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A Mechanism for Diagnostic Assessment and Monitoring of Future Teachers' Methodological Competence in A Virtual Reality Environment Based on Reactive Avatars

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Abstract: The article provides a scientific and methodological justification for a mechanism designed to diagnose and monitor the development of future teachers' methodological competence in a virtual reality environment. The central idea of the study is that VR technology should not be interpreted merely as a means of visual demonstration; rather, it should function as a controlled, activity-oriented, reflective, and diagnostically measurable pedagogical environment in which future teachers make methodological decisions in response to simulated classroom situations. The proposed model is based on virtual pedagogical situations, reactive student avatars, classroom climate indicators, an event-log system, and criteria-based assessment. The article clarifies how methodological decisions made by a future teacher in VR may influence avatar engagement, understanding, discipline, and emotional response. The model also specifies how these simulated consequences can be recorded and used for diagnostic monitoring. The study argues that the effectiveness of such a methodology must be established not through the mere existence of a VR scene, but through pre-test/post-test diagnostics, comparison of experimental and control groups, and mathematically grounded analysis of empirical data.

Keywords: Virtual reality, future teacher, methodological competence, diagnostic assessment, reactive avatar, pedagogical situation, reflection, VR event-log, pedagogical experiment.

Introduction: In the context of digital transformation, the development of future teachers' methodological competence on an applied and situation-based foundation has become an increasingly relevant task in teacher education. Methodological competence cannot be reduced to knowledge of a lesson plan template or memorisation of the names of teaching methods. It is an integrative professional quality that includes the ability to analyse a real pedagogical situation, select an appropriate method, organise learner activity, make a justified decision, evaluate the outcomes of one's actions, and introduce corrective changes when necessary.

Although traditional lectures and seminars remain important in higher pedagogical education, they cannot fully model the complex, dynamic, and partly unpredictable pedagogical situations that occur in real classrooms. From this perspective, virtual reality technologies provide an opportunity to place the future teacher in a controlled but realistic pedagogical environment where he or she can observe learner behaviour, test alternative methodological decisions, see the consequences of those decisions, and reflect on the quality of professional action [3; 4; 6].

For VR to be effective in education, it must not be used as an isolated visual module or as a technical effect. It should be integrated into the substantive and diagnostic structure of pedagogical activity. If a student only enters a VR classroom and observes the environment without his or her methodological decision affecting virtual learners, classroom climate, and assessment results, the VR component remains illustrative. In that case, it cannot serve as a scientific basis for claiming the development of methodological competence through virtual reality.

The aim of this article is to develop a diagnostic model based on reactive avatars for assessing and monitoring future teachers' methodological competence in a VR environment. The research question is formulated as follows: how can the methodological decision made by a student in a VR environment, the reactions of virtual learners, classroom climate indicators, and diagnostic scoring be integrated into a single assessment mechanism?

METHODS

The study is based on theoretical modelling, a design-based research orientation, pedagogical diagnostics, and systems analysis. The Cognitive Affective Model of Immersive Learning (CAMIL), which explains the role of presence and agency in immersive learning, was used as a theoretical foundation [4]. In addition, systematic reviews and recent studies on immersive VR applications in higher education and teacher training were considered [3; 5; 8; 10]. These studies show that VR is especially valuable when it provides repeatable, safe, situated and interactive practice rather than static visualisation.

In the process of methodological modelling, the activity of a future teacher in the VR environment was defined as a seven-stage diagnostic cycle: observation, diagnosis, decision, avatar reaction, correction, VR-based assessment, and reflection. Each stage was linked to a specific component of methodological competence. For example, the observation stage is linked to the ability to identify learner behaviour and classroom climate; the decision stage is linked to methodological reasoning and lesson design; the correction stage is linked to reflective and adaptive pedagogical thinking.

