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PREPARATION OF FUTURE TEACHERS FOR THE USE OF IMMERSIVE TECHNOLOGIES IN PROFESSIONAL ACTIVITIES

Abstract. The article presents a theoretical examination of the challenges associated with incorporating immersive technologies into education. Based on the analysis of scientific research, the need to train future teachers to utilise immersive technologies in professional activities has been identified, driven by the digitalisation of education and the demands of the labour market. The feasibility of using immersive technologies in education has been substantiated. It has been established that the use of immersive technologies opens up new opportunities, giving the educational process clarity, focus, dynamism, safety, and effectiveness. The organisation of the educational process using virtual, augmented, and mixed reality technologies enhances students' motivation and intensifies their educational activities. An algorithm for developing an Augmented Reality (AR) application is proposed using specialised software environments: the augmented reality software platform Vuforia and the multi-platform Unity toolkit. General requirements for the spatial model of the AR application and the key image, which contribute to their high-quality reproduction, are disclosed. The features of the process for training future teachers to use immersive technologies in their future professional activities, which is based on the implementation of an integrative approach, are revealed. The content of the discipline "Immersive Technologies in Education" is proposed. The course aims to train future teachers to develop virtual and augmented reality tools for visualising educational material and its implementation in the educational process. A pedagogical experiment was conducted to analyse its effectiveness. Analysis of the pedagogical experiment results demonstrates that immersive technologies are promising for education, and their capabilities enhance the quality of future teachers' training and contribute to creating a modern educational environment.

Keywords: immersive technologies; digitalisation; future teachers; educational process; integrative approach.

1. INTRODUCTION

The problem statement. The digital transformation of society and the introduction of digital technologies into all areas of human activity require highly qualified specialists who can solve professional tasks using modern hardware and software. This involves the introduction of new didactic approaches and the improvement of classical educational methods [1], [2]. Modern needs of the labour market and the latest educational trends determine the increase in requirements for graduates of most specialities and professions, in particular for future teachers, who are of great importance in developing national education. Therefore, the need to provide

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the educational process with engaging and accessible content based on the use of modern digital technologies, which can be used in various forms of organising the educational process, is relevant today [3], [4].

We consider the use of immersive technologies, which enrich the educational process with innovation and visibility, to be an effective way of solving this problem [5], [6]. These technologies encourage students to develop sustainable motivation, a creative approach, and critical thinking. In our view, the utilisation of virtual (VR), augmented (AR), and mixed (MR) reality tools will enhance the effectiveness of educational activities for future teachers.

Analysis of recent studies and publications. The prospects for introducing immersive technologies into the educational process are of considerable scientific interest to Ukrainian and foreign scientists today. The analysed studies of scientists O. Hrybyuk, I. Mintii, S. Semerikov, O. Sypchenko, O. Slobodianyk and others prove that one of the urgent problems of digitalisation of the educational process of higher education institutions is the use of immersive technologies [7], [8]. The importance of immersive technologies in education is confirmed by thematic international conferences [9]. In particular, O. Sypchenko [10] and Y. Trach [11] prove that the use of immersive technologies in the educational process contributes to in-depth study of disciplines of various directions, the development of spatial and analytical thinking, increased student motivation, their effective involvement in the educational process, and better assimilation of educational material due to flexibility, adaptability, and ease of access to educational content from any location and at any time.

American scientists N. Bakhmat, K. Kruty [12], studying the problem of modernization of professional training of future teachers, argue that immersive technologies become the basis for creating a learning environment for professional training of a teacher, who must have the appropriate digital skills to be able to organize the educational process in VR format. Ch. Dede emphasizes that immersive learning systems are promising for improving the development of practical skills, and game virtual environments can provide a simulated experience in which students participate in situational challenges, motivating them to learn and practice tasks in the game world. The scientist emphasizes that such training offers teachers new opportunities to study and practice teaching methods in the classroom without consequences [13].

The prospects for the application of virtual and augmented technologies in education provide an opportunity to implement Situated learning [13], develop communicative competences [14] and provide psychological counselling [15]. J. Bailenson and M. Casale, investigating the intelligent creation of content for virtual reality [16], proposed methods for creating an environment that can be used for virtual training.

Having analysed the theoretical foundations of methods for using immersive technologies in education, we agree with researcher V. Volynets [17], who emphasized the problem of underdevelopment of approaches to its application in the humanitarian field of education in Ukraine.

