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Immersive University Model: A Tool to Increase Higher Education Competitiveness

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Abstract: The current paper substantiates the effectiveness of immersive learning applications for youth. Emphasis is placed on the fact that the "immersion" of students can be carried out not only through virtual and augmented reality but also in any constructed environment that provides any "immersion" in active and interactive teaching methods. A bibliometric analysis was conducted for the "immersive learning" search query to identify keywords and phrases' main clusters and their relationships. Based on the bibliometric analysis, the concept of forming an immersive learning model based on a sequential transition between the "dimensions" was formed. The model is developed considering the degree of involvement in the learning scenarios. A multidimensional classification model for immersive learning tools is proposed. A university case of building an immersive learning environment as part of the "electronic university" information system is presented. A technological solution is proposed for evaluating the effectiveness of testing immersive learning tools.

Keywords: immersive university; bibliometric analysis; instruments; testing; model

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1. Introduction

Sustainable development is becoming one of the most crucial development concepts these days. Virtually all over the world, this approach is receiving unprecedented acceptance; unsurprisingly, as it is based on the most critical aspects of everyday life at all levels—from local to global. Society 5.0, which the Japanese government proposed in 2016, is embedded in the sustainable development idea. It assumes the emergence of a sustainable human-centric society. Its characteristic feature is a higher level of convergence between digital reality and the real world, which significantly facilitates the embedding of cyberspace in the real world [1,2].

Information and communication technologies have significantly changed how people, societies, economies, and organizations, including universities, function. Sustainable development goals are to provide quality education for all and promote lifelong learning. Adapting the educational system to Society 5.0 requires open, adaptive, interoperable educational resources that enable the use of educational facilities and engage students in the learning process.

An electronic university is no longer something new in educational practice; however, it requires the creation of new tools to attract students to effectively master the skills demanded by society and the job market. Students enroll in university to study (self-educate), and the university actively uses models that allow students to complete this

task: the "flipped" class technology [2] and models such as "Flex" [3], "Rotation" [4], "Positive-U" [5], and others.

It should be noted that students, like other young people, are addicted to their gadgets. Millennials spend an average of 2.5 h on social media [6]; according to other sources, teenagers use an average of nine hours of entertainment media per day, and then [7] spend nine hours a day with digital technology [8]. Thus, the effective self-learning of students is also connected to devices. It is necessary to "immerse" students in an educational environment that fits their comfort zone. Although acquiring new skills is associated with leaving one's comfort zone, the first step to it is precisely in line with young people's gadgets. In addition, under lockdown conditions, the role of gadgets in the educational process has increased significantly [9,10]. Gadgets have turned from technical means of processing information into tools for obtaining the skills necessary for the "socio-economic" growth of the individual.

Immersive learning technologies are rapidly entering universities' educational activities [11–13], and this is noted in the significant number of papers [14–19]. However, despite the widespread use of immersive technologies, the definition of "immersive learning" remains open.

Immersion is a concept used in many sciences and practice fields. It denotes the complete immersion of the user in a virtual environment. It is so realistic and convincing that the person feels as if they are actually in that environment. Immersion is often associated with virtual reality (VR) technology, in which the user moves and interacts with other objects using special equipment (such as VR goggles and motion controllers). Immersion can be used in various fields, such as education, training, medicine, architecture, design, and entertainment.

In an educational context, immersion allows students to learn interactively in a more accessible and engaging way. According to Brown and Cairns, immersion is a psychological process that consists of three levels: (1) engagement, (2) engrossment, and (3) total immersion [20]. In this education process, stage one involves engaging the student in learning by determining their preferred instructional method and where they will best acquire knowledge. The engrossment stage involves getting the student interested in the educational material and emotionally attached to a particular method of acquiring knowledge. The process culminates with total immersion, the feeling of belonging to a virtual education world. The student delves into the subject so that he loses his sense of time and space, and his attention is focused exclusively on the task or activity. In this way, he assimilates the transmitted knowledge seamlessly.

The authors of [21] note that "immersive learning is an experiential training methodology that uses virtual reality to simulate real-world scenarios and train employees in a safe and engaging immersive training environment". This simple definition limits the list of immersive learning tools. Other definitions expand the list of tools by adding augmented reality, mixed reality, gamification elements, and other interactive activities. However, in our opinion, the definition taken from [21] should be considered the most accurate—"immersion learning refers to any education approach that teaches by placing a student directly in an environment". This definition significantly expands the range of "immersion" tools and does not exclude any approaches to knowledge and skills transfer from the list of immersive technologies. This definition is not about tools but about approaches in which one can use any tools that are suitable for a particular situation. "Immersive learning environments are learning situations constructed using various techniques and software tools, including game-based learning, simulation-based learning, and virtual 3D worlds. ILEs are distinguished from other learning methods by their ability to simulate realistic scenarios and environments that allow learners to practice skills and interact with other learners" [22]. Thus, the immersive learning model is based on practical cases implemented by simulating various scenarios. It is vital that scenario simulation can take place not only in the electronic environment but also in the real world.

In this paper, the authors propose a multidimensional classification of immersive learning tools as elements of an immersive university, the functioning of which also involves testing the effectiveness of each tool. An immersive university is not limited to tools for immersion in virtual worlds but should also use on-site scenarios for practical cases.

2. Theoretical Background

We used the scientometric databases Scopus (Scopus database) and Web of Science (Web of Science database) for bibliometric analysis. The bibliometric analysis tool is VOSviewer (VOS).

The bibliometric analysis was conducted as follows. In the first stage, over 24,000 articles were found using the keyword "immersive" in the Scopus database. The need for more specification for immersive technologies' application in a particular field of knowledge (including educational activities) is due to the presence of interdisciplinary research in this field. Subsequently, the following restrictions on the search query were introduced: knowledge field: "Social Sciences"; the first thousand articles by the number of citations for the period 2010–2021; keywords (phrases) in the search results must be mentioned at least ten times.

The limitation of the field of knowledge allows us to observe the growing interest in using immersive technologies (Figure 1), including in the educational process. This fact will be demonstrated based on the analysis of the keyword "immersive". The interdisciplinarity mentioned above is displayed in Figure 2.

After applying restrictions on the search query, a list of about 4700 articles was obtained, of which the first 2000 most cited were selected for analysis. The keyword map for these articles is shown in Figure 3.

