists of real-world geodata, population, vehicle, and energy data. The game is a simulation of a smart city design. Our main aim is to educate VR users about the smart city concept. The environment and scenario of the project is the digital twin of the real landscape data of the NAR Future City project in Esenler, Istanbul. (Figure 2., 3., 4.).

Fig.2: NAR Project City Masterplan produced via Spacemaker.

Fig.3: NAR Project City Model with low level of detail.

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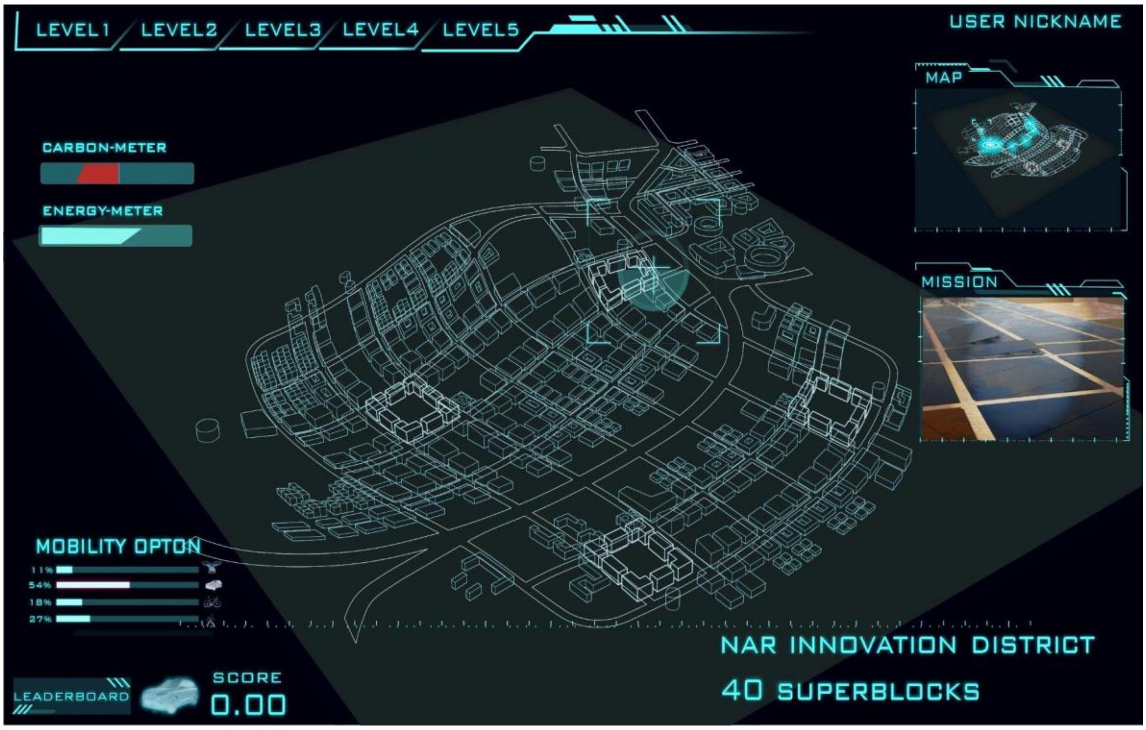

Fig.4: NAR Project area representation in the game environment.

User experience and behaviours in the game environment and social interaction with other users is stored in the unique Data Base Management System (DBMS) of the game. All mission detail, every success, and failure will be saved in DBMS and provides unique data points for understanding user activities, and patterns. The metadata makes it possible to produce future predictions and offer quantitative analysis. (Figure 5.)