Furthermore, both Ukrainian and foreign scientists studying the issue of implementing immersive technologies in higher pedagogical education institutions emphasise their significance for ensuring the multimodality of the educational process [18], [19]. Noting the advantages and disadvantages of the impact of the implementation of these technologies on the educational process, researchers argue that their further integration into the academic space is unconditional [20].

Despite the growing body of research in this area, the issue of targeted professional training of teachers to use these technologies in their professional activities remains understudied [7]. Therefore, the problem we are investigating is relevant both in theoretical and applied aspects, and corresponds to the strategic directions of development of pedagogical science.

Based on the analysis of scientific research and the relevance of the problem of introducing immersive technologies into the educational process, we consider it necessary to reveal the features of the process for training future teachers to use immersive technologies in their future professional activities.

Therefore, we believe that today, a promising area of research is the formation of professional competencies of a teacher through a balance of traditional and innovative forms and methods of teaching.

The research goal. To reveal the main provisions of the process of training future teachers to use immersive technologies in professional activities and to verify its feasibility in the educational process.

2. THE THEORETICAL BACKGROUNDS

This section contains concepts, approaches, principles, and main provisions of research. The basic concepts and categories are provided. The need for high-quality training of future teachers for innovative activities in the conditions of digitalisation of education requires rethinking the methods of their training and, accordingly, updating the scientific and methodological support. One of the important directions of digitalisation of education is the introduction of the latest digital technologies, which also include virtual, augmented, and mixed reality tools.

Visualization technology using augmented reality (AR) provides a combination of real-world objects and digital information (images, videos, text, graphics), “overlaying” virtual content on the real world in the user's field of perception. VR fundamentally differs from augmented reality in that this technology constructs a new artificial world, while augmented reality only introduces individual artificial elements into the perception of the real world. Mixed reality (MR) is sometimes called hybrid reality, which is the fusion of real and virtual worlds to create new environments and visualisations where physical and digital objects coexist and interact in real time. Mixed reality does not only occur in the physical or virtual world, but is a mixture of the reality of our world and virtual reality, encompassing both the addition of reality and the addition of virtuality [6], [18]. Increasing the effectiveness of learning using such technologies is due to students' significant interest in new technologies, which in turn leads to an increase in their motivation and learning activity.

The realism of virtual objects allows you to most accurately convey information about the functionality, size, texture, and other features of the studied object [21]. The work of students in a virtual environment qualitatively improves their learning outcomes, but requires new professional skills from the teacher, which are associated with the selection, creation, integration of a virtual object, analysis and choice of software tools, as well as the ability to make creative decisions and introduce innovations into the educational process [22]. Under such conditions, it is worthwhile to pay attention to immersive technologies when updating teaching methods for future teachers.

To solve the above problem, in the process of our research, we relied on a number of methodological approaches. The integrated approach allowed us to study and analyse the possibilities of combining modern pedagogical and digital technologies. The contextual approach allowed us to link the processes of digitalisation with the sphere of education and to substantiate the need to find methods and means of knowledge transfer based on a rational ratio of different forms of learning. The integrative approach allowed us to combine the possibilities of immersive technologies and pedagogical principles, which is the basis of the methods we have proposed.

3. RESEARCH METHODS

To conduct the study, a theoretical analysis of the problem of using immersive technologies in education was carried out. Based on the analysis, their importance in ensuring multimodality of transmission and perception of educational information by students was established. A process for training future teachers to use immersive technologies in professional activities was proposed.

Theoretical methods of scientific research were applied, namely: studying the current state of the problem under study, analysis, and generalisation of theoretical approaches to basic concepts.

Based on the generalisation of the obtained results, guided by the set goal, we proposed an educational discipline for training future teachers in the use of immersive technologies in professional activities. A pedagogical experiment was conducted to verify the effectiveness of the process of training future teachers in the use of immersive technologies. The experimental base of the study is the University. 126 students of the speciality "Vocational Education" specialisation "Digital Technologies" and 3 scientific and pedagogical workers participated in the study.

4. THE RESULTS AND DISCUSSION

4.1. The content of the application of immersive technologies in education

The use of immersive technologies in education allows for the visual modelling of educational material, complementing it with realistic visualisation. In turn, this develops spatial thinking, as well as research and experimentation skills, which contribute to the effective learning of students and make this process interesting and active [23].

Increasing the effectiveness of learning using virtual, augmented, and mixed reality technologies is also due to the significant interest of students in new technologies, which, in turn, leads to an increase in their motivation and learning activity.

