

A MODEL FOR DEVELOPING FUTURE TEACHERS' TESTOLOGICAL COMPETENCE BASED ON THE INTEGRATION OF ARTIFICIAL INTELLIGENCE AND DIGITAL ASSESSMENT TOOLS

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Abstract: The rapid advancement of artificial intelligence and digital educational technologies has significantly transformed teaching and assessment practices in modern education. Future teachers are expected to possess not only pedagogical knowledge but also competencies related to educational assessment, test construction, and the effective use of digital tools. However, many teacher education programs provide insufficient opportunities for developing testological competence and assessment literacy. This study aims to propose a model for developing future teachers' testological competence through the integration of artificial intelligence and digital assessment tools. The research is based on the use of digital platforms such as Quizizz, Kahoot, Wordwall, Google Forms, Canva AI, ChatGPT, Gemini, and Edpuzzle in educational practice. The proposed model supports test design, automated assessment, feedback generation, learning analytics, and reflective learning processes. The findings indicate that integrating artificial intelligence with digital assessment technologies contributes to improving future teachers' professional readiness, assessment literacy, digital competence, and ability to organize effective learning environments. The study also emphasizes the necessity of incorporating testology and modern assessment technologies into teacher education curricula.

Keywords: testological competence, future teachers, artificial intelligence, digital assessment, assessment literacy, educational technology, digital platforms, teacher education, learning analytics, innovative assessment.

SUN'IY INTELLEKT VA RAQAMLI BAHOLASH VOSITALARI INTEGRATSIYASI ASOSIDA BO'LAJAK O'QITUVCHILARNING TESTOLOGIK KOMPETENTLIGINI RIVOJLANTIRISH MODELI

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Annotatsiya: Ushbu maqolada sun'iy intellekt va raqamli ta'lim texnologiyalarining jadal rivojlanishi zamonaviy ta'limda o'qitish va baholash amaliyotini sezilarli darajada o'zgartirgani yoritiladi. Bo'lajak o'qituvchilardan nafaqat pedagogik bilim, balki ta'limiy baholash, test tuzish va raqamli vositalardan samarali foydalanish kompetensiyalari ham talab etiladi. Biroq ko'plab pedagogik ta'lim dasturlarida testologik kompetentlik va baholash savodxonligini rivojlantirish imkoniyatlari yetarli emas. Tadqiqot sun'iy intellekt va raqamli baholash vositalarini integratsiya qilish orqali bo'lajak o'qituvchilarning testologik kompetentligini rivojlantirish modelini taklif etishga qaratilgan. Tadqiqot Quizizz, Kahoot, Wordwall, Google Forms, Canva AI, ChatGPT, Gemini va Edpuzzle platformalaridan foydalanishga asoslangan. Taklif etilgan model test loyihalash, avtomatlashtirilgan baholash, qayta aloqa yaratish, o'quv tahlili va refleksiv o'rganish jarayonlarini qo'llab-quvvatlaydi. Natijalar sun'iy intellektni raqamli baholash texnologiyalari bilan integratsiya qilish bo'lajak o'qituvchilarning kasbiy tayyorgarligi, baholash savodxonligi,

raqamli kompetensiyasi va samarali ta'lim muhitini tashkil etish qobiliyatini oshirishga xizmat qilishini ko'rsatadi.

Kalit so'zlar: testologik kompetentlik, bo'lajak o'qituvchilar, sun'iy intellekt, raqamli baholash, baholash savodxonligi, ta'lim texnologiyalari, raqamli platformalar, pedagogik ta'lim, o'quv tahlili, innovatsion baholash.