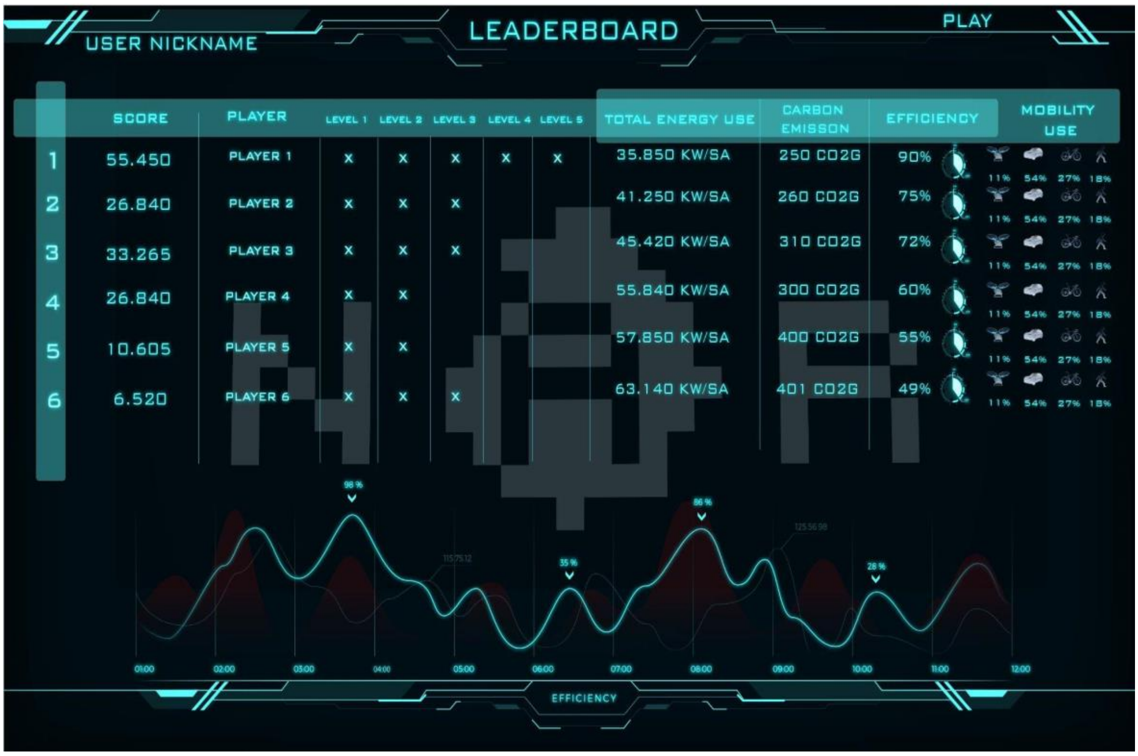

Fig.5: Leaderboard as a part of DBMS.

4. CASE STUDY: FUTURE CITY NAR PROJECT

The design of the city accommodates a portfolio of mobility options, and the gamification allows testing pioneering designs, e.g., parallel streets for pedestrians, vehicles, etc.

The NAR Innovation District (NAR) is designed in Istanbul, Esenler. It integrates new technologies and sustainable principles such as smart city applications, flexible spatial organization, smart grid infrastructure, smart waste management system, environment-friendly public transportation modes, participatory governance, and smart emergency and disaster prevention systems.

The NAR district is made out of 40 superblocks. All superblocks in the project, namely 40 superblocks and 4 squares, are modelled and plugged-in to the VR game. The proposed mobility portfolio, such as bicycle, scooter, and autonomous vehicles constitute the main methods of circulation within the city. The landscape model is produced with photogrammetric techniques with high spatial resolution in addition to the Region of Interest (ROI) area as the project area, neighbouring buildings of the city are also integrated into the 3D model.

Users learn these smart city principles and at the same time experience the design of the NAR Future City in first person. The main goals of the Game are to increase awareness of smart city principles, democratize participation and governance structures, generate interest in smart city technologies, and inform citizens on matters of sustainability.

4.1 Scenario

As opposed to traditional games, the main scenario has been shaped around mobility approaches, e.g., visiting the squares, exploring the streetscapes, and city squares, which are designed via pedestrian and autonomous vehicles. The educational system of the game is defined under 10 'Suggested smart city applications':

1. Crowdsourcing
2. Smart Mobility
3. Smart Buildings
4. Smart Economy
5. Smart Environment
6. Smart Government
7. Smart Energy
8. Smart Health
9. Smart Security
10. Smart Disaster Management (Figure 6.).

