

TENDENCIES XXI CENTURY IN DESIGN EDUCATION DEVELOPMENT

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Abstract: Tendencies in design education form material values, but their assimilation in the training system is carried out through spiritual values, as they are aimed at forming the personality of the future designer and his professional culture. The modern system of design education does not always prepare future professionals for the professional challenges they face, as future designers are entrusted with complex and influential design decisions. The aim of the study is to identify the tendencies in design education in the XXI century based on a survey of students and carry out a SWOT-analysis of the implementation of immersive and innovative technologies for professional training of future designers to establish the benefits of ICT use in educational institutions.

Keywords: Tendencies, Design Education, Designers, Immersive Technologies, Innovative Technologies.

1 Introduction

The twenty-first century is the age of digitalization, and information technology is changing all industries, including design education (Sirghi, Sirghi, 2020). Reforming the academic field and stimulating innovation are key sources of sustainable economic growth, and they are directly related to the introduction of ICT (also distance learning) in the academic process of design education (World Economic Forum, 2021).

Characterizing tendencies in XXI century design education which include new educational tools used in the learning process through ICT (Islami et al., 2019), digitization and e-learning (Conde et al., 2014; Sriyanti, Jauhari, 2014). Social media, such as Facebook (Wang et al., 2012), WhatsApp, etc., are often involved in the concept of virtual learning (Nurtanto et al., 2019), which shifts the role of traditional learning to effectively provide XXI century design education. The concept of e-learning is an alternative learning option at various universities (Andersson, 2019; Stockless, 2018) and is used for distance learning. The development of e-learning technology is happening very quickly and this is one of the reasons why it is important to introduce and develop this concept on a massive scale. Researchers state that based on survey results from various universities as well as statements from the OECD, it has been found that more and more design training is taking place using the Internet (Rabiman et al., 2020). The use of modern pedagogical technologies also requires teachers to connect disciplines with students' actual design experiences.

As a global institution, higher education institutions should not adhere only to the traditional educational process; they must be mobile, flexible, and adaptable to any new opportunity and challenge. This attitude also arises in design education because this education is based on flexibility, know-how, openness, individual autonomy, and creativity. Design graduates must acquire many kinds of abilities that will help them work as part of a team. Design education should prepare students by planning a specific curriculum that will serve as a coherent system that contains goals, outcomes, and is based on design standards. To meet this system, a curriculum that could take into account global development and innovation is necessary. It is necessary to form a certain network and cooperation with the associated design education, as well as the national and international organization of the profession. This network and collaboration will enable graduates to achieve certain standards of achievement so that they can be accepted by an international qualification (Istanto, 2002).

The aim of the research is to identify tendencies in the XXI century design education based on the students' survey and to make a SWOT-analysis of the implementation of innovative and innovative technologies for professional training of future designers to establish the benefits of ICT in educational institutions.

1.1 Research tasks of the article

1. To analyze the proposed model of educational training of designers on the basis of methods of participation and self-study without teaching others and Industry 3.0 and Industry 4.0.
2. To analyze the design competences in the new educational program of bachelor training based on the Integrated Design Environment.
3. Perform a comparative analysis of educational programs with the disciplines of immersive technologies in the training of designers.
4. Conduct an interview with students to establish an assessment of tendencies in design education in the XXI century.
5. To carry out SWOT-analysis of implementation of immersive and innovative technologies for professional training of future designers.

2 Literature review

Recent research shows that skills, knowledge, and creativity are equally important for professional designers (Guo, 2011), which is also true for graduate designers (Zerillo, 2005). Therefore, according to the developed curriculum, teaching, learning and assessment strategies are critical to prepare students for professional practice (Guo, Jamie, 2015).

Design education is a multifaceted process that aims to provide, on the one hand, in-depth knowledge of specialization, professional training, and on the other hand, a deep understanding of art as an object of educational and cultural process (CEDEFOP, 2008). The modern design education has several origins, starting with the Royal College of Art in London, which began operations in 1837 as the Government School of Design, Glasgow School of Art in 1845 as the Glasgow Government School of Design, Rhode Island School of Design (RISD, USA) in 1877, Konstfak (Stockholm) 1844 National Academy of Craft and Art Industry (Norway) began operations in 1818, which is preserved today as the Design Department of Oslo National College. Much of the curriculum developed years in these schools and several European academies persists in design education today (Meyer, Norman, 2020; Friedman, 2019).

