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RESEARCH ARTICLE

Didactic Model for Developing Pre-Service Teachers' Methodological Competence Through Virtual Reality

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Abstract

The article theoretically and methodologically substantiates a didactic model for developing pre-service teachers' methodological competence through virtual reality technologies. The relevance of the study is determined by the need to reduce the gap between theory and practice in teacher education, to prepare future teachers for dynamic pedagogical situations, and to strengthen methodological decision-making, lesson design and reflective analysis. The proposed model interprets the VR environment not as a visual supplement, but as a central didactic environment that integrates virtual pedagogical situations, student-avatar reactions, methodological tasks, diagnostic assessment and reflective correction. The study is based on theoretical analysis, comparative generalization, pedagogical modelling and structural-functional design. As a result, a seven-block didactic model and a cycle of methodological activity in a virtual pedagogical situation are proposed. The model can serve as a methodological basis for designing VR-based learning modules, diagnostic tools and experimental work in pedagogical higher education.

KEYWORDS

Virtual reality, methodological competence, pre-service teacher, didactic model, virtual pedagogical situation, reflective analysis, diagnostic assessment, teacher education.

INTRODUCTION

In the global system of higher education, digital transformation requires a fundamental reconsideration of the content and technologies used for preparing pedagogical personnel. In particular, the methodological training of a pre-service teacher should not be limited to mastering theoretical knowledge. It must also include the ability to analyze real pedagogical situations, design lessons methodologically, select appropriate teaching methods and tools, respond to learners' behavior in a pedagogically justified manner, and evaluate one's own professional actions reflectively.

In traditional teacher education, lectures, seminars, practical classes, teaching practice and case-based assignments play an important role. However, these forms do not always prepare future teachers for complex, dynamic and not fully predictable classroom situations. In an actual lesson, learners' motivation, discipline, readiness level, communicative behavior and learning difficulties require the teacher to make rapid and well-grounded methodological decisions. Therefore, one of the urgent tasks of pedagogical higher education is to organize methodological training on the basis of practice-oriented, situational and reflective learning.

Virtual reality (VR) technologies have significant didactic potential for addressing this problem. VR places the learner or the future teacher into a computer-generated immersive and interactive environment. In such an environment, it is possible to model realistic classroom conditions, practice without fear

of making mistakes, analyze repeated situations and observe the consequences of methodological decisions. In comparison with traditional cases or written assignments, VR can provide a stronger sense of presence, activity and experiential engagement [3; 5; 6].

In the Republic of Uzbekistan, modernization of higher education, development of a digital learning environment and implementation of innovative pedagogical technologies are important priorities of state policy. The Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030 and the Digital Uzbekistan - 2030 Strategy emphasize the need to introduce modern information and communication technologies into education, improve training quality and develop digital competencies [1; 2]. These priorities provide a normative and practical basis for studying the development of pre-service teachers' methodological competence through VR technologies.

The purpose of this article is to substantiate a didactic model that supports the development of pre-service teachers' methodological competence through virtual reality technologies and to define its structural blocks, process cycle and diagnostic possibilities.

METHODS

The article has the character of a theoretical and modelling study; no artificial experimental results were inserted. Four main methods were used in the research process. First, scientific literature on pedagogical higher education, VR technologies, immersive learning, teacher education and methodological competence was analyzed. Second, comparative analysis was used to identify the advantages and limitations of VR in teacher training. Third, pedagogical modelling was applied to design the structural blocks of the didactic model. Fourth, a structural-functional approach was used to determine the interrelations among the goal, content, technological, process, diagnostic and outcome components of the model.

In selecting literature, priority was given to sources published mainly between 2018 and 2025. Jensen and Konradsen reviewed the use of VR head-mounted displays in education and training and showed that VR may be effective for developing specific skills, although it also has technical and methodological limitations [3]. Billingsley et al. analyzed the use of immersive VR in teacher education and emphasized its potential for creating practice opportunities for pre-service and in-service teachers [4]. Radianti et al. conducted a systematic review of immersive VR applications in higher education and pointed out that the effectiveness of VR depends not only on technology but also on instructional design, feedback and assessment [5].

The Cognitive Affective Model of Immersive Learning (CAMIL), proposed by Makransky and Petersen, was also used as an important theoretical basis. According to this model, presence and agency in immersive learning influence learning outcomes through factors such as motivation, self-efficacy, embodiment, cognitive load and self-regulation [6]. This means that VR-based teacher training should be designed not only as a visual simulation, but as a pedagogically structured activity that supports action, feedback and reflection.