Today, immersive technologies are also being introduced for conducting training, quests, gamification of educational modules, organising business games, etc., using some virtual environments (for example, EngageVR, NeosVR, Altspace VR, Google Earth VR, The VR Museum of Fine Art, etc.).

Virtual and augmented reality technologies provide an opportunity to study subjects in more depth, analyse the consequences of any historical events, participate in expeditions, etc., and most importantly, this happens in a game form, which in turn allows you to gain experience that people who are not directly involved in the subject do not usually have access to [24]. VR and AR allow you to get a unique teaching and learning experience, which, by its design, ensures the creation of an individual and interactive learning trajectory.

Based on the studies [2], [8], [17], [18], we believe that the use of the described technologies in the educational process opens up new opportunities and provides the following qualities:

- clarity - virtual space makes it possible to examine any process or object in detail;
- concentration - future specialists are not distracted by external stimuli when immersed in a virtual or mixed environment, which allows them to fully concentrate on learning;
- dynamism - immersive technologies provide the opportunity to control and change the learning process, organise the educational process playfully and interestingly (for example, travel to the past through the eyes of a historical character, go on a journey through the human body in a microcapsule, etc.);

– safety - with the help of immersive technologies, you can observe any process or situation without harming yourself and your environment;
– effectiveness - with the help of immersive technologies, sustainable motivation and cognitive interest are formed, and therefore, such educational process is more effective than a traditional form.

The importance of introducing immersive technologies into the educational process is emphasised in particular by the fact that "teaching a new generation (the digital generation) requires the teacher to be creative and constantly search for new methods and means of teaching. Today, one of such means is augmented reality applications for studying disciplines of different cycles. Such means make it possible to experiment and analyse the result without causing harm to the real objects being studied" [25].

4.2. AR application development in specialised software environments

There are many popular software environments for developing augmented reality tools [21]. A wide range of tools for designing augmented reality objects makes it possible to freely combine and connect them as modules into the Unity package, which is a multi-platform tool for developing two- and three-dimensional programs. Analysing software tools for creating augmented reality objects [26], we consider it advisable to use the integrated Vuforia and Unity environments. Applications created in this way can work on Microsoft Windows, macOS, Linux, PlayStation 4, iOS, and Android operating systems.

Therefore, the implementation of the task will be carried out according to the proposed algorithm for designing systems with augmented reality for educational purposes (Fig. 1).

Figure 1. AR application design diagram

The key components of the presented algorithm are:
– 3D model or video;
– marker (QR code, picture);
– Vuforia SDK, integrated with Unity3D.

When preparing or selecting a model to be integrated into an AR application, one should take into account the general requirements that will contribute to its high-quality demonstration in the application. The model should have a minimum number of polygons for its quick processing by a mobile device (it is recommended to use models with no more than 8-10 thousand polygons). The size of textures for elements that will occupy less than a quarter of the screen area should be chosen no more than 512*512 pixels. The exception is the case when the same texture is superimposed on several elements of different sizes.

After preparing the model, you should select a key image for the label, which will display the 3D model when you point your device camera at the selected label. For the correct operation

of the software application, the main requirements for the image tag should be taken into account:

1. The image size must be at least 320 pixels.
2. The image must contain contrasting elements. Therefore, sometimes it is necessary to slightly increase the contrast and clarity of the image in the photo editor.
3. The image can be in colour or black and white, since the recognition algorithm processes only the brightness channel.

Having prepared the model and label, we register on the Vuforia platform and download the integration package for Unity. We create a free developer license (Developer - License Manager) for the new product. It should be noted that the distribution of applications with such a license is possible only for non-commercial products.

The next step is to add the prepared key image to the Vuforia library (Target Manager). After it is uploaded, the system evaluates the quality of its recognition: if the rating is 4-5 stars, the image will be recognised stably (Fig. 2). We download the created Vuforia database for its subsequent connection to the Unity environment.