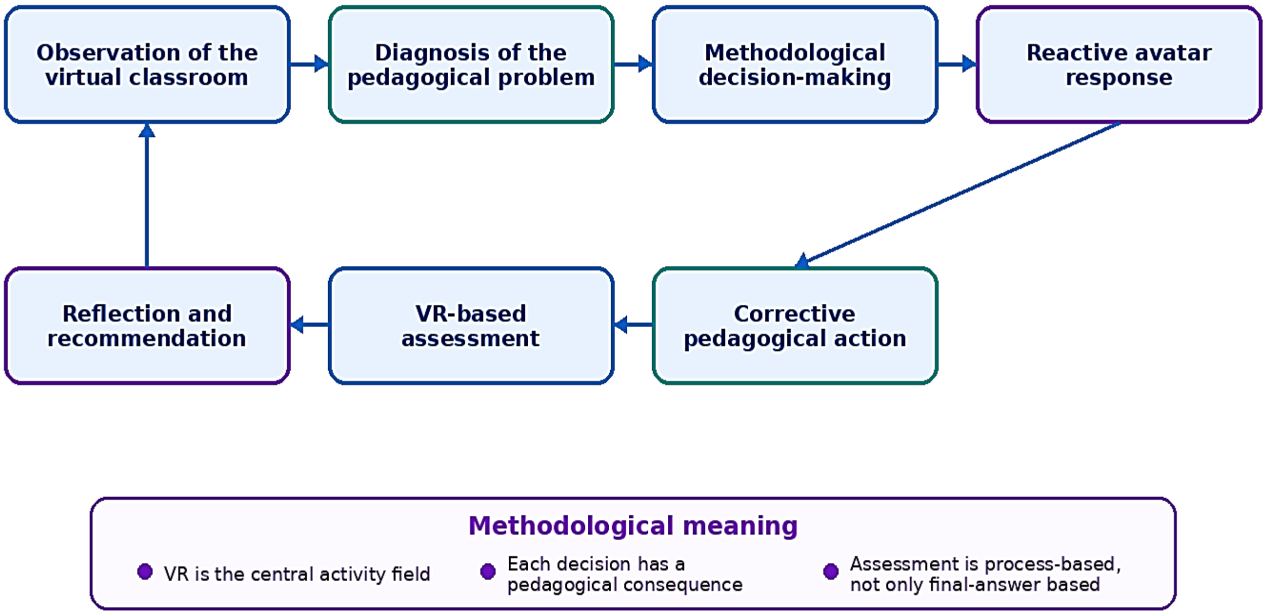

Figure 1. Diagnostic-assessment cycle in a VR environment

The assessment criteria were organised within a 100-point system. In this model, 70 percent of the total score is assigned directly to activity performed inside the VR environment. Such an approach prevents VR from becoming a secondary visual module and supports the core idea of developing methodological competence through virtual reality technologies.

Reactive avatars were treated as a separate methodological indicator in the model. Each avatar represents a specific learner condition: active, passive, asking questions, distracted, needing help, causing a discipline issue, having high readiness, or demonstrating low achievement. The methodological decision selected by the future teacher changes the avatar's state, engagement level, understanding level, emotional condition, and reaction history.

Table 1. Criteria for assessing methodological competence in a VR environment

Criterion	Main indicators	Observable evidence in VR	Points

Motivational-value-based	professional interest, pedagogical responsibility	active completion of the VR situation; attention to learner states	15
Cognitive-methodological	understanding of pedagogical situations; methodological knowledge	correct diagnosis of the problem and justification of its causes	20
Design-activity-based	setting a lesson goal; method selection; task design	appropriate methodological decision and micro-lesson logic	20
Communicative-situational	interaction with learner states; pedagogical response	appropriate response to passive, distracted or confused avatars	15
Reflective-assessment-based	self-analysis; identification of mistakes; correction	reflection after avatar reaction and corrective decision	15
Digital-technological	purposeful use of VR/digital tools	use of digital tools in connection with pedagogical goals	15

RESULTS

As a result of the study, a VR-centred diagnostic assessment model was developed. The main feature of the model is that assessment is not based only on a test or a written response; it is also based on a consistent record of pedagogical actions performed inside the VR environment. This approach makes it possible to evaluate methodological competence as a process rather than as a single final answer.

The first result is the substantiation of a cycle that links observation, diagnosis, decision, avatar reaction, and correction in the VR environment. In this cycle, an avatar is not a decorative 3D object but a simulated learner model that responds to the methodological decision of the future teacher. For example, if the student selects an interactive question-and-answer method, passive avatars may increase their engagement; if the student ignores a discipline issue, the classroom climate may deteriorate.

The second result is the proposal of a reactive avatar mechanism. This mechanism connects a methodological decision with avatar status, classroom climate, and diagnostic score indicators. Avatar movement, colour indicators, short voice or text responses, emotional state, and reaction history are treated as observable evidence of the simulated pedagogical consequences of the learner's decision.