The model was developed on the basis of the following principles: competence orientation, activity orientation, situationality, reflectivity, diagnosticity, technological purposefulness, and the possibility of safe repeated practice. These principles transform the VR environment from a simple visual tool into a methodological competence development environment.

RESULTS

As a result of the study, a didactic model for developing pre-service teachers' methodological competence through VR technologies was designed. The model consists of seven blocks: the target block, theoretical-methodological block, content block, technological block, process block, diagnostic-reflective block and result block. The interrelation of these blocks allows the VR environment to function as a unified methodological system rather than a separate technical module.

The target block is aimed at developing a future teacher's ability to analyze a real pedagogical situation, design a lesson methodologically, select appropriate methods and tools, respond pedagogically to learners' behavior, perform reflective analysis and use digital tools for methodological purposes. The theoretical-methodological block is based on competence-based, activity-oriented, constructivist, reflective and experiential learning approaches.

The content block includes a bank of virtual pedagogical situations, methodological assignments, micro-lesson design tasks, interaction with avatars, the use of digital tools and reflective questions. The technological block consists of a VR classroom, virtual student avatars, classroom climate

indicators, a decision-making panel and diagnostic feedback. The process block covers observation, diagnosis, methodological decision-making, avatar response, corrective action and reflection. The diagnostic-reflective block provides criteria, indicators, rubrics, self-assessment and researcher monitoring. The result block evaluates the development of competence at reproductive, constructive and creative levels.

The conceptual structure of the model is presented in Figure 1. It shows the VR environment as the central didactic space linking the aim, content, process, diagnostics and results.

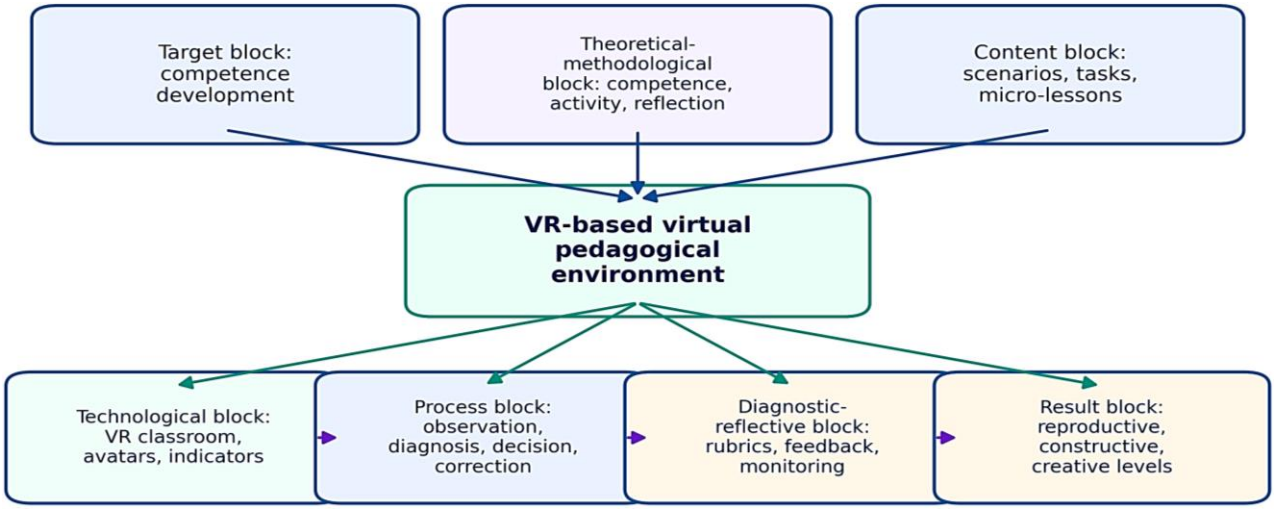

Figure 1. Didactic model for developing methodological competence through VR

The functional description of the model blocks is presented in Table 1.

Table 1. Blocks of the VR-based didactic model and their methodological functions

Model block	Core content	Expression in the VR environment	Expected methodological outcome
Target	Development of methodological competence	Scenario objective and situational requirement	Goal-oriented methodological activity
Content	Virtual pedagogical situations and assignments	Avatars, classroom state, problem cards	Analysis of pedagogical situations
Technological	VR classroom and interactive tools	3D classroom, avatars, climate indicators	Practice in an immersive environment
Process	Observation, diagnosis, decision, correction	Staged VR activity cycle	Experience in methodological decision-making
Diagnostic-reflective	Criteria, indicators and feedback	Rubrics, reflection panel, event log	Assessment and correction of methodological actions
Result	Development level of competence	Reproductive, constructive and creative levels	Individual growth trajectory

The content of methodological competence components is systematized in Figure 2 and Table 2. These components reflect not only the knowledge dimension of teacher preparation, but also motivational, activity-based, communicative, reflective and digital-technological dimensions.

