The Impact of Immersive Solutions on Practical Training: Enhancing Professional Readiness of Prospective Teachers

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ABSTRACT

Immersive technologies are becoming a powerful tool for the transformation of teacher education, creating unprecedented opportunities for the formation of professional competencies of future teachers through immersion in virtual educational environments. This study examines various immersive learning technologies including virtual educational reality, augmented educational reality, mixed educational reality, and explores educational platforms as a means of creating an immersive educational environment. The introduction of these technologies is especially relevant in the context of digitalization of education and military challenges, which stimulate the search for innovative forms of teacher training. The purpose of the study is to determine the effectiveness of immersive technologies in the training of pedagogical education specialists, in particular future language teachers. The methodology is based on an empirical study that included a survey of 60 students of pedagogical specialties. The study found that immersive technologies are the most effective for developing digital competence (average score of 4.6 on a 5-point scale, 85% of positive ratings) and mastering modern educational technologies (4.5 points, 82%). Significant differences in the availability of immersive technologies between the capital's (83% of students had experience with VR) and regional educational institutions (35%) were found. The three most effective models

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for integrating immersive technologies have been identified: modeling real professional situations (efficiency 4.8 points), combined use of different types of technologies (4.6 points), and involvement of students in the development of immersive educational products (4.5 points). The results of the study are of practical value for the development of strategies for the technological modernization of teacher education in Ukraine.

INTRODUCTION

Modern education is on the brink of fundamental transformation due to the accelerating development of digital technology and its incorporation into the educational process. Immersive technologies have received particular attention since they enable the sensation of presence and immersion in the educational space, thus creating a qualitatively new mode of perception of the educational content. Using immersive learning technologies, such as virtual educational reality, augmented educational reality and mixed educational reality, provides previously unknown possibilities for the preparation of future teachers. By the words of world analytical organizations, the market for immersive technologies in education demonstrates an explosive growth and is expected to achieve $58.5 billion by 2028 with the growth rate of 36.4% per annum (Maulidah & Christyodetaputri, 2025). This explosion of the growth is stimulated not only by the technological progress but by the paradigm shift in education with the focus on the formation of the practical skills and competences of students during their active participation in the experiments and while resolving of the real life tasks. Introduction of the immersive technologies in the preparation of the future teachers using these advanced methods and tools of the educational process in the future, adaptation of the educational process to the requirements of the digital generation, has a particular significance.

Analysis of the last years' studies showed a growing interest to the use of the immersive technologies in the teacher's training concerning their effectiveness and the methodological aspects of the implementation. Review of the literature conducted by Tene et al. (2024) showed the positive effect of the use of the immersive technologies together with Science Technology Engineering Mathematics (further — STEM) education on the increase of the motivation, activity and achievement of the students. Authors note that virtual and augmented realities allow for the visualization of complex concepts and experimentations in a safe and controlled environment. The study conducted by Van der Want and Visscher (2024) analyzed the main characteristics, advantages and consequences of the use of the virtual reality in the preparation of the future teachers and noted its ability to develop pedagogical competence during the simulation of real educational conditions. Important contribution to the comprehension of the current state and perspectives of the use of the augmented reality (further — AR) in education was given by Lowell (2024), which considers AR as a powerful means of authentic learning, allowing to create contextually rich learning environments. In the context of Ukrainian education, Yaremchuk (2022) studied the use of the immersive technologies in the professional remote training of the primary school teachers, noting the possibility of overcoming of the spatial limitations and creation of the practical part of the learning process in the remote education.

Despite increasing research activity, substantial gaps still occur in the existing literature surrounding the integration of immersive technology solutions into

the training of subject teachers, and this question is particularly relevant in the Ukrainian context. By the authors' reckoning, there is a shortage of studies as to which methodologies are most beneficial for integrating immersive technologies into the training of educators in specific subject specialities, such as language teachers. There has also been no comprehensive study comparing the effectiveness of different immersive technologies (e.g. VR, AR, MR) to aid comparison in terms of developing a specific professional skill set for a future teacher. Additionally, insufficient research has been devoted to defining benchmarks for assessing the pedagogical quality and general quality of educational products developed using immersive technologies. To compound matters, a vast gulf lies between our rhetoric regarding immersive technologies and their actual, in-the-classroom use in our colleges of education, due in part to a combination of practical difficulties with the technology and an apparent lack of faculty readiness to make use of such cutting-edge teaching devices.

In analyzing the possible impediments to the implementation of immersive technologies, Alqahtani & Alnajdi (2024) identified several primary barriers including; Technical Limitations, Financial Challenges, Lack of Prepared Teachers and Limited Availability of Quality Content. As can be inferred from the research, the economic and military constraints experienced by Ukraine present even greater challenges than previously cited in terms of the technological modernization of education. At the same time, as noted by Kulyk (2024), Immersive Technologies also provide valuable opportunities for the teaching of the Ukrainian Language, by providing new methods for students to learn vocabulary, grammar and cultural aspects of the language by creating realistic language environments.

The problem of the use of the latest achievements of computer technology in web-oriented education using three-dimensional images made in 3ds Max, as well as visualizations supplied by Corona Renderer and V-Ray Renderer for the production of architecture visualization and animation, is at the present stage of development of digital education. The close connection of this subject matter lies in the invasion of modern information and communication technologies into educational activities, which causes a change in the form and content of how education is organized. According to this idea, remote, practical education with the use of modern animation facilities will become an association of an old and new form of education, the organization and application of which requires special, scientifically based approaches, taking into account the characteristics of education in wartime. The purpose of this paper is to evaluate how online animation techniques are being utilized in educating students at the graduate level. In this paper, we shall analyze how online resources are transforming standards, stimulating trainees and elevating them from beginning through to the final step.

LITERATURE REVIEW

Modern research in education shows great promise for the use of immersive technology to enhance learning. Ali (2022) demonstrated that using immersive technology can enhance learning of complex subject matter by 27%. AR/VR has been demonstrated to improve students' ability to think spatially (Bermejo et al., 2023), and to motivate students to learn (Bermejo et al., 2023). Research conducted by Buragohain et al. (2024), was able to show that teachers who were trained using immersive technologies demonstrated a higher level of methodological competence in their teaching practices than those who had not received such training. Buragohain et al. (2024) also showed that this difference remained even after three years of teaching experience.