МОДЕЛЬ РАЗВИТИЯ ТЕСТОЛОГИЧЕСКОЙ КОМПЕТЕНТНОСТИ БУДУЩИХ УЧИТЕЛЕЙ НА ОСНОВЕ ИНТЕГРАЦИИ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА И ЦИФРОВЫХ ИНСТРУМЕНТОВ ОЦЕНИВАНИЯ

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Аннотация: В статье рассматривается модель развития тестологической компетентности будущих учителей на основе интеграции искусственного интеллекта и цифровых инструментов оценивания. Быстрое развитие искусственного интеллекта и цифровых образовательных технологий существенно изменило практику преподавания и оценивания в современном образовании. От будущих учителей ожидается не только владение педагогическими знаниями, но и компетентность в области образовательного оценивания, конструирования тестов и эффективного использования цифровых инструментов. Однако многие программы педагогического образования предоставляют недостаточно возможностей для формирования тестологической компетентности и оценочной грамотности. Предлагаемая модель поддерживает разработку тестов, автоматизированное оценивание, формирование обратной связи, учебную аналитику и рефлексивное обучение. Полученные результаты показывают, что интеграция искусственного интеллекта с цифровыми технологиями оценивания способствует повышению профессиональной готовности будущих учителей, их оценочной грамотности, цифровой компетентности и способности организовывать эффективную образовательную среду.

Ключевые слова: тестологическая компетентность, будущие учителя, искусственный интеллект, цифровое оценивание, оценочная грамотность, образовательные технологии, цифровые платформы, педагогическое образование, учебная аналитика, инновационное оценивание.

INTRODUCTION

The ongoing digital transformation of education has fundamentally changed the ways teaching, learning, and assessment are organized in educational institutions worldwide. The rapid development of artificial intelligence (AI), learning analytics, and digital assessment technologies has created new opportunities for improving educational quality, enhancing learner engagement, and supporting data-driven decision-making in teaching practice. As a result, modern teachers are increasingly expected to possess not only pedagogical and subject-specific knowledge but also competencies related to educational assessment and the effective use of digital technologies.

Assessment is one of the most important components of the educational process because it provides information about learners' achievements, identifies learning gaps, and supports

instructional improvement. In contemporary education systems, assessment is gradually shifting from traditional paper-based testing to technology-enhanced and AI-supported assessment environments. This transformation requires teachers to develop assessment literacy and testological competence that enable them to design valid and reliable assessment instruments, interpret assessment results, provide constructive feedback, and make evidence-based pedagogical decisions.

Testological competence is considered a key component of a teacher's professional competence. It encompasses theoretical knowledge of educational measurement, practical skills in developing test items and assessment tasks, technological skills in using digital assessment platforms, and reflective abilities to evaluate and improve assessment practices. However, despite the increasing importance of assessment in educational quality assurance, many future teachers graduate from higher education institutions without sufficient preparation in testology and modern assessment technologies. In particular, specialized courses dedicated to educational assessment, test construction, and digital evaluation tools remain limited in many teacher education programs.

The emergence of artificial intelligence technologies such as ChatGPT and Gemini, together with digital assessment platforms including Quizizz, Kahoot, Google Forms, Wordwall, Canva AI, and Edpuzzle, has significantly expanded teachers' opportunities for creating innovative learning environments. These tools facilitate automated assessment, instant feedback, personalized learning, content generation, test development, and learning analytics. Furthermore, AI-assisted technologies can reduce teachers' workload and support the development of more effective and engaging assessment practices.

Recent studies have emphasized the growing role of digital technologies and artificial intelligence in improving teaching effectiveness and assessment quality. Nevertheless, existing research mainly focuses on the technological aspects of digital tools, while insufficient attention has been paid to their systematic integration into the process of developing future teachers' testological competence. The lack of pedagogically grounded models that combine artificial intelligence, digital assessment technologies, and competency-based teacher education creates a significant research gap that requires further investigation.

In the context of Uzbekistan's educational reforms and the ongoing digitalization of higher education, preparing future teachers who can effectively utilize modern assessment technologies has become an urgent pedagogical task. Future teachers should be capable of independently designing assessment instruments, employing digital platforms, interpreting assessment data, and integrating AI technologies into teaching and learning processes. Therefore, higher education institutions need innovative approaches that support the development of these competencies during pre-service teacher education.