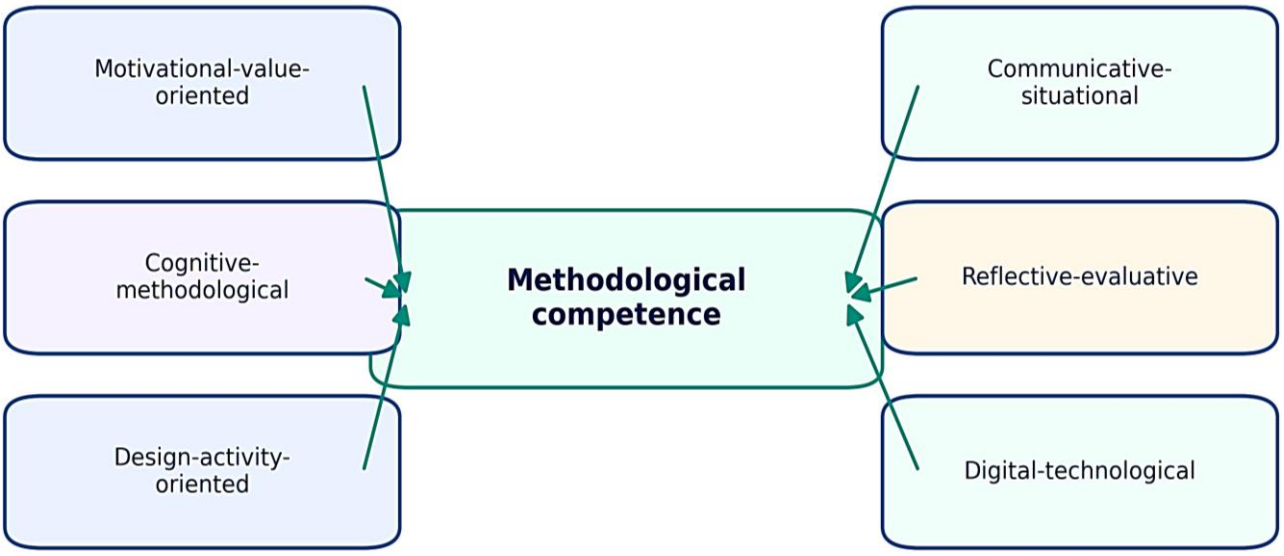

Figure 2. Components of methodological competence

Table 2. Components of methodological competence and VR-based indicators

Component	Content description	VR-based indicator
Motivational-value-oriented	Professional interest, pedagogical responsibility and aspiration for methodological growth	Active participation in VR situations and motivation to complete the task
Cognitive-methodological	Knowledge of didactic concepts, methods and lesson logic	Correct diagnosis of the problem and methodological justification
Design-activity-oriented	Defining the lesson objective, selecting methods and designing lesson fragments	Appropriate design of a micro-lesson and learning activity
Communicative-situational	Responding to learners' behavior and organizing pedagogical interaction	Selection of a situationally appropriate communicative strategy
Reflective-evaluative	Analysis of one's own action, error identification and correction	Reflective comments after avatar reactions and self-assessment
Digital-technological	Purposeful use of VR and digital tools in the lesson	Selection of digital tools according to the pedagogical objective

The process cycle of the model is presented in Figure 3. This cycle implies that in a VR environment, the pre-service teacher does not merely know or observe; rather, he or she sees the situation, selects a decision, acts, analyzes consequences and introduces correction.