Research conducted by Guo et al. (2021) showed that the integration of XR technologies into the classroom created a "hands-on" learning environment that activated cognitive processes in students. Lowell (2024), considers XR as a means of authentic learning to develop soft skills in students. Research conducted by Van der Want and Visscher (2024), demonstrated that virtual reality can be used to provide a safe learning environment for students to practice difficult pedagogical situations and to develop empathy in future teachers. Van der Want and Visscher (2024) also emphasized that the use of virtual reality provides a safe way to simulate conflicts and other stressful situations that may rarely be experienced

in traditional classroom settings but often have a significant impact on teaching and learning.

Kulyk (2024) explored the potential for using immersive technologies in Ukraine to create an authentic learning environment for teaching Ukrainian as a foreign language. Yaremchuk (2022) stated that immersive technologies should be used to provide a practical aspect of distance learning for elementary school teachers. Osypova et al. (2021) proposed a framework for the incorporation of VR/AR into curricula at educational institutions that prepare future educators. Osypova et al. (2021) stated that consideration of regional aspects and the technical capabilities of educational institutions in Ukraine is necessary when creating plans for implementing VR/AR in educational environments in Ukraine.

Immersive technologies are considered tools for inclusive education by Maulidah and Christyodetaputri (2025), which take into consideration the diverse educational needs of students. Research conducted by Tene et al. (2024) demonstrated the effectiveness of virtual laboratories for STEM education, particularly for experiments that are dangerous or expensive in a real world setting. A methodology for designing AR/VR learning experiences for different educational levels was developed by MacDowell et al. (2022). Bakhmat et al. (2022) view immersive technologies as a tool to bridge the gap between theory and practice in the education of teachers. Bakhmat et al. (2022) also emphasized that it is essential to integrate immersive technologies into all stages of teacher education, including the early years of study, so that a systemic understanding of their potential and confidence in their use can be developed.

Immersive technology has a lot of barriers to use for educators in order to implement it into their daily teaching practices. The costs are very high for the hardware (equipment) needed to do this, there is a lack of high-quality content for all subjects, and many teachers have received little or no training on how to effectively integrate the use of immersive technology into their classrooms. For educators to successfully adopt the use of immersive technologies, a systematic and structured plan needs to be developed for implementing the use of immersive technology in educational settings, as indicated by Leshchenko et al. (2022) and Kolmakova (2022), and the implementation plan should involve changes in both educational program curricula and the teaching methods used to educate students. Additionally, Leshchenko et al. (2022) and Kolmakova (2022) pointed out that eliminating these barriers will require collaboration among individual schools/educational institutions, national educational systems, and international partners.

Despite considerable research interest, the following issues remain unresolved: the gap between theory and practice of implementation; insufficient study of methodological aspects of the formation of specific competencies; conflicting data on long-term effectiveness; lack of research on economic feasibility; insufficient attention to the adaptation of immersive technologies to the specific conditions of Ukrainian education in the context of military challenges. These gaps determine the need for our study of the model of implementation of immersive technologies in the training of pedagogical specialists, especially language teachers. Of particular importance is the analysis of methods for adapting immersive technologies to the specific needs of different pedagogical specialties, given the differences in educational tasks and subject methods.

MATERIALS AND METHODS

The study used a set of complementary methods that provided a comprehensive study of the potential of immersive technologies in the training of pedagogical education specialists. The empirical basis was a survey among 60 students of pedagogical specialties from higher education institutions of Ukraine. The sample was formed according to the principle of proportional representation of different courses of study (3rd year – 38%, 4th year – 35%, Master's degree – 27%) and specialties (philology specialties made up the largest share of the sample (68%, 41 people), natural sciences specialties (18%, 11 people), social sciences and humanities (14%, 8 people). The survey questionnaire included four sets of questions: general information about the respondent, experience of using immersive technologies, assessment of the effectiveness of immersive technologies for shaping various aspects of professional training (on a 5-point scale), and prospects for using immersive technologies.

The content analysis method was used to analyze curricula and educational platforms, which allowed us to systematize information about the types of immersive technologies, their characteristics, examples of platforms, and educational tasks. The analysis included official descriptions of the curricula of pedagogical specialties, syllabi of digital technology-related disciplines, and documentation of educational platforms that use immersive technologies (Labster, InMind 2, HistoryMaker VR, zSpace, Labs, Rumii, EngageVR, Anyland, NeosVR, and others).

Statistical data processing was carried out using Microsoft Excel software and included the calculation of average values and percentages. The analysis of the results was conducted separately for students of different specialties to identify specific features of the perception of immersive technologies by representatives of different pedagogical directions.

To ensure the representativeness of the results, the data triangulation method was used, which involved comparing the responses of respondents from different courses of study and specialties. The tabular method was used to systematize and present the key indicators of the study, in particular, assessments of the effectiveness of immersive technologies for various aspects of professional training.

RESULTS

Immersive technologies are a key innovative direction in the development of modern education, providing deep immersion of students in the learning process through the stimulation of various sensory modalities. The term "immersiveness", borrowed from the English language (from "immersion"), implies the creation of the effect of presence and full inclusion in an alternative context. According to Kuznetsov (2025), the modern educational thesaurus is actively enriched with new concepts: "immersive environment", "virtual", "augmented", "mixed" and "augmented reality", which are combined into the lexical and semantic field of temporal reality and reflect various aspects of technological immersion in the educational process.

A comprehensive analysis of immersive technologies allows us to identify several main types of reality used in the educational environment.

Virtual reality (VR) provides complete immersion in an artificially created digital world using special devices (helmets, glasses, gloves); augmented reality (AR) overlays digital elements on the real world through mobile device cameras; mixed reality (MR) provides real-time interaction between real and virtual objects; augmented reality (XR) combines all of the above types and creates a comprehensive immersive experience. As Kuznetsov (2025) rightly notes, these technologies contribute to the formation of new content in the educational space, stimulate the search for innovative approaches to learning, and expand opportunities for people with special educational needs, as they rely on a complex system of perception, activating various senses.