An analysis of the elements of the keyword map was carried out to identify the relationship between keywords and to highlight individual clusters of topics. The analysis is bound to determine the following:

(1) The place of immersive technologies in the educational process;
(2) The main tasks of immersive technologies in the educational process;
(3) The general structure of the immersive learning environment;
(4) The "composition" of immersive learning tools.

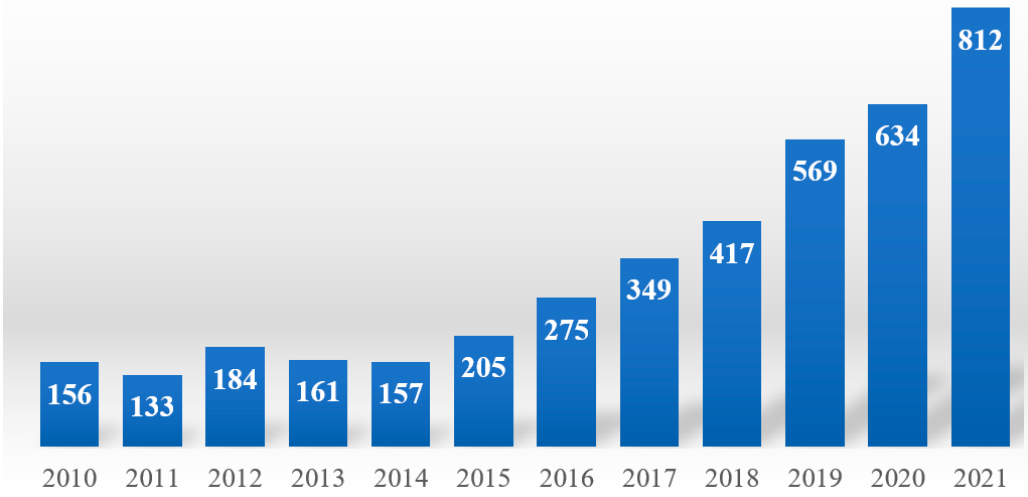

Figure 1. The annual number of articles for the keyword "immersive" in the knowledge field of "Social Sciences". Source: own research.

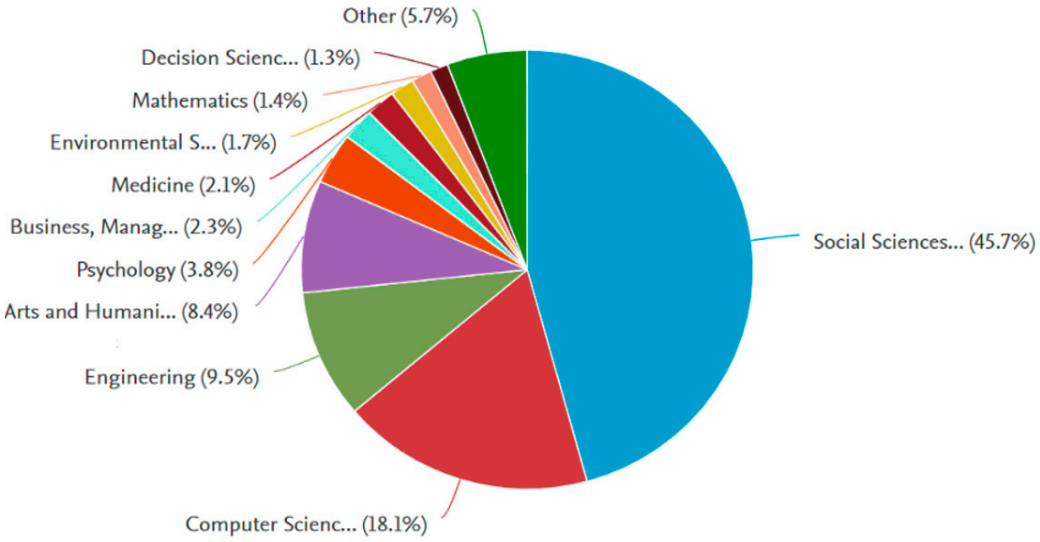

Figure 2. Interconnections of selected "Social sciences" field articles with other fields. Source: own research.