Design is the discipline of shaping and executing a variety of design projects, so quality professional preparation plays an important role. Researchers recommend devoting a significant portion of the curriculum each year to design projects (a common practice in most institutions). Projects can be selected according to the student's specialization. Many projects will be long-term, so students will join a project that is already underway. In the early years of education, students learn not only design skills but also how design teams function, so teaching consistency is as important as teaching leadership, which is often neglected in design project courses. Therefore, at the end of the course, students should be allowed to choose the projects that are most relevant to their major, because simply sending students out to do projects does not produce the desired results. The traditional process of mentoring, guidance, and critique throughout the learning process is important. Projects also need to be selected or improved to encompass concepts, the learning process emphasizes (Meyer, Norman, 2020).

Design in an educational sense becomes a structured basis for new forms of learning. The term "design" in this context is defined as a process: a conception of something that does not yet

exist, which subsequently arranges all the elements necessary to bring that design solution into reality (Yamashita, 2012).

To understand design as a connection between creativity and innovation (Cox 2005), the recent introduction of design and design thinking at all levels of education has been recognized as a method of promoting the professional performance and capacity needed to sustain the transition from a post-industrial economy to a new creative economy based on design knowledge. International analysis of design education highlights the experience of Finland, whose educational program serves as a dynamic example of using design for national innovation and cultural change (Design Commission, 2011).

Significant investments (Macleod et al, 2007) in design research, education, and popularization had a positive impact on the country's global competitiveness and its ranking as an effective education system in 2006 (Ministry of Education and Culture of Finland, 2007). The national cultural policy, Creative Australia, recognizes design thinking as a "potential for innovation" and commits to "provide talent and entrepreneurial initiative to further sustainable business and high-skilled jobs" (Commonwealth of Australia, 2013).

The current challenges and shortcomings around design education in the new learning culture, contribute to encouraging national governments to see the value of design-focused innovation and online design learning platforms in strengthening regional societal sustainability and developing strong economic and social connections (Australian Government, 2012). Education in the XXI century requires a model for understanding a new culture of learning in the face of rapid change, open access data, and geographic diversity (Muntean, 2011). Teachers no longer need to provide the information itself, as students themselves actively play a role in peer collectives, in order to create new design projects. Using digital technology, Design Minds recognizes that interdisciplinary learning helps to engage and empower future professionals to think, implement, and discover new design solutions (Duell et al., 2014).

An analysis of the research on this issue shows that many scholars have paid attention to the problem of studying 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). Scholars have paid significant attention to design learning problems 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 designers. A large number of studies have focused on the integration of immersive engineering technologies (CAD and 3D) in the training of designers: for example, a study by scientists from Poznań University of Technology that focused on the problem of VR in eco-design, in studies by scientists from Novi Sad University and Banjalug University (Grajewski, 2015), Stevens Institute of Technology and Guangdong University of Technology. There are also studies on the use of AR and VR in the educational process of future designers of architects and environmental designers (Milovanovic et al., 2017). Particular attention should be paid to the study of scientists from Nottingham University of Technology "Augmented reality: creating a common context from programmer to designer", which covers quite broadly the problems and interaction of designers and programmers in the process of working with AR technologies, devoted to the internal and external barriers of immersive technologies in design practice (Hoang et al., 2019).

So, the problems of tendencies in design education in the XXI century and the study of obstacles and prospects of providing quality design education are reflected insignificantly in scientific publications in the form of theoretical research and practical studies.

3 Materials and research methods

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

- systematization of the main features of implementation of the proposed model of educational training of designers on the basis of methods of participation and independent learning without teaching others and Industry 3.0 and Industry 4.0;
- systematic and logical analysis, method of information synthesis of the key design competences in the updated bachelor's training curriculum based on the integrated development environment;
- synthesis of the latest scientific publications related to SWOT-analysis of the implementation process of immersive and innovative technologies for professional training of future designers.
- comparison method to distinguish the characteristics of educational programs in institutions of higher education and determine the disciplines for the study of immersive technologies in the preparation of designers.

