The Latest Innovations in Landscape Design

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The rapid and constant development of innovative technology continues to shape new opportunities for the design sphere, including landscape design. With the progress of urban modernization and the improvement of people's living standards, more attention is paid to the city and the environment coordinated development, and the aesthetic and user needs of the landscape are becoming higher. This research aims to identify relevant innovations in landscape design based on a survey of employees of companies in the field of landscape design and carry out a SWOT analysis of the innovative technology implementation process for professional training of future landscape designers to establish the benefits of innovation in landscape design.

Keywords: landscape designers, innovations, innovative technologies, virtual reality technologies

INTRODUCTION

The beginning of the XXI century has seen major global changes, characterized by the intensive development of digital technologies, the revolution in the information space, and the acceleration of economic globalization and digitalization. The transition to digitalization today is one of the principal priorities in world economic development. The latest information, digital technologies, and innovations have become important in landscape design.

The twenty-first century is the century of digitalization, and information technology is changing all industries, including landscape design (Sîrghi, Sîrghi, 2020). Reforming the scientific field and fostering innovation are key sources of sustained economic growth and are directly related to the innovative information technology introduction in landscape design (World Economic Forum, 2021).

In the last decade, digital technology has dramatically changed the way businesses do business (Gray et al., 2013). Companies are transforming digitally not only as a way to reimagine what their customers like (Filieri et al., 2018; Galati and Galati, 2019) but also to create operating models that can fully exploit new opportunities and thus differentiate themselves from their competitors (Berman, 2012). Relevant innovations in landscape design remain crucial for community development, business growth, and supporting competitive advantage in markets (Franklin et al., 2013). Furthermore, the innovation process is still iterative, uncertain, interactive and dependent on direction, context, and multitasking (Hüsig and Kohn, 2009; Pinna et al., 2018). Thus, it remains relevant that a key theme in business is to identify the right solutions to implement the innovation process, from the initial phase of ideas to market diffusion (Brem et al., 2016; Ganzaroli et al., 2016; Agostini et al., 2020).

With the popularization of geographic information systems and PC technologies to explore landscape biogeochemical analysis information and procedures using the advantages of satellite technology and the combination of visual landscape assessment and geographic information systems area, their application has been expanded because of current conditioning (Xu et al., 2019; Shan et al., 2021).

As a global institution, higher education must be mobile, flexible, and adaptable to any new opportunity and challenge because landscape design education is based on flexibility, know-how, openness, individual autonomy, and creativity. A training program that can consider global developments and innovations is necessary to comply with this system. (Istanto, 2002).

This research aims to identify the latest innovations in landscape design based on a survey of companies' employees in the landscape design industry and carry out a SWOT analysis of the innovative technologies introductions for the professional training of future landscape designers to establish the benefits of innovation in landscape design.

Research tasks of the article:

1. To analyze the proposed model of landscape designers' educational training based on participatory and self-study methods without teaching others and Industry 3.0 and Industry 4.0.
2. To analyze the key professional competencies of future landscape designers in Ukrainian universities and determine the programmatic results of completing the study discipline.
3. To carry out comparative characteristics of educational programs for studying innovative technologies' disciplines in landscape designers' training.
4. To conduct a survey among landscape design companies' employees for the installation of popular software for modeling in landscape design.
5. To perform a SWOT analysis of the innovative technology implementation process for the professional training of future landscape designers.
6. To survey students to establish a general judgment on the experience of virtual reality technology for modeling in a virtual environment in the landscape design.

LITERATURE REVIEW

Recent studies show that since the twenty-first century, international research on landscape visual resources has been extended to different sectors such as geography, forestry, tourism, psychology, etc. (Colucci et al. 2020). Many experts have quantified how to describe the visual impact of landscapes from different perspectives and establish visual indicators of landscapes (Koziatek and Dragićević 2017). However, many contemporary studies only start from a particular angle of view of the landscape and reflect one-dimensional visual landscape characteristics from a peculiar perspective (Shirowzhan, Sepasgozar, 2019).

