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FACILITATING PARTICIPATORY ADVANCEMENT IN ARCHITECTURE USING EXTENDED REALITY SOLUTIONS. THE LITERATURE ANALYSIS

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Abstract. Public engagement and participatory advancement in architecture have entered a new level, as public expectations rise and technological innovations create new opportunities. Stakeholders can contribute to architecture through variety of new technological tools that evolved significantly over the last decade and the key question is how to make architecture better by using them. The paper presents findings of the initial stage of research – exploratory literature analysis of emerging trends for adopting virtual reality (VR), augmented reality (AR), mixed reality (MR) and other human–computer interactions in urban design and architecture. The goal is to figure out the most recent trends of how public can participate and improve the quality of architecture through modern technologies. The results show that directions of current investigations on participatory advancement in architecture by using extended reality (XR) solutions develop in these main directions: easy to use tools, simulation of space and content, evaluation of results, continuous participation of stakeholders and adoption of XR solutions in architectural design, urban design and landscape architecture.

Keywords: architecture, architectural design, urban design, landscape architecture, virtual reality, augmented reality, mixed reality, gamification, public participation, stakeholder engagement.

Introduction

Government of the people, by the people, for the people (Lincoln, 1863) – the famous phrase by the father of modern democracy put people in the process of decision making. Likewise, in architecture it is essential mission to understand and reflect human needs in space formation. Higher community awareness, better access to information, easily available technology-based solutions, expansion of internet worldwide stimulates community's involvement in the processes of architectural design, urban designa and landscape architecture. Public participation process ranges from high to low levels, from simple informing to multidimensional and resource-consuming citizen control, described as "ladder of citizen participation" (Arnstein, 1969).

For architects extended reality (XR) solutions if applied wisely can facilitate participatory advancement in architecture and become an effective tool. In this article XR is used as an umbrella term encapsulating augmented reality (AR), virtual reality (VR), mixed reality (MR) and all real and virtual combined environments. AR is defined as a real-world environment digitally augmented or enhanced, VR is a simulation and replacement of a real-world, MR combines both of AR and VR and gamification is a way of interacting with public and other stakeholders.

Nowadays different scale projects on architectural design, urban design and landscape architecture should meet the variety of legal regulation and formal requirements aiming to inform and involve community. For example, in Lithuania regulation requires running formal procedures designed mainly to inform communities about the planned interventions and it is mandatory for further progress of the construction project (Ministry of Environment of the Republic of Lithuania, 2016). In other cases, cities take other society-sensitive solutions such as refurbishment of existing squares, plazas and other open spaces or even more complicated process of removing the existing monuments or constructing the new ones (Seam et al., 2018). These areas might have controversies in their historical appreciation, recognition, or identity issues, which divide people based on their opinions and create resistance to the planned changes. However, with the leap forward of technology in XR and gamification it became

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easier to inform people about the coming changes, obtain their opinions early enough and monitor these processes on different decision-making stages. XR and other solutions, if applied in a smart way, allow "climbing up" the participation ladder as to turn the participation costs into the benefits for the greater success of a project.

The importance and role of public participation in decision-making is imperative globally and is emphasized by international initiatives, EU directives and agreements. For example, The Aarhus Convention establishes a number of rights of the public with regard to the environment, such as, the right of everyone to receive environmental information that is held by public authorities and to participate in environmental decision-making (United Nations Economic Committee for Europe, 1998). The public should be provided with wider and easier access to environmental information (European Parliament and Council of the European Union, 2003a) and contribute to the implementation of public participation in respect of the drawing up of certain plans and programs relating to the environment (European Parliament and Council of the European Union, 2003b), ensure that no one is left behind (The General Assembly, 2015). The global tendencies towards more open, inclusive, and beneficial participation are obvious; therefore, it is crucial to find proper methods and tools to facilitate participatory advancement of architecture.