In order to determine the current characteristics of the tendencies in design education in the XXI century with the use of ICT tools, a survey of students of higher education institutions was conducted using descriptive statistics, the data of which were provided by using MS Forms Pro. The survey was conducted to determine students' perceptions of the ability of modern ICT tools to provide quality professional training for designers. An online survey was conducted from January 10 to June 30, 2021, which collected information from 6,500 students. These participants answered questions about their learning experiences, motivation, expectations, and overall enjoyment of modern ICT tools. The following research questions were addressed in this survey: 1. What are students' perceptions of current tendencies in twenty-first century design education using ICT tools? 2. What are students' perceptions of their ability to absorb information in the context of ICT applications? 3. Are there any shortcomings in the modern tendencies of design education of the XXI century with the use of ICT tools?

4 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 characterized as Internet users, it is not appropriate for all students at universities around the world who are defined as significant technology users and makers. Therefore, design education needs to be updated and take into account the progress of technology, society, and students. Thus, the proposed model of educational training for 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).

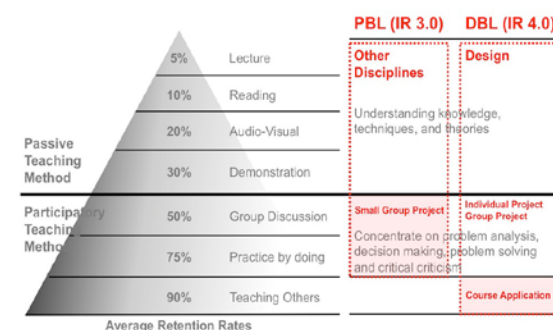


Figure 1 – The model of designers' educational training
Source: Compiled by the authors based on official data of Young Choi (2020).

Table 1, developed in 2020 during the Integrated Design Environment undergraduate program renewal process, presents the current view of the core competencies needed by future designers. These competencies must be available in all design organizations and below in order for organizations to navigate

change and make innovative progress. The competencies listed in Table 1 have so far been used to update undergraduate and graduate programs and to shape the growing supply of current design professionals, as well as to achieve higher education and relevant XXI century professional skills.

Table 1: Design competencies in an updated undergraduate curriculum based on an integrated design environment

Competences	Characteristics
Planning and re-planning of possible design challenges	Designers evaluate the current challenge and gain an understanding of the future context in which the challenge is likely to unfold, given the developments they may anticipate.
Re-evaluation and iterative evaluation to approach the correct decision	Complex problems require iteration, repeated divergent research, synthesis and evaluation. It is necessary to open and create a space of opportunities. When developing solutions, designers often have to look for different options in parallel to find out later, which one impresses them, the most. With regard to complex problems, most solutions appear only when the plans are implemented.
Integrate more relevant perspectives into the working order	The recent emergence of human-centered values in industry (design thinking) and in society (the need for goals, security) requires the creation of empathetic designers who can put themselves in the shoes of all those affected and argue, where possible, with the facts. Knowledge and empirical confirmation of their ideas.
Management of the design process and stakeholders	This requires a carefully thought-out design project process that involves stakeholders in its context. This requires critical thinking among designers and the ability to implement and use criticism from others, leading to the skillful implementation and integration of stakeholder intervention in the status quo. This process means working in an interdisciplinary environment and managing the processes of working together and participating with many who may or may not have design skills.
Work and communication at different and several levels of abstraction and in different disciplinary aspects	Designers must be able to work at different levels of abstraction (the process of eliminating details and focusing on a strategic issue) simultaneously and freely move from the abstract to the concrete and between disciplinary perspectives. Communication at all these levels is key and includes a range of skills, ranging from visualizing abstract ideas, to storytelling and role-playing, to modeling and prototyping, to imagine and rehearse a new future in an interdisciplinary setting and with many stakeholders.

Source: Compiled by the authors based on official data of Voute et al., (2020).

Having investigated the tendencies of design education in the XXI century, we analyzed the process and the potential for introduction of digital technologies into the educational process,

and the results of the analysis of the available information about the official resources of educational institutions are shown in Table 2.