Landscape design is defined as the discipline of shaping and executing landscape design projects variety, so quality professional training plays an important role. Researchers recommend devoting a

significant portion of the curriculum each year to landscape design projects. In the early years of education, students learn landscape design skills and the functioning of design teams, so teaching consistency is just as important as teaching leadership, which is often neglected in design project courses. The traditional process of mentoring, guiding, and critiquing throughout the learning process is important. Because projects need to be selected or improved so that they encompass the concepts emphasized in the learning process (Meyer, Norman, 2020).

Landscape design tasks require geospatial information on the environment, which is traditionally presented through 2D topographic maps, the most common among mapping products (Kent, 2009). Various cartographic techniques are used to represent 3D terrain on maps, which are abstract geographic representations such as contour lines, shading or hypsometric inks, etc. In this way, topographic maps provide an abstract geographic representation of the Earth's surface (Hopfstock, 2005).

An inventory of landforms and surface structures provided by maps has been used as a research tool for landscape analysis and design (Smith et al., 2013). When visualizing a map, the landscape designer needs to know how to interpret these cartographic techniques to perceive the three-dimensional reality of topographic relief in the two-dimensional environment in which the map develops. Punia and Kundu confirmed that "not everyone can read maps or mentally reconstruct a three-dimensional landscape with 2D map images" (Punia, Kundu, 2014).

However, there are other challenges for the landscape design professional. Maps can also integrate geospatial information through multiple views (profiles, elevations, thematic data, etc.) that simultaneously show multivariate geospatial data in separate but dynamically related views. This cartographic representation of geographic information, although a widely used way of representing the geographic environment (Koua et al., 2006), requires additional effort to interpret (Golebiowska et al., 2020). These circumstances create additional challenges in the learning environment, as geospatial visualization (geo-visualization) efforts can be frustrating for students, reducing their motivation.

New 3D rendering technologies can make the task of visualizing landscape environments easier. Technologies such as virtual reality (VR) can help landscape design teachers plan strategies that encourage three-dimensional visualization of terrain. Three-dimensional geographic representations through virtual reality can offer an environment for three-dimensional visualization of terrain that does not require multiple views because they can simultaneously view plan, elevation, and even geospatial information. In addition, they do not require the interpretation of any cartographic technique to visualize the terrain.

The research in teaching emphasizes the potential of virtual reality environments in learning processes (Bailenson et al., 2008; Bowman et al., 2009). VR assessments from an educational perspective have focused on factors such as interaction, sense of immersion (immersive virtual environment, iVE), and motivation, among others (Jia et al., 2012). An immersive virtual environment is "an interactive smart computer system that provides a three-dimensional virtual world" (Tcha-Tokey et al., 2016). However, although immersive virtual learning environments (iVLEs) are considered a powerful educational tool (Dede, 2009; Mikropoulos, Natsis, 2011), many authors believe more research is needed in this area (Dede, 2009; Webster, 2014; Ragan et al., 2012; Carbonell-Carrera et al., 2021).

Virtual reality technology is a software modeling system that is used for landscape design, following the three major software programs such as AutoCAD, Photoshop, and 3S (RS, GIS, and GPS). Virtual reality technology is widely used because of its interactivity, immersion, and imagination, which not only greatly reduces the work time and pressure on the landscape designer but also helps to stimulate the designer's imagination (Xu, Kang, Shao, and Zhao, 2015).

In landscape design, three-dimensional visualization consists of a realistic three-dimensional rendering of the terrain of the geographic environment, which is known as 3D geo-visualization, that is, 3D geographic visualization. The term geo-visualization combines, in addition to the realistic visualization of the geographic environment, the representation of geospatial information, spatial data, and thematic information. This geospatial information can have a complex structure, which contains temporal and thematic data attributes, in addition to geographical information (positioning).

