

**O‘ZBEKISTON RESPUBLIKASI OLIY TA’LIM, FAN VA
INNOVATSIYALAR VAZIRLIGI**

**MIRZO ULUG‘BEK NOMIDAGI O‘ZBEKISTON MILLIY
UNIVERSITETINING JIZZAX FILIALI**



KOMPYUTER ILMLARI VA MUHANDISLIK TEXNOLOGIYALARI
mavzusidagi Xalqaro ilmiy-texnik anjuman materiallari to‘plami
2026-yil 25-26-sentabr

(1-qism)

JIZZAX-2026

Kompyuter ilmlari va muhandislik texnologiyalari. Xalqaro ilmiy-texnik anjuman materiallari to'plami – Jizzax: O'zMU Jizzax filiali, 2026-yil 25-26-sentabr. 507-bet.

Xalqaro miqyosidagi ilmiy-texnik anjuman materiallarida zamonaviy kompyuter ilmlari va muhandislik texnologiyalari sohasidagi innovatsion tadqiqotlar aks etgan.

Globalashuv sharoitida davlatimizni yanada barqaror va jadal sur'atlar bilan rivojlantirish bo'yicha amalga oshirilayotgan islohotlar samarasini yaxshilash sohasidagi ilmiy-tadqiqot ishlariga alohida e'tibor qaratilgan. Zero iqtisodiyotning, ijtimoiy sohalarni qamrab olgan modernizatsiya jarayonlari, hayotning barcha sohalarini liberallashtirishni talab qilmoqda.

Ushbu ilmiy ma'ruza tezislari to'plamida mamlakatimiz va xorijlik turli yo'nalishlarda faoliyat olib borayotgan mutaxassislar, olimlar, professor-o'qituvchilar, ilmiy tadqiqot institutlari va markazlarining ilmiy xodimlari, tadqiqotchilari, magistr va talabalarining ilmiy-tadqiqot ishlari natijalari mujassamlashgan.

Mas'ul muharrirlar: DSc.prof. Turakulov O.X., t.f.n., dots. Baboyev A.M.

Tahrir hay'ati a'zolari: p.f.d.(DSc), prof. Turakulov O.X., t.f.n., dots. Baboyev A.M., t.f.f.d.(PhD), prof. Abduraxmanov R.A., p.f.f.d.(PhD) Eshankulov B.S., p.f.n., dots. Aliqulov S.T., p.f.n., dots. Alimov N.N., p.f.f.d.(PhD), dots. Alibayev S.X., t.f.f.d.(PhD), dots. Abdumalikov A.A., p.f.f.d.(PhD) Hafizov E.A., f.f.f.d.(PhD) dots., Norbekova B.Sh. p.f.f.d.(PhD) dots. Sindorov L.K., t.f.f.d.(PhD), dots. Nasirov B.U., b.f.f.d. (PhD) O'ralov A.I., p.f.n., dots. Aliqulov S.T., t.f.f.d.(PhD) Kuvandikov J.T., i.f.n., dots. Tsoy M.P., Sharipova S.F., Jo'rayev M.M.

Mazkur to'plamga kiritilgan ma'ruza tezislarining mazmuni, undagi statistik ma'lumotlar va me'yoriy hujjatlarning to'g'riligi hamda tanqidiy fikr-mulohazalar, keltirilgan takliflarga mualliflarning o'zlari mas'uldirlar.

PEDAGOGICAL EFFECTIVENESS OF AI-BASED ADAPTIVE LEARNING SYSTEMS

Tojiyev Alisher Hasan o'g'li

*Jizzakh Branch of the National University
of Uzbekistan named after Mirzo Ulugbek*

a_tojiyev@jbnuu.uz

Zhyrgal Zhusupbek kzy

Zh. Myrsabekova. OshGPU, Osh, Kyrgyzstan

Abstract: This paper analyses the pedagogical effectiveness of AI-based adaptive learning systems in higher education. Findings of international meta-analyses are summarized to highlight the impact of adaptive systems on learning outcomes, the factors determining their effectiveness and the criteria for its assessment. The methodological conditions for using adaptive platforms to develop students' cognitive competencies are substantiated.

Keywords: artificial intelligence, adaptive learning, intelligent tutoring systems, pedagogical effectiveness, personalized learning path, cognitive competence, Bloom's taxonomy.

One of the pressing challenges facing higher education in the context of digital transformation is the individualization of learning in line with each student's level of knowledge, pace of mastery and cognitive characteristics. In traditional classroom instruction, the teacher tends to address the “average” student in the group; as a result, high-potential students are insufficiently challenged, while lower-achieving students fall behind. B.Bloom described this situation as the “2 sigma problem”: students tutored one-to-one outperformed their peers in conventional classes by an average of two standard deviations [1]. Since one-to-one tutoring is economically unfeasible in mass education, the idea of modelling it by technological means laid the foundation for the emergence of adaptive learning systems.