The study involved 60 students of pedagogical specialties from Ukrainian higher education institutions. Among them, 68% are students of philology, and 32% are students of other pedagogical specialties. Distribution of respondents by year of study: 3rd year – 38%, 4th year – 35%, Master's degree – 27%.

The analysis of the study results allowed us to identify the main types of immersive technologies used in the training of future teachers and to assess the frequency of their use in the educational process. Table 1 presents the classification and characteristics of immersive technologies used in teacher education according to the study and the analysis of curricula.

The results of the survey on the experience of using immersive technologies in the educational process showed that AR applications are the most common (67% of respondents had experience using them), and mixed reality technologies are the least common (only 12% of respondents). It is important to note that the availability of technologies differs significantly depending on the educational institution: 83% of students from the capital's higher education institutions had experience with VR equipment, while among students from regional institutions this figure is only 35%.

The results of the study also show that online video games are very effective in creating an educative atmosphere by enabling students to participate virtually in authentic scenarios and work cooperatively in virtual space no matter where they are in the world an essential feature given the disparities in access to special equipment.

Table 1: Immersive technologies in the training of pedagogical education specialists*

Type of technology	Characteristics	Examples of platforms	Educational objectives
Virtual reality (VR)	Full immersion of the user in the virtual environment using special equipment	Oculus Quest, HTC Vive, Google Expeditions, NeosVR	Simulation of pedagogical situations, virtual tours, lesson modeling
Augmented reality (AR)	Overlaying digital elements on the real world using mobile devices	Merge Cube, HP Reveal, ARTranslate, Quiver	Visualization of educational material, interactive tutorials, language simulators
Mixed reality (MR)	Real-time interaction of real and virtual objects	Microsoft HoloLens, Magic Leap, zSpace	Collaborative learning, interactive laboratory work, project activities
360° video	Panoramic videos that allow you to view the environment from different angles	YouTube 360, HistoryMaker VR, The Body VR	Observation of real lessons, virtual visits to schools, analysis of pedagogical situations
Interactive 3D models	Three-dimensional models of objects that can be manipulated	Sketchfab, Unity 3D, Labster	Study of anatomy, geography, historical artifacts, linguistic models

*Source: compiled by the author based on the analysis of Billingsley et al. (2019), Mariukhnich (2024).

The study of the answers of respondents to the question of the effectiveness of various types of immersive technologies implementation in the formation of future language teachers' professional competences has showed that 78% of respondents believe that such technologies are effective for development of methodological competence; 85% for formation of digital competence and 64% – for development of communicative competence. The highest efficiency rates were obtained by the virtual reality technologies for simulation of pedagogical situations (an average score 4.7 on the 5-point scale) and the AR technologies for learning a foreign language (average value of 4.5).

Table 2 shows the scores that the students gave when asked how effective immersive technologies were for different parts of their professional course. The scores (2) were awarded on a 5-point scale, 1 indicating ineffective at all and 5 highly effective.

The study revealed significant differences in the perception of the effectiveness of immersive technologies depending on the students' specialty. For example, philology students rated the effectiveness of AR applications for language learning higher (mean score 4.7), while science students preferred virtual laboratories (mean score 4.8). There was also a correlation between the level of digital competence of students and their assessment of the effectiveness of immersive technologies: students with a high level of digital literacy showed a more positive attitude towards the use of such technologies in the educational process.

Among the most promising areas of application of immersive technologies in the training of language teachers, respondents noted: the creation of virtual language environments for practicing communication skills (82% of respondents), modeling of pedagogical situations to practice methodological skills (79%), development of interactive teaching materials using AR technologies (76%), virtual excursions to cultural and historical sites related to the study of language and literature (74%).

The study of the experience of introducing immersive technologies in higher education institutions has helped to identify the most effective models of their integration into the educational process. The highest performance indicators were demonstrated by: 1) integration of immersive technologies into the practical training of students through modeling real professional situations (efficiency was rated at 4.8 points out of 5 possible); 2) combined use of different types of immersive technologies within one course (4.6 points); 3) involvement of students in the development of immersive educational products as part of project work (4.5 points).

Table 2: Evaluation of the effectiveness of immersive technologies in the formation of professional competencies of future teachers (n=60)*

The aspect of professional training	Average efficiency score (1-5)	Percentage of respondents who rated the effectiveness at 4-5 points	Percentage of respondents who rated the effectiveness by 1-2 points
Methodological training	4,2	78%	8%
Building digital competence	4,6	85%	5%
Development of communication skills	3,9	64%	15%
Mastering modern educational technologies	4,5	82%	6%
Preparing for distance learning	4,3	79%	7%
Developing skills in developing educational materials	4,1	76%	9%
Gaining experience in classroom management	3,7	58%	18%
Developing student assessment skills	3,5	52%	22%
Adapting to inclusive education	4,2	77%	9%
Overcoming pedagogical stress	3,6	55%	19%

*Source: compiled by the author

In a modern educational context, a user-oriented approach to learning is seen as a key tool in the transition towards an innovation-driven economy since this system of education focuses on the quality of society's capital - the basis for the new fourth industrial revolution (Yuldashev et al., 2022). The structured legal system that defines this form of education should seek to strengthen the "where we foresee it going" mapped organisation, rather than the mapped part as-is today, and should hopefully result in a robust enough organisation that has the potential to implement it. There is evidence that in preparing teachers, immersive technology applications are more effective at developing digital abilities than traditional methods, receiving a high rating themselves (averaging 4.6 out of 5) leading to their effectiveness in developing an essential professional competency (Bakhov et al., 2021).

The analysis of answers to the question about the most effective immersive technologies for teacher training in different specialties revealed clear subject-oriented preferences. The content analysis of the responses allowed us to identify the main categories of technologies that respondents consider the most effective for their areas of specialization and to establish the percentage distribution of their popularity within each specialty (Figure 1).