An example of interactive 3D geo-visualization of spatial data is the work of Balla et al., who used a novel approach that allowed the user to manipulate temporal and spatial environmental data (Balla et al.,

2020). This research focuses exclusively on realistic 3D geographic geo-visualization, that is, 3D geographic mapping and visualization of the terrain using virtual reality. The use of 3D geo-visualization tools stands out in understanding landforms and ecological processes tasks.

Technologies such as virtual reality offer great opportunities for 3D geo-visualization, offering not only a realistic 3D geo-visualization scenario but also providing immersive and interactive opportunities. These capabilities provide an intuitive 3D geo-visualization and interaction scenario that allows different stakeholders with different experiences, backgrounds, and training to work together on a landscape design project.

3D geo-visualization is a powerful tool for landscape planning and, in turn, provides a platform for participatory planning with spatial management (Newell et al., 2017). Recent work (Jaalama et al., 2021) confirms the need for in-depth research into the perception of 3D geo-visualizations in landscape and urban planning. Strategies have been developed for collaborative platforms between different stakeholders in 3D visualization scenarios, such as VirCA (Virtual Collaboration Arena) (Galambos et al., 2015). This platform allows the development and implementation of shared 3D visualization scenarios in which 3D content is actively communicated and manipulated in a shared and synchronized way. The VirCA system is used in fields such as neuroscience research and industrial engineering, among others, and is an example of an interactive collaborative 3D working environment applicable to landscape design (Carbonell-Carrera et al., 2021).

An analysis of research on this issue shows that many scholars have paid attention to the problem of exploring the processes of applying immersive technologies in the learning process, such as Virtual Reality (VR) (Pellas et al., 2020), Augmented Reality (AR), and Mixed Reality (MR) (MacCallum, 2021). Researchers have paid much attention to the challenges of learning to design with VR (Desurvire, Kreminski, 2018) as well as interface development (Wetzstein, 2016).

There is also research on the challenges of learning immersive technologies by future landscape designers. A great deal of research has focused on the immersive engineering integration (CAD and 3D) technologies in the training of landscape designers (Grajewski, 2015). Particular attention should be paid to a study by scholars from the Nottingham University of Technology, "Augmented Reality: Creating a Shared Context from Programmer to Designer," which extensively highlights the challenges and interactions of landscape designers and programmers while working with AR technologies, addressing the internal and external barriers of immersive technologies in landscape design practice (Hoang et al., 2019).

Given the significant number of scientific publications devoted to various aspects of the application of innovative technologies, it can be noted the lack of development of the problem of implementing the study of innovative technologies in the process of professional training of future landscape designers (Chemerys et al., 2021; Alekhanovich, Abdurakhimovna, 2020).

Consequently, the study of the latest innovations in landscape design and the problems of implementation of innovations in landscape design find little reflection in scientific publications through theoretical studies and practical research. However, the issue of promoting the implementation and introduction of innovations in landscape design remains relevant and open for further research.

METHODS AND MATERIALS

The implementation of the aim of this study involves the use of research methods such as:

- systematization of the main features of educational training implementation of landscape designers proposed model based on participation and independent learning methods without teaching others and Industry 3.0 and Industry 4.0;
- systematic and logical analysis; the method of information synthesis of key professional competencies, which are formed by future landscape designers at universities in Ukraine, and the list of program results at the end of the study of the discipline;
- synthesis of the latest scientific publications related to SWOT analysis of the process of implementing innovative technologies for professional training of future landscape designers.

– comparison method to distinguish the characteristics of educational programs in institutions of higher education and determine the disciplines for the study of innovative technologies in the training of landscape designers, as well as a comparison of five frequently used programs for modeling in landscape design.

