

UDK: 378.147:004

ORCID: <https://orcid.org/0009-0003-1222-0529>

USING VIRTUAL AND AUGMENTED REALITY (VR/AR) TECHNOLOGIES IN THE PREPARATION OF FUTURE PRIMARY SCHOOL TEACHERS

Berdiyev Muxiddin Maxmudovich

Termez State Pedagogical Institute,

Educational and methodological department employee

Email: muxiddinberdiyev1@gmail.com

Tel: +998 93 799 03 05

Abstract: *This article provides a scientific-theoretical substantiation of the use of virtual and augmented reality (VR/AR) technologies in the professional preparation of future primary school teachers. The relevance of the study stems from the persistent gap between the theoretical training of primary-school teacher candidates and their practical readiness for real classroom activity, and from the capacity of immersive technologies to reconstruct authentic pedagogical situations in a safe, repeatable, and controllable form. The aim of the research is to substantiate a structural-functional model for the pedagogically grounded application of VR/AR in primary teacher preparation, to define the stages through which the corresponding professional competence is formed, and to identify the pedagogical conditions ensuring its effective functioning. The study employed the methods of theoretical analysis and systematisation of scientific literature, structural-functional modelling, comparative-pedagogical analysis of immersive learning tools, and pedagogical observation. The analysis established that the model comprises five interrelated components — target, content, technological-immersive, simulation-practice, and diagnostic-reflective — and that the competence in question is formed through three successive stages: orientation-adaptation, simulation-practice, and reflective-professional. It is shown that VR/AR tools such as immersive virtual classrooms, avatar-based teaching simulators, and augmented visualisation of educational content function not as illustrative supplements but as a didactic environment that transforms the very mechanism of professional-skill formation. The conclusion substantiates the necessity of purposefully training teacher educators in immersive-pedagogical design, of developing nationally adapted VR/AR content aligned with*

the primary-school curriculum, and of integrating immersive simulation with the teaching-practice component of teacher-training programmes. Practical recommendations are proposed for the gradual introduction of the model into the educational process of higher pedagogical institutions.

Keywords: *virtual reality, augmented reality, immersive learning, future primary school teacher, professional preparation, pedagogical simulation, microteaching, digital competence, mixed reality, professional readiness.*

INTRODUCTION

The professional preparation of primary school teachers occupies a special place in any national education system, since the quality of the very first years of schooling largely determines a child's subsequent educational trajectory. Yet teacher-training programmes have long faced a structural difficulty: the theoretical and methodological knowledge acquired in lecture halls is frequently disconnected from the complex, dynamic, and often unpredictable reality of the primary classroom, where the young teacher must simultaneously manage attention, motivation, discipline, and the individual needs of six- to ten-year-old learners. Virtual and augmented reality (hereinafter — VR/AR) technologies open a fundamentally new possibility for bridging this gap: they allow authentic pedagogical situations to be reconstructed in an immersive, safe, repeatable, and controllable form, so that a teacher candidate can practise professional actions before entering a real classroom and without any risk to real children.

The strategic documents of the Republic of Uzbekistan aimed at the modernisation of education — in particular, the Decree of the President No. PF-60 of 11 May 2022 “On the Development Strategy of New Uzbekistan for 2022–2026” and the Concept for the Development of School Education until 2030 — set the tasks of digitalising the educational space and of renewing the professional competences of the pedagogical workforce [1; 2]. Within this policy framework, the introduction of immersive technologies into the system of teacher preparation acquires not only scientific but also practical and normative significance, since the future teacher is expected to master, and subsequently to employ, contemporary digital and immersive means of instruction.

Despite a rapidly growing international literature on immersive learning, the question of how exactly VR/AR should be embedded in the preparation of primary-school teachers — as an integral pedagogical system rather than as a set of isolated technical demonstrations — remains insufficiently elaborated. A considerable part of the existing research examines the technical characteristics of immersive devices in isolation from the pedagogical conditions of their use, or studies their application in

secondary and higher subject teaching without regard to the specific features of primary education and of primary-teacher competence. The aim of the present article is therefore to substantiate a structural-functional model for the pedagogically grounded use of VR/AR in the preparation of future primary school teachers, to describe the stages through which the corresponding professional competence is formed, and to identify the problems arising in practice together with scientifically grounded solutions.