Table 2: A comparative characteristic of educational programs with the disciplines of immersive technologies

Higher education institution	The theme of the educational program	Immersive technologies		
		VR	AR	MR
The University of Adelaide	Immersive media – virtual reality	as a separate discipline (Core modules) is indicated		
The Asia Pacific University of Technology & Innovation	Multimedia technology with a specialism in VR/AR	as a separate discipline (Core modules) is indicated		
NC State University	Graphic design, industrial design	as a separate discipline (Core modules) is indicated		
Dundalk Institute of Technology	Augmented and Virtual Reality	as a separate discipline (Core modules) is indicated		as a separate topic of the discipline is indicated
Namseoul University	Virtual Reality and Augmented Reality Studies	as a separate discipline (Core modules) is indicated		as a separate discipline (Optional) is indicated
Kingston University	Digital Media Technology	as a separate topic of the discipline is indicated		-
Kharkiv State Academy of Design & Arts	Multimedia Design	as a separate topic of the discipline is indicated		-
New York Institute of Technology	UX/UI design and development	as a separate topic of the discipline is indicated		-
Shenandoah University	Virtual Reality Design	as a separate topic of the discipline is indicated	as a separate discipline (Optional) is indicated	-
Zaporizhzhia National University	Graphic Design	as a separate topic of the discipline is indicated		-
University of Winchester	Digital Media Development: 3D Environments	as a separate discipline (Core modules) is indicated		-
Universitat Politècnica de Catalunya	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
Swinburne University of Technology	Design, Multimedia Design	as a separate discipline (Core modules) 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).

The results of the study revealed that the vast majority of educational programs do not include information technology as a

separate discipline, but implement specific topics in professional disciplines or have specific disciplines for students to choose

from. Among the disciplines and special modules for studying immersive technologies at the surveyed universities the most extensive are: Access to VR/AR, multimedia programs, modeling, visualization and virtual reality, cognitive experience of working with technologies of virtual, expanded and mixed reality (VR, AR, MR), multimedia, 3D modeling of objects and environments, digital art and technology, etc.

Most of them stated that tendencies in design education positively influence the provision of professional training of designers with ICT equipment (86.1%), a minority (10.3%) were not satisfied with the quality of professional ICT training of designers, and a small part of the students said that the current tendencies in design education contain certain drawbacks (3.6%) (see Fig. 2).

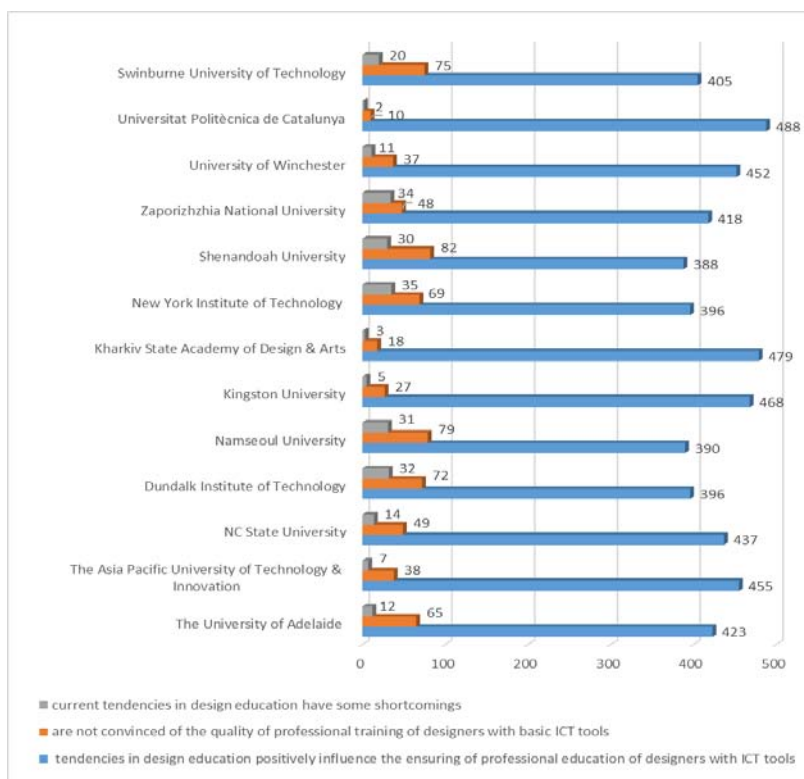


Figure 2 – The assessment of design education tendencies in the XXI century

To analyze design education tendencies in the XXI century SWOT-analysis was conducted, the results of which enabled us to identify the hierarchy and positioning of opportunities and

threats to the implementation of intensive and innovative technologies in the process of professional training of future designers (see Table 3).