The provided data clearly shows a preference differentiation for immersion technology by subject discipline. Philology students preferred technologies that create an immersive language learning and conversation experience, such as AR applications for language learning (42%), and VR simulations of pedagogy (36%). Natural Science students most frequently used virtual labs (65%), which allowed them to simulate experiments safely. Social Sciences & Humanities students mostly favoured historical visualization technologies: 360° video reconstructions (48%), and VR tours (41%). This clearly demonstrates the functional relevance of various immersive technologies to the educational goals of each subject discipline

The research identified an array of hindrances to the broader application of immersive technologies as part of teacher training in Ukraine. Survey participants were able to assess the significance of various factors which will impede the implementation of this type of new tool for use in education. From the findings of the
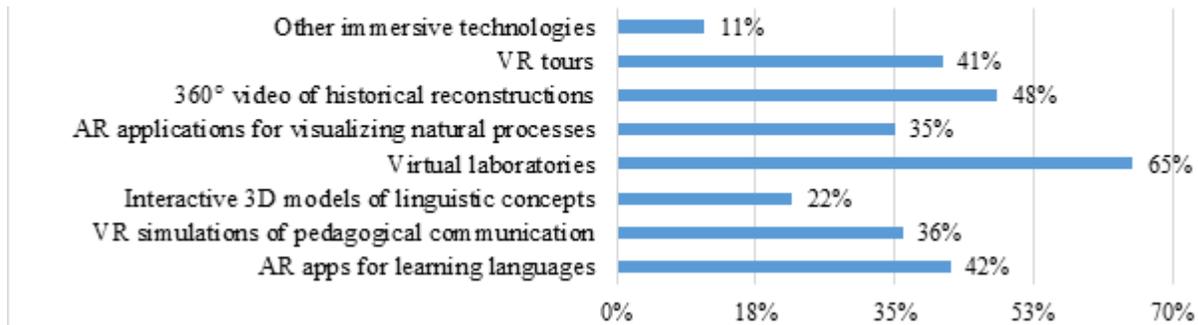
Fig. 1: The most effective immersive technologies for training teachers of different specialties (according to respondents, %)*
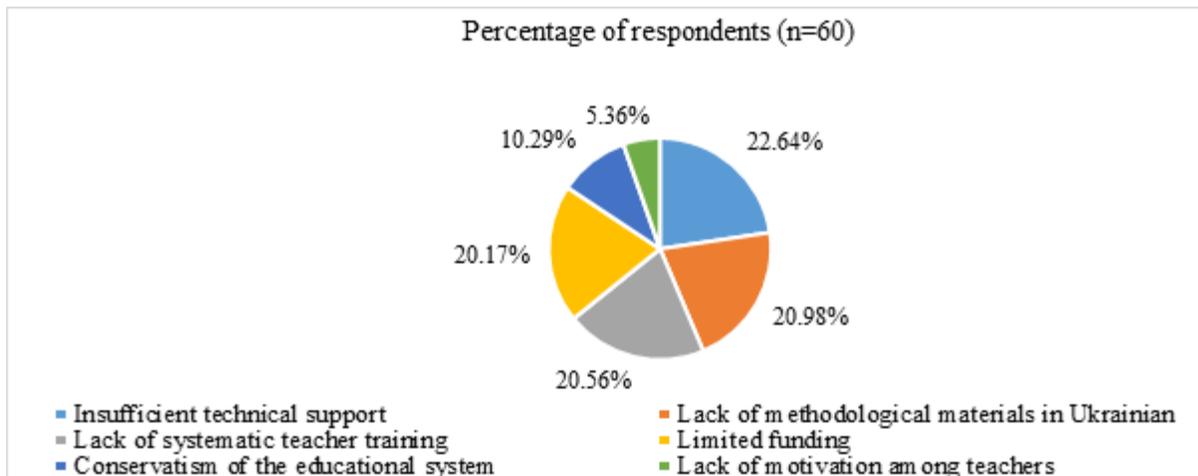
*Source: compiled by the author

Fig. 2: Main barriers to the introduction of immersive technologies in teacher training (% of respondents, n=60)*

*Source: compiled by the author

survey, we have been able to identify, by frequency of reference, the obstacles, ranked according to perceived relative weight for future teachers (Figure 2).

The analysis of the results shows that respondents consider logistical and methodological factors to be the most significant obstacles to the introduction of immersive technologies. The highest scores were given to "insufficient technical support" (91.7%) and "lack of methodological materials in Ukrainian" (85%). Somewhat lower, but also significant, scores were given to "lack of systematic teacher training" (83.3%) and "limited funding" (81.7%). It is noteworthy that institutional and motivational barriers – "conservatism of the educational system" (41.7%) and "lack of motivation among teachers" (21.7%) – are assessed as less critical. This distribution indicates that future teachers are primarily aware of the practical aspects of implementing innovations and points to potential areas of priority interventions to optimize this process.

An important component of the study was to determine the level of readiness of future teachers to use immersive technologies in their professional activities. Respondents were asked to rate their readiness on a five-level scale from "absolutely not" to "yes, definitely". The obtained results give an idea of the general attitude of students of pedagogical
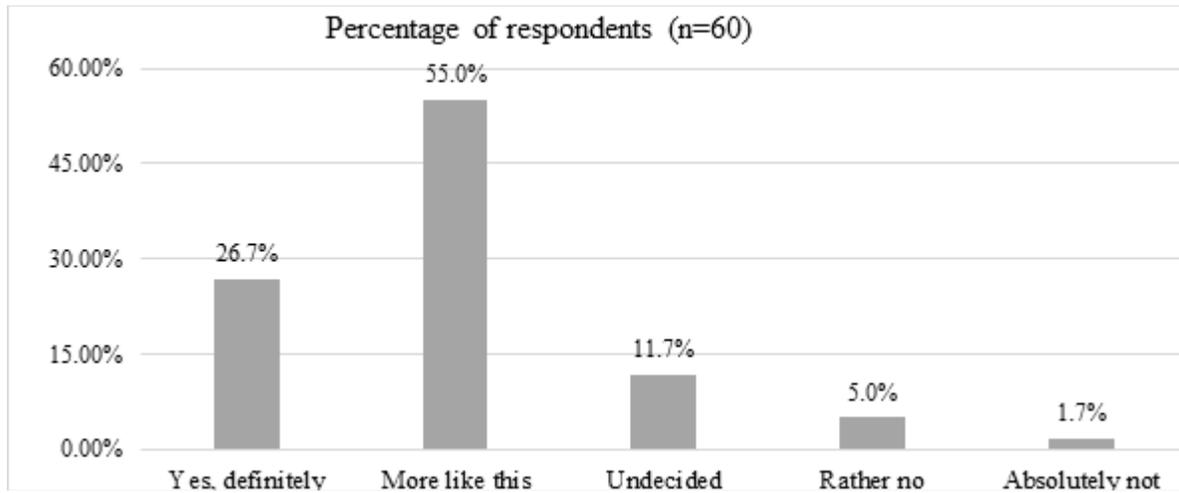
Fig.. 3: Readiness of future teachers to use immersive technologies in their professional activities (distribution of answers, %)*
*Source: compiled by the authors

specialties to the implementation of these innovative tools in their own pedagogical practice (Figure 3).