In 2020, COVID-19 pandemic hit world and because of global lockdown, people became more engaged in online remote work and communication. This opened new possibilities for internet-based public participation procedures of projects under development, and many cities started using this remote nevertheless sometimes even more efficient tool. Expecting the better outcome, modern communities actively claim better opportunity to engage in the different kinds of city development projects at early stages. This is where VR, AR, MR, gamification can show its potential – instantly connect developers, authorities, planners, designers and communities together in an unprecedented pace to achieve the most appreciated and trustworthy outcome.

The paper presents findings of the exploratory analysis of modern and emerging technology-for-participation trends on the most recent literature and embraces on the holistic understanding of architecture as a field encompassing architectural design, urban design and landscape architecture as well as analyzes and compares current tech-based participation practices under research in literature all over the world.

1. Methodology

Guidelines for conducting a literature review have different methods that might include elements from various approaches. For example, Hannah Snyder suggests these types of literature review: narrative, systematic, integrative, and meta-analysis, semi-systematic, review papers and systematic reviews (Snyder, 2019).

A narrative review method is chosen to analyze literature of participatory advancement in architecture using XR solutions. This method provides the explicit information about the application and the benefits earned as well as it illuminates areas for further research in this field. The review focuses on articles from authoritative journal databases, specific journals, website searches, books, papers from conferences. As the volume of research output and the number of literatures is immense and it constantly expands, identifying relevant studies became challenging. To facilitate online search of the article's, keywords and included particular phrases all together: "participatory planning", "virtual reality", "augmented reality", "gamification", "architectural design". The search for English language eligible studies was done by using multiple databases that included the most recent relevant literature from the last decade – period from 2011. The relevant topics from different countries and continents includes the use of XR based solutions for participatory advancement in architecture and other emerging relevant issues. Applications and concepts of AR, VR, MR, gamification and other hi-end approaches is known and developed for many decades. However, during the last decade, advancements in graphics, computing, sensors, and networking finally elevated this emerging industry to the pinnacle of mass-market uptake (Seam et al., 2018). For this reason, the article focuses on the most recent investigations and applications of the abovementioned technology-based solutions used for public involvement. The article's focus of attention to analyze the methodic composition and goal-oriented character of the technology-based applications employed for advancing participatory quality of architecture.

The initial content is analyzed and collected information is structured into five major groups according to the research object and the goal of application. This type of structuring the outcomes is relative but it allows classifying directions for further research in this field. The geographical display analysis indicates where the research of XR solutions for participatory advancement in architecture were performed, and chronologic timeline shows their order of occurrence in chosen time since 2011.

2. Analysis

After initial selection and preliminary review of more than 200 scientific resources available in scientific databases in English from the period 2011–2020, the selected fraction of thematically appropriate literature is analyzed and grouped into the blocks according to the research object and how the research goals are achieved. As dominating XR application trends are the main interest of this paper, the way technology is applied differs depending on the research object, its nature, location and the problem addressed. Having an interest to identify the most advanced regions and research centers in the field the author outlines location of the analyzed research as presented in the relevant papers.

After secondary analysis of additional literature, new possible aspects could be proposed or current aspects could be modified. Therefore, the selected fields of research have to be re-evaluated and adopted critically.

As comes from Table 1, the selected fractions of literature fell into five dominating fields of research directions that analyze implementation of participation and XR-based solutions in architecture in a particular way (Figure 1). Each field represents one of the dominating research directions of XR-based solutions used to facilitate participatory theories and practices in architecture that as presented below.