The present study aims to develop and evaluate a model for enhancing future teachers' testological competence through the integration of artificial intelligence and digital assessment tools. The proposed model is based on the interaction of cognitive, practical, technological, and reflective components of competence and seeks to improve future teachers' professional readiness for assessment activities in digitally enriched educational environments.

Although previous studies have examined digital assessment technologies and artificial intelligence in education separately, limited attention has been given to their integrated application for developing future teachers' testological competence. Furthermore, empirical evidence regarding the effectiveness of AI-supported assessment environments in teacher

education remains insufficient, particularly within the context of higher pedagogical institutions in Uzbekistan. Therefore, this study seeks to address this gap by proposing and evaluating a model that integrates artificial intelligence technologies with digital assessment tools for the development of future teachers' testological competence

LITERATURE REVIEW AND METHODS

The rapid development of digital technologies and artificial intelligence has significantly transformed educational systems worldwide. Modern teachers are expected not only to possess strong pedagogical and subject-specific competencies but also to effectively utilize innovative technologies in teaching, learning, and assessment processes. Within this context, assessment literacy and testological competence have emerged as essential components of teacher professional development. Educational assessment serves as a critical mechanism for monitoring learning outcomes, identifying learners' needs, and ensuring the quality of education. Therefore, preparing future teachers who are capable of designing valid assessments and effectively applying digital evaluation technologies has become a pressing issue in contemporary teacher education.

The concept of assessment literacy has been extensively discussed in international educational research. Stiggins emphasizes that teachers must possess sufficient knowledge and skills to make informed assessment decisions and accurately interpret student performance data. According to the author, assessment-literate educators are better equipped to improve teaching effectiveness and student achievement. Similarly, Popham argues that teachers should understand the principles of validity, reliability, fairness, and practicality when designing assessment instruments. Without such competencies, assessment may fail to accurately reflect students' actual knowledge and abilities.

Recent studies have demonstrated the growing role of digital technologies in educational assessment. Brookhart notes that technology-enhanced assessment environments facilitate continuous feedback, learner monitoring, and data-driven instructional decision-making. Digital assessment tools allow teachers to automate routine evaluation processes while simultaneously increasing learner engagement and motivation. Redecker further highlights that modern teachers require both digital competence and assessment competence because contemporary educational environments increasingly rely on technological solutions for instructional and evaluative purposes.

The emergence of artificial intelligence technologies has created additional opportunities for improving educational assessment practices. Holmes et al. emphasize that artificial intelligence can support adaptive testing, automated feedback, personalized learning, and learning analytics, thereby enhancing both teaching and assessment quality. Similarly, Kasneci et al. argue that generative artificial intelligence tools such as ChatGPT provide substantial support for educators in designing assessment materials, creating test items, generating lesson plans, and developing learning resources. These technologies reduce the time spent on routine tasks and enable teachers to focus more on instructional design and student support.

Despite these advancements, a review of the existing literature reveals several unresolved issues. Recent national studies have highlighted the growing importance of developing testological competence within the context of digital transformation in education. Findings suggest that the use of digital approaches, reflective technologies, and competency-oriented learning environments positively influences future teachers' assessment literacy, technological readiness, and professional development. Furthermore, evidence indicates that the systematic

implementation of digital assessment tools supports the development of practical skills related to test construction, data analysis, feedback provision, and educational evaluation processes.

Most previous studies investigate assessment competence, digital technologies, or artificial intelligence as separate constructs. Relatively limited research has examined the integrated application of artificial intelligence and digital assessment tools for developing future teachers' testological competence. Furthermore, in many higher education institutions, undergraduate teacher education programs still provide insufficient opportunities for students to acquire practical experience in digital assessment design and AI-supported educational technologies.

This challenge is particularly relevant within the context of teacher education in Uzbekistan. Although significant efforts have been made to modernize higher education and promote digital transformation, specialized courses focusing on testology, educational measurement, and digital assessment technologies remain limited within many teacher preparation programs. Consequently, future teachers often enter the profession with inadequate knowledge and practical skills related to modern assessment systems, digital platforms, and innovative evaluation methods.