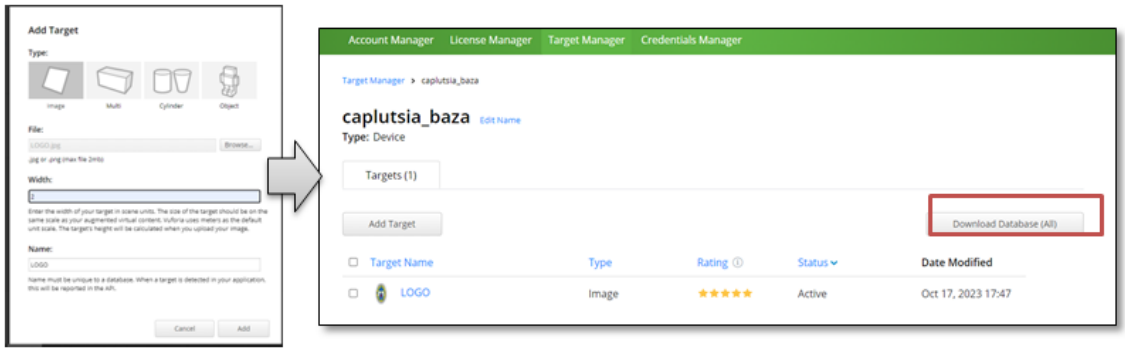

Figure 2. Creating a key image in the Vuforia library

The next stage of developing an AR application is carried out in the Unity environment. We create a new AR Core project and, first of all, install the Vuforia module that we previously downloaded. We delete the standard camera that is available in the new project and add the AR camera from Vuforia instead. In the tool inspector for camera settings, we open the configurations and add the license key created on the Vuforia website (copy it into the appropriate field). The next step is to import the database with key images from the Vuforia library. To do this, after loading the database, drag it into the project window and confirm its import. To create a label on the project scene, in the hierarchy panel from the Vuforia Engine section, we add an image from the imported database (Image Target). In the tool inspector for label settings, we open the configurations and add an image from the database. If the key image is not displayed on the project scene, but looks like a white rectangle, then in the “Project” window in the Vuforia Engine – Image Target Textures section for each image in the settings inspector, you should select the texture type – “2D”.

We load the prepared 3D model (Assets – Import new asset), add it to the scene and scale it to the required size (Fig. 3). We adjust the textures and animation of the model and make it a “descendant” of the key image that is already in the project scene.

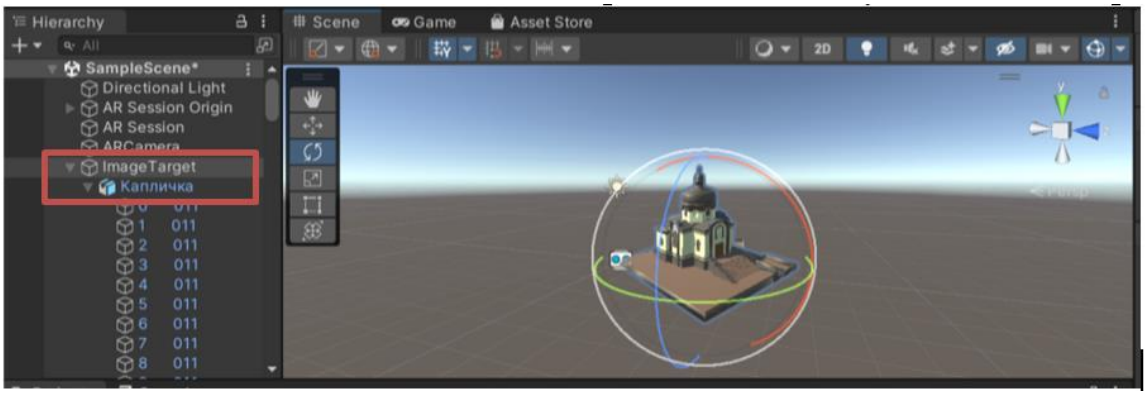

Figure 3. Setting up a 3D model for an AR application

As an example, we used a model of a temple on a student campus, since such objects are distinguished by the complexity of designing their non-standard elements. The social and cultural aspects are also no less important, because the creation of models of significant cultural and historical places contributes to the development of general competencies of future specialists, which corresponds to the "Concept of Digital Competence Development" [27].

It is convenient to check the correctness of the developed application using a webcam. To do this, click "play" and point the webcam at the printed key image (Fig. 4).