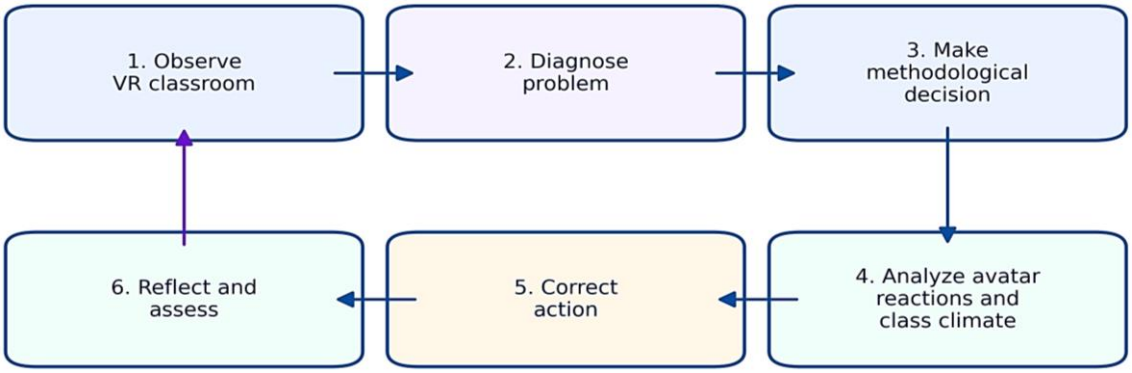

Figure 3. Cycle of methodological activity in a virtual pedagogical situation

Table 3. Virtual pedagogical situations and methodological competence indicators

Type of virtual situation	Didactic task	Component developed	Assessment criterion
Low learner activity	Selecting an interactive method and activating learners	Motivational and communicative	Growth of participation and quality of interaction
Learner needing support	Differentiated task and individual help	Design-activity-oriented and cognitive	Task appropriateness and understanding level
Discipline problem	Choosing a pedagogically balanced response	Communicative-situational	Improvement of classroom climate
Different readiness levels	Adapting tasks to readiness levels	Design-activity-oriented	Differentiation and methodological flexibility
Inappropriate use of a digital tool	Connecting the tool to the pedagogical objective	Digital-technological	Purposefulness of digital tool use

DISCUSSION

The scientific and methodological significance of the proposed model lies in the fact that it interprets VR technology not as a simple technical novelty in education but as a didactic system for organizing the development of methodological competence. In this system, the VR environment does not keep the student in the position of a passive observer; instead, it requires situation analysis, decision-making, interaction with avatars, evaluation of consequences and reflective correction.

Recent studies on pre-service teacher education indicate that VR can create safe and diverse virtual environments for practicing professional competencies, monitoring student development and modelling situations that are difficult to access in ordinary teaching practice [4; 8; 9; 10]. These possibilities are especially important for teacher education, because future teachers often need repeated practice in classroom management, communication, learner engagement and method selection before entering real pedagogical practice.

At the same time, existing literature also emphasizes that the effectiveness of VR is not automatically guaranteed. Jensen and Konradsen show that VR head-mounted displays may be beneficial in some contexts, while in other cases cognitive load, technical difficulties or insufficient instructional content may limit their effectiveness [3]. Similarly, Radianti et al. note that immersive VR in higher education requires careful instructional design, meaningful interaction and well-organized assessment [5]. Therefore, it is not sufficient to introduce a 3D classroom into the learning process. The virtual environment must be integrated with pedagogical tasks, feedback and reflection.

Consequently, in a VR-based model of methodological competence, the main criterion should not be the technological effect itself, but the quality of pedagogical design. A VR environment influences learning outcomes only when it is connected with a methodological situation, learner behavior, decision consequences, correction, reflection and diagnostics. For this reason, the proposed model places the VR environment at the center of the pedagogical process and links all blocks of the model to the learner's methodological activity.

The practical significance of the model is that it gradually strengthens pre-service teachers' readiness for pedagogical practice. In a real classroom, an incorrect decision may negatively affect learners, whereas in a VR environment a mistake becomes a learning resource for methodological analysis and correction. This makes VR a valuable tool for developing methodological competence, especially in the transition from theoretical training to practical teaching activity.

CONCLUSION

The article theoretically substantiated a didactic model for developing pre-service teachers' methodological competence through virtual reality technologies. The main idea of the model is to interpret the VR environment not as a visual demonstration tool, but as an integrated didactic environment that combines virtual pedagogical situations, methodological decision-making, avatar reactions, diagnostic assessment and reflective correction.

The proposed model is aimed at developing methodological competence as a unity of motivational-value-oriented, cognitive-methodological, design-activity-oriented,

communicative-situational, reflective-evaluative and digital-technological components. The process cycle includes observation, diagnosis, methodological decision-making, avatar reaction, corrective action and reflective evaluation. This cycle allows the future teacher to observe a pedagogical situation, act within it, see the consequences of decisions and develop an individual trajectory of methodological growth.

In future research, it is advisable to test the effectiveness of the model through pedagogical experimentation involving experimental and control groups, to compare pre-test and post-test results, to determine the dynamics of competence levels, and to draw conclusions on the basis of mathematical and statistical analysis. Therefore, the proposed model can serve as a scientific and methodological basis for the further development of VR-based training systems for pre-service teachers.

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