Table 1. Methods and research object in the analyzed literature

Article	Location of research	Application (Implementation) method	Research object
1.1. Development of easy to use tools			
Jenney et al. (2018)	Germany	Tools for decision-making in early strategic design phases and Game. Research of potentials of gamification in communication processes in planning between different stakeholders	Motivational factors of the different main stakeholder when designing, engaging sensible and sustainable exchange of knowledge and interests
Mueller et al. (2018)	Germany	User friendly web application development. Gamified elements to encourage experience the underlying mechanisms under alternating planning scenarios	A web application – easy to use tool for smaller urban administrations
Seam et al. (2018)	US	True ubiquitous connectivity and ultra-low-latency mobile access to remote computing power for AR and VR technology	AR and VR industries as a challenge to operators to design 5G network
Kamel Boulos et al. (2017)	United Kingdom	VRGIS technology as a combination of VR and GIS technologies, integrating three-dimensional GIS (3D GIS) and Internet-oriented GIS (Web GIS)	VRGIS and ARGIS solutions for public and environmental health problems and bringing safer and healthier living options to individuals and communities
Allen et al. (2011)	New Zealand	Smart-phone for 3D virtual representations on top of existing real-world architecture	Smart-phone based AR architecture for public participation in urban planning
Imottesjo and Kain (2018)	Sweden	An iterative research by design approach applied to functioning MAR tool: the Urban CoBuilder	Set of specifications detailing performance of MAR tool Assessment of the MAR tool prototype
Nechita (2019)	Romania	Good practice for a creative and innovative way of using digital media tools for engaging citizens with their cities	Digital communication tools used in business and brand communication: co-creation, digital storytelling, virtual worlds or gamification for engaging citizens in urban design or urban regeneration projects
Olsson et al. (2012)	Finland	Evaluation the usefulness and overall strengths and weakness of AR system for participatory planning	Evaluation of usefulness of a mobile AR system for visualizing urban plans of an area reconstruction project
Milovanovic et al. (2017)	Turkey	System CORAULIS, including both VR and SAR (smart device / screen or any surface) technologies	VR and AR devices selected from conferences and journals on CAAD (Computer Aided Architectural Design)
1.2. Creation of space and content using XR based solutions			
Graham et al. (2013)	USA	Social actors, distributed power and communication power; and connected primarily via software, code power and timeless power	Mediation through technological artefacts, code and content to produce place
Jiang et al. (2016)	Italy	Audio-visual scenarios of urban developments, including different traffic control actions and street designs built in game engine, and published online in the form of a WebGL game. Then application tested in trial e-participation in urban sound planning	An online VR application for e-participation in urban sound planning, following the concepts of gamification, easy accessibility, and real-time naturalization
Sassmannshausen and Radtke (2020)	Germany	AR-App as a gamification aspect to encourage intrinsic motivation and contribute to citizen participation	Research project Creative Citizen as a human-centered design approach – citizen integration in the design process of the AR
Maffei et al. (2016)	Italy	In real and laboratory settings, two independent groups of participants invited to fill out questionnaires concerning: global qualitative evaluations, coherence and familiarity for acoustic and visual stimuli	How acoustic and visual stimuli of a simulated environment in immersive virtual reality (IVR) were sufficiently congruent with their correspondent elements in the real context

End of Table 1

Article	Location of research	Application (Implementation) method	Research object
1.3. Evaluation of results through gamification			
Markopoulou et al. (2018)	Austria	VR, AR, Gaming interfaces for acquiring qualitative and quantitative data of technologically mediated design participation	Responsive technologies and gaming interfaces for architects and urban designers as a tool for enhanced participatory design and evaluating existing planning or future design decisions
Stauskis (2014)	Lithuania	Public involvement through virtual simulation – VR and spatial modelling integrated on gaming platforms	VR simulation used as for setting a participation platform to improve environmental, social and energy sustainability of urban development
Sulemana and Ngah (2012)	Malaysia	Seven (7) questions to ask whether a process is participatory or not	Questioning what participation actually mean in contemporary times
Steiniger et al. (2012)	Italy	Planning platform merges social networking with GIS	Functionality of participatory planning platform and constraints considering the platform user, the intended user activities, the context of use, and access to data
Rufat and Minassian (2012)	France	Convergence between simulation and video games through a selection of strategy and city builder video games	Simulations and video games
1.4. Participation of stakeholders			
Fegert et al. (2020)	Germany	Meta requirements for an e-participation application employing e-participation technology	Qualitative study on using AR for e-participation
Legacy (2016)	Australia	Citizen's participation through politics and how to reshape participatory planning	Participation manifests from the politicizing participatory moments in planning
Akmentiņa (2020)	Latvia	Meta-analysis as a methodological approach to combine information from various sources	Research of participatory planning practices in a post-socialist urban context since 1990.
Mustanir et al. (2019)	Indonesia	Participatory Rural Appraisal (PRA) as a method of participatory planning	Creation a system of participatory rural development planning involving the community as a whole
1.5. Adoption of XR in architectural design, urban design and landscape architecture			
Cirulis and Brigmanis (2013)	Latvia	AR for urban planning experts to move around the city streets and project virtual three-dimensional buildings, allowing to see real city and virtual buildings at the same time	Evaluation of new constructions, objects and visual influence on environmental surrounding
Broschart and Zeile (2014)	Germany	Formation of opinion towards the changes of man-made environment	AR techniques to show possible use cases in the fields of AD and urban planning
Jaalama et al. (2021)	Finland	Sense of presence and sense of place through a web-based 3D geo-visualization	Photorealistic 3D geo-visualizations as a tool for communication in urban planning
Portman et al. (2015)	Israel	VR research opportunities and challenges and what can be gained from sharing VR systems for research and education	VR environments for research and teaching in architecture, landscape architecture and environmental planning
Noghabaei et al. (2020)	USA	Analysis to assess the current state, growth, and saving opportunities for AR and VR technologies for the AEC (Architecture, Engineering, and Construction) industry	Understanding the industry trends and identifying gaps in adopting AR and VR technologies