LITERATURE REVIEW AND METHODS

The theoretical foundation of the study draws on several complementary strands of pedagogical and psychological thought. D. Kolb's theory of experiential learning proceeds from the premise that professional knowledge is formed through a cycle of concrete experience, reflective observation, abstract conceptualisation, and active experimentation [4]. Immersive technologies are of particular value from this standpoint, since they furnish precisely the concrete, first-person experience that is otherwise difficult to organise within the walls of a teacher-training institution; VR/AR thus supplies the initial, experiential link of the learning cycle upon which subsequent reflection and conceptualisation depend.

The reality–virtuality continuum proposed by P. Milgram and F. Kishino provides the conceptual basis for distinguishing the didactic possibilities of different immersive formats, from augmented reality, which overlays digital objects onto the real environment, to fully immersive virtual reality, which replaces it [5]. This distinction is essential for the pedagogically appropriate selection of technology: augmented reality is well suited to enriching the visualisation of educational content for young learners, whereas fully immersive virtual reality is better suited to the reconstruction of holistic classroom situations for teacher practice. C. Dede's studies of immersive interfaces further establish that the sense of presence generated by such environments enhances engagement and supports the transfer of learned actions to real contexts, which is why immersion is treated in this study as a didactic resource rather than a merely technical property [7].

At the same time, J. Sweller's cognitive load theory imposes an essential caution: the rich sensory stimulation of immersive environments may increase extraneous cognitive load and thereby hinder rather than assist learning if the environment is not pedagogically structured [8]. This position underlies the understanding, adopted in the present study, that the educational effect of VR/AR depends not on the technology as such but on the pedagogical design that regulates the learner's attention and manages the balance between the immersive experience and the professional task to be mastered.

A. Bandura's social-cognitive theory of learning, with its emphasis on observational learning and the modelling of behaviour, provides the psychological basis for one of the most valuable pedagogical uses of immersive technology in teacher training — the opportunity to observe, imitate, and repeatedly rehearse professional actions within a realistic yet risk-free context. In an avatar-based virtual classroom the teacher candidate is able to model pedagogical behaviour, to receive immediate feedback, and to repeat the attempt as many times as necessary, thereby realising the principle of deliberate practice that is difficult to implement in a real classroom of live children.

The TPACK model of P. Mishra and M. Koehler, describing the intersection of technological, pedagogical, and content knowledge, is used as a methodological reference point for defining the competences that the teacher educator must possess in order to employ immersive technologies pedagogically rather than merely to demonstrate them, and that the future primary teacher must in turn acquire in order to integrate such technologies meaningfully into instruction [6].

Toshpulatov's earlier works on personalised education, on the comparative analysis of individualised and differentiated learning, and on the prospects of applying digital tools in school education emphasise that technology functions as a catalyst for, rather than a substitute for, pedagogical guidance, and that its introduction must be subordinated to educational goals and value orientations [3; 9; 10]. This position is extended in the present study to the specific question of how immersive technologies should be embedded in the preparation of primary-school teachers so as to strengthen, rather than displace, the pedagogical core of professional training.

The following research methods were employed: theoretical analysis and systematisation of scientific literature; structural-functional modelling, used to substantiate the component composition of the proposed model; comparative-pedagogical analysis of immersive learning tools and their didactic functions; and pedagogical observation, used to identify the typical difficulties encountered by teacher candidates and teacher educators in the use of VR/AR.

RESULTS AND DISCUSSION

1. The pedagogical essence of using VR/AR in the preparation of primary school teachers. The pedagogically grounded use of immersive technologies in primary-teacher preparation is understood in this study as the integration of virtual and augmented reality into the professional-training process in such a way that the teacher candidate acquires and rehearses professional competences within reconstructed, controllable models of real pedagogical situations. Unlike the traditional verbal-illustrative transmission of methodological knowledge, this approach places the

candidate in the position of an acting subject who makes pedagogical decisions, observes their consequences in the simulated environment, and corrects the mode of action on the basis of feedback, while the teacher educator performs the functions of designer of the immersive situation, moderator of the practice, and diagnostician of its results.

2. Structural components of the model. The analysis allows the model of pedagogically grounded VR/AR use in primary-teacher preparation to be represented as a unity of five interrelated components.

The target component defines the expected result — a future primary school teacher who is professionally and psychologically ready to act competently in the classroom and who is capable of the pedagogically appropriate use of immersive technologies in his or her own future practice.

The content component comprises the professional knowledge and procedures that must be mastered by means of immersive technologies: methods of organising and managing a primary classroom, techniques of maintaining attention and motivation among young learners, procedures for the visual presentation of educational material, and criteria for the pedagogical evaluation of immersive resources.

The technological-immersive component includes the digital means through which the competence is formed — immersive virtual classrooms, avatar-based teaching simulators, augmented-reality applications for the visualisation of educational content, and the corresponding devices and software — which function not as illustrative supplements but as the very environment of professional practice.