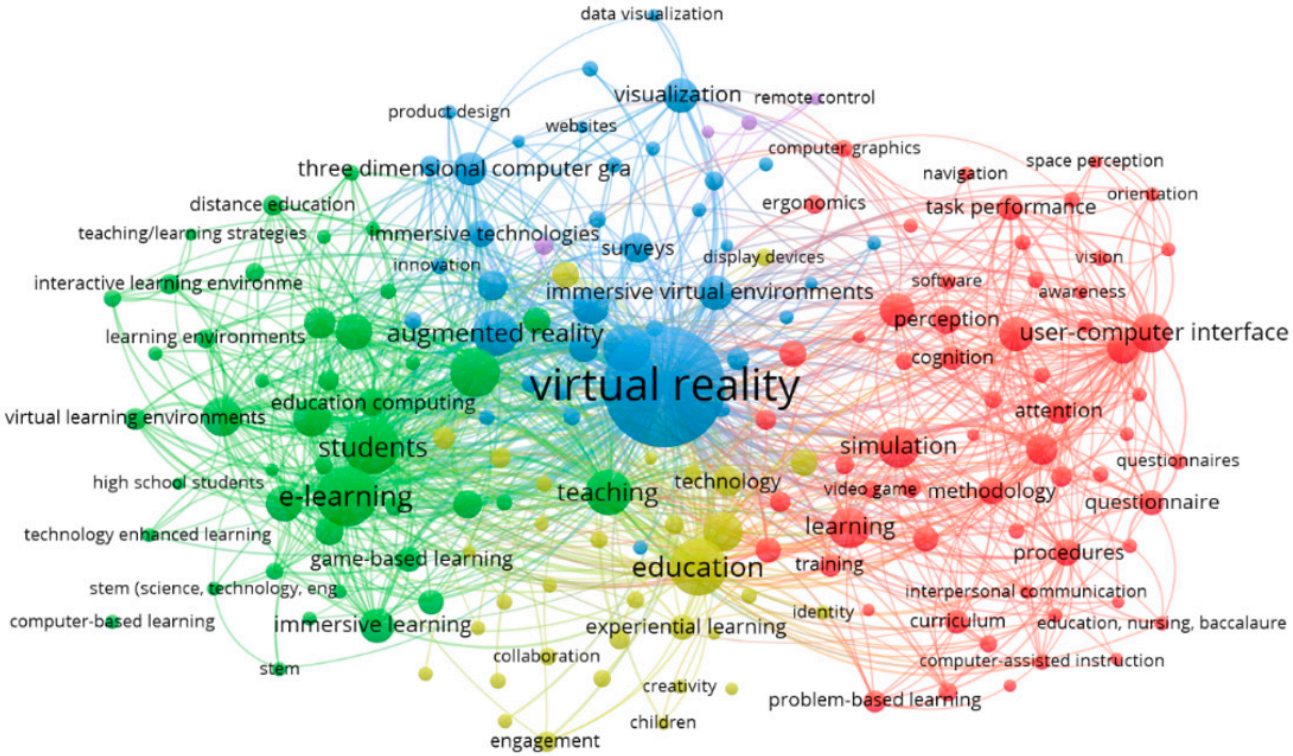

Figure 3. Keyword map for the query "immersive" for the first 2000 most cited articles in the "Social Sciences" field for 2010–2021. Source: own research.

As can be seen from the data in Figure 3, the educational process has been significantly digitalized over the past few years, and learning tools from planar methodological materials and volumetric live communication with the teacher are partially moving to newly constructed worlds, places of "immersion". This cluster reflects not only the place of immersive learning in the educational process but also demonstrates immersive learning tools. Immersive technologies in education are a broader concept than the simple use of virtual and augmented reality, as seen in this cluster.

The results of the research [23] allow us to expand the list of keywords related to immersive learning:

- Game-Based Learning;
- Educational Games;
- Gamification;
- Augmented Reality;
- Authoring Tools;
- Online Learning;
- Social Presence;
- Virtual Worlds;
- Virtual Learning Environment;
- Pedagogical Support;
- Educational Process;
- Professional Competence.

The next cluster (Figure 4) demonstrates the primary function of the educational process in general and immersive learning in particular: decision-making and actual student-involved development of the skills employers need. If we talk about a specific set of skills, then we can distinguish the following [24]:

- Evaluation and analysis of information;
- Critical thinking;
- Quantitative, analytical, and strategic thinking;
- Curiosity and imagination;
- Creativity;
- Emotional intelligence;
- Innovation and creative skills;
- Personal responsibility;
- Comprehensive multi-level solution of problems;
- Forming one's own opinion and decision-making;
- Customer orientation;
- Negotiation skills;
- Mind flexibility;
- People interaction;
- Management capabilities.

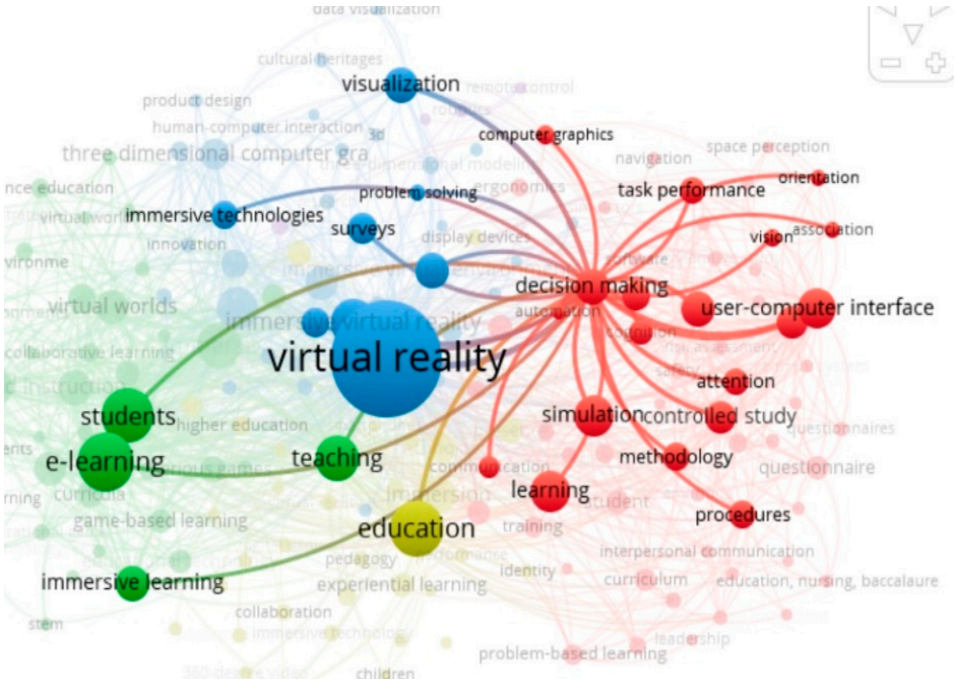

Figure 4. Cluster with the nodal key phrase "decision making". Source: own research.

We derived the question: Why must one "immerse" into training? This answer is: to enhance skills. In this case, immersive learning should expand its toolkit, as shown in the cluster in Figure 5.

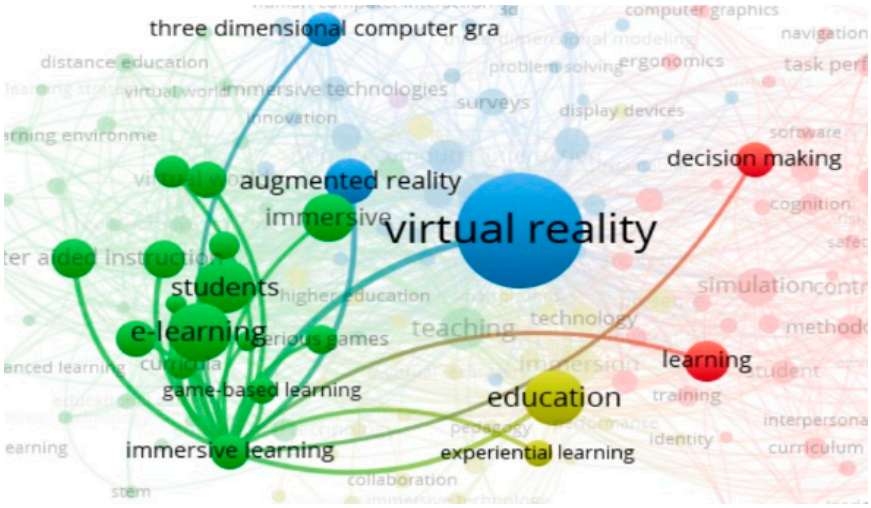

Figure 5. Cluster with the nodal key phrase "immersive learning". Source: own research.

