Ilmiy tadqiqotlar va ularning yechimlari jurnali
Aoka guvohnoma № 323759 ISSN: 3060-4818

IMPROVING THE PROFESSIONAL SKILLS OF TEACHERS USING ARTIFICIAL INTELLIGENCE TECHNOLOGIES

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https://doi.org/10.5281/zenodo.20127966

Abstract — In the context of digital transformation, it is necessary to implement educational technologies based on artificial intelligence (AI) in order to develop the professional potential of future teachers, rather than relying on traditional digital tools. This study is aimed at identifying the effectiveness of introducing a digital learning environment with the integration of artificial intelligence in the training of future teachers and the formation of teachers' professional skills using the example of higher education institutions in Uzbekistan. The scientific novelty of the research is that for the development of the professional potential of future teachers, an adaptive assessment system based on artificial intelligence, an AI module that forms individual educational directions, and intelligent virtual laboratories are combined within a single methodological model. During the scientific research, theoretical analysis, pedagogical experience, online questionnaires, statistical analysis, and automatic control of learning outcomes using artificial intelligence were used. Through adaptive tests based on AI and algorithms designed to analyze educational activities, the level of knowledge, error patterns, and professional competence indicators of students were determined in real time, and individual educational directions were formed. In particular, AI-based assessment and virtual laboratories increased students' logical thinking, independent decision-making, and interest in the educational process. The results obtained during the study confirm that the introduction of AI-based educational technologies into training programs for future teachers is an innovative mechanism for improving the quality of education and forming professional qualifications.

Keywords — artificial intelligence, professional competence, adaptive education, AI-based assessment, laboratory, teacher training

I. Introduction

In recent years, the transition to digital systems has penetrated all areas of the education system. The widespread implementation of information and communication technologies has changed the form and content of the educational process, requiring teachers not only in-depth knowledge of the subject, but also the ability to effectively use modern digital and intellectual technologies. In particular, the implementation of educational solutions using digital technologies, along with artificial intelligence (AI), in the training of future teachers is emerging as an urgent scientific and pedagogical problem. Since the subjects mainly consist of complex theoretical concepts, multi-stage calculations and experimental laboratory work, traditional teaching methods cannot always fully ensure the level of knowledge of students. Although digital educational tools have partially eliminated this problem, most of them are static in nature, and the possibilities for personalizing the learning process are limited. From this point of view, flexible educational systems, intelligent assessment mechanisms and virtual laboratories developed on the basis of artificial intelligence create an opportunity to radically improve the quality of education. The use of artificial intelligence technologies in the educational process allows for the analysis of students' educational activities in real time, automatic assessment of their level of knowledge, identification of errors encountered in the educational process and design of individual educational

directions. This approach plays an important role in the formation of the professional potential of future teachers and serves to develop not only their knowledge in the field of science, but also their ability to logically and scientifically think, free and effective decision-making in problem situations and the skills of using digital pedagogical technologies. Although a number of scientific studies have been carried out in recent years on the development of teachers' digital potential, the issue of the systematic and comprehensive use of technologies based on artificial intelligence in the process of forming the professional competence of future teachers has not been sufficiently introduced. In existing scientific works, digital technologies are mainly interpreted as a general tool, and the adaptive, intellectual and predictive capabilities of artificial intelligence have not been sufficiently revealed.

For this reason, this study aims to scientifically investigate the introduction of a digital educational environment with the integration of artificial intelligence into the process of training future teachers and its effectiveness in developing professional competence. The main goal of the study is to determine the impact of adaptive assessment systems based on SI, intelligent virtual laboratories and mechanisms for forming individual educational paths on the professional potential of future teachers. To achieve this goal, a methodological model based on artificial intelligence was developed and its effectiveness was evaluated through pedagogical experience.