Table 3: SWOT-analysis of the process of implementation of immersive and innovative technologies for professional training of the future designers

Strengths (S)	Weaknesses (W)
<ul style="list-style-type: none"> - high level of scientific and pedagogical staff involved in the teaching of immersive and innovative technologies; - increasing the level of motivation and productivity of students' learning activities by focusing developments in the attractiveness and image of immersive and innovative technologies; - demand for skills in the development of immersive and innovative technologies; - strengthening the position of the future designer in the labor market, in particular the global; - high price of reward for the project in which immersive and innovative technologies were applied. 	<ul style="list-style-type: none"> - the high cost of equipment for educational institutions to develop and test the development of immersive and innovative technologies; - loss of motivation among students due to the complexity and the large amount of time spent on the process of learning a software product based on immersive and innovative technologies; - the niche of development of immersive and innovative technologies contribute to the emergence of a small number of projects with high value.
Threats (T)	Opportunities (O)
<ul style="list-style-type: none"> - low interest of teachers in mastering new immersive and innovative technologies; - shifting attention from creative solutions to technical skills; - insufficient level of formation of multimedia competence, necessary for the successful development of the future designer as a professional. 	<ul style="list-style-type: none"> - opportunities for academic and professional mobility; - opportunities to adapt to the current changing realities of the design market; - advanced training, including in design development through immersive and innovative technologies.

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

5 Discussion

The results of the study of tendencies in design education in the XXI century led to the following conclusions. In the modern world, design education is changing to holistic harmonious

personality, fluent in logical and creative thinking (Alekseeva et al., 2017). Now education around the world is undergoing a process of profound modernization, primarily due to the

tendencies and policies of using information and communication technology tools in the preparation, delivery of classes and assessment of knowledge. The use of immersive and innovative technologies should encourage and provide intellectual pleasure to students from a well-done design project (Sirghi, Sirghi, 2020).

Improvements in information technology focus on solving more intelligent, scientific problems (Smith & Koppel, 2014). Data visualization, image processing, and virtual environment creation allow the future designer to achieve holistic and innovative approaches to solving complex problems. Today, immersive and innovative technologies are formed as learning materials, which are a small piece of information that is presented in a certain logical sequence, which contributes to the formation of students' intellectual, creative and communicative skills. It should be noted that the use of ICT jointly with the use of other educational technologies, but they complement each other without denying it.

The tendencies in design education in the XXI century contribute to the improvement of the learning process with the help of immersive and innovative technologies is explained primarily by the fact that the use of new information technology in the learning process led to the expected increase in learning efficiency (Muntean, 2011). Therefore, according to many researchers, a radical solution to the problem of increasing the effectiveness of education is to expand the technical capabilities of modern information technology.

The organization of design education using modern information and communication technologies in education serves to enhance students' creative thinking, independent decision-making and teamwork skills by organizing practical and laboratory classes in special subjects. Obviously, the introduction of ICT in design education will be the basis for improving the effectiveness of education in the preparation of designers (Alekhovich, Abdurakhimovna, 2020).

Therefore, the tendencies in design education in the XXI century based on ICT application will face new challenges, in accordance with the changes in innovative and globalization requirements for the professional competence of future designers, and in-depth research, which will lead to increased attention to improving knowledge in the field of ICT in the professional training of specialists.

6 Conclusion

As a result of the analysis of tendencies in design education in the XXI century, it was found that the use of immersive and innovative technologies in different educational institutions occurs differently. Many problems require special methodology and research methods. In this regard, it is useful to use and integrate the experience of other educational institutions.