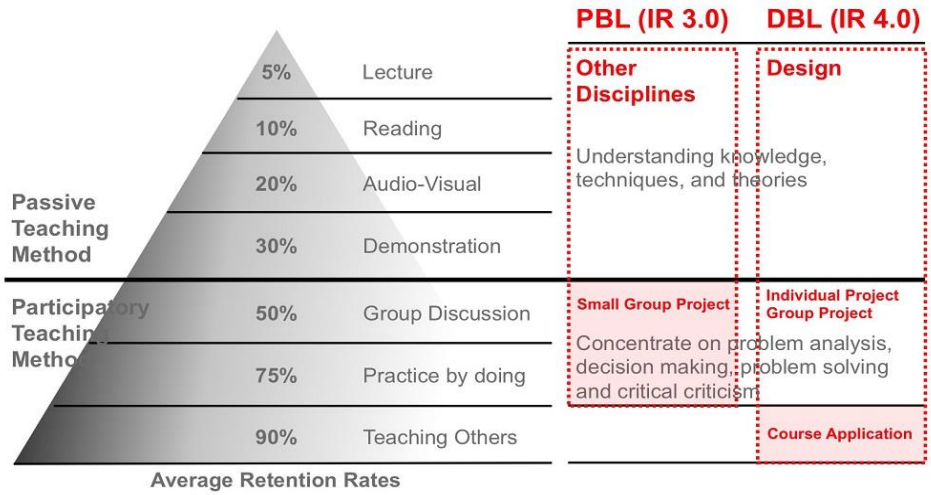
To determine the current innovations in landscape design, were surveyed students of Kyiv National University named after Taras Shevchenko, University of Economics and Law "CROC", Kyiv National University of Technology and Design, and Odesa State Agrarian University using descriptive statistics, which data was provided using MS Forms Pro.

The survey was conducted to establish a general judgment about the experience of applying virtual reality technology for modeling in a virtual environment in the field of landscape design. An online survey was conducted from May 10 to August 30, 2021, collecting information from 250 students. These participants answered questions about their experiences with virtual reality technology in landscape design, motivation, expectations, and overall enjoyment of modern ICT tools.

RESULTS

The fourth industrial revolution (Industry 4.0), which began in the XXI century, was a phase of cyber-physical systems, the Internet of Things, networks, cloud computing, big data, and artificial intelligence. While the problem-based learning process is a vital method of instruction for students who are characterized as Internet users, it is not appropriate for all students at universities around the world who are defined as significant technology users and producers. Thus, landscape design education needs to be updated and responsive to advances in technology, society, and students. The proposed model of educational training for landscape designers is an updated and combined version of participatory and independent learning methods without teaching others and based on Industry 3.0 and Industry 4.0 (see Figure 1).

FIGURE 1
LANDSCAPE DESIGNERS' EDUCATIONAL TRAINING MODEL



Source: Compiled by the authors based on official data of Young Choi (2020).

Having studied the professional training of future landscape design specialists, we analyzed the process and potential of introducing innovative technologies into the educational process. The available information analysis of the educational institutions' official resources is reflected in Table 1.

The study revealed that most educational programs do not include immersive technologies as a separate discipline but implement distinct topics in professional disciplines or have individual courses for students' choice. Among the subjects and special modules for the study of immersive technologies in the studied

universities, the most common are: introduction to VR/AR, multimedia programs, modeling, visualization and virtual reality, user experience with virtual, augmented, and mixed reality technologies (VR, AR, MR), multimedia, 3D-modeling objects and environments, digital art and technology.

There was conducted a comparative analysis of forming future landscape designers' professional competencies in Kyiv National University, named after Taras Shevchenko, University of Economics and Law "CROC," Kyiv National University of Technology and Design and Odesa State Agrarian University (see Table 2).