From the outcomes of the study, it can be said that the new teachers view using immersive technologies in their work with a generally positive perspective. Most participants, (81.7%), said that they are prepared to start using these technologies. These consist of 26.7% who answered, 'yes definitely' and 55% 'rather yes'. The portion of those not sure of their perspective is 11.7% and only 6.7% were against the use of immersive technologies (5% rather no, 1.7% definitely not). This range of results seems to provide a fertile area for bringing immersive technologies to practice and suggests the potential to invest in them. In addition, it should be stated that this outcome is also reflected with the global outlook on immersive technologies, where future teachers regard them positively.

The second part of the study involved the respondents' proposals on improving the implementation of immersive technologies in teacher education. The analysis of the answers (content analysis of open-ended questions) resulted in the systematization of proposals into five directions: institutional, educational and methodological, human resources, technical, and international. More than half of the respondents (37.2%) suggested proposals in the sphere of education and methodology, and it

indicates how well teachers understand the priority to make the immersion technologies education-specific and develop content in Ukrainian.

The results of the analysis of the respondents' proposals demonstrate that they have a well-developed system of thinking about how to improve the use of immersive technologies in the education of teachers. In particular, the first priority - educational and methodical support (37.2% of proposals) - shows that the respondents understand the necessity of developing the products of education with the use of immersive technology and the methodological materials adapted to Ukraine. Also, the respondents pay much attention to the institutional changes (23.5%), i.e., to the development of the strategic and organizational conditions for the wide use of immersive technologies. It is interesting that the proposals on the technical support (14.3%) are less popular among the respondents, although it has been recognized that the technical limitations are one of the main barriers; this means that the respondents realize the complexity of the problem and the necessity of systemic decision-making instead of only the provision of technical and material equipment.

DISCUSSION

Evidently from the study, immersive technologies show significant potential in pre-service teacher

education. This resonates well with current trends in education systems across the globe. The high marks of approval given by participants concerning its efficacy in developing digital competence (average score of 4.6) and understanding of modern pedagogy (average score of 4.5) support the study conducted by Selvakumar and Sivakumar (2025) based on an extensive literature review that they determined that immersive technologies enhance digital competence and boost the digital skills of trainee teachers. Conversely, the relatively low scores given for student assessment skills (3.5) and classroom management (both items rated at 3.7) also echo what Hales and Kalyvaki (2017) found when analyzing limitations immersive tools face in modeling complex social interaction and psychological processing. The large discrepancy in experienced between urban schools (where 83% of participants have used VR equipment) and those located off metropolitan centers (35%) also illustrates how current advanced teaching and learning technologies are being unevenly distributed across schools globally, aligning with Alnagrat et al. (2022)'s concerns regarding bridging this digital divide.

The patterns of higher evaluation of the effectiveness of AR applications among philology students (mean score 4.7) and virtual laboratories among science students (mean score 4.8) revealed in the study confirm the hypothesis that a differentiated approach to the implementation of immersive technologies is needed depending on the subject area. These results complement the findings of Shkliar (2023), who emphasizes the particular effectiveness of immersive technologies in STEM education, but our study proves that, with proper adaptation, immersive technologies are highly effective in the humanities as well. The correlation between the level of students' digital competence and their assessment of the effectiveness of immersive technologies reflects the key role of technological readiness in the perception of innovation, which is consistent with the model of technology acceptance proposed by Suh and Prophet (2018). However, contrary to the predictions of these researchers, our data show a generally higher level of readiness of Ukrainian students to integrate immersive technologies into their own pedagogical

practice (81.6% of respondents expressed a positive attitude), which may be explained by the cultural characteristics and specifics of the Ukrainian educational system, which is actively transforming under the influence of military challenges.

The barriers to the introduction of immersive technologies identified in our study (insufficient technical support, lack of teaching materials in Ukrainian, lack of systematic teacher training, limited funding) largely coincide with the obstacles identified by Grybiuk (2021), who studied the specifics of introducing immersive technologies in children's education in Ukraine. However, our research has identified an additional factor - the specifics of the education system in wartime, which creates a unique context for innovation. This factor is not reflected in international studies and is of particular interest for understanding the adaptability of educational systems in crisis conditions. The most effective models of integrating immersive technologies into the educational process identified in the study (modeling real professional situations, combined use of different types of immersive technologies, involving students in the development of immersive educational products) correlate with the principles of constructivist pedagogy and the learning by doing approach, which corresponds to current trends in teacher education identified by Shyshkina and Nosenko (2023), who emphasize the need to integrate artificial intelligence technologies and immersive environments to form

We have a number of limitations within our study including an overall sample size that is quite small (60 students) and therefore potentially impacts on the representative nature of the findings; in addition we have focused on assessing the subjective effectiveness of immersive technology in terms of the assessment of the use of immersive technology by the students and we did not investigate other objective measures of student learning outcomes. In addition to this, we acknowledge that there is variation in the experience of using immersive technologies amongst the respondents, and this may impact the validity of their assessments. Finally, it should be also noted that at the time of conducting this study Ukraine was under the Conditions of Martial Law, which might influence both the response rate and the general

psychological state of our participants. Despite the mentioned limitations we feel that the findings of this research offer some preliminary insight into the possible use of immersion technologies in the area of teachers training and might serve as the basis for the development of practical guidelines on their application.

