

UDC: 712.256: 004.946

doi:10.5379/urbani-izziv-en-2022-33-02-02

Received: 22 March 2022

Accepted: 10 October 2022

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Playgrounds in the digitally mediated city: An approach from augmented reality

Today, the use of technological devices is commonplace among children, which has also diminished children's presence in the city. Although children, as novel citizens, develop some of their skills (such as social, mental, and educational skills) in the city, many children face some kind of city exclusion. Therefore, the way the physical environment of their city is shaped and how children interact with it plays a principal role in child engagement. A child-friendly city can be a place to engage children using contemporary tools such as augmented reality (AR), which helps children communicate better and fosters

abilities such as spatial cognition and physical and social skills in the physical and digital world. This study explores various examples and analyses the child-friendly city features of each. This article presents AR and its capabilities as a potential tool utilized in the city to pave the way toward a child-friendly mediated city – an inclusive social urban environment where children play or spend their leisure time and effectively mature into adulthood.

Keywords: augmented reality, child-friendly cities, urban perception, digital cities, digital social engagement

1 Introduction

Urban environments are becoming primary contexts in which new generations of children will flourish, following the current trend of global urbanization and the growing attraction of cities for families with children (Aji et al., 2016). By 2025, the UN estimates that 60% of the world's children will be living in cities (Krishnamurthy, 2019). UNICEF has defined the notion of a child-friendly city as a city where the children are actors with the ability to influence policy as citizens and which is a guarantor of all children's rights. Children can also participate in family, community, and social life, as well as receive basic health and education services while remaining safe from human trafficking, brutality, and mistreatment. Based on this concept, children have the right to feel safe on the street while meeting and playing with their friends, live in a non-polluted environment, participate in social and cultural activities, have accessibility to green spaces, and, regardless of their ethnicity, be able to access relevant services (Ceren Mavikurt, 2019).

Meanwhile, over the last few decades, rapid technological advancement has resulted in a new wave of emerging technologies that are poised to change both personal and professional experiences in urban spaces (Luusua, 2016). One of these digital technologies is augmented reality (AR), which has appeared in various fields, including architecture and urban design. Today the use of technological devices is prevalent among children and has been documented in many countries by numerous researchers in recent years. Touchscreen devices such as tablets and smartphones have become significantly more commonplace during the past decade. More recently, the COVID-19 pandemic has influenced the rhythm of city life and substantially decreased people's presence and activity, especially in urban areas. Although the lifting of restrictions has gradually returned cities to their normal state, this period has nonetheless caused increasing interaction of children with digital devices (Romanillos et al., 2021). Nowadays, the amount of time that children spend on mobile devices is increasing. According to data from the United States, in 2020 97% of households had at least one smartphone, 75% of families owned a tablet computer, and 44% of young children had their own tablet computer (Konca, 2021). These findings show that in many developed countries even a very young child can communicate with technology and spend a significant amount of time using it. However, the other side of the coin of children being entertained at home with a tablet, a mobile phone, or other technologies is their diminished presence in the city. Some AR games such as *Pokémon Go* require the user to move around the city to explore Pokéstops and catch items, thus increasing the users' activity time and consequently improving their overall health and wellbeing (Potts et al., 2017; Oduor & Perälä, 2021).

This article investigates AR as a technology choice that children can engage with, as an interface to encourage children to be in the city, and as an enabler of various factors of the child-friendly city. Below, we investigate three examples that show how AR applications can help realize some child-friendly city features that children can experience in their city to gain various useful skills through their presence in an urban environment enhanced by the digital world. The analysis of the examples also exhibits features that can help engage children with the city to further develop and foster their interaction with their urban environments. The practices in this article are examined in developed countries but, due to the rapid development of technology around the world in the future, similar cases could be identified in most parts of the world.

The research questions are as follows:

Q1: How can children improve their urban spatial perception with AR?

Q2: How can today's children become absorbed into the city and develop various skills via AR?