2.1. Development of easy to use tools

The tools for using AR, VR and gamified environment solutions and technologies are being constantly developed for facilitating involvement of stakeholders. It is becoming more user friendly and necessarily need sophisticated equipment. The development of technologies shows potential use of VR and AR on everyday mobile devices, such as smart phones. The combination of GIS, internet and smart phones shows possibilities to use XR at site to see the result before decision is made. The importance of tools that are user friendly, easy to use and implement are mostly emphasized in articles. Tools are usually understood as development of new advanced applications, as well as the devices themselves. Authors emphasize the importance of easy VR and AR accessibility in daily life engaging their smart phones (Allen et al., 2011), the importance of high capacity internet solutions that facilitate use of VR and AR (Seam et al., 2018). Authors highlights the challenges that can be easily solved by applying XR solutions. Articles show the tendency that researchers in more technologically advanced countries are more engaged in the development of XR tools. Development of easy to use

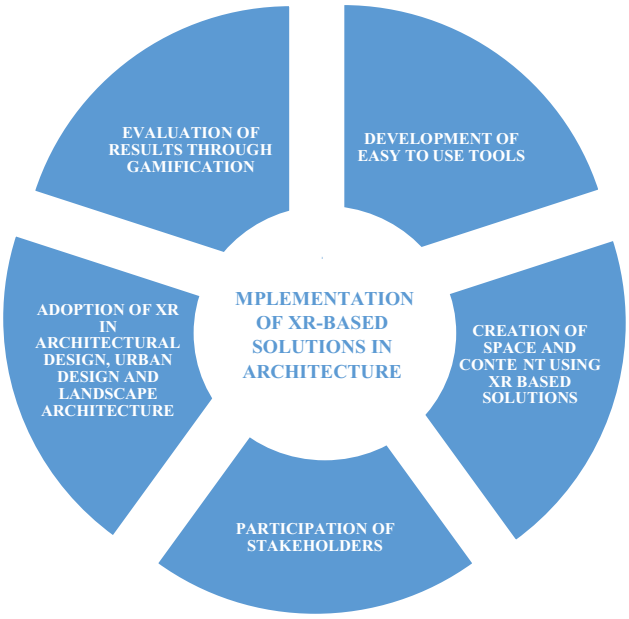

Figure 1. Dominating fields of research for implementation of XR-based solutions in architecture

tools is the next step of developing XR solutions, enabling easier and more inclusive public participation.

2.2. Creation of space and content using XR based solutions

While some case studies concentrate on the tools how to adopt modern XR solutions in decision making process and make them user friendly, other case studies examine the content and what makes stakeholders more involved in the process. Researchers are interested on visual content as well as acoustic content and how it effects the engagement of participators. Multiple stimulus can be used to encourage motivation and contribution for citizen participation (Sassmannshausen & Radtke, 2020). The quality of feedback of participators is influenced by the quality of simulated environment in the immersive virtual reality (IVR). Gamification can influence citizen self-determination to participate and redesigning public spaces. Motivation to participate arises when changes in a familiar place can be seen in real time. Simulation of space using XR is one of the most interactive method of engaging public participation that helps intuitively choose the most optimal decision-making way while playing or simulating different situations. This method helps to discover the most acceptable solutions to the public, which would be extremely difficult to find out in other ways.