As noted in the literature [25], the essential attribute of immersive learning is the virtual learning environment. The following cluster (Figure 6) confirms this fact.

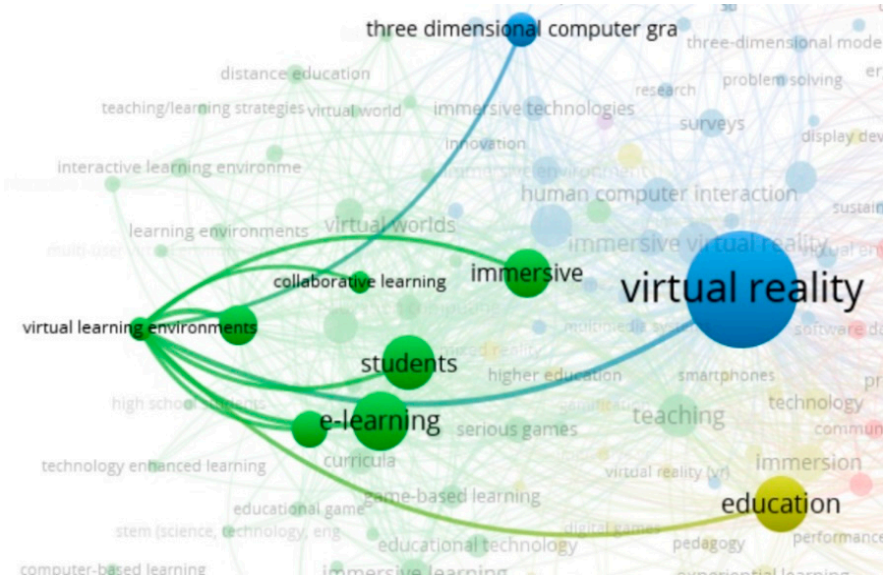

Figure 6. Cluster with the nodal key phrase "immersive learning". Source: own research.

In the second stage of the bibliometric analysis aimed to expand the list of immersive learning tools, more than 17 thousand articles were found in the Web of Science database for the keyword "immersive". Subsequently, the following restrictions on the search query were introduced: knowledge field: "education"; the first thousand articles by the number of citations for 2010–2021; keywords (phrases) in the search results must be mentioned at least ten times.

The results of building a keyword map are shown in Figure 7. The keyword map was not divided into clusters but only analyzed to complement the immersive learning tools.

An additional analysis of the popularity of search queries corresponding to the research direction of this work was also carried out using the Google Trends product [26] (Figure 8).

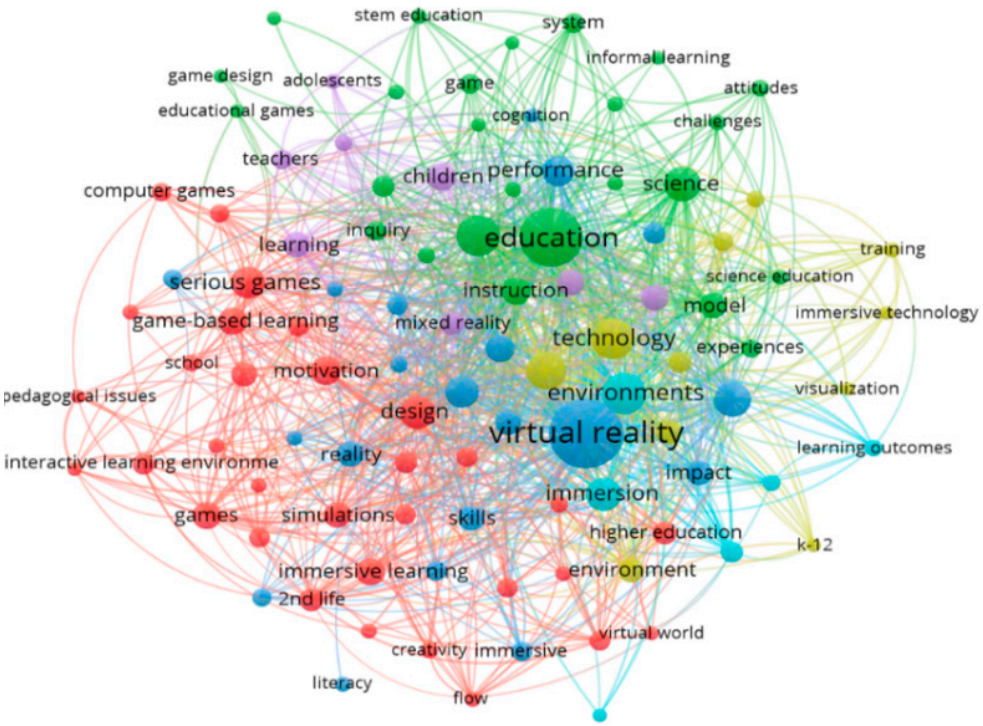

Figure 7. Keyword map for "immersive" for the top 2000 most cited articles in the "Education" field in 2010–2021. Source: own research.

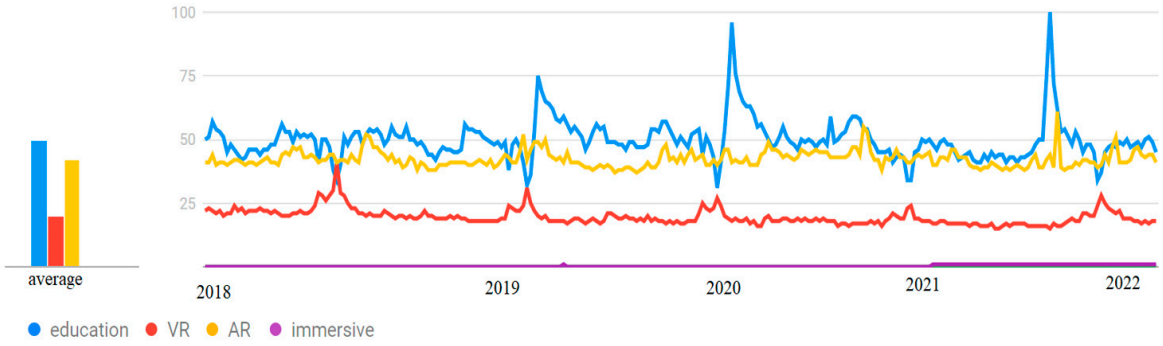

Figure 8. The results of determining (with comparative analysis) the popularity of search queries corresponding to the research direction. Source: own research.