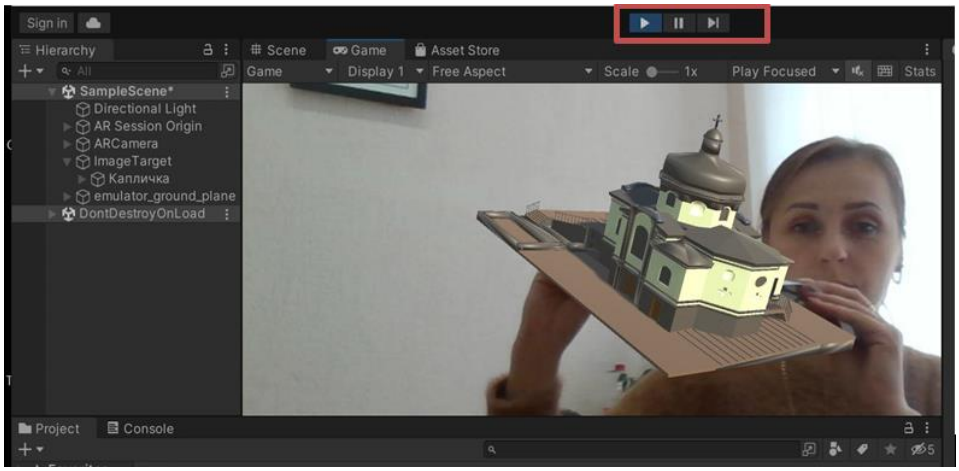

Figure4. Setting up a 3D model for an AR application

After testing the development, we created a mobile application in Unity. Settings specific to the selected platform (iOS or Android) are made in the Edit – Project Settings – Player section (Fig. 5).

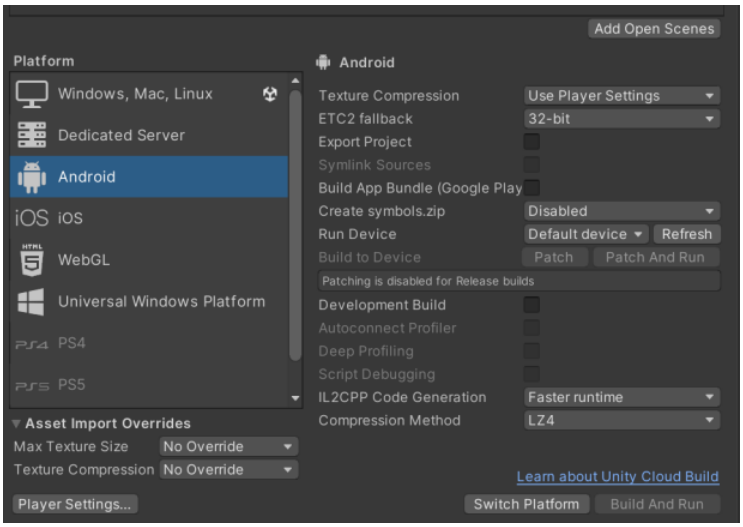

Figure 5. Converting a project into an AR application

To work with the application, you need to print the image that was selected as the key and download the application to your device. After launching the application, point the camera at the image and examine the 3D model (Fig. 6).

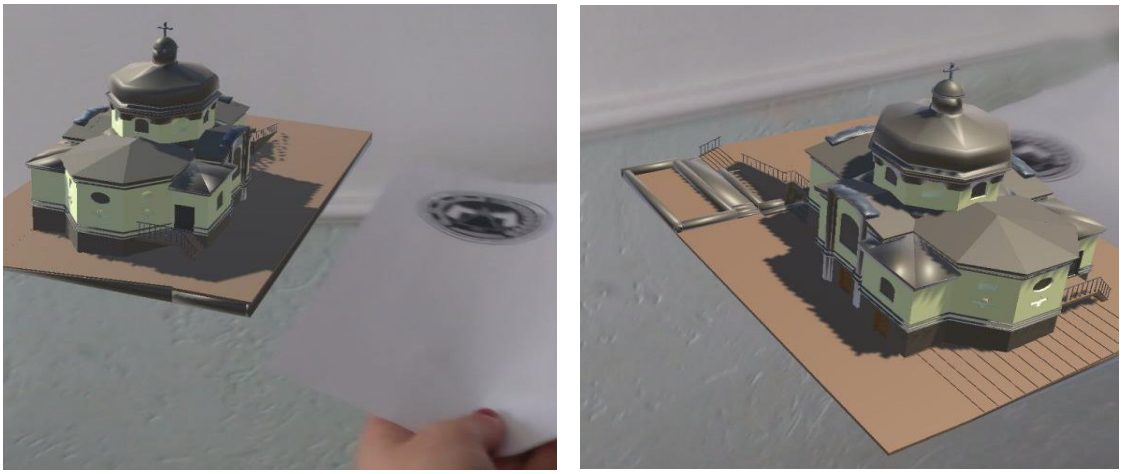

Figure 6. The result of the developed application

4.3. The process of training future teachers to use immersive technologies in professional activities

The process of training future teachers to use immersive technologies is based on the implementation of an integrative approach, which ensures its introduction into the content of training future teachers, taking into account the specifics of their professional activities. Thus, in this case, an interdisciplinary connection of educational components is implemented, which expands the boundaries of mastering educational material and forms an innovative digital educational environment.