2.3. Evaluation of results through gamification

XR tools are sufficient at decision making phase when the design process has been started. A gamification method could be implemented for better understanding of the community and developer needs and preferences. Therefore, acquiring qualitative and quantitative data by using gamification and evaluation of the results can solve many flaws of the projects. Architectural design, urban design and landscape architecture is a complex and far-reaching process that addresses wider societal challenges. While thinking how to plan urban areas of the future it is important to get information about the development of trends using gamification. City building games are identified as one of the sources (Rufat & Minassian, 2012). As a type of "serious games", application of a gamified environment allows to obtain personal preferences without even asking a person if he prefers a project or not. Sophisticated scenarios are used to encrypt the question into a game and afterwards decipher it from a recorded user's behavior. Different gaming interfaces could be addressed to attract more participation and to collect more useful data. Specific methods of VR simulation can be a bridge for stakeholders to achieve best results in urban development (Stauskis, 2014). Gamification and simulated strategy tools can help to evaluate and identify problems in order to address them in urban design in early stages.

2.4. Participation of stakeholders

XR in their origin and essence are the tools to facilitate participation of stakeholders in planning and design process. There are many case studies on participation and each of them evaluates different approaches, methodologies and purposes. Therefore, it is crucial to involve people in the design process and get a desired feedback. The reviewed literature showed different tools for stakeholders to participate and involve in time, easily and correctly. Facilitating participatory advancement in architecture could be difficult if there is a lack of stakeholder's interest. While some authors justify the importance of participation manifests through politics (Legacy, 2016), others encourage new tools of engaging participation of stakeholders. One of them – e-participation based on technological approach (Fegert et al., 2020).

2.5. Adoption of XR in architectural design, urban design and landscape architecture

XR techniques combined with gamification and public participation might provide architects with huge amount of valuable information. The key question is how to use this data in architecture and urban design and how to adopt it in certain urban areas for the architectural design, urban design and landscape architecture. Intervention using augmented reality solutions for stakeholder's participation in urban planning and architectural design creates emotions and forms opinion of citizens (Broschart & Zeile, 2014). Collected information of public expectations can reflects positive attitude towards emerging changes. As every individual is different their opportunities to visualize also differ and this creates risks of miscommunication and misunderstandings that can prolong or even put into danger the planned projects. VR and AR in participatory planning enables stakeholders to identify and emphasize emerging opportunities and challenges in architecture, landscape architecture and urban planning (Portman et al., 2015).

3. Results

Analysis of the selected literature allowed identifying the dominating fields of research for implementation of XR-based solutions in architecture. These fields combine hi-tech tools to enable easier and more inclusive public participation in different phases of building, urban and landscape projects. Each selected field of research shows unique contribution to the implementation of XR-based solutions in architecture, in particular – development, creation, evaluation, participation, adoption.

The geographical display of countries shows global engagement of researchers in promoting discussions in this field (Figure 2, Figure 3). European Union as a region stands out from the others: more than a half of the analyzed case studies – 16 of 26 – were developed in the EU countries, and the rest of them – in North America, South East Asia and Australia. These countries and academic communities are more developed economically; they are more advanced socially and politically and have better opportunities and experience to use modern technologies for addressing acute societal issues of architecture as more advanced participation.

Timeline analysis shows that this field of research holds permanent researcher's attention: it remains relevant during all the selected period (Figure 4). In 2020, more research was published on combining different fields of research by merging XR technologies, embracing on gamified environment for using these solutions to improve efficacy of participatory approaches in architecture.