In a practical perspective the implications of this study concern the need to establish a coherent national policy for the implementation of immersive technologies in teacher education, considering the barriers identified in this study and the needs of every subject field; in particular, there should be a focus on the revision and development of methodological resources in Ukrainian language and the training of teachers to the application of immersive technologies. In a theoretical perspective implications are related to the understanding of how immersive technologies impact on the developmental paths of future teachers' professional competencies and the identification of the relationship between different factors affecting the successful introduction of immersive technologies into the educational processes. Future research should explore the finding of objective criteria for the measure of the effectiveness of immersive technologies; the analysis of the long-term impact of immersive technologies on teachers' professional development; and the analysis of the performance of the synergy created through the combination of different kinds of immersive technologies in education.

Conclusions

Thus, the study conducted convincingly proved that immersive technologies are an effective instrument for changing the teacher professional training of prospective teachers that considerably promotes the efficiency of digital, methodological, and inclusive competencies formation. The differential effect of immersive technology types depending on subject specificity is proved; it shows AR applications to be particularly effective in language and literature education and VR – in natural sciences, which emphasizes the need for differentiated approach in creating specific methodological guidelines for their application. It was also established there is

a significant disparity in immersive technologies' availability between urban and regional institutions which suggests a need for the governmental policy aimed at technological equality. Identified barriers in applying immersive technologies in the research (lack of adequate technical facilities, lack of native language teaching materials, lack of a systematic process of teacher training) present a well-defined action plan for educational institutions and authorities to be applied.

The greatest practical interest is of the readiness of future teachers for application in their future pedagogical activity of immersive technologies (over 80% of respondents) because that means a suitable area for the spread of innovation in Ukrainian education, even in the conditions of the military conflict. Empirically established validity of 3 models of implementation of immersion technologies in pedagogical process (modeling real professional activity of teacher, integrative use of immersion technologies of various types, participation of students in the creation of immersive educational product) allow for forming a practical application for these technologies in the teacher education system. Although the limitations of the research lie in the relatively small quantity of respondents and reliance on subjective judgments, the research results provide a holistic perspective on the future of the immmersion of teacher education in Ukraine.

In future research should be carried out in areas like devising objective methods for assessing the impact of immersive technologies through indicators of readiness for professional activity; designing flexible immersive environments taking into account individual educational path of future teachers and long term research on the use of immersive technologies in teacher professional development; investigate the possibility of using immersive technologies for psychological support of future teachers and development their stress resistance in war circumstances and finally immersive technologies paves the way to completely new conception of teacher education, where virtual and real are mutually completed providing strong synergetic effect making learning efficient and responsive to the modern requirements.

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APPENDIX A

Research questionnaire "Immersive technologies in the training of pedagogical education specialists"

I. General information about the respondent

1. Specialization: _____
2. Course of study: □ 3rd year □ 4th year □ Master's degree
3. Self-assessment of digital competence: □ Beginner □ Intermediate □ Adequate □ High

II. Experience in using immersive technologies

5. Have you had any experience of using the following technologies in the educational process? (Check all that apply) □ Virtual Reality (VR) □ Augmented Reality (AR) □ Mixed Reality (MR) □ 360˚ video □ Interactive 3D models □ Other (specify) _____ □ No/low experience of using immersive technologies
6. If you have had experience using immersive technologies, please rate it on a 5-point scale: □ 1 (very negative) □ 2 □ 3 □ 4 □ 5 (very positive)

III. Evaluation of the effectiveness of immersive technologies

7. Assess the effectiveness of immersive technologies for the formation of the following aspects of professional training on a 5-point scale (where 1 is "not at all effective" and 5 is "extremely effective"):
   • Methodological training: □ 1 □ 2 □ 3 □ 4 □ 5
   • Formation of digital competence: □ 1 □ 2 □ 3 □ 4 □ 5
   • Development of communication skills: □ 1 □ 2 □ 3 □ 4 □ 5
   • Mastery of modern educational technologies: □ 1 □ 2 □ 3 □ 4 □ 5
   • Preparation for distance learning: □ 1 □ 2 □ 3 □ 4 □ 5
   • Developing skills in developing educational materials: □ 1 □ 2 □ 3 □ 4 □ 5
   • Gaining experience in classroom management: □ 1 □ 2 □ 3 □ 4 □ 5
   • Development of student assessment skills: □ 1 □ 2 □ 3 □ 4 □ 5
   • Adaptation to inclusive education: □ 1 □ 2 □ 3 □ 4 □ 5
   • Overcoming pedagogical stress: □ 1 □ 2 □ 3 □ 4 □ 5

8. What specific immersive technologies do you consider to be the most effective for teacher training in your specialty? Why?

IV. Prospects for the use of immersive technologies

9. What areas of immersive technologies application in teacher training do you consider the most promising? (Please select up to 3 options) □ Creation of virtual language environments for practicing communication skills □ Simulation of pedagogical situations for practicing methodological skills □ Development of interactive teaching materials using AR technologies □ Virtual excursions to cultural and historical sites □ Simulation of lessons with virtual students □ Formation of inclusive skills through simulation of special educational needs

10. In your opinion, what barriers prevent the widespread introduction of immersive technologies in teacher education? (Check all that apply) □ Insufficient technical support □ Lack of teaching materials in Ukrainian □ Lack of systematic teacher training □ Limited funding □ Conservative educational system □ Lack of motivation among teachers □ Other (specify) _____

11. Would you like to use immersive technologies in your future pedagogical activities? □ Yes, definitely □ Rather yes □ Undecided □ Rather no □ Absolutely not

APPENDIX B

Primary research data (n=60)

Table 1B. *Data on respondents and their experience of using immersive technologies*

№	Course	Digital competence	Experience in using technology	Evaluation of experience
1	3	3	1,2,4	4
2	3	2	2,4	3
3	4	3	1,2,4,5	5
4	4	4	1,2,4,5	5
5	M	3	1,2,4	4
6	M	4	1,2,3,4,5	5
7	3	2	2,4	3
8	4	3	1,2,4	4
9	M	3	1,2,4,5	4
10	3	2	2,4	3
11	3	3	1,2,5	4
12	4	4	1,2,3,5	5
13	M	3	1,2,5	4
14	4	3	1,2,5	4
15	3	2	2,5	3
16	M	4	1,2,3,5	5
17	3	2	2,5	3
18	4	3	1,2,5	4
19	M	3	1,2,5	4
20	4	1	2	2
21	3	3	2,4	4
22	3	2	2,4	3
23	4	3	2,4,5	4
24	4	3	2,4,5	4
25	M	3	2,4	4
26	M	4	1,2,4,5	5
27	3	2	2,4	3
28	4	3	2,4	4
29	M	3	2,4,5	4
30	3	1	4	2
31	3	3	2,5	4
32	4	3	2,5	4
33	M	3	2,5	4
34	4	3	2,5	4
35	3	2	2,5	3