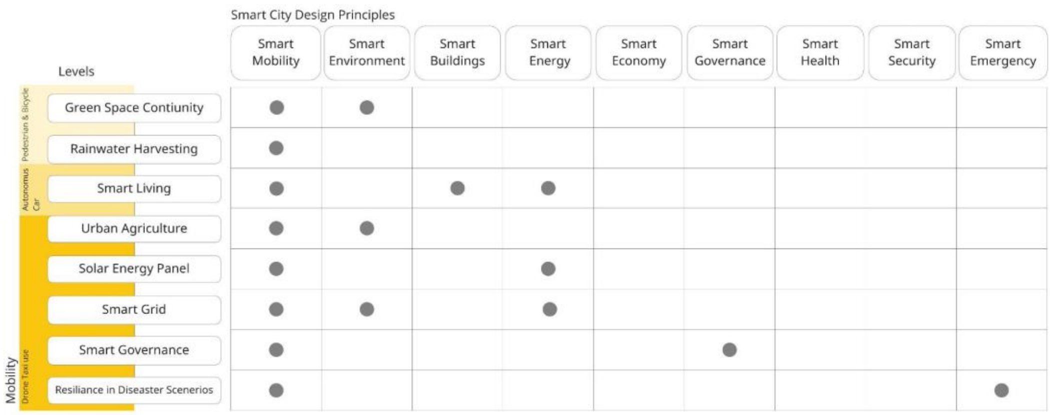

Fig.6: Smart city design principles relations with mobility scenarios.

Users pass the levels by learning seminal topics with the help of lightboxes that provide information about smart city applications at each stage. Mobility options become available after users completed certain tasks and have collected various points, i.e., as the user progresses through the levels and learns the fundamentals of the smart city, s/he can get access to say the autonomous drone taxi and experience the city from a birds-eye.

In the first version of the game, eight levels are defined that have unique missions to promote the city in terms of at least one of the mentioned smart city applications. The eight levels are named with the following titles: maintaining green space continuity, rainwater use, optimization of the energy use, urban agriculture, renewable solar energy, smart grid, smart governance, and plan for a post-disaster resilient city.

All dynamic and static components of the game have an ID and an attribute table. Statistics data is displayed as pie and bar charts throughout the game and usage data is collected in the IDs of the users. In this way, users' carbon emission values, user behaviors, and in-game development are displayed. Carbon emission values will be displayed as actual values from vehicle engines in the NAR area. The comparison will be made with the actual data of the fossil fuel consuming vehicle engine of the same power. In addition, since each building has a separate ID number, attribute table, building information is shared with the users in a certain level of detail.

The titles that are hosted in the game interface are defined, and the necessary game scenario and fiction, such as the editing, interface, and endgame reports, are created to evaluate the experience of the game from start to finish (Figure 7.) In addition to smart city applications, smart home applications are also being introduced in the designed VR game.