4. Discussion

Researchers in different fields have investigated how AR, VR, MR affect architectural design, urban design and landscape architecture in the last decade. The results of the review indicate the wide possibilities for improving quality of architecture through technology-based solutions. The results of review draw attention to the importance of easy to use tools, motivation for citizen participation, gamification to solve flaws in the projects, involvement of communities in the process and inclusion of XR-based solutions. The research demonstrates how the combination of these elements help increasing public and community awareness, consolidation, environmental security and other so-

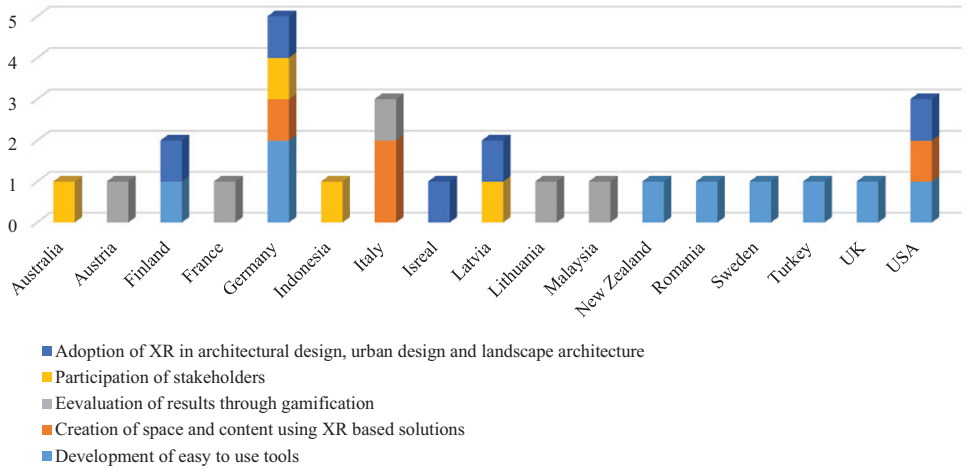

Figure 2. Geographical distribution of the fields of research in the analyzed literature

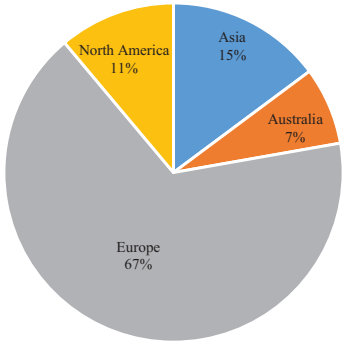

Figure 3. Geographical distribution of the analyzed literature by the global regions

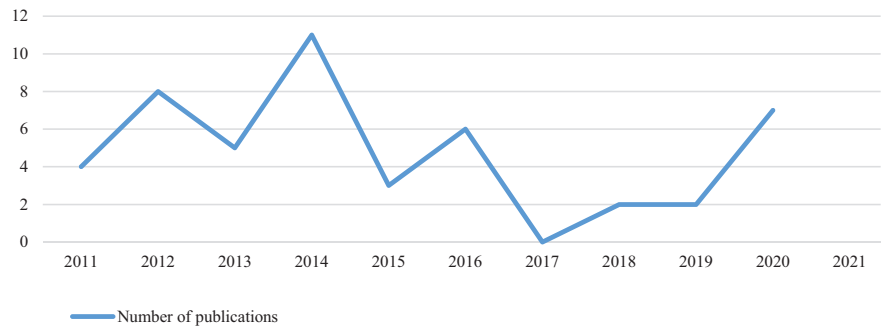

Figure 4. Number of publications per year in the analyzed field

cial merits. Some real case studies have been mentioned for trying out VR, AR, MR with the stakeholder's participation in design process for creating better architecture.

As technological opportunities constantly rise, it becomes possible to simplify an easy to use spatial simulation for crowd-sourced applications of emergent urban development patterns. The research showed different approaches how the AR, VR, MR methods help to facilitate the stakeholder's involvement. This gives an opportunity to address the new methods or the new combinations of existing ones for more engaging, inclusive and efficient public participation in architecture. As mobile devices become a part of everyday life, researchers investigate how to combine smart-phone, AR, merge Social Networks and Participatory GIS in architecture and landscape. The advanced studies examine ability for co-creation, adoption, gaming and e-participation through AR and VR. Different modes of participatory engagement give new possibilities of using digital media with 5G Networks and applications of virtual reality GIS (VRGIS) and augmented reality GIS (ARGIS). In recent years we see the increase of interest in participatory advancement in architecture through XR-based solutions and it will increase in the future along with the scale of urban, environmental and social issues in modern cities.