Thus, the results of the bibliometric analysis made it possible to draw the following conclusions acting as problems in the current paper:

1. The immersive learning model requires expanding the list of tools.
2. The immersive learning model requires systematization in terms of the tools' descriptions.
3. A structural and logical model of an immersive university and some cases of its elements should be proposed.
4. The model of an immersive university requires a unit for testing the effectiveness of the tools used.

The formulated problems correlate with general trends in the development of education and in ensuring its quality in terms of achieving sustainable development goals [27,28], digitalization of education [29–31], knowledge management [32], education quality assurance systems [33–35], and external assessment of the university educational system positioning [36–40].

3. Research Objectives, Methodology, and Data

Considering the literature review results and bibliometric analysis, the article aims to propose a model of an immersive university that encompasses the learning techniques of various engagement levels. The objectives of the presented research include the formulation of the concept of immersive educational tools' collection classification and usage which, in turn, allows higher education institutions to develop a competitive toolkit for the modern higher education landscape. The design of the study consists of the following research activities: (1) describe "Immersive University" as an information system with all necessary attributes and identify immersive educational scenarios' place in the current information system; (2) propose a versatile method to assess the engagement levels of various levels of immersion; (3) present cases that demonstrate the effectiveness of the application of nD-immersion concept in an actual educational environment.

In order to systematically describe the immersive university model, we use a UML component diagram to present the immersive university as an information system. Classification of immersive educational instruments is given using the authored concept of nD-engagement levels.

The behavioral study design is proposed as a technique to evaluate the effectiveness of immersive learning instruments. The study design as a deliverable of the current article poses particular interest for immersive education practitioners since it can be transferred to any external agency, allowing behavioral studies and presenting management with precise analytics on the effectiveness of immersive learning innovations.

The case study method illustrates the nD-immersion concept and the "electronic university" information system. We present examples of innovative learning tools successfully approbated at Sumy State University, which fall under the proposed classification.

4. Results and Discussion

In order to describe the model of an immersive university, it is necessary to introduce some explanations:

1. Immersive university is a part of "university in a gadget" concept. However, an immersive university in a gadget is not a guide app but a set of tools including augmented reality apps, 360 video apps, VR supplements, necessary gaming mobile apps, etc. (Figure 9).
2. The Immersive Learning Environment is part of the e-learning environment, not something that exists independently. In addition, the Immersive Learning Environment goes beyond e-learning as the scenario of practical case implementation can be realized in the real world.
3. The immersive university is a set of tools and scenarios, but one can use all the tools simultaneously (Figure 10).
4. The immersive university is not only the constructed worlds but also the methods based on which these worlds are constructed (Figure 11).

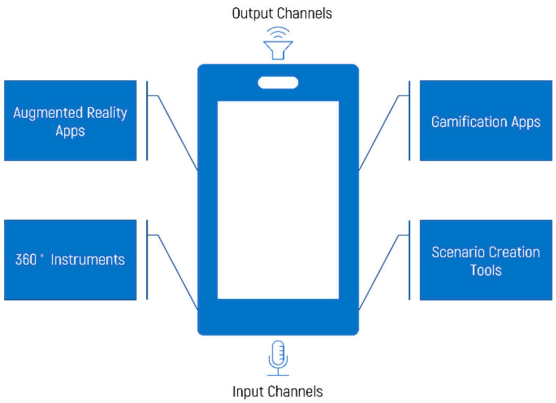

Figure 9. Immersive university in a gadget. Source: own research.

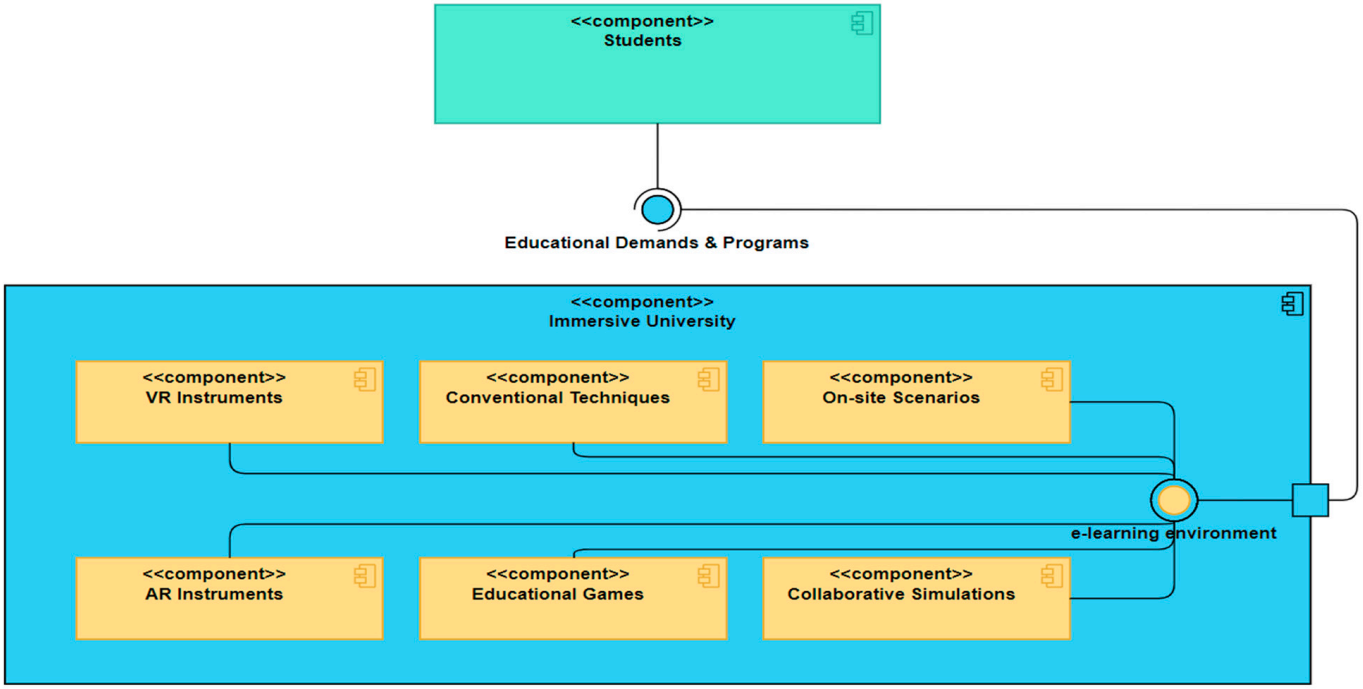

Figure 10. Immersive university as an information system (component diagram). Source: own research.