TABLE 1
COMPARATIVE CHARACTERISTICS OF EDUCATIONAL PROGRAMS FOR THE SPECIALTY "LANDSCAPE DESIGN" BY THE INNOVATIVE TECHNOLOGIES STUDY DISCIPLINES

Higher educational institution	Educational program topic	Immersive technologies		
		VR	AR	MR
Harvard University	Immersive media - virtual reality	as a separate discipline (Core modules) is indicated		
University of Pennsylvania	Multimedia technology specialized in VR/AR	as a separate discipline (Core modules) is indicated		
University of Florida	Graphic design, industrial design	as a separate discipline (Core modules) is indicated		
Cornell University	Augmented and Virtual Reality	as a separate discipline (Core modules) is indicated		as a separate topic of the discipline is indicated
University of Georgia	Virtual Reality and Augmented Reality Studies	as a separate discipline (Core modules) is indicated		as a separate discipline (Optional) is indicated
Michigan State University	Digital Media Technology	as a separate topic of the discipline is indicated		-
Iowa State University	UX/UI design and development	as a separate topic of the discipline is indicated		-
Mississippi State University	Virtual Reality Design	as a separate topic of the discipline is indicated	as a separate discipline (Optional) is indicated	-
Temple University	Digital Media Development: 3D Environments	as a separate discipline (Core modules) is indicated		-
University of Connecticut	Computer Graphics and Virtual Reality	as a separate discipline (Core modules) is indicated	as a separate discipline (Optional) is indicated	as a separate topic of the discipline is indicated
Kyiv National University named after Taras Shevchenko	Modern landscape design technologies	as a separate discipline (Optional) is indicated	as a separate topic of the discipline is indicated	

University of Economics and Law "CROC"	3D modeling	as a separate discipline (Optional) is indicated	as a separate topic of the discipline is indicated	-
Kyiv National University of Technologies and Design	Computer design	as a separate discipline (Optional) is indicated	as a separate topic of the discipline is indicated	
Odesa State Agrarian University	Project graphics	as a separate discipline (Optional) is indicated	as a separate topic of the discipline is indicated	-

Source: Compiled by the authors based on official data of Chemerys et al., (2021).

TABLE 2
THE LIST OF CURRICULUM RESULTS AND PROFESSIONAL COMPETENCIES WHICH ARE FORMED AMONG THE FUTURE LANDSCAPE DESIGNERS IN THE UKRAINIAN UNIVERSITIES

Academic disciplines	Current technologies of landscape design	3D modeling	Informational and digital technologies	Project graphics	Computer design
Program learning outcomes as defined by the curriculum standard					
1. Apply gained knowledge and understanding of the subject area and professional field in practical situations.	+	+	+	+	+
2. Create design objects through design and graphic modeling		+		+	+
3. Develop compositional solutions for objects design with appropriate techniques and materials	+			+	+
4. Take into account the properties of materials and constructive constructions, apply the latest technologies in professional activity	+	+	+	+	+
5. Apply modern general and specialized software in professional activity	+	+	+	+	+

Professional competencies					
1. Ability to succeed in a professional career, develop and present visual presentations, portfolio of own works, and have entrepreneurial skills to carry out design activities.	+	+	+	+	+
2. Ability to depict objects in the environment	+	+		+	+
3. Ability to use modern software to create design objects	+	+	+	+	+
4. Ability to perform form, layout, and modeling of design objects.	+	+	+	+	+
5. Ability to carry out compositional construction of design objects		+		+	+
6. Ability to apply special techniques and technologies in design-art activities in appropriate materials	+	+	+	+	+
7. Ability to apply design graphics skills in professional activity	+	+	+	+	+
8. Ability to carry out technical calculations in projects, feasibility studies, and functional-value analysis of the effectiveness of designed activities	+		+		+
9. Ability to make inventories of green spaces	+				+
10. Ability to develop technologies for growing ornamental plants	+				+
11. Ability to assess economic efficiency and innovation-technological risks of implementing new technologies in growing planting material	+		+		+
12. Ability to design and implement measures for engineering preparation of the territory, construction, landscaping, planting, and maintenance of garden and park facilities, objects of cultural heritage, and devastated landscapes	+	+	+	+	+

Source: Compiled by the authors based on official data.