In the Republic of Uzbekistan, this direction is supported at the level of state policy. The Concept for the Development of the Higher Education System until 2030 sets the task of the wide introduction of digital technologies into the educational process [2], while the resolution on the accelerated introduction of artificial intelligence technologies provides for creating conditions for their application in the economy and social sphere [3].

An AI-based adaptive learning system is understood as a software and pedagogical system that continuously collects and analyses data on a student's learning activity and, on this basis, adjusts the learning content, task difficulty, mode of presentation and nature of feedback in real time. Such systems typically comprise a domain model (the knowledge to be learned and the relationships between its elements), a student model (level of knowledge, typical errors, learning characteristics) and a pedagogical model (rules determining which instructional action to take in a given situation) [4]. Artificial intelligence techniques – machine learning and natural language processing – transform these models from a static set

of rules into a dynamic, self-improving system, enabling automatic task generation, analysis of open-ended answers and prediction of the student's next step.

Research conducted abroad provides empirical support for the pedagogical effectiveness of adaptive systems. According to K.VanLehn, the effect size of step-based intelligent tutoring systems (ITS) reached 0.76, closely approaching that of human tutoring (0.79) [5]. A meta-analysis by W.Ma and colleagues found that the use of ITS produced higher outcomes than teacher-led large-group instruction ($g = 0.42$) [6]. Having analysed 50 controlled evaluations, J.Kulik and J.Fletcher reported that in 92% of them students taught with ITS outperformed the control group, with a median effect size of 0.66 [7].

The main findings of these meta-analyses are summarized in Table 1. The results were interpreted using J.Cohen's benchmarks: 0.2 – small, 0.5 – medium and 0.8 – large effect [9].

Table 1

Findings of meta-analyses on the effectiveness of intelligent tutoring systems

Source	Comparison	Effect size
K.VanLehn, 2011 [5]	Step-based ITS vs. instruction without tutoring	$d = 0.76$
W.Ma et al., 2014 [6]	ITS vs. teacher-led large-group instruction	$g = 0.42$
J.Kulik, J.Fletcher, 2016 [7]	ITS vs. conventional instruction (50 studies)	median = 0.66

As the table shows, all three meta-analyses report ITS effects of at least moderate magnitude. The dependence of effectiveness on the type of feedback is clearly illustrated by K.VanLehn's data (Figure 1).

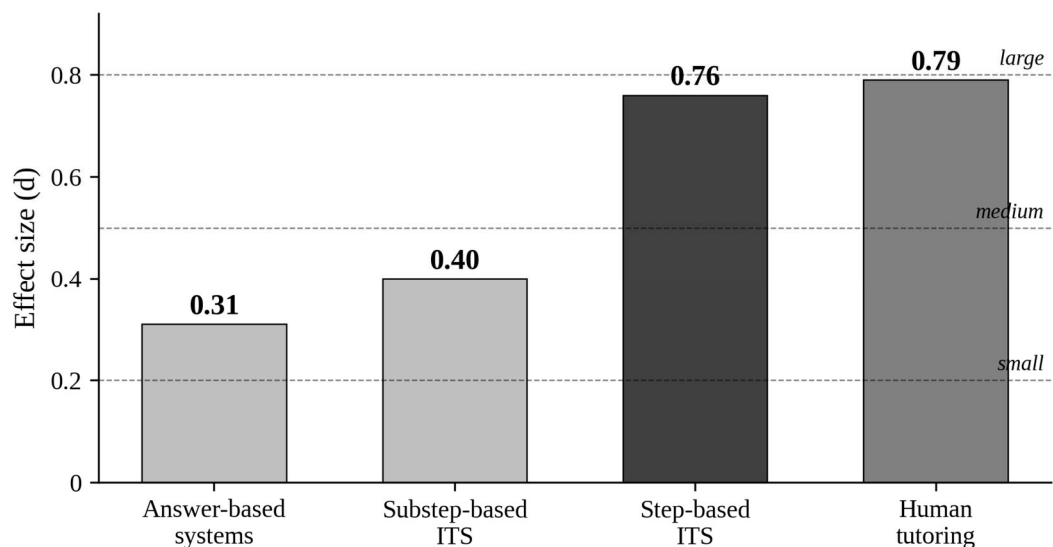


Figure 1. *Effectiveness of tutoring systems by type of feedback (based on K.VanLehn's data [5])*

The chart leads to an important pedagogical conclusion: the difference between systems that check only the final answer ($d = 0.31$) and systems providing step-by-step feedback ($d = 0.76$) is nearly 2.5-fold, while step-based systems almost match human tutoring ($d = 0.79$). Breaking feedback into units finer than a step ($d = 0.40$) did not increase the effect. Thus, the effectiveness of an adaptive system is determined not by technological complexity, but by feedback organized at a pedagogically optimal level of granularity[10].