Creation of space and content using XR helps to discover the most acceptable solutions to the public in difficult situations. Evaluation of results through gamification and simulated strategy tools can help to evaluate and identify problems and obtain public preferences. New XR tools helps stakeholders to participate and involve in time, easily and correctly. Adoption of XR in architecture combined with gamification and public participation provides architects with valuable information that can lead to better quality of space for living.

For proper use of XR-based solutions in architecture the gaps and limitations of XR technologies has to be identified critically as it depends on the place, time, object, method of implementation, knowledge of participants. However, the current achievements in this field worldwide are evident; the benefits at stake are credible and demonstrated both in the scientific and practical ways. Furthermore, the presented analysis includes only literature in English, therefore, it is possible that this issue is under active research in even more countries and the range of XR-based solutions might expand.

Conclusions

Virtual and augmented reality instruments can be widely used in the field of architecture, from design itself to launching communication and collaboration in decision-making processes. To get a full image of the usability, efficacy, access and usability of the reviewed XR-based participatory solutions should be analyzed in detail, consolidated, differences and similarities indicated, possible risks and opportunities evaluated. The qualitative criteria, indicators for the quality of architecture, urban and landscape design, algorithms of VR, AR, MR, gamification based participation-oriented solutions have to be developed.

The research suggests a further investigation to capture how adoption of solutions influences implementation of participation and XR-based solutions in architectural design, urban design and landscape architecture (Figure 1). A deeper investigation would help to consider the variety of factors used to improve a better design outcome.

As it comes from the results, projects could benefit from using these tools and methods, if treated in a complex way. There is a space for further research in this field aiming at scientifically advanced, regionally applicable and socially inclusive solutions for participatory progress of architecture.

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DALYVAUJAMOJI PAŽANGA ARCHITEKTŪROJE NAUDOJANT IŠPLĖSTOSIOS REALYBĖS SPRENDINIUS. LITERATŪROS ANALIZĖ

V. Misius

Santrauka

Visuomenės įsitraukimas ir dalyvavimas architektūroje pasiekė naują lygį. Visuomenės lūkesčiai auga, o technologinės naujovės sukuria naujas galimybes. Visos suinteresuotosios šalys gali prisidėti prie architektūros kokybės naudodamos įvairias naujas technologijas, kurios itin ištobulėjo per paskutinį dešimtmetį. Pagrindinis klausimas, kaip jas naudojant gerinti architektūros kokybę. Straipsnyje pateikiamos pradinio tyrimo išvados – žvalgomoji literatūros analizė apie besiformuojančias kryptis urbanistikos ir architektūros projektavimo srityje panaudojant virtualios realybės (VR), papildytosios realybės (AR), mišriosios realybės (MR) ir kitus žmogaus bei kompiuterio sąveikos įrankius. Straipsnio tikslas – susipažinti su naujausiomis tendencijomis ir galimybėmis, kaip įtraukti visuomenę architektūros kokybei gerinti pasitelkiant šiuolaikines technologijas. Rezultatai rodo tolimesnes dalyvaujamosios pažangos architektūroje naudojant išplėstosios realybės (XR) sprendinius tyrimo kryptis: paprasti įrankiai, erdvės ir turinio modeliavimas, rezultatų vertinimas, nuolatinis suinteresuotųjų šalių dalyvavimas ir XR sprendimų naudojimas architektūriniame projektavime, urbanistikos projektavime ir kraštovaizdžio architektūroje.

Reikšminiai žodžiai: architektūra, architektūrinis projektavimas, urbanistinis projektavimas, kraštovaizdžio architektūra, virtuali realybė, išplėstoji realybė, mišrioji realybė, sužaidybinimas, visuomenės dalyvavimas, suinteresuotųjų šalių įsitraukimas.