Based on the theoretical analysis, the present study conceptualizes testological competence as a multidimensional construct consisting of four interconnected components: cognitive, practical, technological, and reflective. The cognitive component encompasses theoretical knowledge of educational assessment, measurement principles, validity, reliability, and testology. The practical component includes the ability to construct test items, develop assessment instruments, and implement evaluation procedures. The technological component reflects proficiency in utilizing digital assessment platforms and artificial intelligence technologies. The reflective component refers to the ability to critically evaluate assessment practices and continuously improve professional performance.

Table 1. Components of Testological Competence

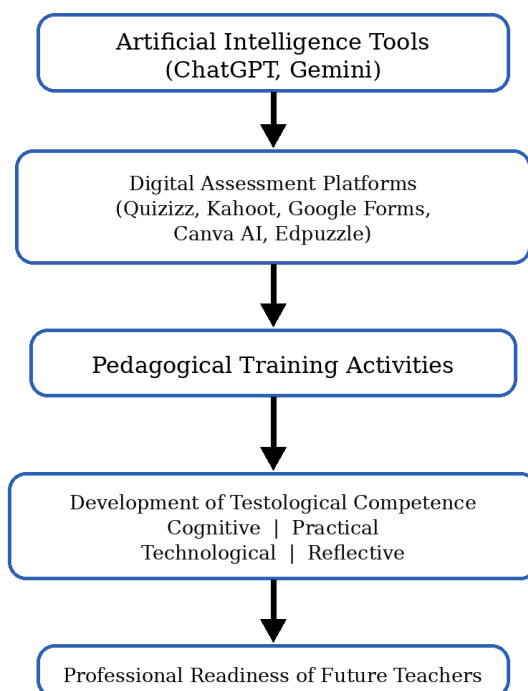
Component	Description
Cognitive	Knowledge of educational assessment, testology, validity, reliability, and measurement principles
Practical	Skills in test construction, assessment design, and evaluation procedures
Technological	Ability to use digital assessment platforms and AI-based educational tools
Reflective	Self-assessment, critical reflection, and continuous professional development

To investigate the effectiveness of developing testological competence through artificial intelligence and digital assessment technologies, a quasi-experimental research design was employed. The study was conducted during the 2025–2026 academic year and involved second-year students from Termez State Pedagogical Institute and Denov Institute of Entrepreneurship and Pedagogy. A total of 90 students participated in the research. The experimental group consisted of 45 students from Termez State Pedagogical Institute, while the control group included 45 students from Denov Institute of Entrepreneurship and Pedagogy.

The experimental intervention lasted four months. During this period, students in the experimental group participated in specially organized training sessions three times per week. The training focused on developing practical skills related to educational assessment, digital technologies, test construction, and artificial intelligence applications in teaching and learning processes.

Several digital and AI-based educational tools were systematically integrated into the training process. Quizizz and Kahoot were used to create interactive assessments and gamified testing activities. Google Forms enabled students to design online tests, collect learner feedback, and automate evaluation procedures. Canva AI was employed for creating educational presentations, visual materials, and instructional resources. Edpuzzle facilitated interactive video-based learning and formative assessment activities. Furthermore, ChatGPT and Gemini were introduced as tools for generating test questions, creating lesson plans, developing classroom activities, preparing educational materials, and supporting pedagogical decision-making.

Figure 1. Model for Developing Future Teachers' Testological Competence



The proposed model was developed based on competency-based education principles, digital assessment technologies, and contemporary approaches to teacher professional development. The model integrates four key components of testological competence: cognitive, practical, technological, and reflective competence. Previous studies have shown that the systematic use of digital assessment tools and reflective learning technologies positively influences assessment literacy, technological readiness, and professional self-development among future teachers [9]. Building upon these findings, the present study extends the existing framework by incorporating artificial intelligence technologies as an additional mechanism for enhancing assessment practices and professional competence development.