There was conducted a SWOT analysis, which results allowed to determine the hierarchy and positioning of opportunities and threats to the implementation of the innovative technologies study during the professional training of future landscape designers (see Table 3).

TABLE 3
SWOT ANALYSIS OF THE PROCESS OF IMPLEMENTATION INNOVATIVE TECHNOLOGIES FOR PROFESSIONAL TRAINING OF THE FUTURE LANDSCAPE DESIGNERS

Strengths (S)	Weaknesses (W)
– high level of scientific and pedagogical staff involved in the teaching of innovative technologies in the field of landscape design; – increasing the level of motivation and productivity of educational activities of future landscape designers by focusing development on the attractiveness and image of innovative technologies in the field of landscape design; – demand for skills development of innovative technologies in the field of landscape design; – strengthening the position of the future landscape designer in the labor market, including the global; – the high price of remuneration for the landscape project, in which innovative technologies were applied.	– the high cost of equipment of educational institutions for the development and testing of innovative technologies in the field of landscape design; – loss of motivation among future landscape designers due to the complexity and a large amount of time spent on the process of learning the software product based on innovative technologies in the field of landscape design; – niche development of innovative technologies contributes to the emergence of a small number of projects with high prices.
Threats (T)	**Opportunities (O)**
– low interest of teachers in mastering new innovative technologies in the field of landscape design; – shifting attention from creative solutions to technical skills; – insufficient level of formation of multimedia competence, necessary for the successful development of the future landscape designer as a professional.	– opportunities for academic and professional mobility; – opportunities to adapt to the current changing realities of the landscape design market; – advanced training, including in the field of landscape design through innovative technologies.

Source: Compiled by the authors based on official data of Chemerys et al., (2021).

A workshop was held using an interactive 3D geo-visualization environment based on a low-immersion 2D desktop environment. The Unity 3D game engine was used to create a VR environment in which students performed tasks related to geo-visualization and landscape design. The overall experience with VR technology for modeling in landscape design is reflected in Table 4.

TABLE 4
SURVEY OF STUDENTS' EXPERIENCES WITH THE VIRTUAL REALITY TECHNOLOGY APPLICATION

Question	Assessment (1–10) (s.d.)
1. "Personally, I would say that virtual reality technology is practical."	8,16 (1,70)
2. "Personally, I would say that virtual reality technology is understandable."	7,52 (2,54)
3. "Personally, I would say that virtual reality technology positively contributes to modeling in landscape design."	8,24 (1,96)
4. "I have found that virtual reality technologies contribute to original modeling in landscape design."	7,20 (2,55)
5. "I have found that virtual reality technologies are modifiable to make the job easier."	6,36 (2,94)
6. "I found that virtual reality technologies were easy (1)/complicated (10) to work with"	4,00 (3,06)
7. "I found virtual reality technologies to be unpleasant (1)/pleasant (10) to use."	7,00 (2,16)
8. "I found this virtual environment cautionary (1)/motivating (10)"	6,64(SD = 2,29)

Source: Compiled by the authors based on official data.

To install currently popular software for modeling in landscape design, we surveyed "Vash Noviy Sad", "VIVE GROUP", and "V POLE DESIGN" employees and compared them in Table 5.

TABLE 5
COMPARISON OF FIVE FREQUENTLY USED MODELING PROGRAMS

Software	Modeling Speed	Modeling Ability	Modify the Convenience	Whether design-oriented
3DS MAX	slow	Strong	Convenient	yes
Maya	slow	Very strong	Convenient	yes
SketchUp	very fast	Strong	Very convenient	yes
CINEMA4D	fast	Strong	Convenient	no
Rhino	fast	Very strong	Convenient	no

Source: Compiled by the authors based on official data of Li (2018).

Since landscape design modeling requires design-oriented and user-friendly software, SketchUp is the first choice for modeling. In addition, SketchUp software is widely used in landscape design because of its easy operation, robust interaction, online model sharing, rich plug-ins, and multiple software interfaces.