Figure 11. Immersive worlds' construction methods. Source: own research.

We propose the following classification of immersive education tools:

1D-immersion—verbal experience transfer, creation of scenarios (designs) of the educational environment, including those engaging students;

2D-immersion—existing scenarios for creating an immersive space in the virtual or real world;

3D-immersion—three-dimensional training models;

4D-immersion—AR+, on-site role-playing games;

5D-immersion—full-scale VR;

nD-immersion—gamification in the virtual world, created and dynamically changing directly during the game.

Below are examples of immersive learning tools in authored courses focusing on academic integrity according to the proposed classification. It should be noted that the maximum efficiency of "immersion" can be achieved by combining different tools in different periods. Therefore, the description of the tools is carried out in blocks with

the allocation of several "dimensions" (however, not additive) per the classification proposed above.

Students' motivation increases with the application of interactive teaching methods, interactive approaches, and "anti-standardization" of involving students in a complex environment.

A set of electronic tools is used for multi-level popularization of academic integrity for entrants and students, which can also be successfully used for the professional development of teaching and research staff. The complex includes a massive open online course, "Academic Integrity: Challenges, Actions, Success Stories" (Figure 12), a book with augmented reality elements, "Academic Integrity for Quality Education: An Open Conversation on Fair Learning" (Figure 13), and a series of posters on academic integrity with elements of augmented reality (Figure 14).

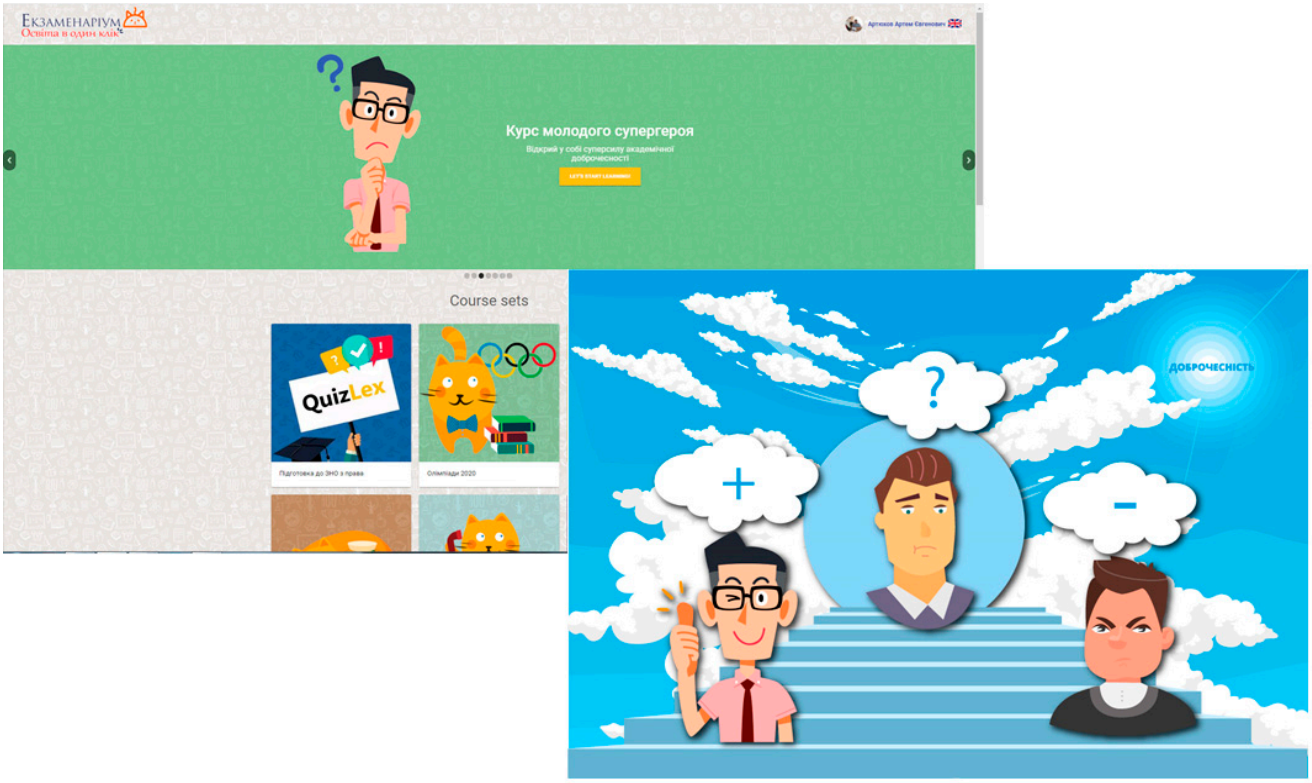

Figure 12. Massive open online course "Academic Integrity: Challenges, Actions, Success Stories" (Academic Integrity). Source: own research language—Ukrainian (Sumy State University case).

The method of educational activities' gamification is widely used at all levels of education. Two types of gamification can be used: gamification in a natural environment using different approaches (role-playing games, "pirate meeting" in brainstorming, etc.) and gamification in a virtual environment using different platforms in which the educational process is embedded. The second type of gamification is becoming more widespread due to the development of various games with a predetermined set of tools to implement the user's scenario. At the same time, an exciting approach to gamification is the integration of approaches from the natural environment into the virtual environment, and this works with students not within a fixed predesigned scenario but in dynamically changing circumstances. It is possible to implement such a combined approach with the help of the Minecraft game (Figure 15).