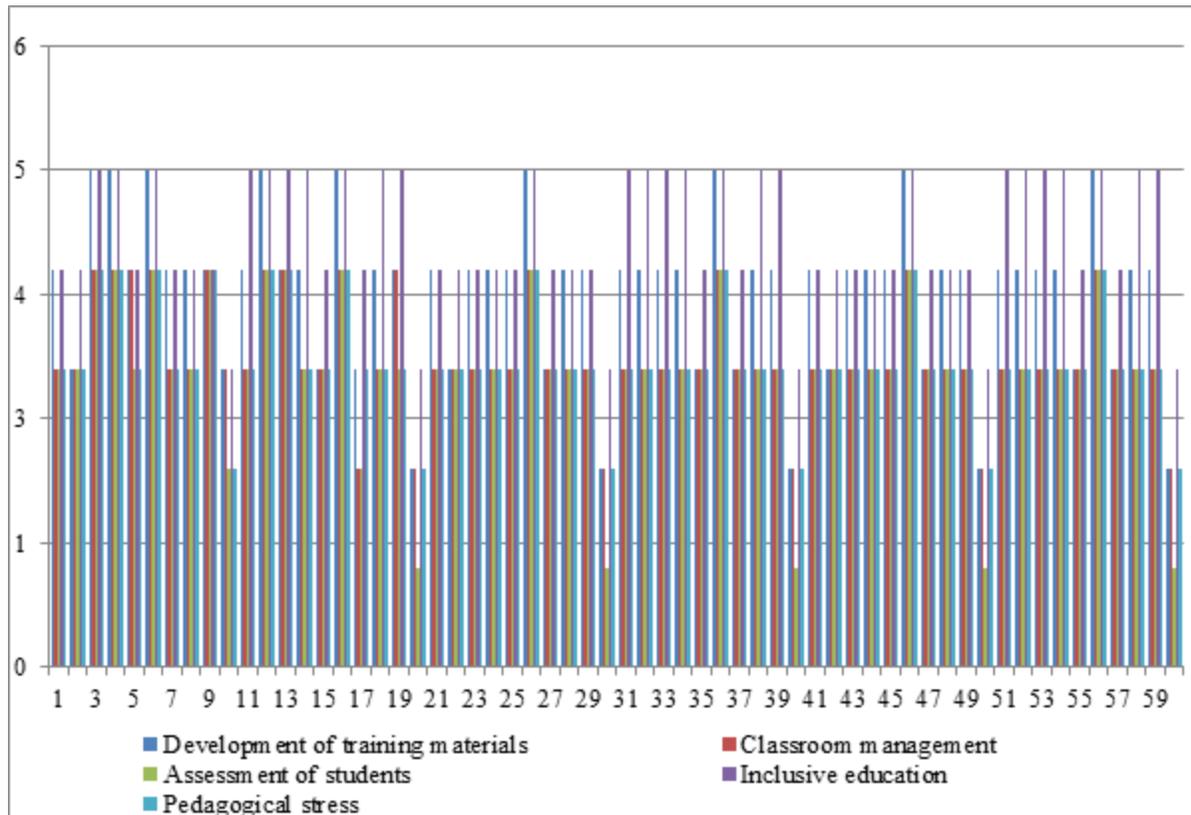| №	Course	Digital competence	Experience in using technology	Evaluation of experience
36	M	4	1,2,5	5
37	3	2	2,5	3
38	4	3	2,5	4
39	M	3	2,5	4
40	3	1	5	2
41	3	3	2,4	4
42	3	2	2,4	3
43	4	3	2,4	4
44	4	3	2,4	4
45	M	3	2,4	4
46	M	4	1,2,4	5
47	3	2	2,4	3
48	4	3	2,4	4
49	M	3	2,4	4
50	3	1	4	2
51	3	3	2,5	4
52	4	3	2,5	4
53	M	3	2,5	4
54	4	3	2,5	4
55	3	2	2,5	3
56	M	4	1,2,5	5
57	3	2	2,5	3
58	4	3	2,5	4
59	M	3	2,5	4
60	3	1	5	2

Fig. 1B. Assessment of the effectiveness of immersive technologies (on a 5-point scale)
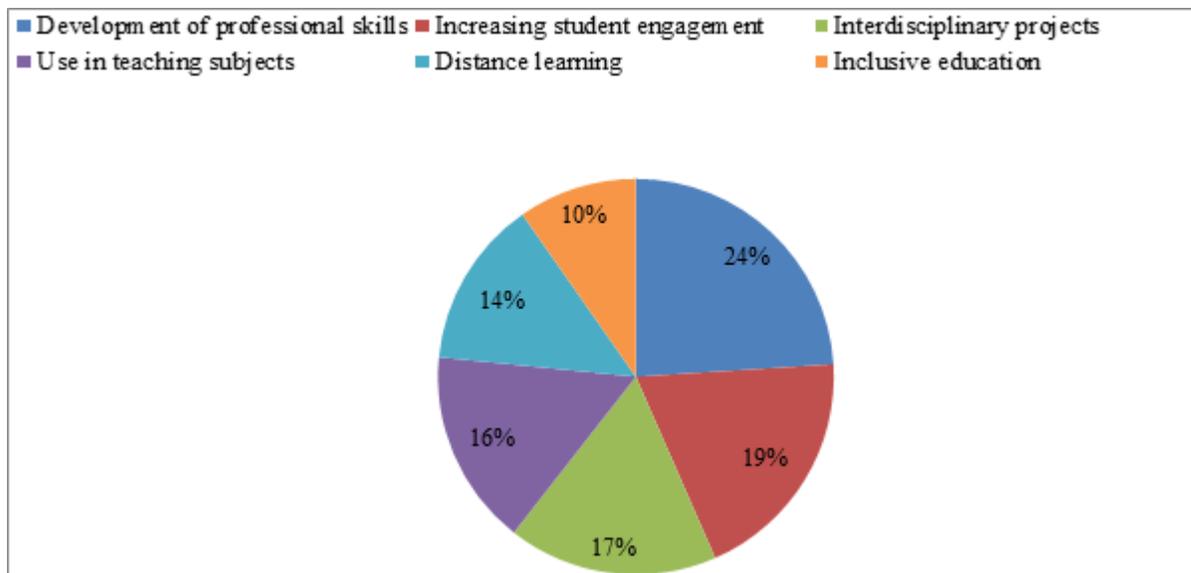
Evaluating the effectiveness of immersive technologies