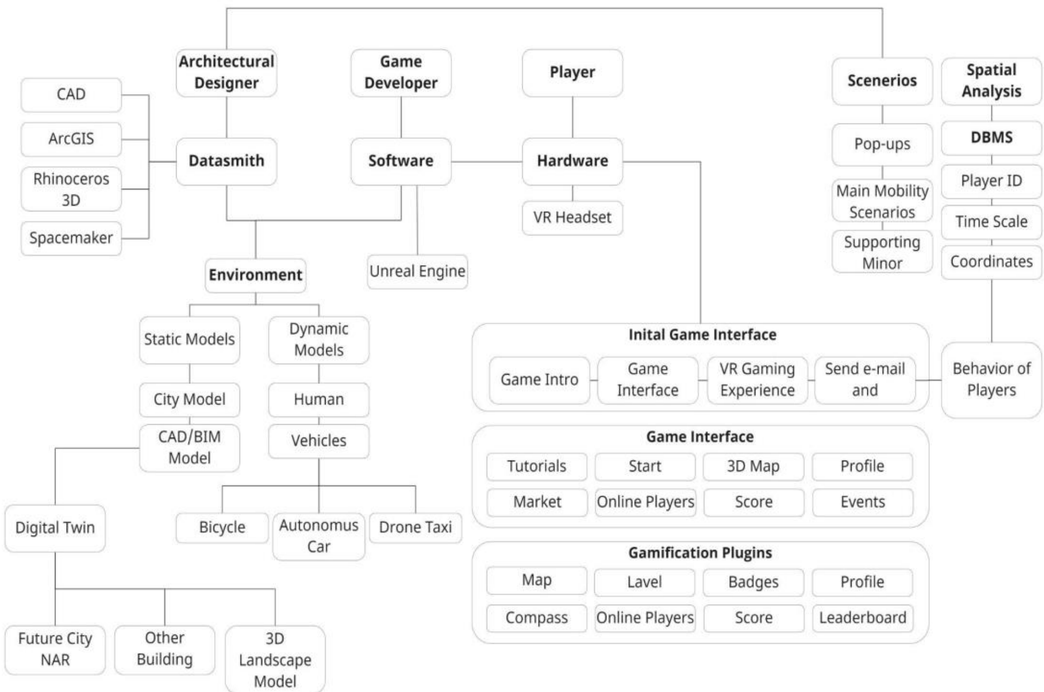

Fig.7: Workflow of the VR Smart City Game.

4.2. Game Structure

The mobility-centric gamification focused on carbon neutrality. The background, in reality, and gamification, the main of the system focus on the basics of sustainable and renewable energy in the NAR project and this study. The player controls unexpected circumstances that result in carbon emissions and resolve problems that raise energy consumption throughout the game. Successfully accomplishing the eight tasks' results in the City's future being preserved and its being carbon neutral. The general structure of the game is based on the smart mobility systems that consist of pedestrian walking, bicycles, autonomous cars, and a flying drone car (Figure 8., 9., 10., 11.).

Fig.8: Pedestrian mode

Fig.9: Mobility by bike

Fig.10: Autonomous car as mobility option

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Fig.11: Air navigation process of The CEZERI Air Taxi

1st Level: Maintaining Green Space Continuity. Currently, the amount of green space per person in the Esenler district is 1 m2/person. This rate has been increased to 22 m2/person in the NAR Innovation District. The purpose of this task is to preserve the continuity of green areas inside and outside of the NAR and to learn about the features of plants in the district. The user encounters problems that damage the continuity of the green line and collects points by solving these problems. These tasks are watering a drying tree, repairing the broken irrigation system, extinguishing the fire caused by the climate crisis in the green area, and learning information about the climate crisis. At the same time, while rescuing the plants, the user gains points by learning about the features of plants. After successfully completing this task, the player won points and was entitled to use an autonomous vehicle (Figure 12).

Fig.12: Maintaining Green Space Continuity.

2nd Level: Rainwater harvesting Players plant a vegetable in the cultivating area of the NAR Smart District. This cultivating area is irrigated by the rainwater harvesting system. Players learn the green system of rain harvesting and collecting water. After successfully completing this task, the player goes to the next task in an autonomous vehicle (Figure 13.).

Fig.13: Rainwater harvesting system

3rd Level: Smart Living is a daily housework simulation. The player does daily housework using water and electricity while using these sources minimum. The aim of the player is to optimize the water and energy in housework routines and explore the waste management system (Figure 14.).

Fig.14: Smart Waste Management System.

4th Level: Urban Farming Zone is located on the roof of the building. The user goes to the roof, sees an agricultural area on the roof, plants vegetables or fruit on the ground, and waters it. After successfully completing this task, the player passes to another roof (Figure 15.).