In line with the aim and research questions of this review article, the literature review extracted from books, articles, and theses is based on keywords such as *augmented reality*, *augmented reality and child development*, *children's presence in urban environments and their perception of it*, and *child-friendly cities*.

1.1 Literature review

Researchers around the world have worked to develop theories, facts, and experiences to explain and illustrate the characteristics, features, and capabilities of AR, which has attracted attention to its potential over the past decade. This review article adds to the research exploring the relationship between the city, technology, and play, developed in a doctoral programme. For example, Navarro Redón (2020) and Roig Segovia (2014) investigated the relationship between play space in the physical world and videogames, and augmented environments as a common ground of digital technology and traditional spatial structures in line with the convergence of physical and digital environments.

Regarding conceptual aspects of AR and its features, one can mention the studies by Mackay (1996), Azuma (1997), Ariso (2017), Saßmannshausen (2021), and other scholars that have explained this technology as a tool that exists in different fields and offers users the possibility to see the physical world enhanced with virtual objects superimposed upon or composited with the physical world (Ariso, 2017; Saßmannshausen et al., 2021). These studies also mention that AR helps users improve their physical, spatial, and mental skills. Nijholt (2017a) takes

a look at playfulness and playability in smart and intelligent cities, addressing pervasive games, urban games that change a city into a “gameful city”, urban experiences, and how to involve residents in urban city design and development. Nijholt also mentions the playful hacking of smart city technology, mischief in smart cities, and playful interactions between residents and smart city technology in public spaces.

1.2 Children and urban space

Children need to gain experiences in various environments – such as the home, school, and urban environments – to develop their abilities and skills. Outdoor activities are an opportunity for children to experiment freely, run, climb, and jump to explore the world. To this end, cities as an outdoor space play an important role in children’s health, wellbeing, and development. Furthermore, urban spaces can provide opportunities for children’s play, social interaction, and independent mobility (Kytä et al., 2018). Historical data show that while growing up children use the same urban spaces as adults, such as buildings, bazaars, public spaces, and pathways (Nooraddin, 2020). Compared to adults, children probe their environments by being more physically active and playing in various ways, such as climbing, jumping, and balancing. In this way, children communicate with their environment through their preferred forms of activities while enjoying their time in that space. Streets, as an urban space used by children as a playground, are a place to spend time with peers and encounter adults. In the early 1960s, Jacobs (1961: 81) wrote that children need “an unspecialized outdoor home base from which to play, to hang around in, and to help form their notion of the world”. Streets and alleys could be exactly this type of space. While in the street, children can explore their social relations, improve social competencies, and gain independence. Furthermore, streets provide a variety of playing choices for children such as ball games, wheeled toys, and equipment brought from home (Gospodini & Galani, 2006). The other spaces that children use in the city are playgrounds. Playgrounds are specialized open spaces in towns and cities that are designed for children. The concept of playgrounds arose during the nineteenth century, when the rapid growth of urbanization occurred (Metin, 2003). Aldo Van Eyck was one of the pioneers in playground design. Cities, architecture, and playgrounds for children were his main subjects, which led him to introduce the concept of the city as a playground around sixty years ago in Amsterdam (Kim et al., 2017). Aldo Van Eyck playgrounds are simple and contain familiar shapes that children can easily perceive and communicate with (Lidón de Miguel, 2015).

In the early 1970s, the *Growing Up in Cities* project by Kevin Lynch in collaboration with UNESCO investigated how children’s utilization and understanding of the environment

affects their behaviours and characteristics. That study showed that children learn to use the urban environment as a learning ground through roaming and playing in the city. The study was revisited, expanded, and performed in several more cities during the 1990s. The study also found that children that are involved in the social and cultural life of their city acquire a sense of belonging and a strong personal identity (Bourke, 2012). Nowadays, technology plays an important role in various aspects of children’s lives, such as in games, relations with friends, and education. Children’s familiarity with technology develops day by day, and the technologies that children use today have also substantially changed from past decades. Children use a variety of digital technologies for gaming, including video game consoles, computer games, games on phones and tablets, handheld video games, and augmented reality and virtual reality games on various platforms (Flynn et al., 2019). Compared to the previous generation, today’s children also start their interaction with the digital world at earlier stages of their development of environmental perception. This further emphasizes the digital divide between generations. However, as a result of children being entertained with technology at home, their presence in the city is slowly diminishing. Developing the use of technology toward improving the mental and physical activity of users in urban environments may be a solution to this issue. As residents of the digital city, children can also be entertained by healthy experiences using such technologies. In this way, children can become fonder of and more satisfied with the environment, which in turn improves their quality of life and encourages them to engage more with the city environment (Nijholt, 2017b).