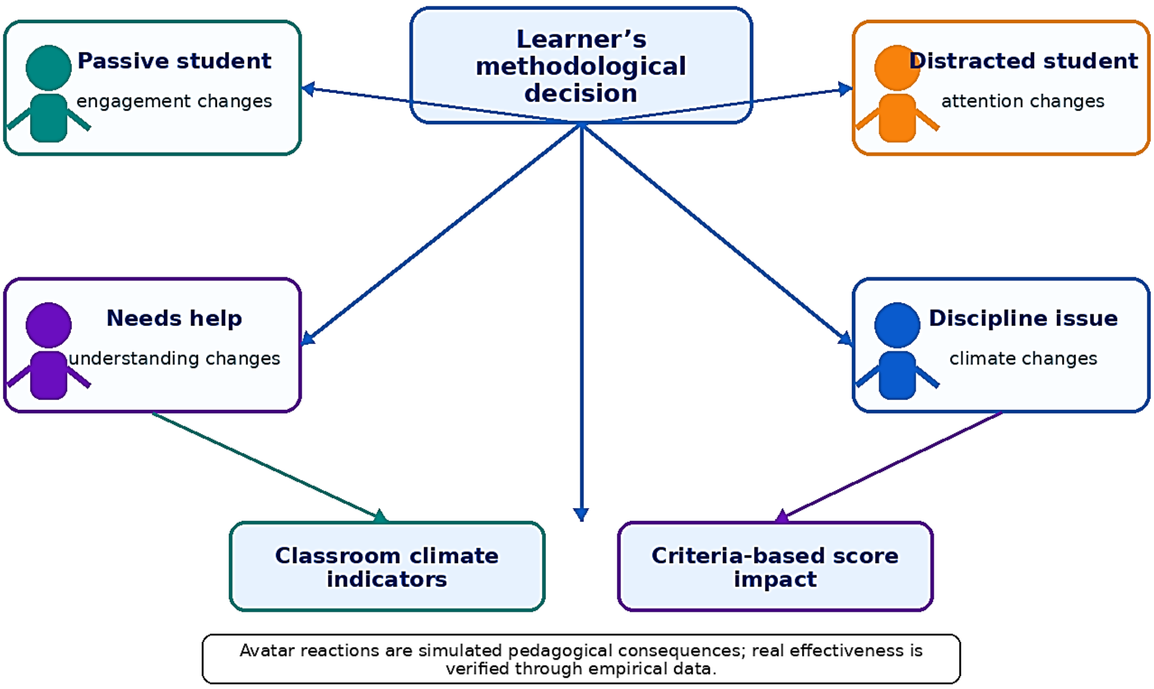

Figure 2. Mechanism for assessing methodological decisions through reactive avatars

The third result is an assessment structure that gives priority to VR-based activity. In this structure, 70 points out of the total 100 are assigned to observation, diagnosis, methodological decision-making, correction, and VR reflection performed inside the virtual environment. This model turns VR into the central mechanism for developing methodological competence rather than into an auxiliary visual element.