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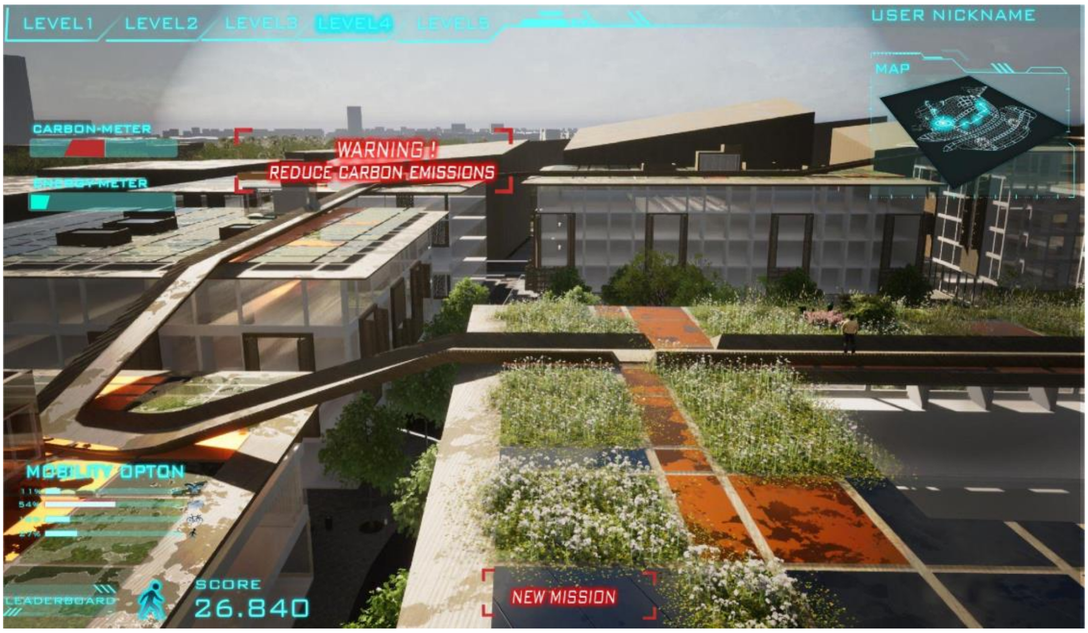

Fig.15: Urban farming

5th Level: Solar Energy Panel raises awareness about the use of renewable energy. The player gets points by cleaning the solar energy panel with special cleaning techniques. In addition, annual energy saving of solar panels and their effect on carbon neutrality is shown (Figure 16.).