1.3 Children’s urban perception: the obsolescence of traditional public space

Traditionally, perception has been understood as the process by which people receive information, process it, and utilize it to understand their environment. In this regard, Kotler (1974) defines perception as a thought process that involves receiving information, selecting, categorizing, and then interpreting it. People can communicate with the environment by taking part in it and obtaining information to perceive their surroundings. Norberg-Schulz (1966) states that people’s immediate awareness about their environment is obtained through perception. This process helps humans understand, translate, and draw relationships with their surroundings.

Children recognize their environment and perceive it using tactile, auditory, and visual senses, and they develop environmental cognition by observing, questioning, and using their skills over time (Duzenli et al., 2019). Children’s growth and skill development is substantially influenced by their interaction with the environment. They learn and become familiar

with urban space through cognitive, affective, and evaluative means. Cognitive development occurs with the child's recognition of play spaces and discovering spaces, facilities, and features. Affective development is gained through awareness and sensitivity to physical and environmental factors. It also alludes to positive feelings and emotional attachments to a place (Aziz & Said, 2016). Finally, evaluative development considers the relation of values of nature to child development. Among those values are aesthetic values (physical attraction and appeal of nature) and humanistic values (emotional affection for nature), which familiarize children with nature and inspire them to form a sense of closeness to it. Children in the urban environment become sensitive to its features, which permits them to explore space and communicate with it (Kellert, 2002). Children's experiential perception of the environment gives them the chance to experiment with various skills while growing up and helps them further develop their knowledge (Sulaiman & Ibrahim, 2019).

2 The opportunity of a child-friendly city

Creating cities for everyone and considering children's needs in particular was introduced by a UNICEF initiative in Italy in 1996 (Titis Rum Kuntari, 2018). To address the inadequate attention paid to safe, secure, and healthy living conditions for children, a workshop was held the same year during the International United Nations Habitat II Conference. In this workshop it was reported that in a healthy habitat children's wellbeing is the ultimate indicator of a healthy environment, decent governance, and democratic society (al Arasi, 2013).

The concept of a child-friendly city is not based on a predetermined end state or closed scenario. This concept is a template for every city to use to make its environment, governance, and services more child-friendly. International conferences in recent decades have led to the drafting of Agenda 21 – an action plan from the United Nations Conference on Environment and Development (United Nations, 1992) – and the Habitat Agenda from the Second United Nations Conference on Human Settlements (United Nations, 1996). Most recently the series of documents *A World Fit for Children* (UNICEF, 2008), intends to make cities and communities more child-friendly through children's collaboration, proposing legal obligations and responsibilities for families, institutions, and governments toward realising children's rights (Ceren Mavikurt, 2019). Children as residents of the city have their own perceptions toward their city's surroundings, and their needs should be considered in the city's design. Tonucci (2015) stated that a suitable city for children is an optimal city for all. Along the same lines, Ward (1979) emphasizes the importance of city

design appropriate for children, which makes it convenient for them to live alongside other generations.

3 AR and child development

These days, AR is a technology that has been described as a live, direct, or indirect physical view of a real-world environment. AR includes the overlay of computer graphics on the physical world, whereby its elements are augmented or supplemented via videos, sounds, GPS data, or graphics created by computer-generated sensory input (Hammad & Srivastava, 2017). As the virtual and physical worlds merge, a new type of physical space emerges, which could be referred to as an augmented urban space (Mesárošová & Hernández, 2018).