In our study, based on an integrative approach, the content of the discipline “Immersive Technologies in Education” was developed and introduced into the educational process of future teachers of vocational education. Such an approach will contribute to increasing the level and quality of professional competencies of education seekers, taking into account the principles of integration and the specifics of the professional activities of future teachers, and, as a result, will ensure the training of a competitive specialist.

The purpose of the course "Immersive Technologies in Education" is to teach future teachers to develop virtual and augmented reality tools for visualising educational material and its implementation in the educational process.

Thus, taking into account the features of the integrative approach, as well as the importance of immersive technologies in the education system, the structure of the course "Immersive Technologies in Education" is proposed (Table 1).

Table 1

Structure of the discipline "Immersive Technologies in Education"

Names of content modules and topics	Number of hours			
	Total	Including		
		Lectures	Lab work	Inde-pendent work
Content module 1. The concept of immersive technologies and their role in education				
Topic 1. General information about immersive technologies.	8	2	1	5
Topic 2. Possibilities of immersive technologies and the role of game engines in the organisation of the educational process.	10	1	1	8
Topic 3. Application of AR in education.	10	1	2	7
Content module 2. Development of virtual and augmented reality tools				
Topic 4. Virtual reality. Physical interactions and the camera.	16	2	4	10
Topic 5. 3D user interface. Navigation in virtual reality.	18	2	6	10
Topic 6. Augmented reality.	12	2	2	8
Topic 7. Using the capabilities of 3D graphics to create and animate spatial objects.	14	2	4	8
Topic 8. Features of working with Vuforia libraries.	14	2	4	8
Topic 9. Configuring tools in the Unity 3D environment.	18	2	6	10
Total	**120**	**16**	**30**	**74**

The study of this discipline is offered to students after mastering the basics of didactics, pedagogy, psychology, as well as educational components that provide the formation of skills in working with graphic environments, programming skills, and digital information processing.

Thus, future teachers will be able to apply the formed skills when studying the process of professional training, educational technologies, pedagogical practice, as well as in further professional activities. The integrative nature of the proposed course is ensured by interdisciplinary connections of educational components and, accordingly, the integration of knowledge and skills of students within their educational program.

4.4. Analysis of the effectiveness of the proposed course in the educational process of future teachers

In the course of the study, a pedagogical experiment was conducted, the main task of which was to verify the feasibility of implementing the course for training future teachers of vocational education to use immersive technologies in their professional activities, as well as to ensure the conditions for the implementation of scientific achievements of teachers in their practical activities.

126 students studying in the speciality "Vocational Education" with a specialisation in "Digital Technologies" were involved in the experiment, as well as 3 qualified teachers. During the experiment, all participants in the educational process were in equal conditions and control was carried out according to the same assessment criteria.

During the study, students carried out project-based practical tasks and developed their projects, enabling us to assess their theoretical knowledge and practical skills in developing AR applications. After analysing the results of the study, it was found that the implementation of the proposed course contributed to improving the quality of respondents' knowledge regarding the use of immersive technologies in their future professional activities, which increased significantly (Fig. 7). Thus, the quality of knowledge of future teachers increased by 33.4%, and the average score increased accordingly ($\Delta\mu$=14.6). A significant achievement of the pedagogical experiment within the framework of this study is the transition of students from low and average levels to sufficient and high, respectively.