The results of this study allow us to develop scientifically based conclusions and practical recommendations on the introduction of educational technologies based on artificial intelligence in the training of future teachers. At the same time, it makes a significant contribution to the development of modern pedagogical educationmethodology

The research methodology was developed based on a step-by-step and systematic approach (Figure 1).



Fig. 1. Methodological approach to developing a model for research.

Stage 1. At the initial stage of the study, the level of knowledge, laboratory skills, digital and pedagogical potential of future teachers were determined using diagnostic tests, questionnaires and practical tasks. This stage served to form an initial database for training artificial intelligence algorithms.

Stage 2. Data collection and storage.Students' test results, actions in the virtual laboratory and independent work were compiled in a single digital database. This data was used by the SI system for further analysis.

Stage 3. SI-based analysis.With the help of artificial intelligence algorithms (machine learning and learning analytics), students' knowledge level, error repetition, and learning speed were analyzed in real time. As a result, the needs for individual education for each student were identified.

Stage 4. Formation of an individual educational path. Based on the SI analysis, an individual educational path was formed, including adaptive tests and intellectual virtual laboratories. This approach allowed for personalization of the educational process.

Stage 5. SI integrated educational process. In the experimental group, the educational process was managed using artificial intelligence. The SI system adjusted the complexity of the tasks, made recommendations, and generated analytical reports for the teacher.

Stage 6. Final assessment.At the end of the experiment, the professional competence of future teachers was reassessed using an adaptive assessment system based on SI.

Stage 7. Statistical and intellectual analysis of the results

The results were analyzed using mathematical and statistical methods (t-test, percentage analysis) and SI prediction modules. The reliability of the results was statistically confirmed.

A. Multidimensional model of professional competence

Professional competence is represented as a multi-component system by the following vector:

$$C(t) = \begin{matrix} c_1(t) \\ c_2(t) \\ c_3(t) \\ c_4(t) \end{matrix}$$

Where $c_1(t)$ - theoretical knowledge,

$c_2(t)$ - practical knowledge, $c_3(t)$ - decision-making in difficult situations, $c_4(t)$ - independent learning and flexibility.Integral competence,

$$C_{\text{int}}(t) = \sum_{i=1}^{4} w_i c_i(t) \qquad \sum_{i=1}^{4} w_i = 1$$

B. Dynamic equation of competence

The development of competence under the influence of SI-based education is expressed by the following differential equation,

$$\frac{dc_1(t)}{dt} = a_i L_i(t) + B_i A_i(t) - \gamma_i c_i(t)$$

Where $L_i(t)$ - educational intensity, $A_i(t)$ - SI adaptive recommendations, γ_i - knowledge forgetting coefficient

C. Optimal management model of adaptive learning

The educational process as a problem of optimal management,

$$J = \int_0^T (T_{torget} - C_{\text{int}}(t))^2 dt + \tau \int_0^T u^2(t) dt$$

J - cost function, $C_{\text{int}}(t)$ - real state of the system, u(t) - control signal, $\tau > 0$ - penalty coefficient imposed on control energy, First term $(T_{torget} - C_{\text{int}}(t))^2$ minimizes the error, Second term $\tau u^2(t)$,→ penalizes very large control signals,If τ is large → cautious, slow control, If τ is small → fast, aggressive control, Optimal control law,

$$u^*(t) = -K(T_{torget} - C_{\text{int}}(t))$$

Where $u^*(t)$ - optimal control signal, K>0 - amplification factor, T_{torget} - target value, $C_{\text{int}}(t)$ - current system status / internal measured value

D. Probabilistic Model of Valuation

Taking into account the uncertainty in the valuation,

$$P(R \quad r) = 1 - \phi\left(\frac{r - \mu(t)}{\sigma(t)}\right) \qquad (6)$$

Where R - random variable, r - given threshold value, $\mu(t)$ - time-dependent mathematical expectation, $\sigma(t)$ - time-dependent standard deviation, $\phi(z)$ - The distribution function of the standard normal distribution is, $\frac{r - \mu(t)}{\sigma(t)}$ - this is a standardized value (z-score), $\phi(.)$ - probability up to this value, $1 - \phi(.)$ - the area to the right of this value, i.e. $P(R \quad r)$

II. Research results

Experimental study and results

A. Experimental settings

The experiment was conducted on 120 participants. The control group received traditional training, while the experimental group received SI adaptive training.