Digital technologies have been widely used by children at an increasingly rapid pace over the past decade. This generation is society's future; children play a vital role in society's development and constitute a substantial customer base for the latest technological advancements. Children in most developed countries can use contemporary technologies to play games, speak with friends, tell stories, and learn, which introduces new dimensions to learning, communication, and social interaction (Mridha, 2018). Furthermore, the effects of digital age on children's lives are now more pronounced than ever because children are exposed to such technologies from a very early age in their homes and communities. Hence, children's lives, experiences, and opportunities are becoming increasingly mediated by their use of digital technologies (Marsh et al., 2019).

AR can help children interact with their environment and the virtual world. This communication can foster spatial cognition and physical and social skills (Gómez-Galán et al., 2020). With AR, children have the potential to learn about spatial content, which means that children can explore and understand spatial relationships between digital and physical objects located in mediated cities (Parmaksiz, 2017). AR also enhances the perception of the physical world and complements reality with additional sensory input to enrich children's senses of touch, sight, and hearing, and it enables them to see and/or hear beyond what already exists in the physical world (Bozkurt, 2017; Kiryakova et al., 2018). AR can simulate physical entities to attract children and at the same time help them experience imaginative participation and cognitive interaction. Furthermore, AR helps children's psychological development and arouses their desire to learn (Chen et al., 2017). According to Hedley and Shelton, AR interfaces are a combination of procedural and configurational knowledge. This technology is procedural knowledge because of the immersive senses that users can experience through the 3D display while standing or moving inside a mixed reality world. The configurational knowledge of AR is

due to the interaction experienced by learners while holding a 3D model in their hands and observing the geographical space (Hedley & Shelton, 2004). With AR, children can thus perceive their environment and learn many things to develop their abilities and skills. On the other hand, because children are inherently attracted to using new technologies, tools such as AR should be utilized in a positive and appropriate way to help them improve their skills and get ready for participation in society. When used as a teaching tool, AR can also help children develop social, physical, and spatial skills.

If sufficient supervision and control are not imposed, these types of technologies can cause some negative effects on human health, and other problems for children, such as physical inactivity and addiction to technology use (Ng & Ma, 2019). If used incorrectly, AR, just like many other technologies, can make users dependent on their devices and distance them from society in the physical world. Because it is inevitable that children will use digital devices in today's world, when used appropriately AR can be an opportunity for children to interact with the physical world. In some cases, AR can also encourage children to engage in physical activities. Although this has some complexity, it will conceivably be mitigated through advancements in technology in AR gadgets and applications, and the skills of the generation of digital natives.

4 Examples studied

Minecraft Earth, EduPARK, and UrbanAR have been selected as examples due to the opportunities they provide for a child-friendly city with augmented features and also the opportunities they provide for children in fostering and developing various useful skills using AR in the urban environment. Some child-friendly city features that children can collaboratively experience in the physical and digital world are analysed and compared for these examples.

Minecraft Earth is an AR game that was developed by Mojang Studios in 2009; it ended its support for the game in June 2021. This game brings a blocky construction set into the physical world. Minecraft Earth users do not pursue any specific goal; they can merely create, build, and explore in freedom while playing alone or cooperatively in a real territory or in an environment created by the players (Riordan & Scarf, 2017). Here, the user can develop a scaled-down version of the intended AR creation on a table indoors, like when assembling a Lego set, and then lay it down outdoors, where it scales up to real-life dimensions. These virtual structures are steady and set to a specific location, letting any other player that visits that place admire or disassemble and rebuild other people's creations. Minecraft Earth can be a collaborative environment

in which multiple users can brainstorm and cooperate to make virtual creatures and structures (Irving, 2019).