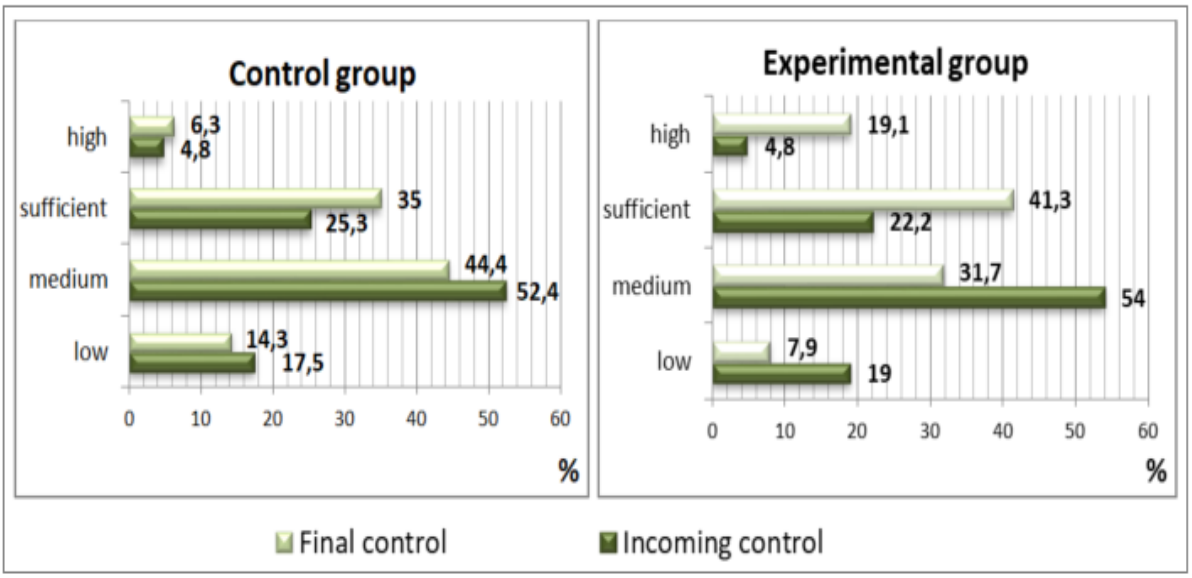

Figure 7. Analysis of the results of the pedagogical experiment

To confirm the statistical significance of the results of the pedagogical experiment, we used the method of statistical calculations of the Student t-test [28]. Based on the calculated average values of scores and standard deviations for the corresponding number of students in the control and experimental groups (63 students in each group), we calculated the t-empirical value at a significance level of $\alpha = 0.01$. (t_{emp} =8.65). We compared the empirical value with the tabular critical value at a given significance level (t_{crit} =2.617). Therefore, since t_{emp} is greater than t_{crit}, the results of the pedagogical experiment are statistically significant, and the proposed course is effective in the educational process.

Additionally, at the start of the experiment and after studying the discipline "Immersive Technologies in Education", a questionnaire was conducted to assess students' abilities for innovative pedagogical activities and to determine their motivation levels to utilise immersive technologies in their future professional work. The survey contained several questions, the key ones of which are:

1. Do you consider it advisable to use immersive technologies in education?
2. What do you think: are virtual and augmented reality technologies necessary for education in modern conditions of social development?
3. Do you consider the course “Immersive Technologies in Education” useful for study by future teachers?

It should be noted that the results of the questionnaire showed a high level of interest among future teachers in the implementation of immersive technologies in the educational process after the completion of the experiment (Table 2).

Table 2

Summary of survey results

Control stage	Number of respon-dents	Question								
		1			2			3		
		Yes	No	I can't give a definite answer	Yes	No	I can't give a definite answer	Yes	No	I can't give a definite answer
		Results in %								
Incoming	126	54.0	31.8	14.2	30.2	24.6	45.2	52.4	14.3	33.3
Summary		94.4	1.6	4.0	96.0	1.6	2.4	99.2	0	0.8

In addition, survey results confirm that students show significant interest in using the latest technologies in the educational process, which also include immersive technologies (Fig. 8).

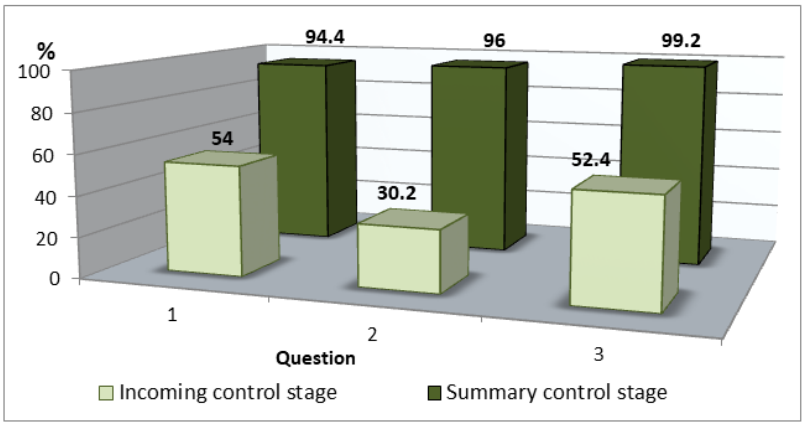

Figure 8. Analysis of survey results

Summing up the results of the questionnaire, it was found that modern digital technologies, including immersive ones, are promising in the education system, and their capabilities ensure the quality of training of future teachers and their competitiveness in the global educational space.