B. Growth of competence over time

Time	$C_{ingt}(t)$	Level
0	0.42	Low
4	0.63	Average
8	0.79	Good
12	0.91	High

C. Comparing SI and traditional approaches

Indicator	Traditional	SI adaptive
Final competence	0.74	0.91
Acquisition time	16 weeks	12 weeks
Sustainability	Medium	High

D. Statistical reliability

Student t-test: $t=5.336$, $p<0.001$. The results are statistically reliable.

During the study, the impact of modern testing technologies based on artificial intelligence on the formation of professional potential of students of technical disciplines was tested experimentally. In the process of scientific research, control and experimental groups were formed, and initial (pre-test) and final (post-test) assessments were carried out in both groups.Analysis of the results of the initial test showed that there was no statistically significant difference in the level of professional competence between the control and experimental groups. ($p > 0.05$). This proves that the level of knowledge and skills of the groups before the start of the experiment was almost the same. During the experimental phase, adaptive tests, scenario-based tasks, and automated assessment systems developed based on artificial intelligence were used in the experimental group. Traditional testing and assessment methods were used in the control group. The analysis of the final test results showed that the professional competence of students in the experimental group significantly increased. In particular, the proportion of students with high and medium levels of competence in the experimental group increased sharply, while the low levels decreased significantly. Positive changes were also observed in the control group, but their growth rate was much lower than in the experimental group.

The results of statistical analysis (Student t-test) showed that the results obtained in the experimental group were more reliable than in the control group ($p < 0.05$). This proves that artificial intelligence-based testing technologies had a positive effect on the process of forming professional competence.

At the same time, it was found that the data obtained based on learning analytics allowed to identify gaps in students' knowledge and form an individual learning path. The test results, automatically analyzed using artificial intelligence, showed significant positive changes in students' ability to solve professional problems, logical thinking, and practical decision-making skills.

III. DISCUSSION

The results obtained are consistent with the approaches of adaptive assessment and automatic analysis of competence based on SI, noted in previous studies.

A significant increase in the level of competence in the experimental group is explained by the fact that artificial intelligence provides an individual approach, that is, the ability to form test tasks that are appropriate for the student's level of knowledge. This served to identify the individual learning characteristics of students, which are not sufficiently taken into account in traditional testing methods.Also, the assessment of scenario-based and practical tasks using artificial intelligence had a positive effect on the development of students' professional thinking and effective decision-making skills in problem situations typical of technical students. Analysis based on learning analytics made it possible to constantly monitor the process of forming students' competence.

However, the study has some shortcomings, and the limited size of the experiment and the short period of the study require a careful approach to generalizing the results. In the future, studies conducted by expanding the student contingent and based on long-term observations may further reveal the sustainable effectiveness of artificial intelligence-based assessment methodologies.

IV. Conclusion

The results of the study showed that the use of modern testing technologies based on artificial intelligence significantly increases the effectiveness of forming professional competence of technical students. The proposed approach, combining adaptive testing, tasks and automated assessment mechanisms, allows for a complex assessment of the level of knowledge, skills and practical thinking of students. The results of the experiment confirmed that the assessment process organized using artificial intelligence provides an individual approach and serves to more accurately determine the professional readiness of students. Also, analyses based on learning analytics allow for continuous monitoring of the process of forming professional competence and adjusting the educational process.The results of the study indicate the feasibility of introducing artificial intelligence-based testing technologies into the process of training specialists in technical areas in higher educational institutions. In future work, developing this approach across more disciplines and based on long-term research will help create more effective and reliable models for assessing professional competence

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