In Minecraft Earth, a user can invite a friend using a QR code so that they can work together on a creation. This way, friends nearby that have the game installed can scan the QR code and join the buildplate and interact with others (Warren, 2019). This AR game forms communities and groups that share creative creations, demonstrating the social aspect of Minecraft Earth (Riordan & Scarf, 2017). In this digital world, children can bring their imagination to life using digital representations of various materials. Furthermore, they can play, learn, and explore various skills in this augmented space, which they can identify with and own. Minecraft Earth allows users to build creative structures such as buildings, streets, sidewalks, urban parks, entire cities, and landscapes, or even elements of the environment such as forests, trees, and other components. The base of these constructions can be real or fictional spatial contexts, which allows the players to create an environment that shows a city, a landscape, or any other place on Earth (de Andrade et al., 2020). Based on children's opinions about this game collected from November 2019 to December 2021 on the Common Sense Media webpage, children like Minecraft Earth because it is fun and is an educational game for them that develops their art, creativity, and motor skills, and it is also appropriate for children of all age groups (Common Sense Media, 2019).

The EduPARK project is an AR geocaching game that develops technology-enhanced learning environments. Geocaching is another similar game that is based on a global positioning system (GPS) receiver, the internet, and users' ability to discover their environment. In this high-tech treasure-hunting game, users hide a cache (typically a small waterproof container) in a location and post its coordinates along with some clues on the internet (Mcnamara, 2004: 9). In the EduPARK game, a quiz with multiple-choice questions has been provided alongside content such as images, text, or audio. The game encourages the players to go to specific locations in the park and find the temporary markers or the physical caches with markers. EduPARK has four stages, each one corresponding to a path with multiple-choice questions that the players should answer based on the app's map (Pombo & Marques, 2018). The game also contains AR markerless tracking, which provides more opportunities for contextual and realistic learning in the park. Players receive a clue to a virtual cache at the end of each stage that, if found, rewards the players with points and virtual objects, which can be traded for assistance with the questions. In a survey of children that had used this game, children's perception of the game was positive. In this study, 90.2% of children had the opinion that the app helped them learn about their environment by showing them physical world information, and



Figure 1: a) selected screens of the EduPARK app and game (source: Pombo & Marques, 2021); b) plaque with an AR marker, next to a botanical specimen (source: Pombo & Marques, 2017: 176).

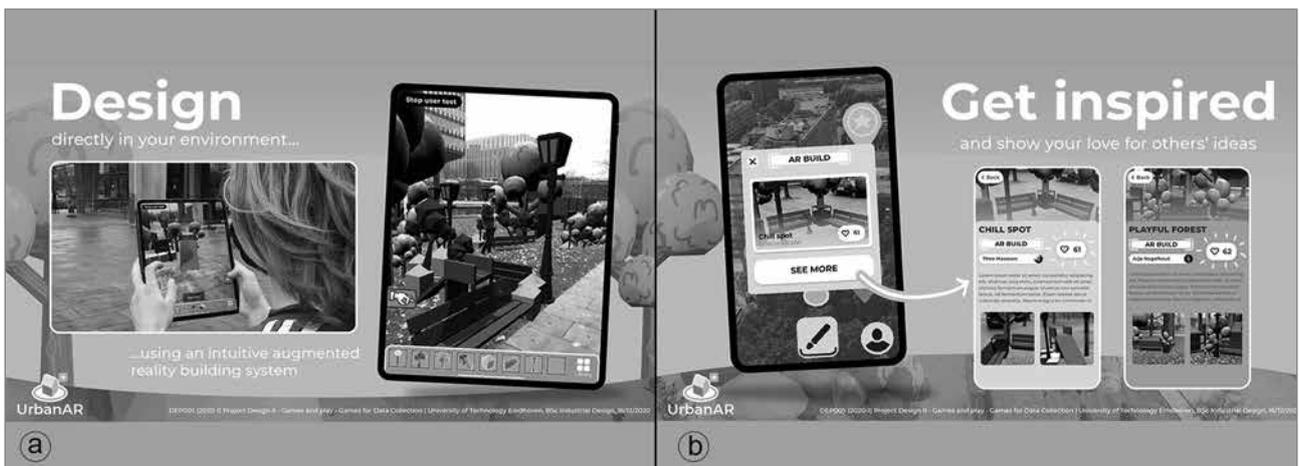


Figure 2: a) selected screenshots of the UrbanAR app (source. Dutch Design Daily, 2020); b) sharing ideas with other users (source: Dutch Design Daily, 2020).