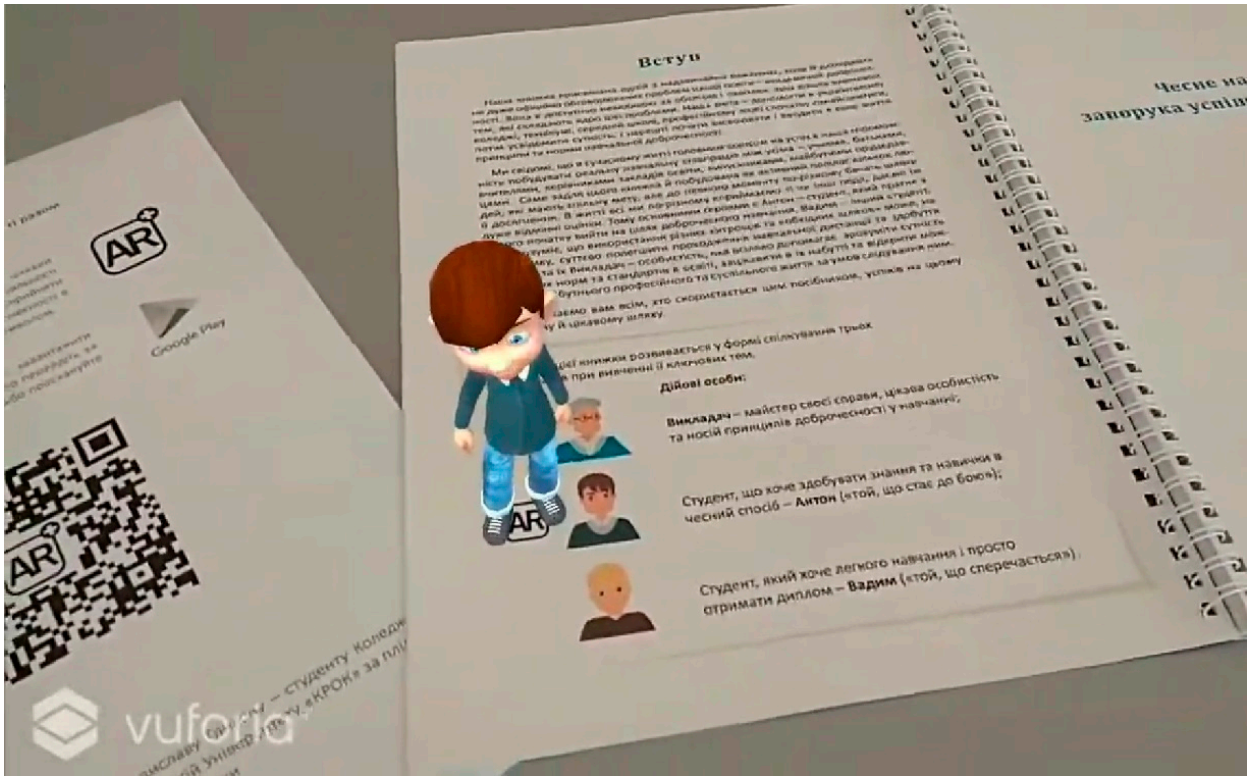

Figure 13. Book with augmented reality elements "Academic Integrity for Quality Education: An Open Conversation on Fair Learning" (Academic Integrity for Quality Education). Source: own research, language—Ukrainian (Sumy State University case).

Figure 14. Series of posters on academic integrity with augmented reality elements. Source: own research, language—Ukrainian (Sumy State University case).

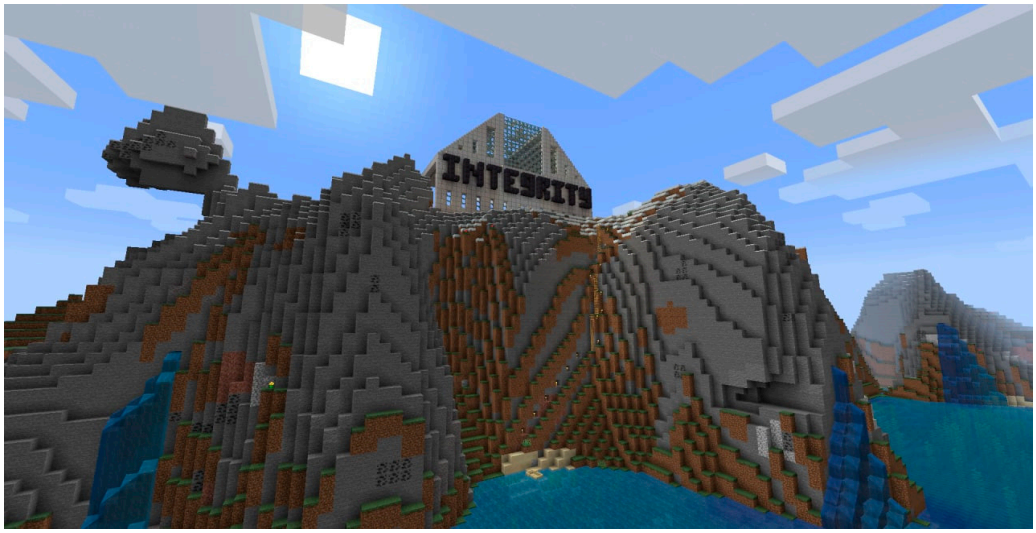

Figure 15. Minecraft world creation. Source: own research.

Choosing an appropriate immersion instrument with a certain dimensionality (nD) might pose a challenge. One must possess a methodology and equipment to evaluate immersion tools' effectiveness and assess the implementation's expediency. One of the possible solutions to this challenge is to use behavioral studies engaging proper equipment and software. We propose to use iMotions 9.3 software (software packages used: iMotions Module-CORE, iMotions Module - Screen-Based Eye Tracking, iMotions Module—GSR, Affectiva AFFDEX 5.1, Denmark) with a Tobii Pro Nano eye-tracker (Sweden) and Shimmer 3 GSR+ Kit sensor (Ireland). This combination allows us to conduct full-scale behavioral studies and evaluate immersion instrument effectiveness.

In Figure 16, we propose an experimental design to test the hypothesis "nD-immersion application enhances student involvement in the learning process compared to (n − 1)D immersion". While conducting similar experiments for each immersion class, we can then build up the understanding of advisability of switching to the next dimensionality of immersion. The current study design can be directly used in the abovementioned behavioral lab setup with minor clarifications such as stimuli formulation and participant selection.