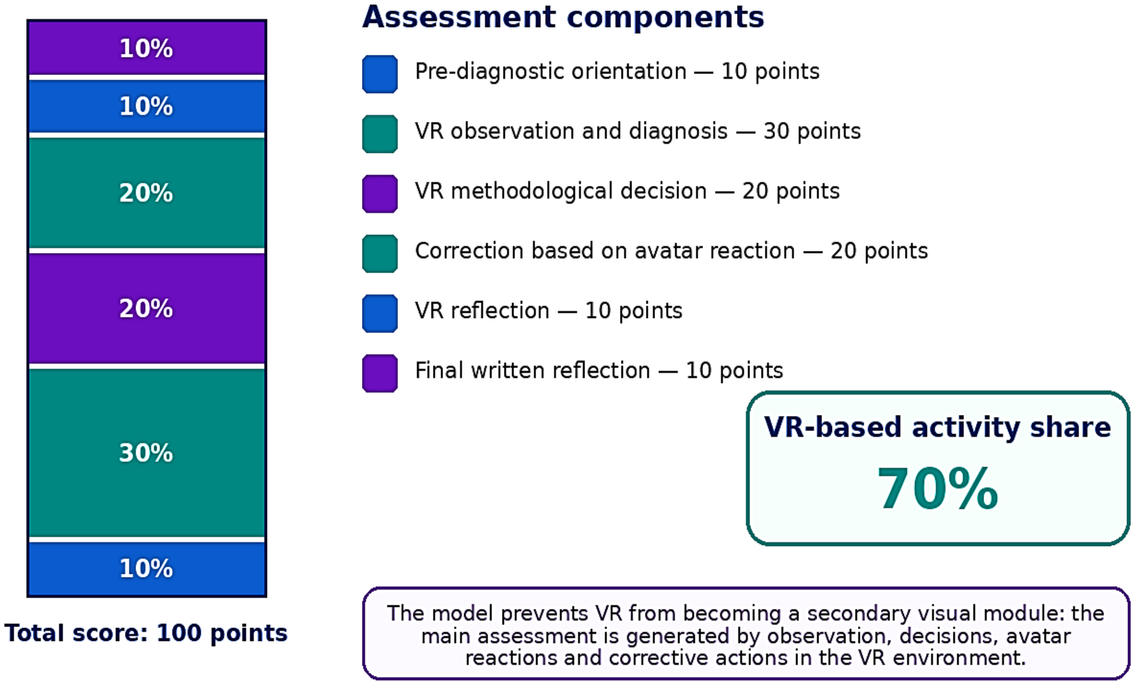

Figure 3. VR-centred assessment structure

Table 2. Diagnostic data collected through the VR event-log

Log type	Content	Pedagogical interpretation	Impact on assessment	Dashboard display
Avatar state	engagement, understanding, discipline, emotional condition	indicates the learner's pedagogical need	communicative and cognitive criteria	avatar dynamics
Student decision	method, tool, assessment and communication strategy	quality of methodological decision	design-activity criterion	decision list
Avatar reaction	movement, voice line, text response, state change	consequence of pedagogical action	score impact by criterion	reaction timeline
Classroom climate	activity, understanding, discipline, collaboration, reflection	overall quality of the simulated learning situation	integrated VR score	before/after indicators
Corrective action	additional explanation, differentiated task, individual support	reflective and adaptive pedagogical thinking	reflective-assessment criterion	correction effectiveness

The fourth result is the identification of analytical indicators that can be transmitted to a researcher dashboard: average VR score, increase in avatar engagement, difference in classroom climate before and after intervention, most frequent incorrect decisions, most effective methods, comparison of experimental and control groups, and CSV export. These indicators allow the researcher to connect process-based VR actions with empirical data used in the pedagogical experiment.

DISCUSSION

The proposed model interprets VR not as a technological novelty in teacher education, but as an environment for organising and assessing methodological activity. This view corresponds to recent studies that emphasise the importance of risk-free practice, repeatability, presence, agency, and pedagogical decision-making in VR-based teacher education [4; 6; 7; 9].

The reactive avatar mechanism enables process-based assessment of methodological competence. A conventional test may demonstrate the future teacher's theoretical knowledge, but it does not sufficiently reveal the ability to understand learner conditions, select an appropriate method, and correct an error in a situation close to a real lesson. The VR event-log can record these actions and transform them into diagnostically meaningful evidence.

A strength of the model is its multi-source assessment logic. Pre-diagnostics indicate initial readiness; VR observation demonstrates situational awareness; methodological decision-making reveals activity-based competence; avatar reactions stimulate corrective thinking; and reflection demonstrates the level of self-analysis. In combination, these elements provide a more complete view of methodological competence than a single test or written assignment.

At the same time, the model has limitations. Reactive avatars are simulated models; they cannot fully represent the psychological, social and cultural complexity of real learners. Therefore, real scientific effectiveness must be determined only through experimental and control groups, pre-test and post-test results, statistical significance analysis, and expert evaluation of the alignment between avatar reactions and pedagogical reality.

CONCLUSION

The article developed a mechanism for diagnostic assessment and monitoring of future teachers' methodological competence in a VR environment. In the proposed model, the VR classroom is considered the central didactic field: the learner observes virtual students, identifies the problem, makes a methodological decision, receives avatar reactions, applies corrective action, and analyses the result through reflection.

Reactive avatars, classroom climate indicators, and event-log-based monitoring make it possible to assess methodological competence not only through a final answer but also through the process of pedagogical activity. This approach allows the motivational, cognitive, design-activity, communicative, reflective and digital-technological components of methodological competence to be represented in a single diagnostic system.

In future research, the model should be tested with real experimental groups, pre-test and post-test results should be compared, VR event-log data should be statistically processed, and the consistency of avatar reactions with expert pedagogical evaluation should be examined. Only after such empirical verification can the real effectiveness of the VR-based methodology be scientifically substantiated.

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