Table 1: Examples and their features.

	Opportunities through AR (digital + physical world)	Child-friendly city features
Minecraft Earth	Encouraging children's collaborative practices versus isolated digital practices Fostering children's social skills by brainstorming and cooperating through creative processes	Forming communities and groups that share creative creations
EduPARK	Learning about environmental contexts in the digital and physical world Training children's perception (touch, sight, and hearing) to allow sensing capacities beyond the physical world	Educational experience Accessibility to green spaces
UrbanAR	Users visualize their ideas in the physical world Collective collaboration in the urban design process	Effect of people's decisions on planning and building their city People express their point of view about urban features they like

Source: Authors (2022).

86.9% of children generally had a good feeling about using this app for learning purposes (Marques & Pombo, 2019).

UrbanAR is an application that utilizes AR to make urban design more accessible to all by allowing people to express their opinions while having fun using it. This project allows

people to offer their own insights and opinions regarding solutions to urban planning. Furthermore, municipalities can utilize the data and opinions of users fetched from the application to build or rebuild cities more accurately based on people's needs and desires. In this way, the project helps make the city a better place for everyone in a collaborative manner.

In this application, people can directly visualize their ideas in the physical world. Then all the builds submitted can receive votes from other users, which encourages mass participation during the process (Dutch Design Daily, 2020; UrbanAR, 2021a). In a survey carried out by the developers of UrbanAR, users mentioned that the application does not depend on users' subjective imagination because they can already see the elements in the physical world. Furthermore, they stated that this application helps them objectively instantiate their imaginations and ideas and also allows them to see the best arrangement of the urban elements visually (UrbanAR, 2021). Although this application is appropriate for all age groups, it especially provides an opportunity for children to develop their visual literacy and a sense of responsibility toward the city they will be living in for years to come.

Table 1 analyses the examples in terms of opportunities rendered by AR and child-friendly city features. The features of the examples have been categorized based on the children's activity and their interaction with their environment during the game. These features have been extracted from articles and the main web pages of the game developers that are referenced in this article.

As shown in Table 1, children gain various benefits from these AR games. By using AR in Minecraft Earth, children experience playing together in the digital and physical world while developing social skills. At the same time, they communicate with others and enhance their teamworking skills through the game's platform. In EduPARK, children experience multiple modalities of AR content through text, video, and 3D models, which encourages them to use their senses of touch, sight, and hearing in the physical and digital world. With the opportunity that UrbanAR provides, users can express their insights and opinions throughout the urban design process and see their builds instantiate in the physical world. The other possibility that this AR application provides in its platform is that people can comment on each other's work and help improve each other's designs.

In each one of the three examples presented above, some of the child-friendly city features are evident. Children in Minecraft Earth associate with their friends and play with them. The EduPARK app is designed to be explored in an urban green park, a setting that can be used to promote new modes of learning in science education, where experiences in real environments improve one's ability to understand ecosystems (Pombo & Marques, 2020: 2). In turn, children in UrbanAR can experience taking part in designing their city and bringing their imagination to life using digital representations.

5 Conclusion

AR facilitates the development of diverse skills among children. In addition, it develops inquiry-based learning, spatial ability, and practical skills, and it can further create hybrid learning environments that combine digital and physical objects. In this way, AR can promote the growth of skills such as problem-solving, communicating, and critical thinking. As native digitals that are nowadays entertained with technology at home, children can utilize AR to be more present in the city and perform physical activities to develop various skills. Although living in the city has a pure physical form, AR can act as a connector to bring the physical and digital worlds together and help create child-friendly cities.

Based on the literature review and analysis of the examples selected, AR can provide the urban environment with more features of a child-friendly city to inspire children toward a more active presence in the city. As part of future work and as AR is more widely used in urban environments, more feedback needs to be collected from children around the world about their experience using AR in the city to more accurately quantify and compare the role of AR within the child-friendly city.

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