Thus, the proposed course contributes to the formation of practical skills in the application of immersive technologies in professional activities among future teachers. This confirms the importance of introducing the latest technologies and methods for developing creative potential in students and ensuring a high-quality educational process as a whole.

4. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

Based on the analysis of the results of the problem under study, the relevance of the problem of training future teachers to use immersive technologies in professional activities was substantiated. Having analysed the possibilities of immersive technologies in education, it was found that they provide the opportunity for visual modelling of educational material, supplementing it with clarity, developing spatial ideas and research and experimentation skills in students, which contributes to effective learning and makes this process interesting and active. The use of immersive technologies allows to create innovative educational content.

Today, one of such tools is augmented reality applications for studying disciplines of different cycles, which make it possible to safely experiment with the objects under study.

It was established that for the development of AR applications, the integrated use of Vuforia and Unity environments is advisable, since applications created in this way are cross-platform. Therefore, an algorithm for designing systems with augmented reality for educational purposes was proposed for the development of AR applications.

A course for training future teachers to use immersive technologies in professional activities has been developed. Based on an integrative approach, the content of the discipline "Immersive Technologies in Education" was developed and introduced into the educational process of future teachers of vocational education.

A pedagogical experiment was conducted, the results of which showed that the quality of knowledge of future teachers increased by 33.4%, and the average score increased accordingly ($\Delta\mu$=14.6). This indicates that the quality of training future teachers to use immersive technologies in their future professional activities has increased significantly. A survey of students showed that they show significant interest in using the latest technologies in the educational process, namely immersive technologies. So, there is a need to ensure a high-quality educational process based on the implementation of new methods and approaches.

Thus, immersive technologies are promising in the education system, and their capabilities ensure the quality of training of future teachers and contribute to the creation of a modern educational environment.

The prospects for further research include the development of appropriate methodological support and its implementation in the educational process. In addition, we consider it necessary to improve the proposed course by implementing virtual reality tools to enable the reproduction of the interior of the objects under study.

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ПІДГОТОВКА МАЙБУТНІХ ПЕДАГОГІВ ДО ВИКОРИСТАННЯ ІМЕРСИВНИХ ТЕХНОЛОГІЙ У ПРОФЕСІЙНІЙ ДІЯЛЬНОСТІ

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Анотація. У статті здійснено теоретичний аналіз проблеми застосування імерсивних технологій в освіті. На основі аналізу наукових досліджень визначено потребу в підготовці майбутніх педагогів до застосування імерсивних технологій у професійній діяльності, що обумовлено цифровізацією освіти і потребами ринку праці. Обґрунтовано доцільність застосування імерсивних технологій в освіті. Встановлено, що використання імерсивних технологій відкриває нові можливості та надає освітньому процесу властивостей наочності, цілеспрямованості, динамічності, безпеки та результативності. Організація освітнього процесу з використанням технологій віртуальної, доповненої та змішаної реальності сприяє підвищенню мотивації здобувачів освіти та активізації їх навчальної діяльності. Запропоновано алгоритм розробки AR-додатку за допомогою інтегрованого застосування спеціалізованих програмних середовищ: платформи програмного забезпечення доповненої реальності Vuforia та багатоплатформового інструментарію Unity. Розкрито загальні вимоги до просторової моделі AR-додатку та ключового зображення, які сприятимуть якісному їх відтворенню. Розкрито особливості процесу підготовки майбутніх педагогів до застосування імерсивних технологій у майбутній професійній діяльності, яка ґрунтується на реалізації інтегративного підходу. Запропоновано зміст дисципліни «Імерсивні технології в освіті». Метою курсу є навчити майбутніх педагогів розробляти засоби віртуальної і доповненої реальності для унаочнення навчального матеріалу та його впровадження в освітній процес. Для аналізу його ефективності проведено педагогічний експеримент. Аналіз результатів експерименту доводить, що імерсивні технології є перспективними в системі освіти, а їх можливості забезпечують якість підготовки майбутніх фахівців і сприяють створенню сучасного освітнього середовища.

Ключові слова: імерсивні технології; цифровізація; майбутні педагоги; освітній процес; інтегративний підхід.

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