The ever-growing influence of technology provides a destabilizing influence on traditional models of education. It is becoming recognized worldwide that a shift toward a "new culture of learning" is necessary to function successfully within the paradigms of the twenty-first century. Design, the process of creatively and rationally exploring complex challenges, provides an ideal framework for facilitating this cultural shift.

The general trend of the virtual and augmented reality marketplace as innovative means of communication has led to a reorganization of the training content for future designers as professionals with professional visualization skills. Increased profits from the use of these technologies, attracting maximum attention, novelty in use, prospects and opportunities in the field of design is only a part of all possible positive effects from the use of augmented and virtual reality in the professional sphere of future designers.

The practical significance of the conducted research lies in the fact that the conclusions and recommendations developed by the author and proposed in the article can be used for the selection of

immersive tools and innovative technologies to provide design education, which will allow the implementation of quality professional training.

Further research can be aimed at improving and developing research methods of practical principles of introducing immersive and innovative technologies in the professional training of future designers and the study of the effectiveness of their implementation, corresponding to each level of the higher education system in the training of specialists in the field of design. This will make it possible to determine and adjust not only basic, but also special subject competencies in specific disciplines and correctly build the training process of future designers. Only after that, it is important to determine whether the content of education, its function in the formation of quality professional training, the effectiveness of its types, methods, forms and means in design education. Increased opportunities and wide application of immersive and innovative technologies in the process of professional training of future designers can become the basis of the educational process in higher education institutions for future periods.

Literature:

1. Alekhanovich, M. N., Abdurakhimovna, U. F. (2020). Improving the Effectiveness of Education using Modern Information and Communication Technologies in the Training of Designers. *Journal La Edusci*, 1(5), 6-10. Retrieved from: <https://doi.org/10.37899/journallaedusci.v1i5.253>.
2. Alekseeva, I.V., Barsukova, N.I., Pallotta, V.I., Skovorodnikova, N.A. (2017). The Innovation Blaze-Method of Development Professional Thinking Designers in the Modern Higher Education. *European Journal of Contemporary Education*, v. 6, n. 4, pp. 615-626. Available at: <https://eric.ed.gov/?id=EJ1164027>
3. Andersson, T. (2019). Learning Management Systems (LMS) Case study on an implementation of an LMS and its perceived effects on teachers. Available at: https://www.researchgate.net/publication/350287112_Learning_Management_Systems_LMS_towards_helping_Teachers_and_Students_in_the_pursuit_of_their_E-Learning_Methodologies
4. Australian Government. (2012). Australia in the Asian Century White Paper. Retrieved from: <http://asiancentury.dpvc.gov.au/white-paper>.
5. CEDEFOP (2008). Terminology of European education and training policy: A selection of 100 key terms. Luxembourg: Office for Official Publications of the European Communities. Retrieved from https://www.cedefop.europa.eu/files/4064_en.pdf.
6. Chemerys, H., Vynogradova, A., Briantseva, H., Sharov, S. (2021). Strategy for implementing immersive technologies in the professional training process of future designers. *Journal of Physics: Conference Series*. 1933. Retrieved from: doi:10.1088/1742-6596/1933/1/012046.
7. Commonwealth of Australia. (2013). Creative Australia: National Cultural Policy. Retrieved from: <http://creativeaustralia.arts.gov.au/>.
8. Conde, M. Á., García-Peñalvo, F. J., Rodríguez, M. J., Alier, M., Casany, M. J. and Piguille, J. (2014). An evolving Learning Management System for new educational environments using 2.0 tools. *Interact. Learn. Environ.*, vol. 22, no. 2, pp. 188–204. Available at: <https://dergipark.org.tr/en/pub/mjen/issue/41506/485411>
9. Cox, G. (2005). Cox review of creativity in business: building on the UK's strengths. Retrieved from: <http://www.designcouncil.org.uk/publications/TheCox-Review>.
10. Design Commission. (2011). Restarting Britain: Design education and growth. Retrieved from: <http://www.policyconnect.org.uk/apdig/design-educationinquiry>.
11. Desurvire, H. and Kreminski, M. (2018). Are game design and user research guidelines specific to virtual reality effective in creating a more optimal player experience? Yes, VR PLAY, in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 10918 LNCS, pp. 40–59. Retrieved from: doi: 10.1007/978-3-319-91797-9_4.