Data collection was carried out through diagnostic testing, practical assignments, classroom observations, self-assessment questionnaires, and expert evaluations. The collected

data were analyzed using descriptive statistical methods and comparative analysis techniques. Such a methodological approach made it possible to evaluate changes in students' levels of testological competence before and after the intervention and to determine the effectiveness of integrating artificial intelligence and digital assessment technologies into teacher education programs.

RESULTS AND DISCUSSION

The purpose of the experimental study was to determine the effectiveness of integrating artificial intelligence technologies and digital assessment tools in developing future teachers' testological competence. Prior to the intervention, diagnostic assessments revealed that most participants possessed limited knowledge regarding digital assessment systems, AI-supported educational technologies, and modern approaches to test development. Many students reported using ready-made tests obtained from internet resources without understanding the principles of validity, reliability, item construction, and assessment design.

The pre-experimental findings indicated that future teachers experienced difficulties in creating digital assessment materials independently, selecting appropriate technological tools for classroom assessment, and utilizing artificial intelligence platforms for pedagogical purposes. These findings support previous research emphasizing that teacher education programs often provide insufficient practical preparation in educational assessment and digital technologies.

To address these shortcomings, a four-month intervention program was implemented with the experimental group. During the intervention, students received systematic training three times per week focusing on digital assessment tools, AI-supported instructional design, and test construction methodologies. The training emphasized both theoretical understanding and practical application of assessment technologies in authentic educational contexts.

Special attention was given to the development of four interconnected components of testological competence: cognitive, practical, technological, and reflective competence. Students learned to create formative and summative assessments using Quizizz, Kahoot, Google Forms, Canva AI, and Edpuzzle, while ChatGPT and Gemini were utilized for generating assessment tasks, lesson activities, rubrics, and instructional materials.

The comparative analysis of pre-test and post-test results demonstrated substantial improvements in the experimental group

Table 2. Changes in Testological Competence Levels Before and After the Experiment (%)

Components	Experimental Group (Before)	Experimental Group (After)	Increase (%)	Control Group (Before)	Control Group (After)
Cognitive Component	62	78	+16	63	67
Practical Component	58	74	+16	60	64
Technological Component	54	71	+17	55	60

Components	Experimental Group (Before)	Experimental Group (After)	Increase (%)	Control Group (Before)	Control Group (After)
Reflective Component	60	75	+15	61	65
Average	58.5	74.5	+16.0	59.8	64.0

As shown in Table 2, the average level of testological competence in the experimental group increased from 58.5% to 74.5%, representing an overall improvement of approximately 16%. In contrast, the control group demonstrated only marginal progress. These findings suggest that the integration of AI-supported educational technologies and digital assessment platforms significantly contributed to the development of future teachers' professional competencies.

The most substantial growth was observed in the technological component. This finding can be explained by students' active engagement with digital platforms throughout the intervention period. Prior to the experiment, many participants had never independently created online assessments or utilized artificial intelligence tools in educational settings. Following the intervention, students successfully designed interactive quizzes, digital feedback systems, multimedia learning materials, and AI-supported lesson plans.