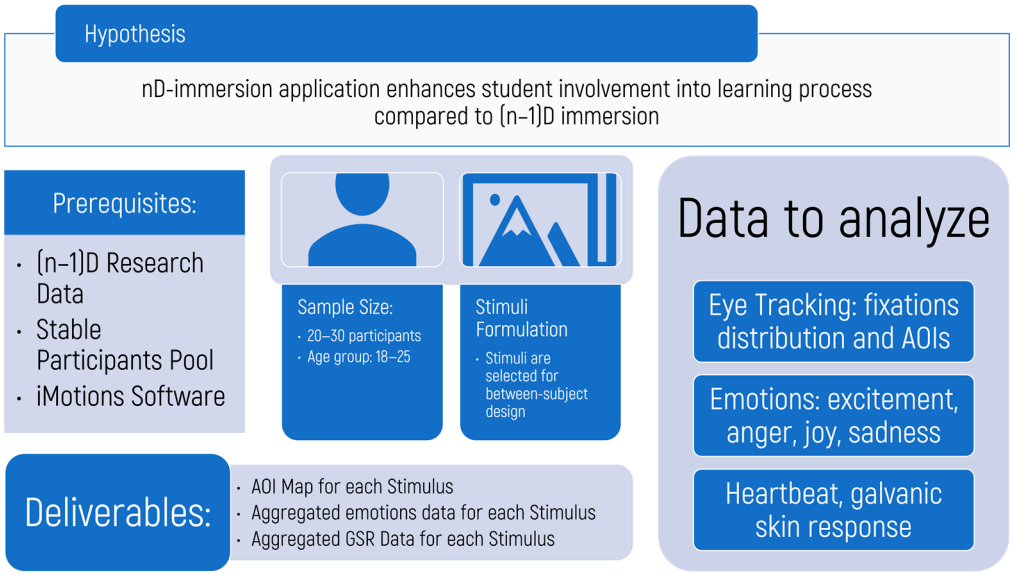

Figure 16. Behavioral study design aimed at immersion techniques' analysis. Source: own research.

Using the deliverables produced in the experiment, we can formulate the immersive university strategy regarding the engagement of new immersion tools and applications.

Multidimensional immersion and the opportunity for collaborative creation of educational scenarios allow students to be involved in improving the quality of educational programs. The correct selection of immersion tools will allow educators to implement any training course using interactive learning methods.

Example

"Puzzle" lecture

Each "live meeting" is formed from F2F, MOOC, VR, and AR+ blocks.

Element 1: "Flexible lecture". In the F2F block, there is an opportunity to move from one type of lecture to another, for example, "problem"–"obviously incorrect answers"–"discussion" (skills: complex multi-level problem solving, critical thinking, forming one's own opinion, and making decisions).

Element 2: "Lecture-transformer". In the F2F block, there is an opportunity to move from lecture to practical class using active learning practices, MOOC, VR, and AR+ (skills: creativity in a broad sense)

Element 3: In the F2F block, interactive learning is applied, "replacing" teacher–student communication with student communication among themselves (skills: emotional intelligence, customer orientation, negotiation skills).

Element 4: In the F2F block, the practice of "active games" is applied, for example, tasks with handouts (skills: flexibility of mind, interaction with people, ability to manage people).

Implementation

Course: "Organization of scientific activity".

Topic: "Research Integrity"

Duration: 80 min

Elements of the "puzzle" (in the sequence of use during the "live meeting"):

- Lecture with obviously incorrect answers → lecture-discussion—15 min.
- Implement a practical case study from the author's MOOC "Academic integrity: challenges, actions, successful stories"—20 min.
- "Moving game"—definition of the algorithm for conducting scientific research and the place of research integrity in this algorithm (cards for students), a transition from active to interactive learning—15 min.
- Consideration of violations of research integrity using author's posters with augmented reality elements, discussion, and online games—20 min.
- Problem lecture—10 min.

To discuss the possible difficulties and problems associated with the usage of the nD-immersion model, we present a risk management table addressing this issue (Table 1).

Table 1. Risks associated with usage of nD-immersion model and mitigation strategies.

Immersion Level	Risk Description	Likelihood	Impact	Risk Level	Mitigation Strategies
1D	Miscommunication or misunderstanding during verbal experience transfer	Medium	Low	Medium	Encourage active communication, provide clear instructions and guidelines.
2D	Technical issues with existing scenarios or tools used to create immersive space	High	Medium	High	Regular maintenance and updates to software and hardware, use of reliable and tested tools.
3D	Difficulty in understanding or navigating three-dimensional training models	Low	Medium	Low	Provide clear instructions and guidance, user testing and feedback.
4D	Safety concerns during on-site role-playing games or AR+ experiences	Medium	High	High	Establish safety guidelines and protocols, provide appropriate safety equipment and training.
5D	Motion sickness or discomfort during full-scale VR experiences	Medium	High	High	Provide breaks and limit exposure time, provide guidance on safe usage.
nD	Technical issues or glitches during gamification in the virtual world	High	Low	Medium	Regular maintenance and updates to software and hardware, use of reliable and tested tools, provide clear instructions and guidance.

5. Conclusions

Within the framework of the current paper, we proposed a new perspective on immersive learning concept formulation, which stands different from the considered literature. Immersive learning is not limited to virtual, augmented, and mixed-reality worlds. Any active or interactive action with the participation of students is an "immersion" in the world with a scenario given or created in the learning process. This scenario can be implemented in the constructed world both electronically and on-site. Guided by the definition of "Immersive learning environments are learning situations that are constructed using a variety of techniques and software tools . . . ", we proposed an approach that combines techniques, scenarios, and software tools into one complex, called the "immersive university". The "highlight" of the proposed model is the ability to test immersive learning tools based on user feedback and behavior study.

Thus, we create a complete cycle for each component of immersive learning "development–trial access–testing–improvement–implementation".

The university's immersive model assumes that students should have the opportunity to be fully immersed in their study field, allowing them to gain the maximum benefit from their abilities and skills. What is also important is their involvement in class and their interactions with other students and academic teachers. Discussions, exchanges of opinions, and cooperation allow for idea exchange and knowledge enhancement. Therefore, the immersive university model allows students to obtain the theoretical knowledge and practical skills necessary for their future careers. However, for this university concept to be practical, the university's teaching staff and students should be digitally competent at an appropriate level.

In the educational context, the significance of digital competence continues to grow [38,39]. It is regarded as a vital component of the critical competencies of modern man. The European Framework for the Digital Competence of Educators (DigCompEdu) is aimed at teachers at all educational levels. DigCompEdu covers six differentiated competence areas for educators to create effective, inclusive learning strategies using digital tools. The framework aims to specify how digital technologies can be used to improve and modernize education and training [40]. Introducing immersion elements into the educational process can help students achieve better academic results and prepare for future challenges.

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