12. Duell, C., Wright, N., Roxburgh, J. (2014). Developing 'design minds' for the 21st century through a public sector initiated online design education platform. *International Journal of Technology and Design Education*. 19. 62-74. Available at: https://www.researchgate.net/publication/277345920_Developin_g_'design_minds'_for_the_21st_century_through_a_public_secto_r_initiated_online_design_education_platform
13. Friedman, K. (2019). Design Education Today: Challenges, Opportunities, Failures. Chatterjee Global/150th anniversary Commemorative Lecture, College of Design, Architecture, Art and Planning, the University of Cincinnati. Retrieved from: <https://www.academia.edu/40519668>.
14. Grajewski, D. et al. (2015). Improving the Skills and Knowledge of Future Designers in the Field of Ecodesign Using Virtual Reality Technologies, in *Procedia Computer Science*, vol. 75, pp. 348–358. Retrieved from: doi: 10.1016/j.procs.2015.12.257.
15. Guo, F. B. (2011). Industrial Design Education.
16. Guo, F. B., Jamie P. (2015). Finlay educating design professionals in the 21st century. The 17th International Conference on Engineering & Product Design Education Great Expectations: Design Teaching, Research & Enterprise. 200-205.
17. Hoang, D., Naderi, E., Cheng, R. and Aryana, B. (2019). Adopting immersive technologies for design practice: The internal and external barriers, in *Proceedings of the International Conference on Engineering Design, ICED*, vol. 2019, pp. 1903–1912. Retrieved from: doi: 10.1017/dsi.2019.196.
18. Islami, R. E., Sari, I. J., Sjaifuddin, S., Nurtanto, M., Ramli, M. and Siregar, A. (2019). An Assessment of Pre-service Biology Teachers on Student Worksheets Based on Scientific Literacy, *J. Phys. Conf. Ser.*, vol. 1155, 012068. Available: https://www.researchgate.net/publication/331775218_An_Assessment_of_Pre-service_Biology_Teachers_on_Student_Worksheets_Based_on_Scientific_Literacy
19. Istanto, F. H. (2002). A Global Perspective, A Keyword For Design Education Facing XXI Century. *NIRMANA*, Vol. 4, No. 2, 99 – 105. Retrieved from: <http://puslit.petra.ac.id/journals/design/>.
20. Kompaniets, A., Chemerys, H. and Krashenninik, I. (2019). Using 3D modelling in design training simulator with augmented reality, in *CEUR Workshop Proceedings*, vol. 2546, pp. 213–223. Retrieved from: <http://ceur-ws.org/Vol-2546/paper15.pdf>
21. MacCallum, K. (2021). Supporting STEAM learning through student-developed Mixed Reality (MR) experiences, *Pacific J. Technol. Enhanc. Learn.*, vol. 3, no. 1, pp. 6–7. Retrieved from: doi: 10.24135/pjtel.v3i1.83.
22. MacLeod, D., Muller, L., Covo D. and Levy, R. (2007). Design as an instrument of public policy in Singapore and South Korea. Vancouver, BC: Asia Pacific Foundation of Canada.
23. Meyer, M., & Norman, D. (2020). Changing design education for the 21st century. *She Ji: The Journal of Design, Economics, and Innovation*, 6, 13-39. Retrieved from: <https://doi.org/10.1016/j.sheji.2019.12.002>
24. Milovanovic, J., Moreau, G., Siret, D. and Miguët, F. (2017). Virtual and Augmented Reality in Architectural Design and Education: An Immersive Multimodal Platform to Support Architectural Pedagogy. Retrieved from: <http://panoscope360.com/>.
25. Ministry of Education and Culture of Finland. (2007). OECD PISA 2006: excellent results for Finnish students. Retrieved from: <http://www.minedu.fi/OPM/Tiedotteet/2007/12/pisa.html?lang=en>.
26. Muntean, C. I. (2011). Raising engagement in e-learning through gamification. In *Proc. 6th international conference on virtual learning ICVL*, Vol. 1, pp. 323-329.