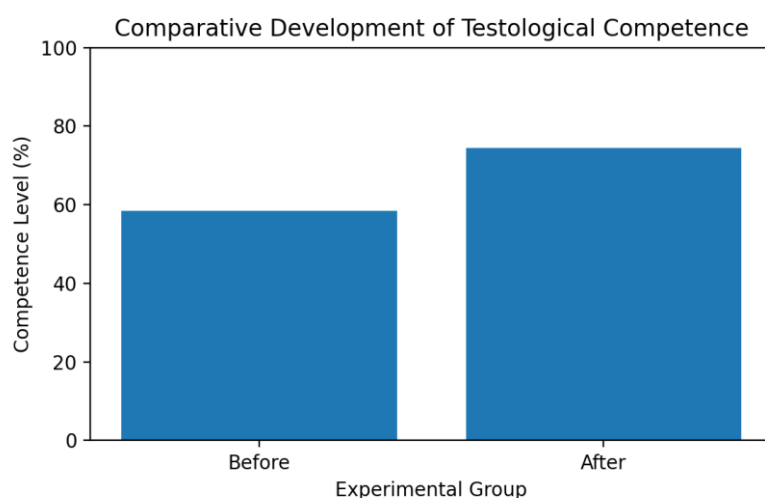


Figure 2. Comparative Development of Testological Competence

The diagram clearly illustrates the positive dynamics observed in the experimental group after the implementation of the proposed model.

An additional outcome of the intervention was the enhancement of students' perceptions regarding artificial intelligence in education. At the beginning of the study, many participants associated AI tools primarily with information retrieval. However, by the end of the experiment, students recognized the broader pedagogical potential of AI technologies, including automated feedback generation, assessment design, lesson planning, instructional material development, and learner support.

Furthermore, students demonstrated increased confidence in applying assessment principles during classroom activities. They became capable of selecting appropriate assessment

methods, constructing quality test items, analyzing assessment outcomes, and modifying instructional strategies based on learner performance data. Such developments indicate the successful integration of assessment literacy and digital competence within teacher preparation programs.

The findings of this study correspond with recent international research highlighting the transformative role of artificial intelligence in educational assessment. UNESCO emphasizes that AI technologies have the potential to improve educational quality by supporting personalized learning, adaptive assessment, and data-informed decision-making. Similarly, Luckin argues that artificial intelligence can enhance teachers' professional effectiveness by automating routine tasks and enabling more informed pedagogical decisions.

Another important finding concerns the reflective component of testological competence. Students not only improved their technological skills but also developed the ability to critically evaluate their own assessment practices. Reflection activities encouraged future teachers to identify strengths and weaknesses in assessment design and to continuously improve their professional performance. This result aligns with contemporary competency-based teacher education models that emphasize lifelong learning and reflective practice.

Overall, the study demonstrates that a systematic integration of artificial intelligence technologies and digital assessment tools can significantly enhance the development of future teachers' testological competence. The proposed model contributes to the modernization of teacher education by combining assessment literacy, digital competence, AI-supported learning, and reflective professional development within a unified pedagogical framework.

CONCLUSION

The findings of this study confirm that the integration of artificial intelligence technologies and digital assessment tools significantly contributes to the development of future teachers' testological competence. The experimental results demonstrated positive changes across all components of testological competence, including cognitive, practical, technological, and reflective dimensions.

The implementation of a four-month training program based on AI-supported educational technologies enabled students to acquire practical skills in assessment design, digital test construction, automated feedback generation, and technology-enhanced learning activities. The use of platforms such as Quizizz, Kahoot, Google Forms, Canva AI, Edpuzzle, ChatGPT, and Gemini increased students' ability to effectively organize assessment processes and apply modern educational technologies in pedagogical practice.

The results revealed that the average level of testological competence in the experimental group increased by approximately 16%, indicating the effectiveness of the proposed model. In particular, significant improvements were observed in the technological and practical components, suggesting that systematic exposure to digital assessment environments enhances future teachers' readiness for professional activity in modern educational settings. The study also demonstrated that artificial intelligence technologies can serve not only as information retrieval tools but also as effective instruments for lesson planning, assessment development, educational content creation, and reflective professional growth. Therefore, the integration of AI technologies into teacher education programs should be considered an important direction for the modernization of higher pedagogical education.

Based on the research findings, it is recommended that higher education institutions introduce specialized courses and practical training modules related to educational assessment,

digital technologies, artificial intelligence, and testology. Such initiatives would support the preparation of competent, technologically literate, and assessment-oriented future teachers capable of meeting the demands of contemporary education.

Finally, the proposed model may serve as a methodological framework for developing testological competence in teacher education programs and can be adapted for use in various educational contexts and subject areas.

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