At the same time, research shows that effectiveness is not guaranteed automatically. In particular, J.Kulik and J.Fletcher noted that effect sizes were considerably higher on tests developed by the researchers themselves than on standardized tests [7]. O.Zawacki-Richter and colleagues found that most studies on AI applications in higher education show weak connection to pedagogical theory and give insufficient attention to the role of the teacher [8]. Consequently, the pedagogical effectiveness of an adaptive system depends not on the technology itself, but on its sound instructional design and integration into the learning process[11].

Based on this analysis, the following factors determining the pedagogical effectiveness of an adaptive learning system can be identified: the accuracy and continuous updating of the student model; the timeliness and informativeness of feedback – not merely “correct/incorrect”, but an explanation of the cause of the error; the differentiation of tasks by cognitive level; and the teacher's management of the learning process on the basis of analytics provided by the system[13].

Relying solely on final grades is insufficient for assessing pedagogical effectiveness. In our view, it is advisable to assess it using a set of criteria: a cognitive criterion – the dynamics of knowledge acquisition and performance on tasks at the higher levels of Bloom's taxonomy (analysing, evaluating, creating); an activity-motivational criterion – engagement in independent work, time spent on tasks and consistency of participation; and a metacognitive criterion – the accuracy of students' self-assessment of their knowledge and their ability to plan their own learning[12].

Within the framework of our research, the adaptive learning platform “EduPlatforma” is being developed for teaching programming courses. The platform is designed to provide AI-assisted evaluation of learning resources and generation of test items, adaptive testing, analysis of tasks by the levels of Bloom's taxonomy, and recording of students' learning behaviour indicators – time spent per question, loss of focus and answer changes. These indicators make it possible to assess not only the learning outcome but also the learning process itself, that is, to measure the metacognitive and activity-motivational criteria outlined above. Determining the pedagogical effectiveness of the platform through a pedagogical experiment is planned for the next stage of the research.

In conclusion, AI-based adaptive learning systems have considerable potential for individualizing learning and developing students' cognitive competencies. International meta-analyses indicate that their effectiveness relative to traditional

instruction is moderate to large. However, realizing this potential requires that such systems be designed on the basis of pedagogical theory and that their effectiveness be assessed using a combination of cognitive, activity-motivational and metacognitive criteria.

References:

1. Bloom B.S. The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring // *Educational Researcher*. – 1984. – Vol. 13, No. 6. – P. 4–16.
2. Decree of the President of the Republic of Uzbekistan No. PF-5847 of 8 October 2019 “On Approval of the Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030”.
3. Resolution of the President of the Republic of Uzbekistan No. PQ-4996 of 17 February 2021 “On Measures to Create Conditions for the Accelerated Introduction of Artificial Intelligence Technologies”.
4. Holmes W., Bialik M., Fadel C. *Artificial Intelligence in Education: Promises and Implications for Teaching and Learning*. – Boston: Center for Curriculum Redesign, 2019.
5. VanLehn K. The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems, and Other Tutoring Systems // *Educational Psychologist*. – 2011. – Vol. 46, No. 4. – P. 197–221.
6. Ma W., Adesope O.O., Nesbit J.C., Liu Q. Intelligent Tutoring Systems and Learning Outcomes: A Meta-Analysis // *Journal of Educational Psychology*. – 2014. – Vol. 106, No. 4. – P. 901–918.
7. Kulik J.A., Fletcher J.D. Effectiveness of Intelligent Tutoring Systems: A Meta-Analytic Review // *Review of Educational Research*. – 2016. – Vol. 86, No. 1. – P. 42–78.
8. Zawacki-Richter O., Marín V.I., Bond M., Gouverneur F. Systematic review of research on artificial intelligence applications in higher education – where are the educators? // *International Journal of Educational Technology in Higher Education*. – 2019. – Vol. 16. – Article 39.
9. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. – 2nd ed. – Hillsdale, NJ: Lawrence Erlbaum Associates, 1988.
10. Тоджиев А., Норкузиёв К. The role of artificial intelligence technology in individualized teaching // *Информатика и инженерные технологии*. – 2023. – Т. 1. – №. 2. – С. 153-156.
11. Zaripova , D. A., & Tojiyev , A. (2026). RAQAMLI TA'LIM PLATFORMALARIDA O'QUV MATERIALLARINING SEMANTIK MOSLIGINI BAHOLASH: <https://doi.org/10.5281/zenodo.20620862>. *Scientific Practical Conference*, 1(2), 214-221. <https://d-pressa.com/index.php/spc/article/view/832>
12. Tojiyev , A., & O'rozqulov , S. (2025). A LINEAR REGRESSION MODEL FOR PREDICTING STUDENTS' FINAL TEST SCORES BASED ON ASSESSMENT RESULTS. *Scientific Practical Conference*, 1(1), 30-33. <https://d-pressa.com/index.php/spc/article/view/160>