27. Nurtanto, M., Widjanarko, D., Sofyan, H. R., and Triyono, M. B. (2019). Learning by Creating: Transforming Automotive Electrical Textual Material into Visual Animation as A Creative Learning Products, *Int. J. Sci. Technol. Res.*, vol. 8, №. 10. Available at: <https://www.semanticscholar.org/paper/Learning-By-Creating%3A-Transforming-Automotive-Into-Nurtanto-Widjanarko/2e022637f0bc5fed476aa66261fae427f1b7d33d>
28. Pellas, N., Dengel, A., Christopoulos, A. (2020). A Scoping Review of Immersive Virtual Reality in STEM Education, *IEEE Transactions on Learning Technologies*, vol. 13, no. 4. Retrieved from: doi: 10.1109/TLT.2020.3019405.
29. Rabiman, R., Nurtanto, M., Kholifah, N. (2020). Design And Development E-Learning System By Learning Management System (LMS) In Vocational Education. *International Journal of Scientific & Technology Research*. 1059-1063. Available at: https://www.researchgate.net/publication/338594694_Design_And_Development_E-Learning_System_By_Learning_Management_System_LMS_In_Vocational_Education
30. Sirghi, S., Sirghi, A. (2020). Design for online teaching and learning in the context of digital education. *Știința culturii fizice*. Nr. 35/1, 50-54. Retrieved from: <https://doi.org/10.52449/1857-4114.2020.35-1.08>
31. Smith, S. W., Koppel, R. (2014). Healthcare information technology's relativity problems: a typology of how patients' physical reality, clinicians' mental models, and healthcare information technology differ. *Journal of the American Medical Informatics Association*, 21(1), 117-131. Available at: <https://pubmed.ncbi.nlm.nih.gov/23800960/>
32. Sriyanti, I. and Jauhari, J. (2014). Development Of Learning Management System (LMS) As An Effort In Increasing Learning Effectiveness And Learning Activities Of Students In Sriwijaya University, *Eurasia Proc. Educ. Soc. Sci.*, vol. 1, pp. 196–201. Available at: <https://dergipark.org.tr/tr/download/article-file/332934>
33. Stockless, A. (2018). Acceptance of learning management system: The case of secondary school teachers', *Educ. Inf. Technol.*, vol. 23, no. 3, pp. 1101–1121. Available at: <https://link.springer.com/article/10.1007/s10639-017-9654-6>
34. Voute, E., Stappers, P. J., Giaccardi, E., Mooij, S., Boeijen, A. (2020). Innovating a Large Design Education Program at a University of Technology. *She Ji: The Journal of Design, Economics, and Innovation*. 6. 50-66. 10.1016/j.sheji.2019.12.001.
35. Wang, Q., Woo, H. L., Quek, C. L., Yang, Y. and Liu, M. (2012). Using the Facebook group as a learning management system: An exploratory study, *Br. J. Educ. Technol.*, vol. 43, no. 3, pp. 428–438. Available at: <https://bera-journals.onlinelibrary.wiley.com/doi/10.1111/j.1467-8535.2011.01195.x>
36. Wetzstein, G. (2016). Computational Near-Eye Displays: Engineering the Interface to the Digital World, *Bridg.*, vol. 46, no. 4, pp. 5–9. Retrieved from: www.nae.edu/TheBridge
37. World Economic Forum. (2021). The Future of Jobs 2018. Retrieved from: <http://reports.weforum.org/future-of-jobs-2018/>
38. Yamashita, K. (2012). Why CEOs are the world's best designers. San Francisco, CA: SYP Partners. Available at: <https://www.sypartners.com/news/keith-yamashita-why-ceos-are-the-best-designers/>
39. Young Choi, A. (2020). Understanding Design-based Learning (DBL) for teaching Z-Gen learners as Design Education in the 21st Century. Retrieved from: <http://www.teachingdesigners.org/design-education-in-the-21st-century>.
40. Zerillo, P. (2005). Deep or Wide-Between Education and the Design Profession, Chicago. Retrieved from: www.core77.com/design.edu/09.04_zerillo.asp.

Primary Paper Section: A

Secondary Paper Section: AM