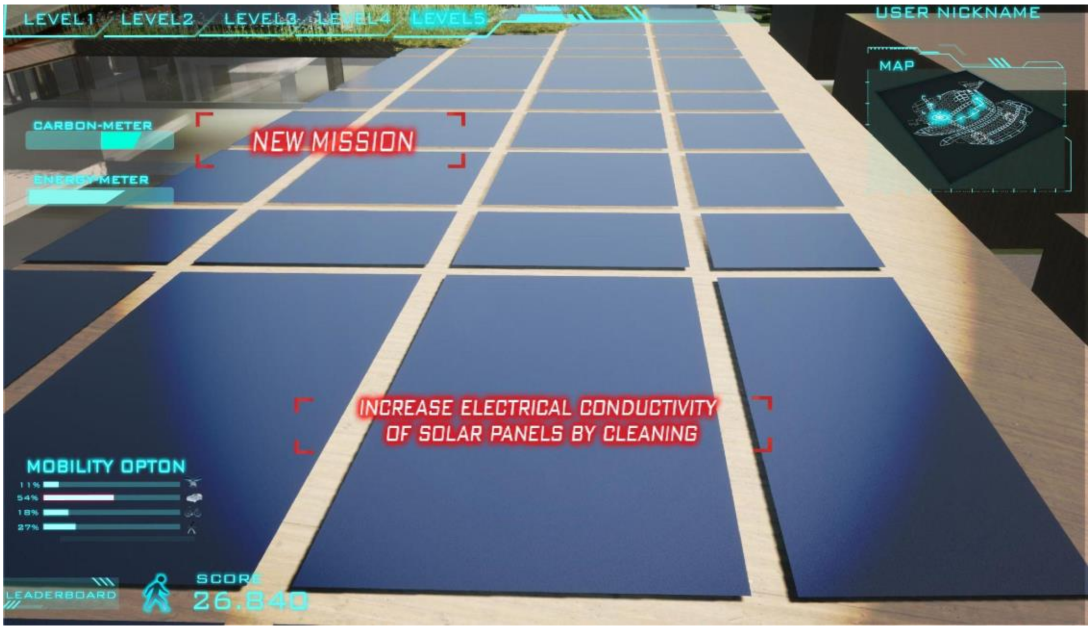

Fig.16: Learning about the solar panels

When the player reaches the necessary point by successfully completing the 5th task, is granted access to the air taxi Cezeri and can explore the Nar Area by visiting superblocks, innovation districts and cultural centers (Figure 17.).

Fig.17: Landing process of the autonomous air taxi Cezeri

6th Level: Comprehension of the Smart Grid is the task that will give information about the modern grid-centric urban design of the city.

7th Level: Smart Governance will give the user an opportunity to vote about current city problems, e.g., hours of the events, etc. The users will decide about city issues in a fast, democratic, and cooperative way.

8th Level: Resilience in disaster scenarios provides information to users about the disaster management approach and plans of the city. For instance, the new pandemic policy and application plan of the city will be described to users. As another example, the city's water policy, such as the city's infrastructure, rainwater collection tanks, and gray-black water treatment, will be introduced regarding the expected future water crisis in the region of Istanbul, etc.

The main purpose of the game is to ensure the carbon neutrality of the NAR Smart District. Every task contributes to this purpose. Players try to decrease the carbon emissions of the city by completing tasks, but this is not a finite process. Players keep trying to ensure carbon neutrality and energy efficiency. Every player has a scoreboard that shows carbon emissions, energy consumption, and the point score. The Player tries to use minimum energy and tries to reduce its carbon footprint. Energymeter and carbon meter hands are tried to be kept at a minimum level. Tasks and learning about the city provide the player points. Players can buy some items like solar energy panels, agriculture areas, or energy-saving devices. Thus, players can save more energy and even generate it. Therefore, players can share these produced energy or agricultural products with other players. In this way, a player would get more points.

5. CONCLUSION

The study describes the effort and process of developing a smart city game in the VR environment with all semantic and ontological approaches and details. This study initially redefines a study in which the NAR Future City project is transferred to an immersive VR environment and designs a game which is engaged with smart city applications. Game scenarios and data relations were created via the literature review process, and data preparation of the study was delineated. The main effort of the study is to create relationships among city data, VR game scenarios, and other components of the game such as users, hardware, software, and all other entities of the game. The system was created as a mobility-centric VR game for exploring the smart city and its' smart city applications. The study allows to experience future smart city applications and future examples like electric consuming mobility alternatives, e.g., the use of air taxis as well as indoor of buildings, streets, squares, roofs, and urban infrastructure as a utopic underground city VR experience. Furthermore, the game motivates citizens to understand sustainability and offers citizens a competitive environment in the context of ecological awareness and energy saving.Therefore, future publishing of the VR Smart City Game will be a shining example for citizens and all other enthusiasts of smart cities around the globe. At last with the consumption of the game users will gain a. VR smart city experience, b. entertainment and education about smart city components, e.g. drone delivery, air taxi, smart city infrastructure, smart building, smart mobility, eco-friendly city, c. the integration of real-time, multi-user digital city experience, d. VR gamification acts as a significant simulation of the NAR Future City with its' digital twin spatial data and real-time mobility data as well as will provide spatial analysis, future predictions, and to identify problems. The missions and interfaces in the game are designed in a way that can be improved over time. The designed VR environment technically has the possibility to combine and work together with other smart city projects to be designed in the future. In the future smart cities that are separate cells can be merged in the future in a VR environment. It is clear that this VR application will attract attention to the topics of virtual reality, smart city gamification, and Metaverse.

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