The simulation-practice component constitutes the didactic core specific to teacher training: it provides for the repeated rehearsal of professional actions — the conduct of a lesson fragment, the resolution of a disciplinary situation, the individual support of a struggling pupil — within virtual or augmented environments, thereby realising the principle of deliberate practice in a risk-free form.

The diagnostic-reflective component provides for the collection of data on the candidate's actions in the immersive environment — including recorded lesson fragments and behavioural indicators — and for their subsequent joint analysis and reflection, on the basis of which the professional action is corrected and the competence itself, rather than the technical mastery of the device, is assessed.

3. Stages of competence formation. The formation of the competence in the pedagogically grounded use of VR/AR proceeds through three successive stages.

At the orientation-adaptation stage, the candidate, with the support of the teacher educator, becomes acquainted with the immersive devices and environments, masters

the elementary operations of interaction with them, adapts to the specific perceptual conditions of immersion, and forms an initial understanding of the pedagogical, rather than merely technical, possibilities of the technology.

At the simulation-practice stage, the candidate independently conducts lesson fragments and resolves modelled pedagogical situations within the virtual classroom, uses augmented-reality tools for the presentation of educational content, and repeats professional actions under gradually decreasing guidance from the teacher educator, thereby accumulating first-person pedagogical experience.

At the reflective-professional stage, the candidate analyses the recorded materials and feedback accumulated in the immersive environment, evaluates the effectiveness of the professional actions performed, and, together with the teacher educator, transfers the rehearsed competences into the conditions of real teaching practice, thereby closing the experiential cycle described by Kolb.

4. Pedagogical conditions for the effective functioning of the model. The effectiveness of the described model depends on several conditions: the readiness of teacher educators to act as designers of immersive-pedagogical situations rather than as demonstrators of technology, in accordance with the logic of the TPACK model; the availability of VR/AR content adapted to the national primary-school curriculum and to the age characteristics of young learners; the provision of the requisite technical infrastructure together with observance of the health and safety norms of immersive-technology use; and the organic integration of immersive simulation with the teaching-practice component of the teacher-training programme, so that the experience gained in the virtual environment is systematically transferred to the real classroom.

5. Problems and solutions. The first problem consists in the scarcity of VR/AR educational content adapted to the primary-school curriculum and to the national educational context; the corresponding solution lies in the purposeful development of such content through the cooperation of pedagogues, methodologists, and developers. The second problem is the high cost of immersive equipment, which limits its large-scale introduction; the solution consists in a phased approach — the establishment of shared immersive-learning laboratories and the wider use of comparatively inexpensive mobile augmented-reality applications that operate on ordinary devices. The third problem is the insufficient preparedness of teacher educators for the pedagogical, rather than technical, use of immersive tools; the solution lies in introducing specialised courses on immersive-pedagogical design into higher pedagogical education and in-service teacher training. The fourth problem is the risk of the health-related and cognitive side-effects of prolonged immersion, together with

the danger of technology being used for its own sake; the solution consists in the elaboration of pedagogically and medically grounded guidelines that regulate the duration and structure of immersive sessions and subordinate the use of the technology to clearly defined educational goals.

CONCLUSION

The results of the study show that the effective use of virtual and augmented reality technologies in the preparation of future primary school teachers requires a purposefully constructed pedagogical model rather than the incidental application of individual immersive devices. Such a model unites target, content, technological-immersive, simulation-practice, and diagnostic-reflective components, and the corresponding professional competence is formed gradually, through the orientation-adaptation, simulation-practice, and reflective-professional stages.

The analysis confirms that immersive technologies acquire their full pedagogical value only when they are embedded within a system that assigns the teacher educator the role of a designer of immersive-pedagogical situations and the future teacher the role of an active subject who rehearses professional actions in a safe, repeatable environment and subsequently transfers them to real classroom practice. VR/AR thereby transforms not the external form but the very mechanism of professional-skill formation, converting methodological knowledge into rehearsed and reflectively mastered professional experience.

The development of nationally adapted VR/AR content aligned with the primary-school curriculum, the training of teacher educators in immersive-pedagogical design, and the organic integration of immersive simulation with the teaching-practice component of teacher-training programmes are proposed as the principal directions for translating the described model into practice. The consistent implementation of these measures would allow the preparation of primary-school teachers in the Republic of Uzbekistan to move from the predominantly theoretical transmission of methodological knowledge towards a scientifically grounded practice of immersive professional training, thereby bringing the national system of teacher education closer to contemporary international standards.

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