Fig. 2B. Promising areas of immersive technologies implementation (%)
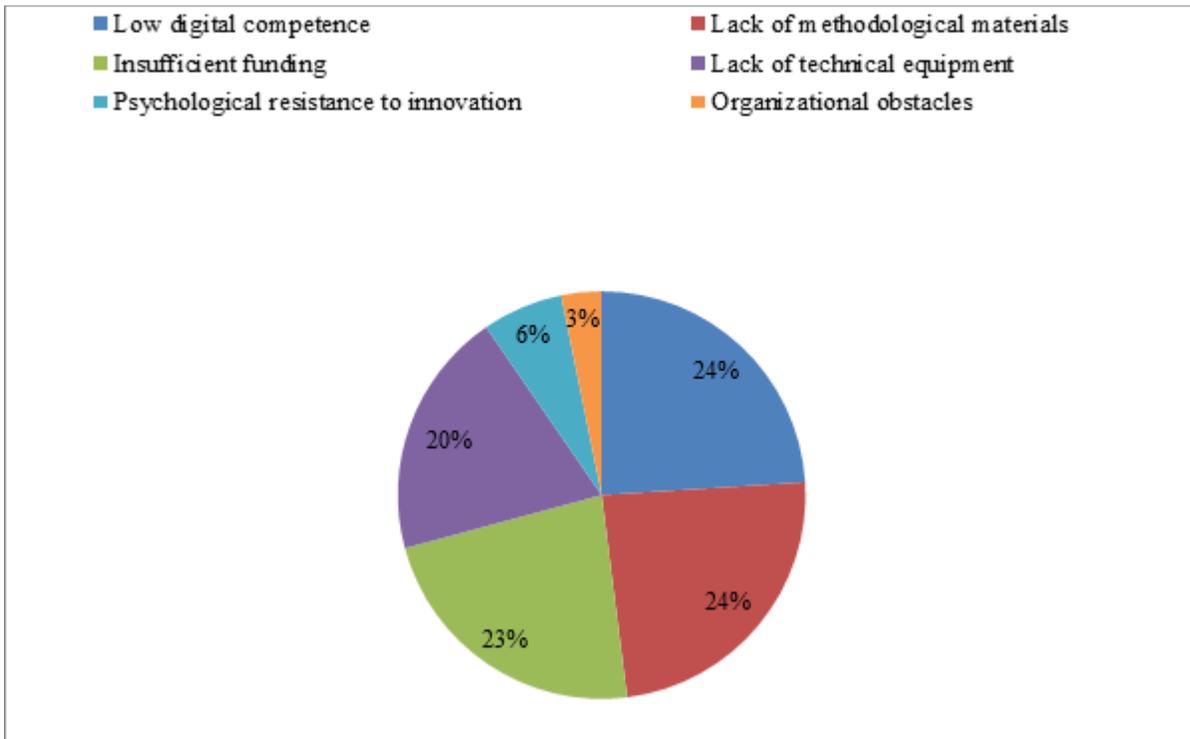
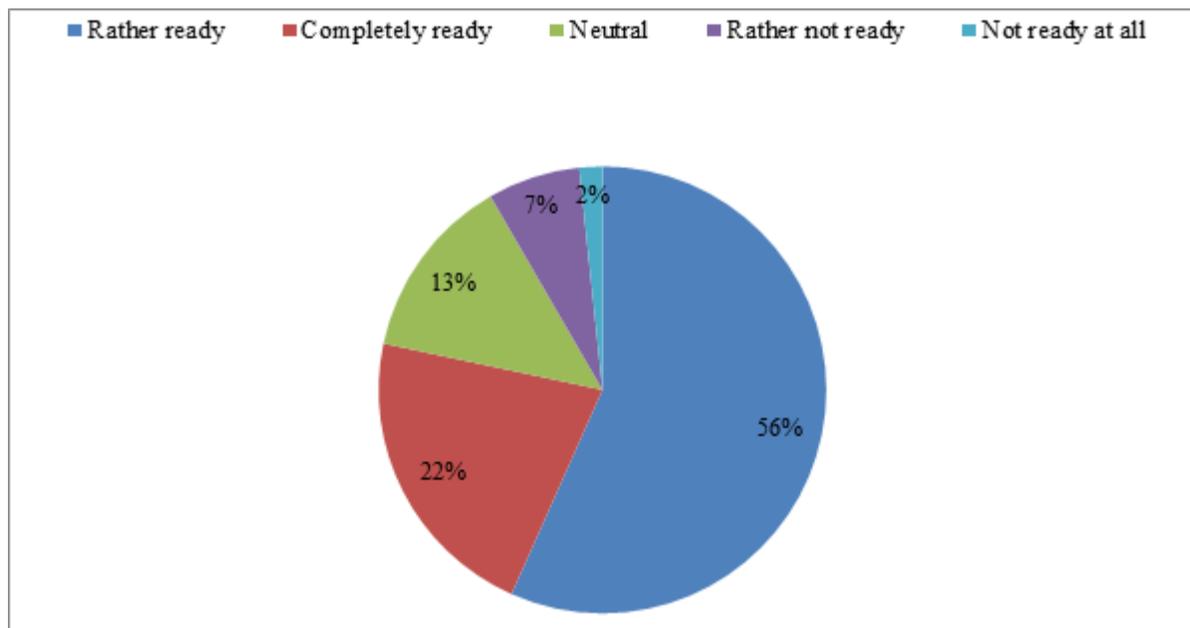**Fig. 3B: Barriers to the adoption of immersive technologies (%)**

Fig. 4B: Level of readiness to use immersive technologies (%)