DISCUSSION

The study results of current innovations in landscape design led to the following conclusions. Education around the world is currently undergoing a profound modernization process, primarily due to trends and policies for the use of innovative technology tools in the preparation, delivery of classes, and assessment of knowledge. The innovation technology use should encourage and provide students with intellectual satisfaction from a well-executed landscape design project (Sîrghi, Sîrghi, 2020).

Participants' feedback on the workshop using an interactive 3D geo-visualization environment based on a low-immersion 2D desktop environment was quite interesting. They were positive about the originality of the learning approach of geo-visual activities in landscape design. The game-engine approach to learning applied was motivating for students because motivation plays the main role in learning processes, especially those where visualization of geospatial information is necessary. These 3D visualization-based learning strategies are still new to students. An engaging 3D geo-visualization environment using a game-based mechanism to teach and explore landscape design through low-immersion desktop screens is an alternative to iVR.

The rating subscale measures "overall judgment of experience with virtual reality technologies." This subscale highlights a mean value of 8.16 (SD = 0 1.70) for "Personally, I would say virtual reality technologies are practical" and a mean value of 7.52 for "Personally, I would say virtual reality technologies are understandable (not confusing)." We also find values such as 6.64 (SD = 2.29) in the item "I found this virtual environment cautionary (1)/motivating (10)." It is interesting to know that students rate positively (with scores above 5.0) this 3D geo-visualization environment in low-immersion work environments as a practical, understandable, manageable, original, motivating, and even engaging learning environment. Although on the other hand, appreciating it is closer to the amateur sphere than to the professional one. In this regard, it would be necessary to investigate whether better results could be obtained with virtual reality technology with HDM devices (head-mounted displays) and external tracking sensors to prevent motion tracking (Carbonell-Carrera et al., 2021).

Organizing design education through the modern innovative technologies used in teaching serves to enhance students' creative thinking, independent decision-making skills, and teamwork through hands-on and lab-based landscape design classes. The introduction of innovative technologies in design education will be the basis for improving the effectiveness of education in the preparation of landscape designers (Alekhanovich, Abdurakhimovna, 2020).

Consequently, the latest innovations in landscape design based on the application of innovative technology tools will face new challenges under changes in innovation and globalization requirements for professional competencies of future landscape designers and in-depth research that will lead to increased attention to improving knowledge in the field of innovative technologies. professional training of specialists in the field of landscape design.

CONCLUSION

The analysis of actual innovations in landscape design has established that the general trend of the virtual and augmented reality market as innovative means of communication has led to the reorganization of the content of training future landscape designers as professionals with professional visualization skills. Increased profits from the use of these technologies, the attraction of maximum attention, a novelty in use, prospects and opportunities in the field of landscape design - this is only a part of all possible positive effects of the use of augmented and virtual reality in the professional sphere of future landscape designers.

Virtual reality technologies have added a new aesthetic perspective to landscape architecture and brought a new vitality to design and modeling. Virtual reality technology may well achieve a breakthrough from two-dimensional thinking mode to 3D mode so that designers can freely encompass space and realize a design scheme more intuitively. VR technology can bring designers' thinking closer to reality and break through the limitations of the traditional form of expression and create new trends in landscape design.

This research is of practical importance because the conclusions and recommendations developed by the author and proposed in the article can be used for the innovative technology tools selection to provide educational training for future landscape designers.

Further research can be aimed at improving and developing research methods of practical principles of implementation and study of innovative technologies in the professional training process of future landscape designers. It will allow to identify and adjust both basic and special subject competencies in specific disciplines and build the training process for future landscape designers correctly. For future research, it would be interesting to analyze the possibilities of interactive and collaborative platforms of 3D

visualization in the field of landscape design. Expanded opportunities and wide application of innovative technologies in the professional training process of future landscape designers could become the basis of the educational process in higher education institutions in the future.

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